CROSSOCHIR KOELZI: A NEW CALIFORNIAN
SURF-FISH OF THE FAMILY EMBIOTOCIDAE

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In the preparation of a monographic review of the fishes of the family Embiotocidae—the viviparous perches of the North Pacific—it has become evident that one of the most distinct species of the California coast has remained unnamed. The characters of this form are, however, so clear that a new genus appears needed for its sole reception.

This form has only once been distinguished. In my 1918 revision of the family, it was keyed out as Holconotus rhodoterus, which among previously named forms is probably its closest relative. In preparing that revision, I had specimens of Crossochir but none of the true Holconotus at hand, and so rather naturally made the misidentification, no more suspecting than did Dr. David Starr Jordan or other ichthyologists that an unnamed species existed in this well-studied family.

The distinguishing features of Crossochir koelzi, the new genus and species, and of other members of the subfamily Amphistichinae are indicated in the following key:

KEY TO THE GENERA AND SPECIES OF THE EMBIOTOCID SUBFAMILY AMPHISTICHAEN

a'. Anal fin of breeding male without definite horned excrescence and huge fleshlike gland, but with one ray (about the twelfth, at the angle in the fin base) enlarged and ossified into a strong triangular plate with serrated edge, and with the next ray following also somewhat strengthened (in the female the homologous rays are somewhat modified in the same direction, sufficiently so for purposes of identification). No oval depression on body near front of anal fin. No sexual variation in number of fin rays or vertebrae. Spinous portion of dorsal shorter than the soft part. Teeth unicusp. in two series in each jaw (the inner row of lower jaw more or less confined to front of jaw). (Subfamily Amphistichinae.)  

b'. Lower lip with posterior groove continuous across chin. Mouth decidedly oblique, rising to opposite lower part of eye anteriorly.
Dorsal spines rather slender and weak, abruptly graduated to the long middle spines, behind which the margin of the fin is nearly straight. Anterior interneurals not greatly strengthened, with low and blunt lateral ridges. Pectoral fin longer, with upper edge nearly straight to tip, and lower rays only slightly frayed and silky. Fins pale, with or without black markings.

d'. Lower jaw very strong, projecting forward at the symphysis beyond the upper, so that the teeth of the two jaws are far from being opposed. Body more nearly oblong (depth about two-fifths standard length). Anal fin relatively short, with fewer than 20 soft rays.

c'. Gill rakers long and numerous (about 20 below angle). Mouth strongly oblique. Vertebræ 32 (15 + 17), of which only 11 support anal base. Dorsal and ventral contours about equally curved. Body rather strongly compressed.

f'. Eye little enlarged (about one-fifth length of head). Anterior ventral edge not sharpened or strongly curved. Color: Sides not barred; pelvic fins plain; anal with a black blotch. **Hypocritichthys annulus**

d'. Lower jaw less prominent; the teeth of the two jaws nearly opposed. Body more rounded and deeper (depth about half standard length). Anal fin longer, with more than 28 soft rays.

c'. Gill rakers relatively long and numerous (more than 15 below angle). Mouth excessively oblique. Vertebræ 33 to 35, of which 12 to 14 support the anal base. Dorsal contour somewhat less strongly curved than the ventral. Body very strongly compressed.

f'. Eye excessively enlarged (about two-fifths length of head). Gill rakers longer, and more than 20 below angle of first arch. Anterior ventral edge blunter and less strongly curved. Color: Sides occasionally faintly barred; pelvic fins black distally; anal without black edge or blotch. **Hyperprosopon argenteum**

f'. Eye moderately enlarged (about one-third length of head). Gill rakers shorter; fewer than 20 below angle of first arch. Anterior ventral edge rather sharp and very strongly and evenly curved. Color: Sides rather faintly barred; pelvic fins plain; anal fin with an inky-black margin. **Tocichthys ellipticus**

c'. Gill rakers relatively short, thick and few (only 11 to 13 below angle). Mouth only moderately oblique. Vertebræ 32 (14 + 15), of which only 11 support the anal base. Dorsal and ventral contours about equally curved. Body less strongly compressed.

f'. Eye smaller. Anterior ventral edge blunter and not very strongly curved. Color: Sides rather strongly barred; fins without black markings, but reddish (especially the caudal). **Holconotus rhodoterus**

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1 This is the species previously called *Hyperprosopon argenteum*. On its nomenclature, see Hubbs (1918 and 1928). The supposed difference in dentition, pointed out in the original diagnosis of *Tocichthys*, does not hold well.
c'. Dorsal spines extremely robust and much shorter than the dorsal rays; margin of spinous fin rather evenly rounded. Anterior interneurals very strong, with sharply expanded lateral keels. Pectoral fin shorter and with upper margin strongly curved downward toward tip, so that the fin is more nearly symmetrical than in any other embiotocid; lower rays of pectoral more frayed and silky than in any other genus. Fins mostly dusky (in preservative; probably deep red in life).
d'. Lower jaw not very prominent; the teeth of the two jaws opposed. Body deep (depth about half standard length). Anal fin rather long, with 25 to 31 soft rays.
e'. Gill rakers moderate in length and number (14 to 17 below angle). Mouth only moderately oblique. [Vertebrae not examined.] Dorsal contour much more strongly curved than the ventral. Body not very sharply compressed.
f'. Eye moderate (about one-fourth length of head). Anterior ventral edge blunt and but little curved.
Color: Body speckled, with trace of bars; fins without black markings. CROSSOCHIR KEOZI

b'. Lower lip with the posterior groove interrupted by a broad frenum. Mouth little oblique, not rising to opposite eyes anteriorly.
c'. Dorsal spines, spinous dorsal, and interneurals intermediate between those of groups c' and e'. Pectoral fin as in c'. Fins pale.
d'. Lower jaw and teeth as in d'. Body rather slenderer, distinctly less than half as deep as long. Anal fin averaging shorter, with about 25 soft rays.
e'. Gill rakers short and few, as in Holconotus. Mouth very weakly oblique. Vertebræ 29, of which only 10 support the anal base. Dorsal contour somewhat more strongly curved than the ventral. Body relatively thick.
f'. Eye rather small. Anterior ventral edge blunt and little curved. Color: Strongly though irregularly barred; fins without black markings. Amphistichus argenteus

CROSSOCHIR, new genus

The characters of this genus are those given successively in items a', b', c', d', e', f', of the preceding key. Its relationships appear to be most intimate with Holconotus, though it is almost equally close to Amphistichus. From the latter it differs trenchantly in lacking the frenum, and is further distinguished by the more oblique mouth and deeper body, and usually by the longer anal fin. It differs from Amphistichus weakly, and from Holconotus more decisively, in the stronger and lower dorsal spines, more rounded spinous dorsal, and stronger and more keeled interneurals. From both Amphistichus and Holconotus, as well as other genera, it differs in having the pectoral fin shorter, with more arched upper edge and
frayed and silky lower rays. From these two genera *Crossochir* differs further, though not very trenchantly, in having the gill rakers somewhat longer and more numerous, approaching those of the remaining genera of the Amphistichinidae. In addition to having shorter and fewer gill rakers, *Crossochir* also differs from these other genera in the dorsal spine and interneural characters, as well as in other respects. The color of the type species gives *Crossochir* a distinctiveness of appearance sufficient for quick identification.

The type and only known species is *C. koelzi*, herein described.

The name *Crossochir* (fringed hand) refers to the frayed and silky lower pectoral rays.

*CROSSOCHIR KOELZI*, new species

**PLATE 1**

*Holconotus rhodoterus* Yarrow and Henshaw, 1878, p. 265 (Santa Barbara record not checked); Bean, 1880, p. 88 (San Diego record not checked; Santa Cruz Island and Santa Barbara records checked); Jordan and Gilbert, 1881a, p. 406 (Monterey Bay and Santa Barbara records checked); Jordan and Joy, 1881, p. 10 (Monterey and Santa Barbara records checked); Jordan and Gilbert, 1881b, p. 50 (Santa Barbara record checked; Tomales and Sequel records may also apply to this species); Eigenmann, 1892, p. 156 (San Diego, in surf; record not checked); Eigenmann and Eigenmann, 1892, p. 354 (San Diego record not checked; Santa Barbara and Monterey records checked); Gilbert, 1895, p. 496 (San Simeon Bay record, checked by Myers); Hubbs, 1913, p. 12 (distinguishing, in key). *Amphistichus rho doterus* Eigenmann and Eigenmann, 1890, p. 9 (San Diego record not checked; life colors).

In recording this species repeatedly under the name of *rhodoterus*, none of the authors quoted indicated any doubt in the identification. An examination of the synonymy of *Holconotus rhodoterus* (and of other embiotocids), as given by Eigenmann and Ulrey (1894, p. 388) and by Jordan and Evermann (1898, p. 1592) gives no indication that a name has ever been proposed for the present species. *Cymatogaster pulchellus* and *C. larkinsi*, as nearly as can be told from the original diagnoses by Gibbons (1854), are based on the true *Holconotus rhodoterus* Agassiz. All three nominal species were described from San Francisco, where *rhodoterus* is common.

Another quoted synonym of *Holconotus rhodoterus*, *Cymatogaster ellipticus* (Gibbons, 1854), is clearly the species later called *Hyperproton or Toechichthys agassizii*, as I have already indicated (1928, p. 12). On the other hand, *Embietoca or Eunichthys heermanni* Girard, from Cape Flattery, should certainly be restored to the synonymy of *Holconotus rhodoterus*. It was properly so placed until 1890, when Eigenmann and Eigenmann transferred the name to the synonymy of *Amphistichus argenteus*, presumably because their "*Holconotus rhodoterus" was another species (*Crossochir*
This false synonymy, persisting until my correction in 1928, gave rise to a bad error in statement of ranges: *Holocentrus rhodoterus* was said to range northward only to San Francisco, whereas it is abundant along the surf of Oregon and Washington, and *Amphistichus argenteus* was said to range northward to Cape Flattery, whereas there are no authentic records north of San Francisco.

The range of *Crossochir koelsi*, as determined from the literature records and from the type specimens, is central and southern California, from Drakes Bay to San Diego, and thus approximately coincides with that of *Amphistichus argenteus* and overlaps that of *Holocentrus rhodoterus* about San Francisco. So far as checkable, all records of *H. rhodoterus* from south of San Francisco were based on *Crossochir koelsi*. What little is recorded as to its habitat indicates that this species, like its nearest relatives *Holocentrus rhodoterus* and *Amphistichus argenteus*, is essentially an inhabitant of the surf, ordinarily penetrating the bays only to their more open portions.

**Specimens examined.**—Holotype: U.S.N.M. No. 26901, a specimen 188 mm long to caudal, collected by Jordan at Santa Barbara, Calif., in 1880.

Paratypes in National Museum, 135 mm to 208 mm to caudal: Another specimen from the holotype lot; No. 26933, 3 specimens, same data; No 27074, Monterey, Calif., Jordan, 1880; No. 47110, Santa Cruz Island, Calif., seined, *Albatross*, 1889; No. 54726, Drakes Bay, Calif., *Albatross*.

Paratype in Museum of Comparative Zoology: One adult female, 186 mm long, collected in California by A. Agassiz.

Paratype in Scripps Institution of Oceanography: One adult female, 210 mm long, collected by Percy S. Barnhart in the surf at La Jolla, Calif., in the spring of 1926. Another specimen from La Jolla is in the same institution, according to Mr. Barnhart.

Paratypes in Field Museum of Natural History: No. 7618, 3 specimens 192 to 175 mm long, from San Diego, Calif.

Paratypes in Museum of Zoology, University of Michigan: No. 64925, one half-grown female, 107 mm long, Santa Cruz Island, Calif., seined, *Albatross*, 1889; No. 95030, Scripps Institution Pier, La Jolla, Calif., collected by Percy S. Barnhart in April, 1927.

Specimens (not paratypes) in Stanford University collection (identifications kindly furnished by George S. Myers): No. 2726, five from Santa Cruz Island, Calif.; No. 5964, one from San Simeon Bay, Calif.

Appreciation is expressed to the authorities of the several institutions just named for permission to use their material of this new species as the basis for the present paper.
Description, based on the holotype and all paratypes (counts and measurements of paratypes given in parentheses).—The body is rather deep; depth, not including dorsal sheath, 1.8 (1.8 to 2.1). It is moderately compressed; width, 3.4 to 3.7 in depth. The least depth of the high and thin caudal peduncle is contained 1.7 to 2.2 times in the head. The caudal peduncle is almost twice as deep as its length measured on midline behind vertical from end of anal base. The dorsal contour is decidedly more sharply curved than the ventral; as a whole, it is a high, even arch, but is gently concave in the nuchal region.

The head is a thick, blunt, almost symmetrical cone as seen from the side. The mouth, moderately oblique, rises to opposite lower part of eye. The eye is of moderate size, and the interorbital moderately convex. Length of head, including opercular membrane, 3.4 (3.2 to 3.5) in standard length. Least fleshy interorbital width, 3.6 (3.2 to 4.3) in head; least suborbital width, 2.4 (2.1 to 3) in orbit; greatest diameter of orbit between rims, 3.7 (3.5 to 4.1) in head; length of upper jaw, 2.7 (2.65 to 2.9).

The teeth are in two rows in the upper jaw (sometimes so irregular backward as to appear to form three rows; sometimes uniserial at extreme end of band). In the lower jaw, the teeth are biserial in front, but become irregularly uniserial on the sides. The teeth in the outer row in each jaw are considerably enlarged, somewhat curved, scarcely incisorlike.

The gill rakers are of moderate length and number. The longest is contained 1.7 (1.6 to 2.2) times in the orbit. The number on the first arch is 9 (6 to 8) + 16 (14 to 17) = 25 (21 to 23).

Scales, 66 (61 to 68) in lateral line to end of hypural; 6\% (7\% in one) rows between middle of sheath along first dorsal and lateral line; 22 (20 to 24) in a series from origin of anal to lateral line.

Dorsal rays XI (X or XI, usually X), 26 (24 to 28); anal rays III, 29 (25 to 31); principal caudal rays 14 (outer pair unbranched; 13 in one); pectoral rays, 26 (25 to 29).

The spinous dorsal is relatively low and rounded. The first four spines are short, and graduate rather slowly and evenly; the fifth to seventh are subequal (the sixth rarely considerably the longest); the following spines are progressively shortened. The heterocanthous dorsal spines are very strong, and as a consequence the supporting interneurals are also much strengthened, and produced outward as sharply expanded keels. The soft dorsal is almost straight-edged (slightly convex to slightly concave). The first soft ray is about one-third higher (rarely scarcely higher) than the highest spine, which, measured from the top of the scaly sheath, enters the head 9 (1.8 to 2.9) times.
The caudal fin is wide, with the lobes not sharply pointed. The inner edge of the shortest ray is contained 1.65 (1.5 to 1.8) times in length of longest ray. The strong caudal rays are almost fan-shaped.

The characteristic pectoral fins are a little shorter than the head (rarely as long), and have the upper edge arched (sometimes not very strongly); the tip more rounded than in related species and the lower edge nearly straight. The lowermost several rays are weak and frayed out to a rather silky fringe, almost as in Gobius (in some specimens this modification is less evident than in others, and an approach in the same direction is shown by related species).

The pelvic fins do not quite extend to the origin of the anal in the female, but slightly pass this point in the males.

The anal fin of the male shows to a well-developed degree the modifications characteristic of the Amphistichinae. In this sex the anterior rays form a lobe that is considerably lower than the posterior part of the fin. The several posterior rays of this lobe are considerably thickened about one-third the way out and again near the edge of the fin. In these thickened portions, the articulations of the rays are increased in size and distinctness, whereas elsewhere on these rays the articulations are almost fused. This modification becomes exaggerated toward the posterior end of the lobe. Located at the angle between the two lobes of the fin, one soft ray, the tenth to fourteenth, is grossly exaggerated to form a triangular plate. This is made up of the many branches of the ray, largely fused, and spread out to form a somewhat sawlike edge. The somewhat thickened anterior edge of the plate underlies a fleshy ridge, which becomes enlarged to form a well-marked lobe near the fin margin. Just anterior to this lobe, and just within the outer thickened portions of the rays, another dermal thickening is developed. The posterior edge of the triangular plate is expanded outward and backward on each side, medially, to form a rough-edged bony lobe. The ray next following the one modified into the plate is also considerably thickened and somewhat thickened, and has a serrated lobe on both edges on each side. The next following ray is normal in structure, but is a little wider than those that follow. All these secondary sexual modifications of the anal fin are shown to a small degree by the females. In that sex the anterior rays are not shortened as in the male but form a convex lobe, which is set off by only a shallow emargination from the much straighter posterior portion of the fin. The highest anal ray in the female is contained 2.8 (2.6 to 3.3) times in the head.

In alcoholic specimens the body is silvery, with numerous small, scattered, brown flecks, deeper than long, producing an effect somewhat resembling Eupomotis. Many of the spots are paired, and
these doubled spots are roughly aligned vertically to form a definite suggestion of narrow bars. Some specimens show a trace of three rows of small blotches, each row parallel with the dorsal contour. The fins become dusky to blackish outward, but show no definite black markings.

The life colors of what was almost certainly an example of this species from San Diego were thus described by Eigenmann and Eigenmann (1890, pp. 9–10):

Silvery, the body profusely covered from dorsal to anal and ventral fins, with squarish, bronze spots, the color being exactly like that which forms bars and spots on _A. argentatus_, except that the brassy color in _argentatus_ is modified only by black dots, while in _rhodaterus_ the brassy color is modified by both black and scarlet dots, the scarlet making the sides appear to be strongly tinged with red. The brassy ground color of the spots is not resolved into dots by the aid of a pocket lens, but appears as if evenly applied, and the red and black dots sprinkled upon it. Dorsal surface backward to insertion of dorsal fin, olive; a blue metallic reflection above lat. line from nape backward. Ventral surface backward to base of ventrals strongly scarlet tinged, the red and black dots aggregated on the breast to form crescent parallel with the scale margin; premaxillary posteriorly, and maxillary, checks and opercles also strongly red tinged, this region and the breast appearing, at a glance, to be "bloodshot."

All the fins, except the pectoral, blackish at tips and reddish tinged; an olive streak through the dorsals which is most conspicuous anteriorly. Pectorals reddish at base, otherwise plain and slightly olivaceous.

Percy S. Barnhart, of the Scripps Institution of Oceanography, writes that the specimen he collected at La Jolla had in life almost exactly the color of _Amphistichus argentatus._

This species is dedicated to the well-known explorer Walter Koelz, in recognition of his studies on the American coregonid fishes.
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JORDAN, DAVID STARR, and GILBERT, CHARLES HENRY.


JORDAN, DAVID STARR, and JOY, FISHER L.ouis.

YARROW, HENRY CECILY, and HENSHAW, HENRY WETHERBEE.
CROSSOCHIR KOELZI, NEW GENUS, NEW SPECIES

From a paratype 180 mm long. An adult female collected by the Scripps Institution of Oceanography in the surf at La Jolla, Calif. Drawn by Grace Kramer.
AN AMERICAN FLOUNDER, LIMANDA BEANII, REFERRED TO THE GENUS POECILOPSETTA.

BY CARL L. HUBBS.

In 1881 Goode described, under the name of Limanda Beanii, a small flounder which the United States Fish Commission Steamer Fish Hawk had dredged in deep water off the southern coast of New England. Subsequently the species has been recorded from the Gulf of Mexico.

Although Goode noted some of the differences which widely separate this form from the typical species of Limanda, no author has assigned it to its true position in the system. It is clearly referable, however, to the deep-water genus Poecilopsetta Günther, hitherto recorded only from the Indo-Pacific region; it agrees in all respects with the following characterization of that genus.

**Genus Poecilopsetta** Günther.

Eyes dextral, the margin of the upper entering the dorsal profile; interorbital space very narrow; head short; body strongly compressed, varying from elongate to rather robust; dorsal fin composed of about 60 rays, extending from a short distance behind vertical through pupil nearly to caudal base, of rather even height throughout; anal fin similar, of about 50 rays; anal spine weak; caudal rounded; pectoral short, that of the eyed side with 7 to 10 rays; pelvic short, subequal, but somewhat asymmetric, approaching those of the Psettinae, the one on the eyed side being slightly anterior to the left one, and nearer the ventral ridge; each pelvic fin of 6 rays; scales moderate in size or small, weakly ctenoid on eyed side, cycloid on blind side; interorbital, mouth and jaws naked; lateral line with a large, flat-topped arch on eyed side, obsolete on blind side; mouth narrow, nearly symmetric, and rather small; teeth villiform, in bands, present on jaws only, better developed...
oped on the blind than on the eyed side; gill-rakers rather short, sharp and smooth; anus near on ventral ridge.

Five other species of *Poecilopsetta* are known (*P. maculosa, praelonga, plinius, colorata and hawaiiensis*). *Poecilopsetta beanii* is a more slender fish than any of these except *P. praelonga*, from which it appears to differ in the narrower bands of teeth on the jaws.
NOTES ON A SMALL COLLECTION OF FISHES FROM KAMERUN, WEST AFRICA

By CARL L. HUBBS

In 1907–8 Mr. George Schwab made a miscellaneous collection of animals for the Museum of Zoology at Efulan (or Efulen), Kribi, Kamerun, West Africa; among these are eighteen fishes, representing the ten species listed below. All but one of these (Mastacembelus goro) have been obtained at the same locality by Mr. G. L. Bates, whose collections Dr. Boulenger has already recorded.

1. Marcusenius batesii Boulenger.—Two topotypes.
2. Barbus taeniurus Boulenger.—A single specimen of this very distinctively colored Barbus, originally described from Efulan.
3. Labeo annectens Boulenger.—Two adults, likewise topotypic.
4. Clarias walkeri Günther.—Two specimens, provisionally referred to this species (which apparently is not sharply distinguished from numerous others of the laevis group), differ from Boulenger’s description only in the somewhat shorter maxillary barbels, which, however, are considerably longer than the head.
5. *Allabenchelys longicauda* Boulenger.—The two specimens (112 and 113 mm. long to the caudal fin) of this aberrant genus secured by Mr. Schwab at Efulan depart notably from Boulenger’s account of *A. longicauda*, the genotype and oldest species, in many respects agreeing better with *A. breviar* Boulenger, which will probably prove not to be a valid species. These two species, until lately the only ones known, were both originally described from the Ja River, Kamerun, but only *longicauda* has been recorded from the Kribi.

In the first and third columns of the following table are given the characters assigned by Boulenger respectively to *A. breviar* and *A. longicauda*; in the middle column are listed the corresponding characters taken from the two specimens in the collection being reported upon.

<table>
<thead>
<tr>
<th>Character</th>
<th><em>A. breviar</em></th>
<th>Two Specimens</th>
<th><em>A. longicauda</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of body</td>
<td>7.0-8.5</td>
<td>7.1-9.0</td>
<td>9.0-12.0</td>
</tr>
<tr>
<td>Length of head</td>
<td>5.0-5.5</td>
<td>5.0-5.2</td>
<td>5.5-6.0</td>
</tr>
<tr>
<td>Width of bony casque in width of head</td>
<td>ca. 2.0</td>
<td>small</td>
<td>2.0</td>
</tr>
<tr>
<td>Occipital foramen</td>
<td></td>
<td>small, but distinct</td>
<td>3.0</td>
</tr>
<tr>
<td>Eye in interorbital</td>
<td>5.0-6.0</td>
<td>5.4-6.4</td>
<td>6.0</td>
</tr>
<tr>
<td>Interorbital width</td>
<td>1.5</td>
<td>2.3-2.4</td>
<td>2-2.1</td>
</tr>
<tr>
<td>Length in width, premaxillary band of teeth</td>
<td>3.0-4.0</td>
<td>4.0-6.0</td>
<td>4.0-5.0</td>
</tr>
<tr>
<td>Nasal barbel in head</td>
<td>3.5-4.0</td>
<td>3.4-1.75</td>
<td>1.67-2.0</td>
</tr>
<tr>
<td>Maxillary barbel reaching</td>
<td>or&lt;or&gt;head</td>
<td>nearly to or beyond</td>
<td>yond middle of pectoral</td>
</tr>
<tr>
<td>Occiput to dorsal, in head</td>
<td>1.33-1.5</td>
<td>1.1-1.2</td>
<td>1.0-1.5</td>
</tr>
<tr>
<td>Snout to pelvic, in pelvic to caudal</td>
<td>1.5-1.67</td>
<td>1.65</td>
<td>1.75-2.0</td>
</tr>
<tr>
<td>Length of pectoral</td>
<td>ca. 2.0</td>
<td>1.8</td>
<td>1.67-2.0</td>
</tr>
<tr>
<td>Pectoral spine</td>
<td>feebly serrate</td>
<td>weakly serrate</td>
<td>smooth or slightly serrate</td>
</tr>
<tr>
<td>Length of caudal</td>
<td>1.5-2.0</td>
<td>1.6-1.65</td>
<td>ca. 1.5</td>
</tr>
<tr>
<td>Dorsal rays</td>
<td>65-75</td>
<td>53-58</td>
<td>60-75</td>
</tr>
<tr>
<td>Anal rays</td>
<td>60-63</td>
<td>68 (one)</td>
<td>60-75</td>
</tr>
</tbody>
</table>
In both specimens the body is rather inconspicuously vermiculated with light and dark markings, not mentioned by Boulenger, and the caudal fin is crossed toward the margin by a light bar bounding an area in which the pigment becomes more intense from the base of the fin backward.

6. *Amphilius longirostris* Boulenger.—One specimen, a topotype.

7. *Auchenoglanis ballayi* Sauvage.—One individual.

8. *Doumea typica* Sauvage.—Three.


10. *Mastacembelus goro* Boulenger.—A single specimen, representing a new record-station for the species.
NOTES ON THREE CLUPEOID FISHES COLLECTED BY EDMUND HELLER IN SAN FILIPE BAY, GULF OF CALIFORNIA.

BY CARL L. HUBBS.

Several specimens of clupeoid fishes (herrings and anchovies), collected by Edmund Heller in San Filipe Bay on the gulf coast of Lower California, are now deposited in the Field Museum of Natural History. These include the types of a new species of Anchoviella, named for the collector, and toptotypes of a nominal species, which this added material shows to be a synonym of Ctenagranis mysticetus.

1. Opisthonema libertate Günther.
   Three specimens, each with 20 anal rays.

2. Anchoviella helleri, new species.

   Relationships.—Anchoviella helleri closely resembles nano, starksi, cultrata and delicatisima, differing from each in details of form and proportions, and in the number of fin-rays, gill-rakers, etc.

   Holotype.—A specimen 78 mm. long to caudal base, taken by Edmund Heller (for whom the species is named), with two slightly smaller paratypes, in San Filipe Bay, Gulf of California; Cat. No. 3332, Field Museum of Natural History.

   Description.—Body slender, the contours weakly arched; greatest depth, 4.9 (to 5.2) in length to caudal base; least depth of caudal peduncle, 2.8 (2.8 to 3.2) in length of head; belly rounded both before and behind pelvic fins, but scarcely carinate. Head slender and rather long, its length to end of opercle being contained 3.65 times in length to caudal; its greatest depth, below occiput, 1.8 (1.65 to 1.75) in its length. Snout long, abruptly produced beyond upper jaw and nostrils, rounded terminally; its length slightly less than diameter of eye, 5.5 (to 4.5) in head; length of eye, 4.6 (4.2 to 4.3). Maxillary long, tapering behind its subterminal dilation to its extreme rounded tip; nearly extended to gill opening. Teeth developed in both jaws, all directed vertically. Cheek an acute triangle, its base half the distance from its apex to middle of pupil; opercle oblique, oblong, about one-third as wide as deep. Gill-rakers dentate, bluntly pointed, comparatively short and widely spaced, the longest not quite so long as eye; their number, 18+18 (to 18+20).
Scales deciduous anteriorly; in 40 rows from gill opening to caudal base. Dorsal rays, excluding anterior rudiments, 13 (13 or 14); anal, 19 (19 or 20). Origin of dorsal midway between end of hypural and middle of snout (or front of orbit); height of dorsal 1.6 (to 1.7) in head, about one-fifth longer than base of fin. Height of anal about equal to length of dorsal base; base of anal as long as distance from middle of eye to insertion of pectoral fin. Pectorals 1.7 (to 1.8) in head, not reaching to pelvic fin; the latter a little longer than half the interspace between pelvic insertion and anal origin, or a little longer than distance from tip of snout to posterior border of pupil.

Lateral band brilliant and sharply distinct, bordered above with black, narrowed in both directions from the middle of its length; its greatest width equal to length of snout. Sides and lower surfaces of head, and iris, also bright silver; upper surface of head punctulate, the operculum and nape blackish; vertebral streak consisting of irregular rows of dots before dorsal, and of two blackish streaks behind dorsal, becoming most conspicuous along the upper procurent caudal rays; no conspicuous punctulations along base of anal fin; caudal dark-edged, the other fins pale.

**3. Ctenograulis mysticus** Günther.


Three anchovies, topotypes of *Stolephorus opercularis*, described from injured specimens, were collected by Edmund Heller at San Filipe Bay, Lower California. Having the branchiostegal membranes broadly united, they are referable to the genus *Ctenograulis*, and to the species *mysticus* of the Panama region.

These specimens from the Gulf of California confirm the differences which Gilbert & Starks (l. c., p. 47) observed in comparing *mysticus* with its Atlantic representative *edentulus*. The following figures are given for comparison with those published by Gilbert and Starks.

**Measurements in hundredths of length without caudal.**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Length to end of hypural, mm.</th>
<th>Head (to end of subopercle)</th>
<th>Depth of body</th>
<th>Diameter of orbit</th>
<th>Length of maxillary</th>
<th>Length of snout</th>
<th>Greatest length from procurrent ridge to gill opening</th>
<th>Number of dorsal rays</th>
<th>Number of anal rays</th>
<th>Number of scales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>102</td>
<td>34</td>
<td>27</td>
<td>7.5</td>
<td>20</td>
<td>4.5</td>
<td>15</td>
<td>14</td>
<td>20</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>101</td>
<td>33.5</td>
<td>26.5</td>
<td>7.5</td>
<td>20</td>
<td>4</td>
<td>15</td>
<td>14</td>
<td>20</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>95</td>
<td>32.5</td>
<td>24.5</td>
<td>7.5</td>
<td>19.5</td>
<td>4</td>
<td>16</td>
<td>14</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>
After comparing the published descriptions of *S. barbarae* with specimens of *S. leptorhynchus* from near Santa Barbara, California, the type-locality of *barbarae*, the writer has come to the conclusion that the type and only known specimen of *barbarae* is a *leptorhynchus* with an injured tail. The following table indicates that the proportional measurements of *barbarae* are not clearly distinctive. Those of the first column were taken by Dr. C. H. Gilbert from the type of *S. barbarae*. 
University of Michigan

Sygnathus californiensis Storer

This species is known to range only from central California to Coronado,¹ the Puget Sound records being based on specimens of S. griseo-lineatus,² and the specimens recorded from San Bartolome Bay, Lower California,³ being typical of S. exilis.⁴

Table of Diagnostic Counts and Measurements of Syngnathus californiensis

<table>
<thead>
<tr>
<th>LOCALITY</th>
<th>CORONADO</th>
<th>LA JOLLA</th>
<th>MONTEREY</th>
<th>CENTRAL CALIFORNIA</th>
<th>BALENAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length to caudal, 224</td>
<td>163</td>
<td>135</td>
<td>186</td>
<td>160</td>
<td>157</td>
</tr>
<tr>
<td>Length of eye, 8.2</td>
<td>8.6</td>
<td>8.5</td>
<td>8.0</td>
<td>8.8</td>
<td>7.8</td>
</tr>
<tr>
<td>Length of snout, 2.0</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
<td>1.6</td>
<td>1.75</td>
</tr>
<tr>
<td>Dorsal rays, 43</td>
<td>43</td>
<td>43</td>
<td>42</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td>Precaudal rings, 19</td>
<td>21</td>
<td>20</td>
<td>20</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Caudal rings, 48</td>
<td>47</td>
<td>48</td>
<td>45</td>
<td>47</td>
<td>48</td>
</tr>
<tr>
<td>Rings under dorsal, 1+9</td>
<td>1+9</td>
<td>1+9</td>
<td>1+8</td>
<td>1+8¾</td>
<td>1+8¾</td>
</tr>
<tr>
<td>Rings over brood pouch, 23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
</tbody>
</table>

OOSTETHUS: A NEW GENERIC NAME FOR A DORYRHAMPHINE PIPEFISH

BY CARL L. HUBBS

Duncker (1910, 1912 and 1915) has presented a very able revision of the Syngnathidae. In this work he has divided Doryrhamphus into several genera. One of the constituent elements he has named "Microphis Duncker 1910" (1910: 26, 1912: 229, and 1915: 43). Although proposed in the form of a new genus ("Microphis, mihi") the name was taken from Kaup (1856). In the 1910 paper Duncker has given a diagnosis of the genus, listing and describing only one species, "Microphis brachyurus Bleeker." In his 1912 contribution, he has again described the group (and as before has diagnosed related groups), and definitely given Microphis brachyurus (Bleeker) as the type-species. In 1915 he redescribed Microphis and diagnosed a number of species, M. brachyurus included.

In so using Kaup's generic name Microphis, Duncker clearly violated one of the International Rules of Zoological Nomenclature: "The following species are excluded from consideration in determining the types of genera . . . species which were not included under the generic name at the time of its
original publication." Kaup (1853: 234, and 1856: 64) included under Microphis only two species:


On one of these two species, probably the second, must the genus Microphis rest; on which one we are not immediately concerned, for both belong in Doryichthys, according to Duncker (1915: 52 and 54).

Duncker (1912: 230) selected one of the two species mentioned above, Doryichthys cunoculus (Hamilton), as the type of Doryichthys. This action is equally inadmissible, for Kaup included this species in Microphis and not in Doryichthys, in the paper in which both generic names were first proposed. Furthermore, Jordan and Evermann (1896: 773) had already designated bilineatus as the type of Doryichthys. Fortunately, the two species appear closely related, and both are referred to Doryichthys by Duncker (1915).

Duncker (1912: 229, footnote) has expressed doubt as to the application of the generic name Microphis, and has explained his adopted course by stating that he thought the genus should rest on Kaup's description rather than on the included species. This course is untenable according to the accepted rules. In the first place the original account (Kaup, 1853, not Kaup, 1856) contains no actual diagnosis, but does include the listing of the included species as quoted above. Secondly, Kaup's reference of the genus to the Nerophinae, in which "Die Männchen tragen die Eier in Längsreihen an Brust und Bauch ohne Taschen," while apparently by mere coincidence better describing the brood organ of Microphis (in Duncker's sense) than of Doryichthys, was derived from Buchanan Hamilton's poor description of these structures in the two species originally included in Microphis.
I see no valid reason for applying Raup's name Microphis to the group typified by Doryichthys lineatus Kaup and Syngnathus brachyurus Bleeker. Since I find no other name for this group, I supply the deficiency by creating a new genus.

Oostethus, new genus

Type-species.—Doryichthys lineatus Kaup (1856: 59).

Diagnosis (after Duncker, 1912).—Syngnathid fishes with an abdominal brood organ, having ventrally divergent protective plates, but no covering membranous fold; eggs small, isolated and uncovered, in open honeycomb on the skin of the breast; upper trunk and tail crests discontinuous; dorsal fin chiefly on the tail; anal behind middle of total length; caudal well developed, and having the median rays somewhat strengthened and elongated; snout much longer than rest of head; opercle with continuous keel and radiating ridges. The species usually live in fresh and brackish water.

On classical grounds the name Oostethus should certainly be regarded as of neuter gender, but following general zoological custom and awaiting a pending decision by the International Commission on Zoological Nomenclature, I suggest that it be treated as masculine. It means "egg-breast," and refers to the mode of gestation.

The type-species, Oostethus lineatus (Kaup), is chiefly an inhabitant of the brackish waters along the tropical Atlantic coast of the New World, but ranges also into purely fresh water and doubtless also into the sea.

LITERATURE CITED


THE JAPANESE FLOWNDERS OF THE GENERA TANAKIUS, MICROSTOMUS AND GLYPTOCERHALUS

By CARL L. HUBBS

In the cooler seas of Japan and the adjacent coasts of the Asiatic mainland there are to be found three well-marked species of flounders having small mouths and a much increased number of segments—vertebrae, scales and fin rays. The nomenclature of these species has passed through and remains in a state of complex confusion. With the aid of recent elucidations by the Russian ichthyologist P. J. Schmidt (1929–1931), it now appears possible to bring order out of this confusion.

In this paper there are given: firstly, a brief discussion and characterization of the three genera (and species); secondly, a chronological account of the naming of the three species; thirdly, a synonymy of each, and fourthly, a bibliographic list.

Tanakius kitaeharae, although superficially so similar as to have been confused with them, is probably not immediately related to the other Japanese flounders with small mouths and many segments, as I have already pointed out. Its most intimate relationship appears to be with Deciistes rikuzenius Jordan and Starks (of which Araias ariomimus Jordan and Starks has been shown to be a simple synonym). In propos-
The distinctive characters of *Tanakius* as contrasted with *Dexitistes*, with which it is probably most closely related, and with *Microstomus*, with which it has most often been confused, are given in the two papers just cited. It is distinguished from *Glyptocephalus*, with which Schmidt has recently united it, by lacking the great cavens in the skull bones characteristic of that genus, and also in having the eye balls scaly, the eyes more nearly apposed, etc.

The species *Microstomus achne* and *Glyptocephalus stelleri* have usually been held in these genera, though under other specific names, as explained below. Since *Veraequa achne* proves identical with the species wrongly called *Microstomus stelleri* by authors, *Veraequa* becomes a synonym of *Microstomus*.

The distinctive features of the three species (and genera) under discussion may be indicated in the following:

**Key to the Japanese Flounders with Small Mouths and Many Segments**

1. Eye-ball scaly. A few of the posteriormost dorsal and anal rays branched.


1. *Tanakius kitaharae*

2. *Microstomus achne*
The Japanese Flounders


3. Glyptocephalus stelleri

The involved systematic history of these three species may be outlined, as an introduction to and explanation of the synonymies which follow.

1. The first reference to any of these three species in the scientific literature is apparently that of Otaki (1897: 7, pl. 6, fig. 7), who dealt with a species which has been supposed to be T. kitaharae under the name of the European species Pleuronectes cynoglossus.

2. In 1903 Schmidt merely listed what now proves to be the Glyptocephalus, as “Microstomus Stelleri n. sp.”

3. The following year Jordan and Starks (1904: 625, pl. 7) described two of the species, under the first valid specific names but apparently under wrong generic identifications, as Varaequa achne and as Microstomus kitaharae. The status of kitaharae as a species has not been questioned, except by Schmidt (1929: 366) when he confounded the Japanese species of Tanakius and Glyptocephalus. The generic and specific validity of Varaequa achne has been generally accepted, except by myself (1918: 371). In referring achne to Microstomus, however, I held it distinct from the common Japanese species of the genus.

I am now able to affirm the identity of “Microstomus stelleri” of authors with M. achne; which fortunately makes it unnecessary to propose a substitute name for “M. stelleri.” The small type of Varaequa achne, recently examined in the United States National Museum, is clearly an example of the species generally called Microstomus stelleri. It has the leathery skin and thick fin rays of that form. For a specimen of its size (145 mm. standard length) it is not especially slender. The depth is given in the type description and figure as too
Carl L. Hubbs

narrow (2.87) owing to the fact that the specimen was somewhat shrunken and wrinkled in preservation. The true depth appears to have been 2.65 in standard length. This value compares well with that obtained from two small specimens identified by Jordan and Starks as *M. stelleri*: 2.7 in one 89 mm. long to caudal, and 2.55 in one 170 mm. long. The apparently narrower interorbital is due to the large size of the eyes in the young, and to shrinkage. The scales are of about the same size as in "*stelleri*." The vertical fin rays (counting the last one as double) are not distinctive.

<table>
<thead>
<tr>
<th>&quot;F. achne&quot;</th>
<th>&quot;M. stelleri&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allatross Station</td>
<td>3772</td>
</tr>
<tr>
<td>Number of dorsal rays</td>
<td>84</td>
</tr>
<tr>
<td>Number of anal rays</td>
<td>67</td>
</tr>
</tbody>
</table>

I conclude that *Veraequa achne* is identical with *Microstomus stelleri* of authors, and that the species should be known as *Microstomus achne*.

4. In the next paper dealing with these flounders, Schmidt (1904: 246) described his *Microstomus stelleri*. This name has generally been taken to apply to the Japanese species of *Microstomus*, here known as *M. achne*, but was really based, Schmidt now claims (1929: 367; 1931a: 318; 1931b: 127), rather on the species of *Glyptocephalus*. One of Schmidt's paratypes in the U. S. National Museum, from Aniwa Bay, Sakhalin, is a young *Glyptocephalus*. Even though the original description of *stelleri* may not clearly differentiate the species as a *Glyptocephalus* or as a *Tanakius*, the type-localities fix the name with the former genus. The name *stelleri* therefore goes with the Japanese *Glyptocephalus*.

5. In 1906 Jordan and Starks, reviewing the Japanese flounders, recognized the three species under discussion under four names: *Veraequa achne* (= *Microstomus achne*), *Microstomus kilaharae* (= *Tanakius kilaharae*), *M. stelleri* (= *M. achne*) and *Glyptocephalus* (species not named). For *V. achne* they merely repeated the type description and figure, and misplaced the genus.
6. Pavlenko (1910: 50, pl. 2, fig. 13a, b) gave the Glyptoccephalus its second specific name, *ostromowi*. This was overlooked by American ichthyologists until used by me in 1915 (p. 491).

7. Not acquainted with Pavlenko's action, Snyder followed (1911: 548; 1912: 440, pl. 49, fig. 1) with a description of the *Glyptoccephalus* as *G. sasae*, new species. In the second paper *M. stelleri* (= *M. achne*) was also listed.


9. In my 1915 paper (pp. 489–492) I listed the three species as *Microstomus stelleri* (= *M. achne*), *M. kitaharae* and *Glyptoccephalus ostromowi*.

10. In 1916 (1916b: 390, pl. 106, fig. 326) Tanaka described and figured *M. achne* under the name then current (*M. stelleri*).

11. In the same year (1916a: 67), Tanaka described as a new species *M. kireguro*, and in the following year (1917: 447, pl. 122, fig. 351) gave an English description and a figure of this nominal species. I have identified *kireguro* with *kitaharae* (Hubbs, 1918: 371, and Jordan and Hubbs, 1925: 301), but now think it virtually certain that it is rather a synonym of *Glyptoccephalus stelleri*. The general proportions, ovate form and posteriorly inserted upper orbit all point to this conclusion.

12. In 1918 I indicated the generic distinctness of *kitaharae* from *Microstomus*, and erected for it the subgenus *Tanakius* of *Dexithe*; and synonymized *Verenaqua* with *Microstomus* but retained both *achne* and "*stelleri*" as distinct species.

13. Jordan and Hubbs (1925: 300–301) recognized the three species as *Microstomus stelleri*, *Tanakius kitaharae* and *Glyptoccephalus ostromowi*, and gave a new diagnosis of *Tanakius*.

14. Schmidt in 1919 trenchantly separated the Japanese *Microstomus*, under the unavailable name of *M. stelleri* Jordan and Starks, but wholly confounded the species of *Tanakius* and *Glyptoccephalus*.
15. Soldatov and Lindberg (1930: 412-415), in a work presumably prepared before Schmidt’s 1929 contribution appeared, held to the more conventional nomenclature: *Microstomus stelleri*, *M. kitaharae* and *Glyptocephalus astronovii*. 

16. Schmidt then (1931a: 318) recognized the three species as *Microstomus* sp., *Glyptocephalus kitaharae* and *G. stelleri*.

17. In his last paper Schmidt (1931b: 127-128) did not name the *Microstomus*, but dealt with the other two as *Glyptocephalus (Tanakius) kitaharae* and *G. stelleri*. He further suggested that *Veraequa achne* belonged in the subgenus *Tanakius*.

This discussion of the three Japanese flounders combining small mouths with many vertebrae is summarized in the following synonymies. To facilitate cross reference and to validate the synonymy as listed, each item therein is followed by a number in Italic type, referring to the paragraph head in the preceding discussion.

1. *Tanakius kitaharae* (Jordan and Starks)  
   *Pleuronectes epopeicus* (not of Linnaeus) Otaki, 1897: 7, pl. 6, fig. 7 (1).  

   *Deciota (Tanakius) kitaharae* Hubbs, 1918: 371 (18).

   *Tanakius kitaharae* Jordan and Hubbs, 1925: 300 (19).


   *Glyptocephalus kitaharae* Schmidt, 1931a: 218 (16).

   *Glyptocephalus (Tanakius) kitaharae* Schmidt, 1931b: 127 (17).

2. *Microstomus achne* (Jordan and Starks)  
   *Veraequa achne* Jordan and Starks, 1904: 625, pl. 7, fig. 1 (5); 1906: 210, fig. 16 (5). Jordan, Tanaka and Snyder, 1913: 328, fig. 277 (8). Schmidt, 1931b: 127 (17).


Microstomus ochne Hubbs, 1918: 371 (12).
Microstomus sp. Schmidt, 1931a: 218 (16).

3. Glyptocephalus stelleri (Schmidt)
Microstomus stelleri [nom. nudum] Schmidt, 1903: 522 (8); 1904 (October): 246 (4).
Glyptocephalus stelleri Schmidt, 1931a: 318 (16); 1931b: 127 (17).
Glyptocephalus ostroumovi Pavlenko, 1910: 50, pl. 2, flg. 13a, b (6).
Hubbs, 1915: 491 (9). Jordan and Hubbs, 1925: 301 (15).
Glyptocephalus semei Snyder, 1911: 548, and 1912: 440, flg. 1 (7).
Glyptocephalus ostroumovi Pavlenko, 1910: 59, pl. 2, fig. 13a, b (6).

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Snyder, John Oterhein


Soldatov, V. K., and Lindberg, O. J.


Tanaka, Shigeo


ANARCHOPTERUS, A NEW GENUS OF SYNGNATHID FISHES FROM THE WESTERN ATLANTIC

BY CARL L. HUBBS

Anticipating a much needed revision of the numerous American species of the fish genus Syngnathus, and in a small way clearing the ground for such a review by setting apart one species long confounded with that large genus, I describe in this paper a new genus of Syngnathidae. This action follows the precedent set by Duncker (1912 and 1915), who presented valuable revisions of the genera of syngnathid fishes, and of the species of the smaller genera, but left untreated most of the species of Syngnathus.

Anarchopterus, new genus

Type species: Siphonostoma crinigerum Bean and Dresel (1884: 99), Swain and Meek (1884: 239), Jordan and Evermann (1896: 771).

Tail non-prehensile, with well-developed caudal fin; pectoral fin present; anal fin lacking (hence the name Anarchopterus); dorsal fin very short, with only about 16 rays, confined to anteriormost 4 caudal rings, without elevated base; axis of head in line with that of body; brood organ subcaudal, without protecting plates but with complete dermal roof; opercle without trace of keel, either horizontal or submarginal; erista
media trunci continuous with crista inferior caudae; crista inferior trunci disappearing at edge of peritroch, contacting neither the crista media trunci nor the crista inferior caudae; crista superior caudae lying close below and parallel to the subdorsal extension of the crista superior trunci; one nuchal and one prenuchal plate; seutellae well developed; lateral line present; body with numerous short, simple cirri; head and trunk together only half as long as tail; snout very short, only one-third length of head, little produced, rather weakly keeled above; nuchal keel obsolete.

This genus differs from Syngnathus, as that genus was technically distinguished by Duncker (1912 and 1915) in the discontinuity between the crista inferiores of trunk and tail, in the absence of the anal fin, and the lack of even an anterior trace of the horizontal opercular keel. In the characters of the body crests it agrees with Hippocampus and a number of genera regarded as more or less transitional between Syngnathus and Hippocampus. From the Indo-Pacific genera Trachyrhamphus, Yozia, Halocampus, and Haliauchtys as defined by Duncker (1915: 71), Anarchopterus differs in lacking any trace of an opercular keel, the absence of the anal fin, the non-elevated dorsal base, and the character combination of one nuchal and one prenuchal plate with a lateral line. It seems to be most closely related to Micrognathus Duncker (1912: 235, 1915: 74), from which it differs in lacking an anal fin and all traces of an opercular keel.

Anarchopterus agrees with Bombonia Herre (1927: 274) in lacking the anal fin, but differs greatly in the arrangement of the body crests, for in the latter genus the upper and lower trunk crests are continuous respectively with the upper and lower tail crests.

Among the western Atlantic species of pipefishes (excluding Hippocampus) having the crista media trunci continuous with the crista inferior caudae, Duncker (1915) recognized only Microphis lineatus (Kaup) = Oostethus lineatus (Kaup).1

1 See Hubbs (1929). The Museum of Zoology has lately received three specimens of Oostethus lineatus: one from the west side of St. Simon Island, Glynn County, Georgia, collected by E. P. Creaser and H. R.
Anarchopterus, a New Genus of Syngnathid Fishes

Micropogonatus jonesi (Günther), and, doubtfully, the Patagonian M. crinitus (Jenyns) and the Brazilian M. vittatus (Kaufm.) Of these M. crinitus, described as lacking the anal fin, may on rediscovery prove referable to Anarchopterus. More recently three other species have been described as having this arrangement of the body crests, Corythoichthys cœnasulæ Silvestri and the two species of the odd genus Ampheliurus Parr (for references see Parr, 1930: 27–34).

The four specimens of Anarchopterus crisiger at hand were collected February 20, 1935, by Leonard Giovannoli, in algae in water 2 to 3 feet deep, in Lemon Bay, Englewood, Florida.

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HERRE, ALBERT W.

HUBBS, CARL L.

JORDAN, DAVID S., AND BARTON WARREN EVERMANN

PARR, ALBERT E.

SWAIN, JOSEPH, AND SETH E. MEER

Becker (the first record for the United States); one from grass near the shore of Gudu Lake near Barro Colorado Island, Panama Canal, the second example taken there by Prof. A. M. Chickering; one from a small creek at Puerto Barrios, Guatemala, collected by me.
At the present time both the generic and the specific name of the American "smooth dogfish" are in a state of flux, and much the same uncertainty holds for the "smooth hound" and the "spotted hound" of Europe. From the beginnings of ichthyology, the systematics as well as the nomenclature of the sharks of this type has been replete with errors and confusion.

Highlights in the synonymy of the American smooth dogfish follow:

**Mustelus canis** (Mitchill)

*Squalus canis*—Mitchill (1815: 486).


*Galaxias canis*—Jordan (1885: 6 of separate = 794 of volume; 1904: 10).
Cynias canis.—Fowler (1906: 60; 1907: 254, 2 figs.; 1908: 55).
Galeorhinus canis.—White (1937: 42, Fig. 54).
Mustelus laevis (not Squalus laevis Blainville).—Günther (1870: 386—
New York record).
Rhabdotrachelus laevis.—Jordan and Gilbert (1883: 60).
Galeorhinus laevis.—Garman (1913: 176, Pl. 4, Figs. 6-9, and Pl.
60, Figs. 1-4). Radcliffe (1916: 267, Fig. 19). Bigelow
and Welsh (1925: 35, Fig. 5). White (1937: 64, 69, and
123, Pl. 6, Fig. 6, Pl. 13, Fig. p, and Pl. 41, Fig. n.
Mustelus hinnulus (not Squalus hinnulus Blainville).—Jordan and Gilbert
(1883: 19).
"Mustelus mustelus (not Squalus mustelus Linnaeus).—Fowler (1909:
815; 1913: 5, 14, and 15, Pl. 2). Hildebrand and Schroeder
(1928: 47, Fig. 27). Jordan, Evermann, and Clark (1930: 13).
Bigelow and Schroeder (1936: 231).
"Mustelus or Pleuroarctomyia mustelus."—Jordan (1917a: 87).
"Mustelus asterias (Valmont) or Cynias canis (Mitchill)."—Jordan
(1917a: 87).
This synonymy is restricted to the common smooth dogfish
of the inshore waters of the East Coast of the United States,
from New England to North Carolina. One or more species
have been recorded from other waters in the western Atlantic,
as follows:
Bermuda—Cynias canis and Mustelus mustelus Beebe and
Tee-Van (1933: 24, fig.).
Key West—Mustelus canis Jordan (1884: 148).—A very
doubtful record, on authority of fishermen.
Cuba—Mustelus canis Poey (1868: 453, and 1876: 201).
Brazil—Cynias canis Ribeiro (1907: 161).
Argentina—Mustelus vulgaris Günther (1880: 7); Galeus
canis Berg (1895: 7), Mustelus canis Evermann and Kendall
(1906: 68), and Galeorhinus mustelus White (1937: 30, 86, 92,
and 123, Pl. 41, Fig. 5, and Pl. 49, Fig. d).
Whether the North American form canis ranges into the
West Indian, Gulf of Mexico, and South American regions can
only be determined by careful comparisons. There seems to
have been no sound basis, in previously published data, for the
suspicion of Günther (1870: 386) nor for the indication of
Jordan, Evermann, and Clark (1930: 13) that two species occur on the Atlantic coast of the United States. Günther simply made a wild guess, and the other authors just quoted did not digest the literature carefully: Fowler in recording *Mustelus mustelus* from New Jersey did not add that species to our list, but merely identified (wrongly) the American form *canis* with the European form *mustelus*. We also fail to understand why Beebe and Tee-Van have identified their Bermuda specimens with *Mustelus mustelus*, while accepting other Bermuda and United States records as based on *Cyniδ canis*. The denticle characters which they claim to be diagnostic of *mustelus* are to be seen in our mainland specimens of *canis*.

Recent, unpublished researches of Frank E. Firth and of Stewart Springer have indicated the occurrence of more than one species of *Mustelus* in eastern North America, but their existence does not seem to enter into the nomenclatorial problems here discussed.

In view of the synonymizing of *Galeus* with *Mustelus* the use of the name *Galeus canis* for the European "tope" (*Galeorhinus* or *Eugaleus galeus*) causes concern over the availability of the name *canis* of Mitchill for the common American *Mustelus*. If the combination of *Galeus canis* was ever employed in nomenclatorially acceptable form prior to 1815, Mitchill’s name *canis* would have become a homonym when *Mustelus* and *Galeus* were synonymized and should never be resurrected according to a literal interpretation of the *Rules*. Available synonymies, however, indicate that the name *Galeus canis* was not employed between pre-Linnaean time and 1841 or shortly before that year, when Bonaparte and Müller and Henle used that combination on the authority of Rondelet (1554; see the extensive synonymy in Doderlein, 1881: 36). Therefore the name *Squalus canis* remains available for the common American *Mustelus*.

In brief explanation of the involved synonymy of *Mustelus canis* given above it may be stated that Mitchill differentiated the American form as a distinct species, *Squalus canis*. In general this specific name has been accepted, either for an ex-
Cal'l L. Hubbs

elusively American species or as the supposedly oldest name for a species wrongly thought also to occur in Europe. Others, mostly forgetting this matter of priority, or using a name of older date based on European types, have synonymized canis with one of the nominal European species: Mustelus laevis Blainville (1825: 84), Squalus hinnulus Blainville (1825: 83, Pl. 20, Fig. 2), Squalus mustelus Linnaeus (1758: 235), and Galeus asterias Valmont de Bomare (1768, Vol. 4: 746), non-available, but equivalent to Mustelus asterias Cloquet (1821: 407).

It needs be stated in this connection that Jordan and Evermann's account of Mustelus canis (1896: 29) was obviously based in large measure on the European species Mustelus asterias (for synonymy see Table I), with which they confused our species. The statements "teeth small, many-rowed, flat and smooth, rhombic, arranged like pavement, alike in both jaws, and blunter than in any other sharks," "embryo without placenta," and "sometimes with pale spots" apply to the European species mentioned, and contrast with the characters of the common American form. Our species, especially when young, has rather definitely cusped teeth, hardly to be described as pavement-like; its embryos develop a pseudo-placenta, as clearly shown by Fowler (1909: 815, and 1918: 15, Pl. 2), and it never shows white spots, according to all the information available.

Jordan and Evermann, and before them Jordan and Gilbert, and later Jordan (in "Opinion 93" of the International Commission on Zoological Nomenclature), were thus clearly in error in uniting the American species canis with the European form which has passed (see Table I) under the varied names of asterias, stellatus, hinnulus, albomaculatus, plebejus, vulgaris, and mustelus (the "spotted hound"). If canis is identical with any one of the two or three European species, we should, with Garman (1913: 176), refer it rather to M. mustelus (M. laevis). The taxonomic error of confounding the American canis with the probably less closely related of the European species is the basis of much of the confusion which
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**TABLE I**

<table>
<thead>
<tr>
<th>Names Used by Leading European Authors Who Have Separated the Two Common European Species of the Mustelus Type</th>
<th>Name used for the &quot;smooth hound,&quot; Mustelus mustelus, the unspotted species with more pointed teeth and incompletely ridged scales.</th>
<th>Name used for the &quot;spotted hound,&quot; Mustelus asterias, the white-spotted species with very blunt teeth and completely ridged scales.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rondelet, 1554: 374-76 (after Aristotle)</td>
<td>Galeus laevis</td>
<td>Galeus asterias</td>
</tr>
<tr>
<td>Artedi, 1738: 93-94</td>
<td>Squalus dentibus obtusis seu granulosis, a</td>
<td>Squalus dentibus obtusis seu granulosis, β</td>
</tr>
<tr>
<td>Jeanromen, 1767: 26</td>
<td>Galeus or Mustelus laevis</td>
<td>Galeus asterias</td>
</tr>
<tr>
<td>Duhamel, 1782: 300</td>
<td>Galeus laevis</td>
<td>Galeus stellatus</td>
</tr>
<tr>
<td>Bonnaterre, 1788: 7</td>
<td>L’Ermisole (S. Mustelus)</td>
<td>Le Lentillat</td>
</tr>
<tr>
<td>Lacépède, 1789: 242</td>
<td>Squalus Ermisole (&quot;Squalus mustelus Linne&quot; in synonymy)</td>
<td>Le Lentillat (as variety)</td>
</tr>
<tr>
<td>Cuvier, 1817: 128</td>
<td>Ermisole commune</td>
<td>Ermisole tacheté de blanc</td>
</tr>
<tr>
<td>Cuvier, 1821: 406-7</td>
<td>Mustelus vulgaris</td>
<td>Mustelus asterias</td>
</tr>
<tr>
<td>Blainville, 1825: 81-84</td>
<td>Squalus (Talorchus) laevis</td>
<td>S. (G.) mustelus and</td>
</tr>
<tr>
<td>Risso, 1826: 120-28</td>
<td>Mustelus laevis</td>
<td>S. (G.) hinnulus</td>
</tr>
<tr>
<td>Bonaparte, 1841: 6</td>
<td>Mustelus equestris</td>
<td>Mustelus stellatus</td>
</tr>
<tr>
<td>pp., 2 figs.</td>
<td>Mustelus vulgaris, Var. 1</td>
<td>Mustelus plebejus</td>
</tr>
<tr>
<td>Miller and Henle, 1841: 64-66</td>
<td>Mustelus laevis</td>
<td>Mustelus vulgaris</td>
</tr>
<tr>
<td>Miller and Henle, 1841: 190</td>
<td>Mustelus laevis</td>
<td>Mustelus vulgaris</td>
</tr>
<tr>
<td>Duménil, 1865: 399-403</td>
<td>Mustelus laevis</td>
<td>Mustelus vulgaris</td>
</tr>
<tr>
<td>Günther, 1870: 385-87</td>
<td>Mustelus laevis</td>
<td>Mustelus asterias</td>
</tr>
<tr>
<td>Moreau, 1881, Vol. 1: 310-16, Figs. 43-44</td>
<td>Mustelus laevis</td>
<td>Mustelus asterias</td>
</tr>
<tr>
<td>Doderlein, 1881: 50-35</td>
<td>Mustelus equestris</td>
<td>Mustelus plebejus</td>
</tr>
<tr>
<td>Pietschmann, 1908</td>
<td>Mustelus laevis</td>
<td>Mustelus mustelus</td>
</tr>
</tbody>
</table>

1 For Linnaean.
2 Name not available because proposed in a post-Linnaean reprint of a pre-Linnaean work.
3 Name not available because the author was not consistently binomial.

pertains to the nomenclature of all these species and of the genera which have been based on them.

The American "smooth dogfish," canis, is probably not identifiable with any European species. To be sure, our species...
agrees well with the diagnostic characters of *M. mustelus* as these are given by most European authors (Table I) who have distinguished the two common European species (not considering the doubtful form *punctulatus*, and possibly others). But if we compare *canis* with the most critical distinction of the European species, namely that of Pietschmann (1908), we find that it possesses at least two features in apparent disagreement with those of *mustelus* (the *M. laevis* of Pietschmann). The borders of the two dorsal fins are whitish in the young and half-grown, instead of blackish, and the structure of the denticles is very different. Denticles from the position sampled by Pietschmann, namely on the back to either side of the mid-line and in front of the first dorsal fin, are provided with much stronger ridges than in *mustelus*, as figured by that author. As in *M. asterias* (the *M. mustelus* of Pietschmann), the median pair of ridges, in this part of the body, extend far beyond the middle of the scale, to or almost to the apex. A possibly valid further distinction lies in the much larger areas of the skin which seem to separate the denticles, as is shown in Radcliffe’s figure (1916: 267, Fig. 19). That figure was based on a piece of skin from below the first dorsal, and to judge from our material, from just below the midline of the sides, where the ridges become shorter and weaker, though still usually covering more than half the length of the scale.

The American form *canis* may, on this evidence, be again confidently validated as a distinct species. The problem of its generic nomenclature, however, is one of great confusion. For the solution of this question, it is necessary to review the involved nomenclatorial history of the two common European species.

Some of the pre-Linnaean writers, including Rondelet (1554: 375–76) clearly distinguished between the two European species and generally followed Aristotle in using the name *asterias* (or *stellatus* of similar meaning) for the “spotted hound” and *laevis* for the “smooth hound.” Linnaeus (1758: 235), however, followed others among the pre-Linnaean authors in confounding the two species, calling the complex
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Squalus mustelus. His description of two words, "dentibus obtusis," taken from Artedi’s name, applies better to the "spotted hound" than to the "smooth hound," though the latter can hardly be excluded on this account alone. Furthermore, the references given by Linnaeus, except to S. dentibus obtusis of Artedi, are all to Galeus or Mustelus laevis, which name was used for the "smooth hound" by such of his predecessors as separated the species. However, Garman and others have indicated that the pre-Linnaean accounts quoted by Linnaeus are in part based on the "spotted hound." This certainly is true of Linnaeus’ prime authority Artedi (1738: 93), whose Squalus dentibus obtusis seu granulosis specifically covered a subdivision a for the laevis of authors and β for asterias.

The Linnaean specific name mustelus was therefore a compound, and as such was passed on to the "first reviser" to disentangle. None of the writers immediately following 1758 appears to have qualified as such; almost certainly not Duhamel du Monceau (1782: 300), quoted by Garman (1913: 176) as using the name Galeus laevis for the "emissele" or "smooth hound." Duhamel's work is apparently to be excluded from nomenclatorial consideration on the grounds of its not being consistently binomial (see "Article 25" of The International Rules on Zoological Nomenclature). However, he did definitely separate the two forms, naming them Galeus laevis and Galeus stellatus.

Sherborn quotes the name Mustelus laevis as having been used by P. L. S. Müller in 1767, that is, in Müller's post-Linnaean edition of Knorr's Delicines Naturae Selectae (1767, Vol. 2: 141). This name occurs here, however, merely in a table of plates, in this connection: "H. IV. fig. 1. Un petit Haay, ou Loup marin, ou Requin. Mustelus laevis Ionst Linn"; the species is described on page 55 and there called "un Chien marin jeune encore, que porte le nom de Mustelus, & que quelques un appellent aussi Galeus levis."

So also I find Galeus or Mustelus laevis (and Galeus asterias) described and figured in a post-Linnaean edition of Jonstonus (1767: 26, Pl. 8). But these names, by "Opinion 5" of the
International Commission, are ineligible because they were merely reprinted from a pre-Linnaean account.

Bonnaterré (1788: 7, Pl. 7, Fig. 21), in his great Ichthyology, may be regarded as the first reviser of the Linnaean species Squalus mustelus. He very definitely described and figured the "smooth hound" only under that name. Following his account of S. mustelus, he appended:

a. Le Lentillat, décrit dans Willughby, est moucheté de taches blanches, semblables à les lentilles. Les mers de l'Europe.

This I interpret as excluding the "spotted hound" from the species mustelus, and as restricting that name to the "smooth hound." Since Bonnaterre used the Linnaean names and system, his action must be considered. Lacépède in the following year (1788: 242) described the "smooth hound" as "le Squale Émisseole," quoting "Squalus mustelus, Linné, édition de Gmelin," as a synonym, and indicated the "lentillat" or "spotted hound" as an unnamed variety. Gmelin's Squalus mustelus (1789), although indicated by Garman only in the synonymy of his Mustelus mustelus (the "spotted hound"), remained the composite species of Linnaeus (1758).

Línck (1790) was apparently the first author to use either the specific name laevis or the generic name Mustelus in available form. Línck's diagnoses, as quoted by Gill, were in the following words:

* ORDNUNG. ZÄHNE IN BEIDEN KILODALEN ALLEIN, OHNE UNTERSCHIED DER VORDER- UND BACKENZÄHNE.

a. OHNE KIEHNZÄHNE.

Squalus, Mustelus, Pristis, Raja, Rhinobatus.

Stumpfe Zähne ein rundlicher Körper M. laevis (Squalus Mustelus Linn.) Unterscheiden sich von dem vorigen Geschlecht [Squalus] doch sehr dadurch, dass sie weniger gefrühig sind, sich mehr von vegetabilien nähren, und eine mehr glatte Haut haben.

Gill rightly concluded that "the name is thus accompanied by a good diagnosis and synonym and consequently is well entitled to place instead of Mustelus of Cuvier or Galeus of Rafinesque."
I cannot agree with Gill and with Jordan (1917a: 87; in Jordan and Hubbs, 1925: 100, and in Opinions rendered by the International Commission on Zoological Nomenclature, 1926, No. 91: 8) that Linck’s action in itself “must fix the name Mustelus mustelus on the ‘Smooth Hound’.” Linck, it seems perfectly obvious, merely adopted the specific name laevis out of the synonymy of Squalus mustelus, in order to avoid tautonymy. Since the Rules definitely provide that a specific name shall not be discarded by reason of its being a tautonym, Mustelus laevis Linck reverted, simultaneously with its proposal, into the synonymy of Mustelus mustelus. There is nothing in Linck’s account to suggest that he was dividing or in any way revising Linnaeus’ species mustelus. The only real indication as to what species the laevis of Linck represents is the synonymizing of it with Squalus mustelus Linnaeus. For practical purposes, therefore, the latter name is the type of the genus Mustelus Linck.

The limitation of the specific name laevis therefore still was left by Linck for a first reviser. If the two constituent species are regarded as generically distinct, his generic name Mustelus was also a compound, requiring a first reviser to unsnarl.

Cloquet (1821: 406-7) correctly and with nomenclatorial propriety separated Mustelus vulgaris and Mustelus asterias, but quoted “Squalus mustelus, Linn.” in the synonymy of the latter. This action was contrary to that of Bonnaterre.

Blainville (1825) may qualify as the first reviser of the species name laevis, as he retained the name mustelus for what Moreau (1881: 311), Doderlein (1881: 30), Garman (1913: 170), and others have regarded as the “spotted hound” (also describing this species as S. hinnulus), but separated the “smooth hound” as S. laevis.

Risso (1826) is usually indicated as the first reviser, but Risso definitely referred to Blainville’s treatise by page and figure number, and hence certainly followed him. Risso erected three species of “Mustelus,” namely stellatus, laevis, and punctulatus. The last-named species remains doubtful, though accepted by Müller and Henle (1841: 66 and 190) and Garman.
M. levis Risso is clearly the "smooth hound," according to description as well as references. Risso's stellatus is definitely the "spotted hound," and he indicates among its particular synonyms S. mustelus Blainville and also "S. emissole. Lac. S. Mustelus Lin. (Missola.)" from his own Ichthyologie de Nice (1810: 33). Thus, as Pieschmann (1908: 693) insisted, Risso did involve the name mustelus in his revision, contrary to Jordan's claim. Risso's action if not Blainville's, might have fixed the name mustelus on the "spotted hound" had not Bonnaterre confined this name to the "smooth hound."

This identification of the name mustelus by Risso met with general acceptance by European ichthyologists, although most of them with such exceptions as Pieschmann (1908), have used the name piebejus or vulgaris to avoid the tautonym Mustelus mustelus. Bonaparte, Duméril, Günther, Doderlein, and Moreau are conspicuous examples (references in Table I). Garman in his great monograph (1913: 170) likewise employed the specific name mustelus for the "spotted hound."

These authors, Blainville and Risso as well as their followers, have however used the name laevis for the "smooth hound." Thus if Bonnaterre be rejected as the first reviser, Blainville and Risso could be interpreted as fixing the name mustelus on the one species and the name laevis on the other. Yet as apparently first proposed, laevis was clearly only a substitute name for mustelus, and hence took on the same status. The action of Bonnaterre or of Risso apparently required validation by arbitrary decision. "Opinion 93" of the International Commission made this decision, which supposedly is final and unchangeable, and laevis in the sense of the first reviser became the type of Mustelus, and the name of the European "smooth hound" was officially fixed as Mustelus mustelus (Linnaeus).

The placing of Mustelus in the official list of generic names would seem to render its validity clear despite the earlier use of the feminine form Mustela for a mammal, whether or not generic names differing only in gender be regarded in general as sufficiently distinct for nomenclatorial availability. Of course pre-Linnaean uses of the name are inconsequential.
Thus Garman's (1913: 3) objections to the acceptance of *Mustelus* for a genus of sharks are answered.

It is in a way unfortunate that *Mustelus mustelus* should be fixed as the name of the "smooth hound," as this action opposes the more frequent usage. It is also a misfortune that this action on the part of the International Commission on Zoological Nomenclature should have been based on unnecessarily weak arguments and on several mistakes in fact and in interpretation, in the proposal by Jordan:

1) The "spotted hound" has not usually been called *stellatus* Risso, but rather vulgaris, plebeius, or more recently *mustelus* (see Table I).

2) The earliest post-Linnaean writers who distinguished the European species did use *mustelus*, either directly or as a synonym, for one of the species (the "smooth hound"), or used laevis merely to avoid tautonymy.

3) The use of the name *Mustelus laevis* by Linck, as already indicated, did not in itself fix the specific name *mustelus*, and hence the generic name *Mustelus*, on the "smooth hound." The treatment of Bonnaterre, as pointed out above, would have been a less unsatisfactory basis for the official ruling.

However, any solution of the nomenclature of this group is bound to violate some usages. It may be noted that the name *Mustelus mustelus*, in that form, has hardly become general as the appellation of the "spotted hound." Furthermore, that name has been used in America for the "smooth hound."

Fortunately this official fixing of the name *Mustelus* on *Mustelus mustelus* (= *laevis*) seems to be in harmony with the action of Bonnaterre as first reviser. The uncovering of a still earlier reviser would presumably be of no significance, as the name *Mustelus* is now officially fixed and is therefore ruled as not subject to further changes.

Whitley (1932: 324) has called attention to the generic name *Emissola* Jarocki (1822: 488), obviously based on "l'Emissole." This is the French name accredited in almost all the early fish books to *Mustelus laevis* (= *mustelus*) or to the complex of "laevis" and asterias. In all probability *Emissola* was
based on *Squalus mustelus*. *Emissula* presumably ranks as the first objective synonym of *Mustelus*.

There has long been an argument as to whether *Galeus* Rafinesque and *Galeorhinus* Blainville both take as type the Linnaean species *mustelus* (see Gill, 1864a: 148; Jordan, 1885: 794; Jordan and Evermann, 1896: 29; Garman, 1913: 3-4; Jordan, 1917b: 78 and 95; Jordan, Evermann, and Clark, 1930: 13, etc.). For present purposes this is immaterial, for even if these genera be accepted with *mustelus* as type, they become synonyms of *Mustelus* Linck 1790, an older name.

*Pleuracromylon* Gill (1864a: 148) is a clear synonym of *Mustelus*, as that name is here employed, since *Pleuracromylon* was definitely proposed to contain the smooth-toothed sharks with a placenta, and since *Mustelus laevis* Müller and Henle (1841: 190) was definitely designated as the genotype. If not regarded as generically distinct, *Rhinotriacis* Gill (R. henlei), which is also described as having a pseudoplacenta, may be synonymized either with *Mustelus*, or, following Garman, with *Triakis*.

There remains for consideration the proper generic and specific name for the “spotted hounds,” that is, for the pavement-toothed galeoid sharks allegedly without pseudoplacental development. The name *Galeorhinus* Blainville (1825) would go with the “spotted hounds,” should *Squalus* (*Galeorhinus*) *annulus* Blainville be taken as the genotype. This action, however, is unlikely. The generic name *Cynias* Gill (1903: 960) was proposed for and has rather commonly been used for the “spotted hounds.” It was, however, based on *Mustelus canis*, on the erroneous assumption then prevalent that *canis* develops no pseudoplacenta and is related to the European “spotted hound.” In erecting the genus *Cynias*, Gill remarked:

The genus *Mustelus*, as understood by Jordan [that is, as defined by Jordan and Evermann to include the “spotted hounds,” with very blunt teeth and no pseudoplacenta] and typified by “*Mustelus canis*” [that is, Jordan and Evermann’s *Mustelus canis*] is thus bereft of a name [since *Mustelus* was taken to replace *Pleuracromylon* for the “smooth hound”] and may take that of *Cynias*.
In order to hold the name *Cynias* with the group to which Gill meant it to apply, I as first definite reviser, identify the compound species *Mustelus canis* Jordan and Evermann (1896: 29) nomenclatorially with *Mustelus asterias*, the “spotted hound.”

The specific name *asterias* has occasionally been applied, by recent as well as early ichthyologists, to the “spotted hound,” though usually on the unacceptable basis of some pre-Linnaean writer. Thus Le Danois (1913: 18, Fig. 13) uses the name “*Mustelus asterias* Bond.” The specific name *hinnulus* Blainville (1825) antedates that of *stellatus* Risso (1826). Whether authors prior to Blainville gave available specific names to the spotted hound remains to be determined. Valmont’s names are eliminated by “Opinion 89” of the International Commission, and apparently the names of Duhamel, Knorr (Müller’s edition), and Jonstonus, as mentioned above, are also ineligible. *Galeus asterias* Rafinesque (1810: 46) listed by Doderlein (1881: 34) in the synonymy of *Mustelus equestris* (= *laevis* = mustelus) was a virtual *nomen nudum*, for his entry under *Squalus* was as follows: “347.—*Asterias*. Raf. (Squalus asterias Linn.) Galeo asteriade. Gattupardu imperiali.” “*Squalus asterias*. Linn.” seems nonexistent. The only use of the name *asterias* listed in synonymies which would seem probably available is *Mustelus asterias* Cloquet, 1821. The account by Cloquet (p. 407) is as follows:

*Le Lentillat, Mustelus asterias*.—*Galeus asterias* Bond, 10, 13, cap. 4; *Squalus mustelus*, Linn. Il ressemble beaucoup au précédent; seulement sa peau est moins rude, et toute parsemée de mouchetures ovoïdes ou arroondies ......................... (H. O.)

The description of color and the references to medieval and ancient writers shows that Cloquet described and named the common “spotted hound.”

**Conclusions**

1. The scientific name of the American smooth dogfish should remain *Mustelus canis* (Mitchill).
2. This is the only species yet described from Atlantic North America, but additional species appear to exist on this coast.

3. The identification of *Mustelus canis* with the European "spotted hound" was erroneous.

4. *M. canis* is probably related more closely to the European "smooth hound," but differs in the color of the dorsal fins and the structure of the denticles.

5. If the two common European species are separated generically on the basis of the development or (alleged) lack of a pseudoplacenta, the genus with a pseudoplacenta should hold the name *Mustelus* Linck (1790), and the one without a pseudoplacenta that of *Cynias* Gill (1903). The lack of a pseudoplacenta at all embryonic stages in any *Mustelus*-like shark, however, remains to be proven.

6. The name of the European "smooth hound" is officially fixed as *Mustelus mustelus* (Linnaeus) by the International Commission on Zoological Nomenclature, and this action is in harmony with that of Bonnaterre, who may be regarded as the first reviser.

7. The European "spotted hound" should apparently bear the name *Mustelus asterias* Cloquet, 1821, or *Cynias asterias* (Cloquet) if this species be generically separated from *Mustelus mustelus*. No conclusive basis for such generic separation seems to exist.

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CLOQUET, HIPPOLYTE

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PERCID FISHES RELATED TO *POECILICHTHYS VARIATUS*, WITH DESCRIPTIONS OF THREE NEW FORMS

By CARL L. HUBBS AND JOHN D. BLACK

In 1931 J. Clark Salyer, II, secured for the University of Michigan Museum of Zoology two immature darters from the Big Niangua River, near Buffalo, Missouri. These were tentatively referred to *Poecilichthys variatus* by Hubbs and Trautman (1932: 33), but now, after having been carefully compared with more abundant material, seem to represent a distinct and hitherto unnamed form, herein called *P. tetrazona*. Later, 1 young and 1 adult of the same species, from the Gasconade River system in Missouri, were found in the United States National Museum.

During the summer of 1938, in the course of field work leading to a general survey of Arkansas fishes, the junior author and Mrs. Black obtained in the White River system several specimens of another new darter closely related to *Poecilichthys variatus*. It differs from that species in several respects, and on available evidence appears to be specifically distinct. It is herein named *Poecilichthys curvus curvus*. At the same time A. Hugh Denney, while collecting fishes in connection with a fish-management project of the United States Forest Service in southeastern Missouri, in another section of the White River system, seined several specimens of a very
similar darter, which we regard as subspecifically distinct from the Arkansas form. It is designated *Poecilichthys enzonus erizonus*.

Specimens which may be regarded as *Poecilichthys enzonus enzonus*, approaching *P. enzonus erizonus*, were located in the National Museum. They came from Black and Spring rivers at Black Rock and from the White River at Batesville, Arkansas. These darters, as well as 2 examples of *P. tetrazonus* mentioned above, were incorrectly referred by Meek to *Etheostoma uraindea* Jordan and Gilbert (in Gilbert, 1887: 48-49). The true *Etheostoma uraindea* (Jordan and Gilbert), although often showing a color pattern much like that of *Poecilichthys variatus*, is a very different species. After comparing the types and other material, we regard *Etheostoma* (?*Hadropoterus*) *ojachita* Jordan and Gilbert (in Gilbert, 1887: 49-50) as a synonym of *Etheostoma uraindea*.

We are much indebted to Alexander Wetmore and Leonard P. Schultz for the privilege of examining and reporting on specimens in the United States National Museum.

The material of these 3 new forms, together with additional specimens of 3 related species already named, enables us to present this review of the *Poecilichthys variatus* group, in which we include:

1. *Poecilichthys osburni* Hubbs and Trautman, 1932
2. *Poecilichthys tetrazonus*, new species
3. *Poecilichthys variatus* (Kirtland, 1838)
4. *Poecilichthys enzonus*, new species
   4a. *Poecilichthys enzonus erizonus*, new subspecies
   4b. *Poecilichthys enzonus enzonus*, new subspecies
5. *Poecilichthys blennius* (Gilbert and Swain, 1887)

The 5 species of the *Poecilichthys variatus* group, as here defined, may be recognized by the 4 conspicuous dark crossbars (5 in *P. osburni*), laid down over a pale and more or less uniform ground color above the lateral line. Other common characters—each shared, however, with some other species of the genus—are given as item 1e in the key.
It has just been discovered that 1 other species of *Poecilichthys* bears the 4 or 5 conspicuous oblique saddles characteristic of the *P. variatus* group. As Reeve M. Bailey has pointed out to us, the species described by Radcliffe and Welch (1913: 31–32, Pl. 18) as *Hadropterus sellaris* is not referable to *Hadropterus*, for it lacks all traces of the enlarged, spiny scales along the mid-ventral line, even between the pelvic fins where a very spiny plate is always evident in *Hadropterus* and other genera defined on this squamation character. *Poecilichthys sellaris*, known only from the two types collected in Swan Creek near Havre de Grace, Maryland, close to the head of Chesapeake Bay, may well bear no immediate relationship with the species of the Mississippi Valley having similar coloration. That the agreement in color pattern may have resulted from parallel evolution seems more plausible when we recall that very similar markings are developed in certain totally unrelated fishes of the rifes, for example in species of *Hypentelium* and *Cottus*. *P. sellaris* differs trenchantly from the species of the *P. variatus* group, including *P. blennius*, in the V-shaped border of the gill-membranes and in the scaleless belly. The distinctive genital papilla of the adult male of *P. sellaris* is a subspherical process, preceded and partly covered by a complex flap consisting of a sub-triangular shelf, on either side of which there is a large flat lobe turned under and back at the outer side to produce a small, thickened flap which is nearly hidden in ventral aspect. Other characters suggest relationship with *P. variatus*: (1) the saddles rival those of *P. blennius* in boldness and are similarly set off by light borders; (2) the anal fin is almost as expansive as the second dorsal; (3) the pelvics are separated by an interspace about two-thirds as wide as the base of either fin.

Some doubt is involved in the reference of *Poecilichthys blennius* to the *P. variatus* group. As indicated in the key, it is sharply set off from the 4 other species, which seem to constitute a well-circumscribed *Formenkreis*. No other characters than those of coloration seem to align *P. blennius* definitively with this group.
Generic or subgeneric classification among the darters is extraordinarily difficult. The only respect in which this group of species provides an exception to the statement arises from the circumstance that *varius* is the genotype of *Poecilichthys* Agassiz (1854: 304–6). Consequently, *varius* and its immediate relatives will remain in *Poecilichthys*, whether or not that genus is disrupted. We see no valid occasion for either the subgeneric or generic separation of any of the 4 other species here treated. Jordan and Evermann (1896: 1067) referred *Ethostoma variatum* to the subgenus *Poecilichthys* and *E. blennius* to *Nanoostoma*, but the criteria used by these authors to distinguish the 2 subgenera ("anal fin nearly as large as soft dorsal," instead of much smaller; "spine dorsal with about 13 spines," rather than 9 to 12) fail completely, in the light of the data presented in this paper. Nor is there anything distinctive in the supplementary characters assigned to *Poecilichthys* ("head almost naked; fins very large; colors brilliant"). We therefore interpret *Nanoostoma* as subgenerically synonymous with *Poecilichthys*. There is certainly no trace of justification for the generic separation of *Nanoostoma* from *Poecilichthys*, as advised by Jordan (1916: 26) and as recently practiced by Jordan (1929: 163), and by Jordan, Evermann, and Clark (1930: 289).

The same authors—Jordan (1929: 157), Jordan, Evermann, and Clark (1930: 287)—and some others following their lead, have referred *Poecilichthys blennius* to the genus *Ulocentra*. It is possible that this reference has a natural basis, since *blennius* does strongly resemble the species of *Ulocentra*. It has, however, a definite though narrow frenum, and is therefore retained by us in *Poecilichthys*.

Since all 5 species under discussion seem referable to *Poecilichthys* in subgeneric as well as generic sense, there is no present reason for considering here whether *Poecilichthys* should be divided into subgenera or into genera. The consid-

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1 On the use of this name for all or part of the group called *Ethostoma* by Jordan and Evermann (1896: 1066–99), see Jordan (1916: 25) and Hubbs (1926: 65).
erable diversity in the species here treated, in the degree of
union of the gill-membranes, lessens the taxonomic significance
of this rather intangible character, which, with the equally
tenuous character of the completeness of the lateral line, has
been used in the primary division of the whole group.

In the species group as here established, the lateral-line sys-
tem of the head (Hubbs and Cannon, 1935: 10-11, Pl. 2) is
remarkably uniform. The lateral canal of the head gives off 5
pores, each of which, except the hindmost, opens at the end
of a narrow tube directed, and commonly curved, downward
and slightly backward. The supratemporal commissure is
complete, with the median pore at the end of a short, backward-
extending canal. The lateral pore on either side lies directly
on the canal. In some individuals a small sense organ, super-
icially resembling a pore, is developed on either side of the
supratemporal canal, between the lateral pore and the median
line. The interorbital pores are present, as is the coronal,
which terminates a backward-extending tube. The two nasals
are widely separated, for the anterior one lies slightly in ad-
advance of the anterior nostril, whereas the posterior one is near
the posterior nostril. The infraorbital canal is complete with
8 pores, but presents a peculiarity: although each of the 4 pos-
terior pores lies at the end of a downward-projecting tube, the
posteriormost or fourth of the anterior set is frequently, in some
forms almost invariably, at the end of a short tube which
extends upward to near the eye. In P. bleenius and P. tetra-
zona, however, this pore typically opens out directly on the
canal, or even at the end of ventral tubes (see descriptions of
these species). There is some variation in this character, even
on the two sides of an individual. The operculomandibular
series comprises 10 pores, of which those on the opercle open at
the end of short, downward-projecting tubes.

Due to the previous association of P. bleenius with the sub-
genus or genus Nanomotoa, a check was made on the pores of
the head in the various species referred to that group. P. 
swannanoa alone showed the upward-projecting fourth pore,
and only as a variation from the more usual condition, in
which the pore lies below or on the canal. In P. zonalis, P. zonalis arenos anus, P. lyne cus (=P. elegans), and P. rupestris, this pore opens on the lower side of the canal, as in most other darters, with a complete canal, which we have examined.

**ANALYSIS OF THE SPECIES AND SUBSPECIES OF THE**

**POECILICHThYS VARIATUS GROUP**

1a (common characters).—Lateral line complete (occasionally with 1 or 2 pores missing). Gill-membranes more or less broadly connected. Form robust. Dorsal rays XI to XIV (X to XII in P. tetra zonus)—11 to 16; anal with 2 stiff spines and 8 to 11, commonly 9 or 10, soft rays. Body above lateral line crossed by conspicuous dark bars (5 in P. subalar), on a pale and more or less uniform ground color.

2a.—Snout more or less produced (angle of muzzle 44° to 70°). Gill membranes moderately to rather broadly connected, forming an angle of 50° to 90°. Scales 6 to 9—50 to 73—7 to 11 (9 or 4—47 to 54—7 or 8 in P. tetra zonus). Soft rays 12 to 15 in dorsal fin, 9 to 11 in anal, and 14 to 16 in pectoral. Least bony interorbital width 2.2 to 3.8 in eye. Least suborbital width 5.8 to 12.0 in head. Upper jaw 3.5 to 5.7 in head (3.5 to 4.0 in P. caeruleus arenosanus). Highe st dorsal spine 2.2 to 2.8 in head; longest pectoral ray 0.8 to 1.2; length of pelvic fin 1.0 to 1.5. Dorsal saddles not set off by a light posterior border. Lateral blotches not fused into a zigzag line.

2a.—Five blackish saddles. Head 3.6 to 4.0. Eye 1.3 to 2.0 in snout, 4.4 to 5.6 in head. Snout 2.8 to 3.4. Least suborbital width 5.8 to 7.3.

4a.—Scales 7 to 9—50 to 69 (53 to 57 in a variant form)—8 to 11. Dorsal spines 11 to 14. Saddles and lateral markings fairly well developed in young, becomingobsolete in adult females but intensified in breeding males; lateral blotches in adults forming 9 to 11 rather regular bars, almost encircling body posteriorly; 11 or 12 orange bars in breeding males. Body moderately compressed (width 1.5 in projection of depth). Least bony interorbital width 2.3 to 2.5 in eye. Vertical soft fins high (highest dorsal ray 1.4 to 1.7, and highest anal ray 1.7 to 1.8 in head). Interspace between pelvic fin and union of gill-membranes 1.2 to 1.4 in distance thence to tip of mandible. Breast scaleless (rarely with a few scales near pelvic fins); angle between supratemporal and lateral head canals and the opercle and cheeks
scaleless. **Upper Kanawha River system, Virginia and West Virginia:**

1. *P. osburni*

   - Four blackish saddles. Head 3.3 to 3.7. Eye 0.8 to 1.5 in snout, 3.7 to 4.7 in head. Snout 3.0 to 4.3. Least suborbital width 6.5 to 12.0 (usually more than 7.2).

2. *P. tetrazonus*

   - Scales 6 or 7—50 to 58—7 to 9. Dorsal spines 11 to 13, most frequently 13. Saddles and lateral bars very distinct in young, but becoming obscure in adults, particularly in breeding males; lateral blotches 9 to 11, not forming regular bars, those in the breeding males indistinct and not forming orange bars; the orange bars therefore few (5 or 6). Body more compressed (width 1.5 to 1.7 in projection of depth). Least interorbital width 2.3 to 2.7 in eye. Vertical soft fins high (highest dorsal ray 1.4 to 1.9, and highest anal ray 1.6 to 2.6, in head). Interspace between pelvic fin and union of gill-membranes 1.5 to 1.7 in distance thence to tip of mandible. Breast almost always scaleless, except near pelvic fins; angle between supratemporal and lateral head canals scaleless, or with 1 to 3 embedded scales; opercle ordinarily without scales, rarely with a few; cheeks always naked. **Ohio River drainage basin in New York, Pennsylvania, West Virginia, Ohio, Indiana, and Kentucky, exclusive of the Upper Kanawha, Wabash, Kentucky, and Tennessee River systems:**

3. *P. variatus*

   - A single record for the Cumberland River system, in Tennessee, has been doubted (Hubbs and Trautman, 1932: 33).
dd.—Scales 7 to 9—57 to 73—8 to 11 (6—54—9 in 1 specimen from Spring River with unusually large anterior scales). Dorsal spines 12 to 14, most frequently 13. Saddles and lateral markings very prominent in both sexes, at all ages and seasons. Body more terete (greatest width 1.2 to 1.3 in projection of depth). Least bony interorbital width 3.9 to 3.8 in eye (2.6 to 3.3 in young and half grown specimens from Black Rock and Batesville, Arkansas). Vertical soft fins little elevated (highest dorsal ray 1.8 to 2.5, and highest anal ray 1.8 to 2.4, in head). Interspace between pelvic fins and union of gill-membranes 1.2 to 1.6 in distance thence to tip of mandible. Breast more or less completely scaled (with rare exceptions); angle between supratemporal and lateral head canals with a patch of ctenoid scales; checks with or without scales. White River system in Missouri and Arkansas:

4. *P. cuvierii*

5a.—Cheeks with several ctenoid scales (wholly lacking in 1 of 18 specimens, and limited to 1 or 2 on each cheek in another); breast always well scaled, and the posterior scales usually somewhat ctenoid; opercle covered with ctenoid scales. Scales above lateral line 7, rarely 8. Lateral blotches 8 to 10, usually 8 or 9, less definitely connected with the saddles, more triangular, and becoming more disrupted with age; saddles in adult also less regular and straight-edged; light areas considerably tessellated with dark in adult; stippling of anterior lower surfaces restricted to the cheeks (usually leaving below the eye a clear patch transversed by a faint subocular bar) and to mottlings on the chin. Gill-membranes usually more broadly connected, forming an angle of 52° to 81° (typically 65° to 75° in adults). Snout more constricted and produced (angle of muzzle 40° to 50°), 3.9 to 3.5 in head. Eye smaller, 1.3 to 1.5 in snout, and 3.7 to 4.7, usually 4.0 to 4.5, in head. Highest dorsal ray 1.8 to 2.1 in head. Head 3.4 to 3.7, usually 3.5 to 3.6. Current River (White River system), southeastern Missouri;

4a. *P. cuvierii ericous*

5b.—Cheeks scaleless; breast scaleless anteriorly, with embedded scales posteriorly (wholly scaleless in 1 of 9 specimens); opercle not quite fully scaled. Scales above lateral line 8, rarely 9. Lateral blotches 5 to 8, usually 7 or 8, more definitely connected with the saddles, mostly squarish (somewhat triangular in young), and little disrupted with...
age; saddles in adult also more regular and straight-edged; light areas scarcely tessellated with dark in adult; stippling of anterior lower surfaces densely extended over cheeks, throat, branchiostegal membranes, and fore part of breast (less developed in young, but always better developed at comparable sizes). Gill-membranes usually less broadly connected, forming an angle of 50° to 62°.

Snout heavier and more declivous (angle of muzzle 44° to 57°), 3.3 to 4.6 in head. Eye larger, 0.9 to 1.3, usually 1.1 to 1.2, in snout, and 2.7 to 3.9 in head. Highest dorsal ray 2.9 to 2.5 in head. Head 3.0 to 3.4.

White River system, in typical form above Batesville, Arkansas:

49. P. argus caninus

2h.—Snout more declivous (angle of muzzle 69° to 75°). Gill-membranes very broadly connected, forming an angle of 80° to 110°.

Scales 4 or 5 to 45 or 6 to 7. Soft rays 11 to 13 in dorsal fin, 8 or 9 in anal, and 16 or 17 in pectoral. Least bony interorbital width 1.8 to 2.0 in eye. Least suborbital width 4.8 to 6.8 in head. Upper jaw 3.7 to 4.2 in head. Highest dorsal spine 1.3 to 2.0 in head; longest pectoral ray 0.7 to 0.8; length of pelvic fin 0.9 to 1.0. Dorsal saddles set off by a creamy white posterior border. Lateral blotches fused into a zigzag line.

3c.—Four green-black saddles. Head 3.6 to 4.0. Eye 1.2 to 1.8 in snout, 4.0 to 4.9 in head. Snout 2.7 to 3.4. Tennessee River system, in Alabama and Tennessee:

5. P. bleekeri

Explanation of measurements and counts.—The measurements of the head include the opercular membrane. The eye (rather than the orbit) is measured between the margins of the cornea on the longest dimension. Scales above the lateral line are counted from the origin of the dorsal fin downward and backward to the lateral line, beginning with the one beside the first dorsal spine and ending with the scale row above the lateral line. Scales below the lateral line are enumerated diagonally upward and forward from beside the first anal spine to the lateral line, again excluding the lateral-line scale row, but including the very small row of scales often present next to the anal fin. The lateral-line count begins with the last scale which is in contact with the shoulder girdle and ends at the structural base of the caudal fin. The last ray of the
dorsal and anal fins is always counted as a divided ray—a criterion at times requiring careful examination.

1. Pocilichthys osburni Hubbs and Trautman


This well-marked, isolated species shows direct relationship only with *P. variatus*. Its distinguishing characters are indicated in the original account, and as items 1a, 2a, 3a, and 4c of our key. The material in the University of Michigan Museum of Zoology has been examined. Some collections have been received since the type description was published. All are from the Kanawha (New) River system above Kanawha Falls. Series from the Kanawha system below these falls prove referable to *P. variatus*. Since certain errors in the original description have been discovered, we give here the counts and measurements of the holotype, and, in parentheses, of 6 adult paratypes.

Scales 8—64—9 (7 to 9—59 to 66—9 or 10). Dorsal rays XIII—13 (XII to XIII—13 to 15); anal rays, II, 9 (II, 9 or 10, usually 10); pectoral rays 15—15 (14 to 15, generally 15). Lateral markings 11 (9 to 11), not counting the blotch at the caudal base nor the continuation of the nuchal saddle. These markings form more definite bars than do those in other species. The posterior bars in the adult male almost encircle the body.

Depth 5.0 (4.8 to 5.4). Greatest width 1.5 (1.5) in projection of greatest depth. Head length 3.9 (3.6 to 3.9). Least suborbital width 6.5 (5.8 to 7.3) in head. Least interorbital width 2.3 (2.3 to 2.5) in eye. Eye 5.5 (4.8 to 5.6) in head; 1.8 (1.5 to 2.0) in snout. Snout 3.2 (2.8 to 3.4) in head. Upper jaw 3.6 (3.3 to 3.6). Angle of muzzle 55° (49° to 58°); of gill-membranes 61° (61° to 78°). Eye 2.7 (2.4 to 2.8) in distance from tip of mandible to union of gill-membranes; latter distance 1.8 (1.7 to 2.0) in head, and 1.2 (1.1 to 1.4) times interspace between union of membranes and insertion of pelvic fin. Highest dorsal spine 2.2 (2.2 to 2.5) in head,
2.5 (2.2 to 2.9) in first dorsal base, and 1.4 (1.4 to 1.5) in the highest dorsal soft ray, which enters the head 1.4 (1.4 to 1.7) times and the second dorsal base 1.1 (1.1 to 1.2) times. Length of caudal fin 1.5 (1.4 to 1.5) in head. Highest anal ray 1.7 (1.7 to 1.8) in head, and 1.2 (0.8 to 1.2) in the anal base, which enters the head 1.7 (1.5 to 2.3) times and the second dorsal base 1.3 (1.3 to 1.4) times. Longest pectoral ray 0.9 (0.8 to 1.0) in head; length of pelvic fin 1.2 (1.2 to 1.3). Interspace between pelvic fins 1.6 (1.4 to 1.7) in pelvic base.

In the original description a large-scaled variant of this form was mentioned. Three similar specimens, in the National Museum, were collected by Leonard P. Schultz and Earl D. Reid in Crooked Creek, 4 miles east of Galax, Virginia, July 3, 1938. They show the following characters: Scales 7—53—9 (1) or 10 (2); dorsal, XI (1) or XIII (2), 12 (1) or 13 (2); depth 5.3 to 5.6; eye 1.3 in snout, 4.4 to 5.2 in head; head 3.8 to 4.0; dorsal saddles 5; male with numerous light bars.

2. Poecilichthys tetrazonus, new species

(Pt. I, Fig. 1)

Ethocotoma uranidea (misidentification).—Meek, 1891: 123 (Gasconade River at Arlington, and Little Piney River at Newburg, Missouri).

Poecilichthys variatus (misidentification).—Hubbs and Trautman, 1932: 33 (Missouri record only).

The holotype, University of Michigan Museum of Zoology No. 111330, is a half-grown specimen 33 mm. in standard length. It was seined in Big Niangua River, at mouth of Greasy Creek, 6 miles southeast of Buffalo, Dallas County, Missouri, by J. Clark Salyer, II, on August 28, 1931. One paratype, a young fish 22 mm. long, was taken with the holotype.

The two type specimens of this species were recorded by Hubbs and Trautman as Poecilichthys variatus, but on more detailed study appear to represent a distinct species. The two darters from the Gasconade River system of Missouri, referred by Meek to Ethocotoma uranidea, seem to represent the same form. The contrasting characters of P. variatus and P. tetra-
zonus are given as items db and dc in our key. When com-
pared with the two subspecies of P. euzonus, P. tetrazonus is
seen to differ sharply in the size of the scales and in numerous
other characters, as stated in items db and dd of the key. The
available evidence indicates the full specific separation of tetra-
zonus from variatus and euzonus, but the relationships between
these forms seem rather close. Further material may indicate
subspecific intergradation.

In the following description the counts and measurements
are given first for the holotype, followed, in parentheses, by
determinations for (1) the paratype; (2) the young specimen,
28 mm. long, from Gasconade River; and (3) the adult, 57 mm.
long, from Little Piney River.

Scales 5—51—7 (5—47—7; 6—52—8; 6—54—8). Breast
with several ctenoid scales (with several cycloid scales in para-
type; posterior half of breast well covered with ctenoid scales
and anterior half with some embedded scales, in the 2 other
specimens). Angle between supratemporal and lateral head
canals with 1 large, ctenoid scale on one side but none on the
other side (with none on either side in paratype; with several
large ctenoid scales in the other specimens). Opercle of each
side with 1 large ctenoid scale in the holotype (with a few
ctenoid scales in the 3 others). Cheeks scaleless (in all
specimens).

Dorsal rays XII—14 (X—14; XII—13; XII—13); anal rays II,
9 (II, 10; II, 9; II, 10); pectoral rays 15—15 (14—15; 14—1;
15—16). The dorsal fins are well separated.

The canals and pores of the head correspond with the de-
scription given on p. 5. The posteriormost of the anterior
group of 4 infraorbital pores opens directly from the canal at
its upper edge on one side and at its lower edge on the other
side (at mid-line of canal on both sides; on lower edge of
canal; at ends of short, downward-projecting tubes).

The body is shaped about as in specimens of like size of P.
variatus; depth 5.3 (5.1; 4.6; 4.8). The body is moderately
compressed; width 1.6 (1.4; 1.7; 1.7) in projection of depth.
The head is rather large, 3.3 (3.3; 3.7; 3.7) in standard length. Least suborbital width 9.6 (9.0; 10.0; 8.0) in head. Least interorbital width 3.0 (3.0; 2.5; 2.2) in eye. The eye is rather large: 4.2 (4.2; 4.5; 4.7) in head, 1.3 (1.0; 1.1; 1.5) in snout. The snout is rather short, 3.8 (4.2; 4.3; 3.6) in head, but rather pointed: angle of muzzle 55° (52°; 51°; 57°). Upper jaw 3.6 (3.5; 3.7; 3.6) in head. Angle of gill-membranes 66° (55°; 74°; 77°). Eye 2.4 (2.7; 2.5; 2.7) in distance from tip of mandible to union of gill-membranes; latter distance 1.6 (1.6; 1.6; 1.7) in head, and 1.6 (1.5; 1.4; 1.3) times interspace between union of gill-membranes and insertion of pelvic fin. Highest dorsal spine 2.7 (2.4; 2.3; 2.4) in head, 2.4 (2.0; 2.4; 2.8) in first dorsal base, and 1.3 (1.3; 1.3; 1.4) in the highest dorsal soft ray, which enters the head 2.1 (2.0; 1.8; 1.9) times and the second dorsal base 1.4 (1.4; 1.3; 1.4) times. Length of caudal fin 1.3 (----- ; 1.5; 1.4) in head. Highest anal ray 2.3 (2.0; 2.0; 2.0) in head, and 1.0 (1.0; 1.0; 0.9) in the anal base, which enters the head 2.3 (2.0; 2.0; 1.8) times and the second dorsal base 1.4 (1.4; 1.3; 1.3) times. Longest pectoral ray 1.0 (0.9; 1.0; 1.0) in head; length of pelvic fin 1.4 (1.5; 1.2; 1.3). Interspace between pelvic fins 2.0 (1.5; 1.5; 1.5) in pelvic base.

The coloration of the holotype is as follows: The back is crossed by 4 regular dark saddles, about as in the related species. These crossbars are less blackened than in P. e. ozonus. As in P. e. ozonus erizonus, the anteriormost saddle is expanded backward to include the extreme front of the dorsal fin. This band splits at the pectoral insertion to form 2 narrow lines, 1 on either side of the fin (the anterior fork is under the gill-cover). The second and third saddles, descending from the rear of the spinous and soft dorsal fins, respectively, fail by 1 scale row to reach the lateral line. The fourth saddle, on the caudal peduncle, is continued to near the mid-ventral line. In addition there is a faint spot at the base of the caudal fin. There are about 9 lateral blotches (10 in the paratype). Of these the first 2 are rectangular, the others more or less triangular. The general ground color of the upper surfaces in alco-
hol is olivaceous tan, lighter than in *P. enzonus* because the melanophores on the scales are less dense. The bars radiating from the eye (1 downward and forward, 1 downward, and 1 backward) are short. The opercle and the angle of the pre-opercle are stippled, and there are melanophores near the radiating bars and at the tip of the chin. Otherwise, the lower sides of the head are nearly clear of pigment.

The young paratype, perhaps largely on account of its size, is unusually pale, resembling *Boleosoma*.

The Gasconade River specimen is colored much like the holotype, though the second and third bars show a tendency, with bilateral variation, to connect with lateral bars. The basal caudal spot is conspicuous. There are 10 lateral blotches, mostly squarish. The scale centers tend to be lighter, the crosshatching more conspicuous. A dusky blotch on the upper anterior sides represents a trace of the second saddle of *Poeciliichthys osburni*.

The single adult specimen (from Little Piney River) approaches *P. osburni* in that the lateral blotches, 9 on one side and 10 on the other, form rather definite bars on the lower sides, with weak extensions above the lateral line. There is no definite trace of the second saddle of *P. osburni*. The first saddle is truncated at the base of the first dorsal spine. There are faint connections between the second and third dark saddles and the lateral blotches below them. The basal caudal spot is inconspicuous. The cheeks and the lower side of the head are evenly and densely stippled.

The name *tetrazonus*, derived from *tetrā*, four, and -ξον, -zone, refers to the 4 prominent dark saddles characteristic of this and related species.

3. *Poeciliichthys variatus* (Kirtland)  
(Pl. II, Fig. 1)  

*Ethemostoma variatum*.—Kirtland, 1838: 168 and 192 (virtual nomen nudum; Mahoning River, Ohio; Cuyahoga River record probably based on *P. osburni*); 1841: 274-76, Pl. 2, Fig. 2 (original description; Mahoning River).  

*Ethemostoma variatum*.—Agassiz, 1850: 299 (type of genus *Poecilo-
As Jordan (1885: 163) noted, the name \textit{variatus} was transferred by himself and others for a time to \textit{Poeoilichthys ceculatus}. Vaillant (1873: 84-87) used the name \textit{Bolosoma variatum}, and Jordan and Gilbert (1883: 503) that of \textit{Alvordius variatus}, in describing species of \textit{Hadropterus}.

This species, as here delimited, has been characterized by the authors cited in the synonymy. In our analysis of the species, it is compared in detail with the other forms of the group now recognized. Items la, 2a, 3b, and 4c of the key constitute a description. Additional characters are given below. The determinations were mostly made on 7 Ohio specimens 51 to 73 mm. in standard length.

Dorsal rays XI to XIII–12 to 16; anal rays II, 9 or 10, usually 9; pectoral rays 14 to 16, usually 15. Lateral markings 9 to 11.

Depth 4.6 to 5.4. Head length 3.5 to 3.7. Least suborbital width 8.0 to 9.5 in head. Eye 3.8 to 4.0 in head, 0.8 to 1.0 in snout. Snout 3.3 to 4.0 in head. Upper jaw 3.4 to 3.7. Angle of muzzle 55° to 70°; of gill-membranes 61° to 90°, increasing with age. Eye 2.2 to 2.5 in distance from tip of mandible to union of gill-membranes; latter distance 1.5 to 1.7 in head.
Highest dorsal spine 2.4 to 2.6 in head, 2.2 to 2.5 in first dorsal base, and 1.3 to 1.7 in highest dorsal soft ray, which enters the second dorsal base 1.0 to 1.4 times. Length of caudal fin 1.4 to 1.5. Highest anal ray 0.9 to 1.0, usually 1.0, in the anal base, which enters the head 1.6 to 2.0 times and the second dorsal base 1.3 to 1.4 times. Longest pectoral ray 0.8 to 0.9 in head; length of pelvic fin 1.1 to 1.3. Interspace between pelvic fins 1.5 to 2.0, usually 1.5, in pelvic base.

4. Poecilichthys euzonus, new species

This species is characterized by the very decided contrast between the dorsal saddles and the ground color; the smaller fins, as compared with those of P. variatus and P. osburni; and the more cylindrical body (the body form, especially in P. euzonus erizonus, approaches that of Hadropterus). The scales, about as in typical P. osburni, are somewhat smaller than in variatus. From osburni, the new species differs in the size of the fins, the general body shape, the number of bands, other features of coloration, and in various other characters. The squamation of the head and breast, too, separates this species distinctly from others of the group, though there is considerable difference in this respect between the 2 subspecies of P. euzonus. The details of the specific description are presented in the accounts of the 2 subspecies. Common specific characters are stated as items 1a, 2a, 3b, and 4d.

Poecilichthys euzonus, as here constituted, is a complex of 2 rather distinct subspecies, which are contrasted in items 5a and 3b of the key (p. 8). P. c. euzonus occurs in the White River system of Arkansas, above Batesville, and P. c. erizonus in the Current River of Missouri, which is also in the White River system. Specimens from Spring River and Black River, at Black Rock, and from White River at Batesville, Arkansas, misidentified as Etheostoma uranideum by Meek (1894a: 268; and 1894b: 80), appear more like typical P. euzonus, but approach erizonus in distribution and in some characters. The Spring River specimens have been referred to Poecilichthys variatus by
Hubbs and Ortenburger (1929: 48) and by Hubbs and Trautman (1932: 33). It is possible that these fish should be interpreted as intergrades, but their small size and long preservation preclude a precise subspecific determination. In the Spring and White River series the breast is rather more scaled than in typical *erizonus*, but less so than in *erizonus*, and the cheeks bear no scales except for a few in 1 specimen from Spring River. The individual from Black River has the breast densely scaled and the cheeks about as well scaled as in *erizonus*. In general physiognomy all 3 lots are more like *erizonus* than *erizonus*. The saddles are more like those of *erizonus*; the lateral blotches, rather intermediate. In counts and measurements (Table 1) the resemblances are diverse. As would be expected, the specimens from White River at Batesville seem somewhat closer to *erizonus* than do those from Black Rock.

4a. Poecilichthys *erizonus* *erizonus*, new subspecies

The holotype, University of Michigan Museum of Zoology No. 124597, is an adult male 66 mm. in standard length. It was collected by A. Hugh Denney on August 10, 1938, in Current River, at "The Nook," T. 23 N., R. 2 E., Sec. 9, Ripley County, Missouri. The paratypes were all collected by Denney in Current River in Missouri: 5 with the holotype; 8 from near the Carter County Hunting and Fishing Club, T. 26 N., R. 1 E., Sec. 11 and 12, Carter County, July 25, 1938; 2 from the Doniphan Boat Landing, T. 23 N., R. 2 E., Sec. 27, Ripley County, July 26, 1938; 2 from the river just above the mouth of Pike Creek, T. 27 N., R. 1 W., Sec. 23, Carter County, August 18, 1938. The 18 available specimens of this form range in size from 34 to 70 mm.; 15 are 58 to 70 mm. long.

The diagnostic characters are given as items 1a, 2a, 3b, 4d, and 5d in the key. Probably the most obvious difference between this subspecies and typical *erizonus* is the more extensive squamation of the breast and the scaled cheeks. The blotches on the side and the scale rows above the lateral line each aver-
## TABLE I

Counts and Measurements of *Poecilichthys euzonus*

Extreme counts and measurements, representing only 1 or 2 specimens, are indicated in parentheses for some of the items.

<table>
<thead>
<tr>
<th></th>
<th><em>P. e. euzonus</em></th>
<th><em>P. e. euzonus</em> approaching <em>euzonus</em></th>
<th><em>P. e. euzonus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of specimens</strong></td>
<td>Holotype</td>
<td>Paratypes</td>
<td>Paratypes</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Standard length (in mm.)</strong></td>
<td>66</td>
<td>44-70</td>
<td>65</td>
</tr>
<tr>
<td>Scales above lateral line</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Scales in lateral line</td>
<td>67</td>
<td>(9)7-8</td>
<td>8-9</td>
</tr>
<tr>
<td>Scales below lateral line</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Dorsal spines</td>
<td>13</td>
<td>(12)(13)</td>
<td>12-14</td>
</tr>
<tr>
<td>Dorsal soft rays</td>
<td>14</td>
<td>(12)(15)</td>
<td>12-14</td>
</tr>
<tr>
<td>Anal rays</td>
<td>15</td>
<td>(10)(11)</td>
<td>10</td>
</tr>
<tr>
<td>Pectoral rays</td>
<td>16-16</td>
<td>(14)(15)</td>
<td>15-16</td>
</tr>
<tr>
<td>Lateral blotches below lateral line</td>
<td>8</td>
<td>8</td>
<td>7-10</td>
</tr>
<tr>
<td><strong>Depth in length</strong></td>
<td>5.1</td>
<td>4.9-5.5(5.8)</td>
<td>5.0</td>
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<tr>
<td>Greatest width in projection of depth</td>
<td>1.4</td>
<td>1.3-1.4(1.5)</td>
<td>1.4</td>
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<tr>
<td><strong>Head in length</strong></td>
<td>3.6</td>
<td>3.4-3.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Least suborbital width in head</td>
<td>7.2</td>
<td>(8.5)(8.5)</td>
<td>10.0-12.0</td>
</tr>
<tr>
<td>Least interorbital width in eye</td>
<td>3.0</td>
<td>3.0-3.5</td>
<td>2.6-2.7(2.8)</td>
</tr>
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<td></td>
<td><em>P. c. crounus</em></td>
<td><em>P. c. crounus</em> approaching <em>crounus</em></td>
<td><em>P. c. crounus</em></td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------</td>
<td>--------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>Holotype</td>
<td>Paratypes</td>
<td>Black River</td>
</tr>
<tr>
<td>Eye in head</td>
<td>4.5</td>
<td>(3.7) 3.9–4.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Eye in snout</td>
<td>1.5</td>
<td>1.3–1.5</td>
<td>1.1</td>
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<td>Snout in head</td>
<td>3.3</td>
<td></td>
<td>1.3</td>
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<td>Upper jaw in head</td>
<td>3.6</td>
<td>(3.8) 3.7–4.0</td>
<td>2.5</td>
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<tr>
<td>Angle of nuzzle</td>
<td>45°</td>
<td>40–50°</td>
<td>41°</td>
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<tr>
<td>Eye into distance from</td>
<td>2.3</td>
<td>(2.1) 2.3–2.5</td>
<td>2.3</td>
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<tr>
<td>tip of mandible to union</td>
<td></td>
<td></td>
<td>2.0</td>
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<tr>
<td>Interspace between insertion of pelvic fin and union of gill-membranes in distance thence to tip of mandible</td>
<td>1.3</td>
<td>1.2–1.5</td>
<td>1.3</td>
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<tr>
<td>Highest dorsal spine in head</td>
<td>2.5</td>
<td>2.4–2.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Highest dorsal spine in first dorsal base</td>
<td>2.5</td>
<td>2.4–2.8</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>P. c. cripus</td>
<td>P. c. canorus approaching cripus</td>
<td>P. c. cripus</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------</td>
<td>---------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Holotype</td>
<td>Paratypes</td>
<td>Black River</td>
</tr>
<tr>
<td>Highest dorsal spine</td>
<td>1.3</td>
<td>1.3-1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Highest dorsal soft ray</td>
<td>2.0</td>
<td>1.8-2.3</td>
<td>2.2</td>
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<tr>
<td>Highest soft ray in</td>
<td>1.5</td>
<td>1.4-1.6</td>
<td>1.5</td>
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<tr>
<td>second dorsal base</td>
<td>Highest</td>
<td>1.4</td>
<td>1.4-1.6</td>
</tr>
<tr>
<td>Length of caudal fin</td>
<td>2.0</td>
<td>1.8-2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Highest anal ray in</td>
<td>1.0</td>
<td>1.0-1.1(1.2)</td>
<td>1.0</td>
</tr>
<tr>
<td>anal base</td>
<td>2.0</td>
<td>1.5-1.7(1.8)</td>
<td>2.4</td>
</tr>
<tr>
<td>Highest anal ray in</td>
<td>1.5</td>
<td>1.3-1.6</td>
<td>1.2</td>
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<tr>
<td>anal base</td>
<td>0.85</td>
<td>0.9-1.0(1.2)</td>
<td>1.1</td>
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<tr>
<td>Length of pelvic ray</td>
<td>1.0</td>
<td>1.1-1.2(1.4)</td>
<td>1.3</td>
</tr>
<tr>
<td>in head</td>
<td>1.5</td>
<td>1.4-1.6(1.9)</td>
<td>1.3</td>
</tr>
<tr>
<td>Interspace between pelvic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
age about 1 fewer than in *euzonus*. In *erizonus* the eye averages smaller and the snout longer, so that the eye-snout ratio is quite distinct (1.3 to 1.5 in *erizonus*, 0.9 to 1.2 in *euzonus*). The fins, notably the pectoral, tend to be somewhat larger in *erizonus* than *euzonus*, though smaller than in *osburni* and *variatus*. Distinctions in coloration are evident, and there are several other minor differences. The 2 subspecies are compared as items 5a and 5b of the key, and in Table I.

The dorsal fins are separated in all the types. In preserved specimens the ground color between the saddles of the back is olivaceous tan. Each scale of these regions is finely and closely speckled with black, except at the center, which is clear. Some scales, in irregular patches in the light areas, are much more densely speckled than others and produce a slightly tessellated effect. The back is crossed by the 4 strong fuscous bands characteristic of the *P. variatus* group. The margins of these dorsal saddles are not as sharply defined as in *P. e. euzonus*. The first saddle, extending over the posterior part of the nape, has its posterior margin somewhat extended backward along the sides of the first 1 or 2 spines of the dorsal fin. This mark extends solidly down to the insertion of the pectorals, where it divides, sending one line down behind the fin and another in front of the fin under the gill-cover. The second dorsal saddle begins at the back of the spinous dorsal and slopes more sharply forward than the first saddle. It widens at the lateral line and forks to form, below the lateral line, 2 less blackened lateral blotches, which are more distinctly separated from the dorsal saddles than in *euzonus*. The third saddle, located at the back of the soft dorsal, is quite similar, likewise giving off blotches below the lateral line. The fourth saddle, well back on the caudal peduncle, is not forked, but becomes markedly widened below the lateral line. There is a poorly defined dark spot on the peduncle near the base of the caudal fin.

The blotches below the lateral line, usually numbering 8, occasionally 9, in 1 fish 10, are all decidedly more triangular than in specimens of *euzonus* of similar size, never forming
squarish blocks or bars. With age this triangular pattern breaks down to produce a more irregular pattern, vaguely suggesting right triangles joined by their apices. The lateral markings are definitely more separated from the dorsal saddles than in *euzonous*, usually showing at most a slight connection.

The cheeks are lightly speckled with melanophores. The suborbital region ordinarily remains clear, except for a narrow rim below the eye and a narrow blackish bar extending downward from the middle of the eye. Otherwise the under side of the head and breast is usually immaculate at all ages, except for several black specks on the chin. Some adults show a tendency toward speckling on the under side of the head, but the degree of pigmentation characteristic of adult *euzonous* is never approached.

After 3 months in formalin the holotype and other breeding males retained some of the nuptial colors. A longitudinal band of yellow-orange extends along the lower side of the trunk, above and to slightly behind the depressed pelvic fin. Irregular red dots on the sides tend to be more or less centered, one on each pale area below the lateral line. Above the lateral line red dots begin behind the second blackish saddle, are arranged in groups of 3 or 4 before the third saddle, and become larger and more numerous toward the caudal fin. The light interspaces between the dark lateral blotches are tinted with lemon-orange. The spinous dorsal shows a basal stripe containing blocks of brown, then a clear streak followed by a band of black; then an orange-red submarginal stripe within the clear border. The basal half of the soft dorsal is colored like the caudal; the distal half is clear or nearly so. The caudal fin is marked by wavy vertical lines, alternately dusky and red; the red is intensified toward the base of the fin. The anal and pelvic fins are whitish. The pectoral, reddish orange on the base, is elsewhere marked by alternating blocks of red and dusky. The life colors correspond rather closely with those described for *P. variatus* and *P. osburni*, but the breeding males apparently do not become so intensely pigmented as in *variatus*, since a very strong contrast between the saddles and the ground color is retained.
The name *erizonus* is taken from the Greek: ἐξ, intensive prefix, and ζώνη, zone.

4b. *Poecilichthys euzonus euzonus*, new subspecies

(*Pl. I, Fig. 3*)

*Kiheautoma euzonida* (presumed identification).—Meek, 1894a: 268 (record for White River at Oxford Bend, which is 9 miles northeast of Fayetteville, Washington County, Arkansas).

The holotype, University of Michigan Museum of Zoology No. 123548, is an adult male, 60.5 mm. in standard length. It was collected July 8, 1938, in Buffalo River, 4 miles southeast of St. Joe, Searcy County, Arkansas, by John D. and Ruby Y. Black. The 8 paratypes, all taken by the same collectors in the White River system of Arkansas, comprise 5 specimens collected with the holotype; 2 from King’s River, 3 miles east of Alabam, at Denney Cave, Madison County, June 30, 1938; 1 from White River near Busch, Carroll County, July 8, 1938. The 9 types range in standard length from 28 to 60.5 mm.

The distinctive features of this form are mostly given in the key and in Table I.

The dorsal fins are separated in 7 specimens, united in 2.

The ground color of preserved specimens is a clear tan, apparently lacking the olivaceous tinge of *erizonus*. The side and back are finely and evenly speckled with fine black dots, except at the clear center of each scale. Since very few, usually none, of the scales on the back between the saddles are conspicuously darkened, the tessellated effect of *erizonus* is lacking. The saddles are all fuscous, possibly a little more brownish than in the other members of the group. The first saddle, crossing the nape just before the dorsal fin, is usually sharp-edged behind, extending just to the first dorsal spine, but in some specimens is extended backward as in *erizonus*, so that the saddle surrounds the first 2 spines. This saddle shows considerable variation, but its margins are sharper and straighter than in *erizonus*. The first saddle is continued down to the insertion of the pectoral fin where it divides into 2 rather narrow lines, one running down the side behind the
pectoral, the other extending along the fin base just under the edge of the gill-cover. The second dorsal saddle, extending downward and somewhat forward from the posterior part of the first dorsal base, splits at the lateral line to form an inverted Y. The resulting blotches on the sides below the lateral line are definitely block-shaped in the holotype and other adults, and are connected by at least a corner with a dorsal saddle. The similar third saddle, located at the back of the soft dorsal, shows no offset in the front margin, as the anterior of the 2 associated lateral blotches is continuous with the front half of this saddle. The fourth saddle, well back on the caudal peduncle, is undivided but expanded below the lateral line. There is also a poorly defined caudal spot. As in erizonus, the black speckling fades out rapidly below the lateral line. The sides below the blackish blotches are virtually immaculate.

The blotches along the sides are fewer than in any other species of the group, numbering 5 to 8, usually 7 or 8. In the adults they are clean-cut blocks, losing the more triangular shape which seems characteristic of the younger fish.

The sides and lower surfaces of the head, as well as the anterior half of the breast, are closely and finely speckled with black, particularly in the adults. In this respect the adults of erizonus and euzonus are surprisingly unlike, though immature individuals are not so distinct. The young of euzonus lack most of the speckling, but at comparable sizes are more pigmented than those of erizonus.

Almost nothing is known of the breeding colors of the male. However, the checkered pattern on the pectorals, caudal, and soft dorsal, and some color remaining on the spinous dorsal, indicate that the colors of the fins as a whole are similar to those of erizonus. As in that form, the pelvic and anal are apparently devoid of color.

The name euzonus is from 'ei, well or beautifully, and 'zon, zone.

5. Poecilichthys blennius (Gilbert and Swain)

(pl. II, fig. 2)
This very distinct species was well described by Gilbert and Swain. It is contrasted in our key with the other and more typical species referred to the *Poeciliopsis variatus* group. Its pertinence to the genus *Poeciliopsis* is discussed on p. 3.

Apparently the types are the only previously recorded specimens. Additional material has lately been collected by L. F. Miller, working under A. R. Cahn of the Tennessee Valley Authority: 1 adult 47 mm. long from Greene River, Duck River system, Wayne County, Tennessee, May 16, 1937; 1 small adult, 43.5 mm. long, from Brush Creek, Duck River system, Perry County, Tennessee, May 17, 1937; 1 adult male, 49 mm. long, from Bumpass Creek, Tennessee River system, Lauderdale County, Alabama, February 16, 1938; 13 half-grown, 25 to 27 mm. long, from Second Creek, Tennessee River system, Lauderdale County, Alabama, November 4, 1937.

The scales are relatively large. In the 3 adults and 6 young specimens the counts are: 4 or 5, usually 5—42 to 45—6 or 7. The head and breast are completely naked.

Dorsal rays XI to XIII—11 to 13. Anal rays II, 8 or 9. Pectoral rays 16 or 17, usually 16. The dorsals are well separated in all the specimens.

The lateral-line canals and pores of the head agree with the description for the group (p. 5), except that there is considerable variation in the posteriormost of the anterior set of 4 pores of the infraorbital series. In the Greene River specimens, the pore of one side opens by a short upward-projecting tube; on the other side, by a short downward tube. In all other examples examined, this pore opens into the canal, or just below it.

This is one of the most heavily set of all the darters. It is almost cylindrical, though relatively deep through the shoulders. The contours taper rapidly behind the spinous dorsal.
The abruptly declivous snout accentuates the appearance of robustness.

Considerable differences in proportionate measurements appear when the 2 adult specimens from the Duck River system are compared with the half-grown fish from nearer the type locality, in Alabama. Since the differences may reflect some local variation, as well as age changes, the measurements of the 2 lots are presented separately: those for the Duck River specimens first; those for the Alabama material in parentheses, and separately for the 1 adult and for 6 half-grown. Depth 4.4 to 4.7 (5.0; 4.7 to 5.0). Greatest width 1.3 (1.3; 1.4 to 1.5) in projection of greatest depth. Head length 3.9 to 4.0 (4.1; 3.6 to 3.8). Least suborbital width 5.3 to 5.5 (4.8; 6.0 to 6.7) in head. Least interorbital width 1.9 to 2.0 (1.9; 1.7 to 2.0) in eye. Eye 4.9 (4.6; 4.0 to 4.3) in head; 1.8 (1.6; 1.2 to 1.5) in snout. Snout 2.7 to 2.8 (2.9; 3.1 to 3.6) in head. Upper jaw 4.0 to 4.2 (3.7; 3.8 to 4.1). Angle of muzzle 72° to 73° (70°; 68° to 75°); of gill-membranes 97° to 98° (110°; 89° to 95°). Eye 2.7 (2.4; 2.3 to 2.6) in distance from tip of mandible to union of gill-membranes; latter distance 1.6 to 1.7 (1.9; 1.6 to 1.9) in head; and 1.3 to 1.4 (1.2; 1.4 to 1.6) times interspace between union of membranes and insertion of pelvic fin. Highest dorsal spine 1.9 to 2.0 (1.95; 2.0 to 2.2) in head, 2.2 to 2.3 (2.6; 2.0 to 2.1) in first dorsal base, and 1.2 to 1.3 (1.2; 1.2 to 1.3) in highest dorsal soft ray, which enters the head 1.6 to 1.8 (1.6; 1.7 to 1.8) times, and the second dorsal base 1.2 to 1.4 (1.3; 1.1 to 1.2) times. Length of caudal fin 1.3 (1.2; 1.3 to 1.4) in head. Highest anal ray 1.6 to 1.7 (1.7; 1.7 to 1.8) in head, and 0.8 (1.0; 0.7 to 0.8) in the anal base, which enters the head 1.8 to 2.2 (1.7; 2.1 to 2.4) times, and the second dorsal base 1.4 to 1.6 (1.3; 1.3 to 1.4) times. Longest pectoral ray 0.7 (0.8; 0.7) and length of pelvic fin 0.9 (1.0; 0.9) in head. Interspace between pelvic fins 1.1 to 1.2 (1.3; 1.4 to 1.5) in pelvic base.

The following color notes were made after the specimens had been in formalin about two weeks. In the adult from Greene River, the whole color tone was pinkish, owing to the light
brownish red spot on the center of each scale from the dorsal fins to the side of the belly. These spots became weak and tan colored on the lower sides of the caudal peduncle, but deeper and brighter under the pectorals. The lower sides, especially between and near the lateral blotches, were bright golden. The belly was white. The breast was bright silvery with strong mottlings of ivory before and behind the pectoral fins. The dark bars of the body were blackish green. The head was mottled with light and dark olive. The margin of the first dorsal fin was narrow and blood-red forward, still narrower and yellower posteriorly, but broad and red-brown near the end of the fin. There was a dusky reddish brown stripe on each interspinal membrane from the base well toward the tip, and a somewhat similar, but less reddish mark on each membrane of the second dorsal. The greenish caudal rays were very indefinitely banded with dusky. The anal and pelvic rays were mostly yellow, becoming a little orange forward and outward. The pectoral fin was mostly yellowish on the rays, but the median part of the fin was banded with pink and green. The specimen from Brush Creek was brighter, although the red spots on the scales were fainter (hardly evident on the white underparts). The blackish green oblique saddles were abruptly set off on the posterior edge by bright cream, as in the other specimen, and there was a tannish semicircle on the nape in front of the first saddle. The red border on the spiny dorsal was developed only anteriorly. The dorsal spines and soft rays were individually barred with deep green and amber, and the membranes were only slightly blotched. The greenish caudal was barred with darker and lighter. The pectoral showed 2 pink crescents near the base, and bars of yellowish and greenish outward. The pelvic fin was definitely dappled with pink.

The adult male from Bumpass Creek was described as richly though not brilliantly colored. The light areas covering most of the sides and back were enriched by a strong rosy wash, mostly concentrated toward the centers of the scales. The dorsal spines were set off in translucent streaks, between which
the membranes were deep red-brown. The first dorsal became pinkish brown just within a fine, pale edge. The second dorsal was mostly red-brown on the membranes, becoming sooty outward and pale brown along the rays. The caudal and pectoral fins were dusky green and yellowish; the pelvic, dusky with a cream edge; the anal, pale.

In the small specimens from Alabama the light areas were a rich tan. The base of the pectoral was marked with a conspicuous watery orange crescent.

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FIG. 1. Holotype of \textit{Poccilichthys tetraodon}, a half-grown specimen 33 mm. in standard length, from Big Niangua River, Missouri.

FIG. 2. Holotype of \textit{Poccilichthys cuzonii cuzonii}, an adult male 66 mm. in standard length, from Current River, Missouri.

FIG. 3. Holotype of \textit{Poccilichthys cuzonii cuzonii}, an adult male 60.5 mm. in standard length, from Buffalo River, Arkansas.
PLATE II

Fig. 1. Breeding male of Poeciliichthys variatus, 72 mm. in standard length, from Columbiana County, Ohio.

Fig. 2. Adult of Poeciliichthys boulanius, 42.5 mm. in standard length, from Brush Creek, Duck River system, Tennessee.
Percid Fishes

Plate II

Fig. 1

Fig. 2 Photographs by F. W. Gurnadiik.
The subspecies of the American perchid fish, *Poecilichthys whipplei*

By Carl L. Hubbs and John D. Black

In the course of an ichthyological survey of Arkansas, the junior author has disclosed the existence of two unnamed forms of the redfin darter, *Poecilichthys whipplei*. Although they are only weakly characterized by average differences, these forms are here described as new subspecies. One of them, a very fine-scaled, small-eyed mountain form, is named *P. w. montanus*. It abounds in an Arkansas River tributary variously known and mapped as Clear Creek, Frog Bayou, and Jones Creek, and situated in Washington and Crawford counties, Arkansas. Here it replaces the typical subspecies, which inhabits other Arkansas River tributaries in Arkansas, northeastern Oklahoma, southeastern Kansas, and southwestern Missouri, and the White River system of Arkansas. The Red River drainage basin of Arkansas, Oklahoma, and Texas, and the coastal streams of eastern Texas, are occupied by the new subspecies, *P. w. radiogrus*. The coarser scales of *radiogrus* were indicated by the data given by Meek (1891: 139) and by the count of an especially large-scaled specimen that has been cited as a troublesome variant (Gilbert, 1887: 62; Jordan and Evermann, 1896: 1095). In the size of the scales *P. w. radiogrus* bridges over the distinction between typical *whipplei* and its eastern representative *Poecilichthys artesiae*, which is there-
fore also regarded as a subspecies of *P. whipplii*. Were it not for the higher average number of dorsal soft-rays in the Red River form, it would not be practicable to distinguish *radiosus* from *artesiae*. We find no reason to maintain the nominal form *alabamae* as distinct from *P. w. artesiae*. With the exception of two new records (the Pascagoula River system near Enterprise, and a tributary of the Mississippi River near Hazelhurst, both in Mississippi) *artesiae* is known only from the drainage basin of the Alabama River.

The interesting distribution of the subspecies of *Poeiichthys whipplii* is shown on Map 1. All available record stations are indicated, since almost all of the literature records have been confirmed by a re-examination of the original material. We have studied all specimens of the species in the United States National Museum (U.S.N.M.), the University of Michigan Museum of Zoology (U.M.M.Z.), the Museum of Comparative Zoology (M.C.Z.), and the Iowa State College (I.S.C.). For the privilege of so doing we are very grateful to the authorities of these institutions. We are also indebted to Professor Frank E. Guyton and Dr. Reeve M. Bailey, for making available most of the specimens of *P. w. artesiae* which we have examined. In addition, Professor Guyton took particular pains in preserving and promptly sending a high nuptial male, for a description of the life colors, and Dr. Bailey furnished one of two specimens of *P. w. radiosus* from Texas.

**The Generic Reference**

The vagueness and impracticability of the separation of *Poeiichthys* into small genera is exemplified by the recent reference of the synonyms, *artesiae* and *alabamae*, to different genera (Jordan, Evermann, and Clark, 1930: 292). The status of *Poeiichthys* is treated in another paper (Hubbs and Black, 1940).

The four forms here regarded as subspecies of *Poeiichthys whipplii* agree with one another in essential respects and almost certainly comprise a single *Formenkreis*. The group as a whole differs from every other species of darter in some items of the following description.
No. 429 The Subspecies of Poeciliichthys Whipplii

Map 1. Distribution of the subspecies of Poeciliichthys whipplii, as indicated by all published and original record stations.
COMMON CHARACTERS OF THE SUBSPECIES OF

*Poeciliichthys whipplii*

The body is compressed and moderately slender (depth 4.4 to 6.2 in standard length). The parietal region of the cranium is strongly convex; the interorbital region is of moderate width. The rather sharply pointed snout measures 4.1 to 5.7 times in the slender head. Even when shortened the snout never has an abruptly decurved contour. The well-developed frenum shows no tendency toward obliteration when the mouth is tightly closed. The upper lip projects beyond the snout and slightly beyond the tip of the lower jaw (the mandible is more strongly included in *P. w. montanus* than in the other forms). The mouth is rather large (for a darter); the upper jaw extends to below the pupil. The gape is rather narrow and V-shaped as seen from below. The curved-conic teeth, forming rather broad villiform bands on the jaws, vomer, and palatines, are considerably enlarged only in the outer row of the premaxillary band. The gill-membranes are rather broadly united but retain a V-shaped outline. The distance from the union of the gill-membranes to the tip of the mandible measures 1.6 to 2.0 times in the head.

The genital papilla is typically a squarish flap, rarely subtriangular. It is usually about as broad as long (measured from the anus), but varies considerably in width. The posterior margin is rarely entire, usually with a median incision or emargination, sometimes with one to several flaps between creases on the surface of the papilla. In the adult female the papilla overlaps the front of the first anal ray. In the male it is similar but somewhat smaller. Radiating ridges (rarely papillae) occur about the anus.

The 8 pores of the lateral canal of the head are at the end of short branches extending downward and backward. The supratemporal commissure is complete; the median pore and the lateral pore are each at the end of a short tube. The interorbital pores are present. The anterior and posterior nasals lie a short distance anterior and mesial to the corresponding nostril. The coronal pore is at the end of a tube. The com-
The subspecies of Poeciliopsis Whippii

The infrasphenoidal canal opens in 8, occasionally 9 pores (rarely 7 in *P. w. radiatus*), of which the second and third, rarely the second to fourth, lie near the edge of the suborbital; the following pores usually open at the end of short downward projecting tubes, though the fourth pore is often on the canal. There are 10 operculo-mandibular pores. (See Hubbs and Cannon, 1935: 10.)

The submedian and nearly straight lateral line is typically about three-fourths complete, leaving 2 to 21 unpored scales (occasionally none in *P. w. artesiae*). The scales of the mid-ventral line are not modified. Except for a small temporal patch on each side, the top of the head is devoid of scales. The nape is usually but not always well covered with more or less embedded scales. The squamation of the sides of the head is highly variable; the opercles are usually well covered with scales which are commonly embedded (and rarely lacking in *P. w. radiatus*); the cheek scales are often absent, or developed only near the eye, and when present they are usually cycloid and embedded. The breast is scaleless. In size the body scales vary from moderate to small, numbering from 43 to 75 (Table 1).\(^1\)

Typically, the dorsal fins are neither markedly conjoined nor separated, and are neither low nor notably elevated. The dorsal rays number IX to XII, 11 to 16 (Table IV). In the breeding males the dorsal spines do not bear terminal knobs, and the soft rays are not exerted. The 2 (very rarely 3) anal spines are stiff and pungent. The soft portion of the anal, with 7 to 9 (very rarely 5 or 6) rays, is much smaller than the second dorsal. The anal fin is not greatly expanded and is not tuberculate in the breeding males. The caudal fin is truncate. The pelvics are closely approximated and short, usually extending not much more than halfway to the anal origin. The short and rounded pectoral extends only to above the end of the pelvic (with some variation).

The adults as a rule are irregularly spotted with red, and

\(^1\) The scales in *artesiae* vary from 43 to 58 according to the counts by Gilbert and Swain (in Gilbert, 1887: 62).
the high males are largely crimson. The color pattern of the body is rather vague and extremely variable, but neither bars nor stripes are ever very conspicuous. The black humeral mark is rather well developed. The sides of the head are typically puncticulate and often mottled and are marked with a long, narrow subocular bar, a streak across the snout, a short dash behind the eye, and usually a similar short opercular dash on the same horizontal line. The entire length of the spinous dorsal is normally marked in both sexes by a submarginal red band with clear borders and by a dark margin. The second dorsal and caudal fins are similarly colored in the adult males, but in the females these fins are barred. On the second dorsal the bars are almost wholly confined to the membranes, but on the caudal the markings extend across the rays as well. Of the 3 dark spots in a vertical line on the caudal base, the uppermost is the least developed.

The forms of Poecilichthys whipplii are large (for darters). The maximum standard lengths of the specimens at hand are: P. w. artesiae, 70 mm.; P. w. radiatus, 60 mm. (but commonly mature at a much smaller size); P. w. whipplii, 66 mm.; P. w. montanus, 75 mm.

**Comparison of Subspecies**

The main character by which artesiae has been distinguished from whipplii is the size of the scales. The distinction does not hold as sharply as generally indicated, but is still of value. Each of the four subspecies has a distinctive average number of scales, and the difference between the extreme forms, artesiae and montanus, is well marked (Table I). The two other subspecies bridge over the gap, though radiatus is close to artesiae and typical whipplii is almost as extreme in the other direction as montanus. The differences, however, appear on statistical grounds to be reasonably reliable (Table VI). The counts for montanus are consistently high (Table I), and those for whipplii average less than 65 for all 16 localities for which there are more than 2 counts, with 1 exception: 5 counts for Lees Creek, Van Buren County, Arkansas, average 65.6 (it
is possible that this series should be referred to montanus). The difference between radiosus of the Red River drainage and whipplii of the Arkansas and White River drainages is rather sharp; on the sole basis of the scale counts as represented in Table I, 86 per cent of the specimens of the two forms, when examined in equal numbers, are identifiable if the break in the count is assumed to lie between 59 and 60. In the scale counts of radiosus there is some local variation, without any definite geographic trend.

The Red River form, radiosus, has only a slightly higher average number of scales than the Alabama River subspecies, artesiae. Were it not for a higher average number of unpored scales in the lateral line series (Table III) and of dorsal soft rays (Table IV), it would not be feasible to separate radiosus from artesiae, despite the fact that no representatives of the species are known from a rather wide band of intervening waters. On the bases of the available counts for these respective characters, 71 and 82 per cent of the specimens may be regarded as identifiable (in these computations the specimens of artesiae from the Mississippi River system have been disregarded, though they are essentially typical). In the number of unpored scales and of soft dorsal rays radiosus agrees rather closely with the two other western subspecies. P. w. radiosus seems to be the smallest form.

The two subspecies of the Arkansas River basin, P. w. whipplii and P. w. montanus, would probably not have been separated on the sole basis of the average difference in number of scale rows. There are, however, a number of other average discrepancies. The difference in the scale counts appears much more definite when the numbers of pored scales are compared (Table II); on that basis 84 per cent of all specimens of the two forms when represented by equal numbers may be identified, if we assume that the pored scale count of whipplii should be 36 to 54, and that of montanus, 55 to 68. As a rule the eye is smaller and the snout longer in montanus, at comparable sizes (Table V). P. w. montanus seems to average somewhat larger and usually to have a slightly different
physiognomy: the snout is not only longer but is also somewhat more hooked downward, so that the mouth is more nearly horizontal, and the lower jaw is more definitely included.

1. *Poecilichthys whipplii artemiae* Hay


*Catanotus artemiae*—Schrenkensein, 1938: 232 (characters; Georgia to Texas).


*Claricola alabamae*—Jordan, Evermann, and Clark, 1930: 292 (range and synonymy, after Jordan and Evermann).

*Catanotus alabamae*—Schrenkeisen, 1938: 232 (characters).

*Ethecostoma whipplii* (identification to species only).—Boulenger, 1895: 84–85 (description, synonymy, and range, in part).

In 20 specimens from 19 to 65 mm. in standard length the head enters the standard length 2.9 to 3.4 times; the depth, 4.4 to 5.5 times; the eye enters the head 3.8 to 5.8 times; the snout, 4.3 to 5.7 times. The distance from the union of the gill-membranes to the tip of the mandible measures 1.6 to 2.0 times in the head. The nape is usually completely covered with more or less embedded scales. The opercles are well scaled in nearly all specimens, and generally are not embedded. The cheeks vary from scaleless to about one-fourth covered with embedded scales.

When fresh in formaldehyde, a high male collected by F. E. Guyton at Auburn, Alabama, on April 18, showed the following colors: The background is pale yellowish above, whitish below, becoming blue-gray on the breast. The lower side of
the head is pale. The mid-sides are irregularly splashed with deep, brilliant red. The red spots composing the splashes decrease in size toward the back, becoming faint near the dorsal fin; on the lower side they become larger and are more joined in groups. Almost to the mid-line the sides of the abdomen are red; this color is strongest on the scale borders.

There is a ring of gold around the pupil. Throughout its length the spinous dorsal bears an even, brilliant, deep red band, bounded with pale, and the fin is edged with dusky green (no doubt blue in life). There is a deep red spot near the base of each interspinous membrane. The soft dorsal has a submarginal, deep red band, with tongues extending basally on the membranes, just in advance of each ray, and breaking up ventrally into spots; there is a yellowish streak just beyond the red band and within the dark margin (blue in life). The caudal fin has a broad, submarginal band of deep red, separated from the dark margin by a yellowish streak; the red band sends streamers about one-third the distance to the base of the membranes. On the caudal base there is a band of orange blotches. Except for a wide margin of bright green (blue in life), the anal fin is a bright, deep red, becoming yellow only at the extreme base. The pectoral fin is pale lemon with some red on the rays. The pelvics are deep green (blue in life).

The range of *P. w. artesiae* is commonly given as "Georgia to Central Texas (Palestine)," following Jordan and Evermann (1896: 1094). The only Georgia record, however, is that of a specimen (M.C.Z. No. 24524) in the Museum of Comparative Zoology with no further data; it probably came from the Alabama River system in Georgia. The record from Palestine, Texas, is here referred to *P. w. radiosus*. The specimen (M.C.Z. No. 24563) from "an artesian well in Alabama," mentioned by Jordan and Evermann (1896: 1094), proves on re-examination to be referable to *P. pareipinnis* Gilbert and Swain (in Gilbert, 1887: 59–60), a valid species which was wrongly synonymized with *Etheostoma squamiceps* by Jordan and Evermann (1896: 1096).
2. Poeciliichthys whippii radiosus, new subspecies

Southern Redfin Darter

(Pt. I, Fig. 1)


The holotype, an adult male 50 mm. in standard length, was collected by John D. and Ruby Y. Black on June 19, 1938, in Sugar Loaf Creek, tributary of Caddo River, Ouachita River system, on U. S. highway 70, in Township 4 S., Range 22 W., Hot Spring County, Arkansas; U.M.M.Z. No. 123080. Numerous other specimens from the Red River drainage are designated as paratypes. The localities are indicated on Map 1.

The distinctive characters of this form, as contrasted with its near relatives P. w. artesiae and P. w. whippii are given on pp. 6-7 and in Tables I to V. In most respects radiosus agrees with the other subspecies of P. whippii; the common characters of the species, as given on pp. 4-6, apply completely to this subspecies.

In 13 specimens from 22 to 60 mm. in standard length the head enters the standard length 2.9 to 3.5 times; the depth, 4.5 to 5.5 times; the eye enters the head 4.1 to 5.5 times; the
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snout, 4.6 to 5.3 times. The distance from the union of the gill-membranes to the tip of the mandible measures 1.6 to 1.9, usually about 1.7 times in the head.

The nape is well covered with embedded scales, of which some are exposed in a few specimens. The cheeks and opercles vary from scaleless to well scaled. When the cheeks are well covered, the scales are embedded.

The color pattern of the body is extremely variable. In many specimens the bars are completely disrupted into mottlings. In others they are moderately sharp and either narrow and solid or broader and hollow-centered. Some have a row of small dusky or blackish blotches along the mid-line. These blotches are most distinct and most frequently developed in the upper tributaries of the Ouachita River, where the sides of the head are clearer than usual; but even here large series show the whole range of variation. Some examples are marked with narrow, moderately intense lengthwise stripes.

The life colors are probably similar to those of the other subspecies, but may also show local and individual variation (Jordan and Gilbert, 1886: 13). Fowler's description (1904: 248) is in the main correct, though his account of the fin colors is misleading, if not actually incorrect.

Contrary to the indication of Jordan and Gilbert (1886: 13), this form, like the other subspecies, develops red pigment in the adults. Specimens from Gulpha Creek, tributary to the Ouachita River, near Hot Springs, Arkansas, were described as follows from preserved specimens which still retained some of the life colors: The body is marked with small blackish flecks on a background of olive tan. Similar flecks are especially conspicuous on the otherwise immaculate lower side of the head and breast, and on the cheeks and pectoral base. Small red blotches, covering about 1 to 3 scales, occur both above and below the lateral line. Just below the lateral line a row of 10 to 12 black blotches forms an interrupted lateral band. The back is tesselated with similar blotches. On the lower side the blotches are more scattered and smaller, covering 1 to 3 scales. In both sexes the first dorsal is blue.
on the basal two-thirds, then shows a narrow creamy-clear band, a stripe of red, another and stronger clear band, and a border of blue; the red and clear stripes fade out posteriorly in some fish. In males the soft dorsal is dusky (presumably blue in life) on the basal two-thirds, grading into orange, inside a sharp subterminal clear stripe and strong blue border. In females the second dorsal has the same general pattern, but is checkered with light and dusky, obscuring the striped pattern. The caudal in the males is clear, grading backward through pale orange into red, followed by a narrow clear band, a broad subterminal blue bar, and a narrow clear margin. In females the caudal is finely checkered with dark and light, with terminal bands as in the males. The anal is similar to the soft dorsal, but not checkered, and basally paler, and with the orange band much stronger and much wider, covering about one-half of the fin. The pectoral is faintly checkered with orange and has minute dusky flecks along the edges of the rays. The pelvic shows no orange, but is dusky on the membranes.

In life a highly colored female from Wolf Creek at Delight, Arkansas, showed the following colors: Numerous light spots on the sides vary from lemon to red. There is a prominent wash of chestnut on each side of the belly. The orange bars between the dark blotches on the posterior part of the body do not encircle the caudal peduncle below. Longitudinal striping is rather conspicuous. In the spinous dorsal the spines are clear and the membranes bluish basally, then clear, then blue, then orange red in a prominent stripe widest posteriorly, then clear, and finally bordered with a band of slaty blue. The soft dorsal and caudal fins are checkered with black and reddish orange, with a bluish black terminal band. The anal is similar, but has the orange area more extensive and brighter, with a narrow bluish subterminal band within a clear margin. The pectoral, which is tinged with lemon, and the pelvic are flecked with black along the rays.

The holotype agrees in all respects with the description of the species. Its special features are as follows: Scales,
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8—(40 + 15 = 55)—10. Opercles with a few scales; breast and cheeks scaleless; nape covered with embedded scales. Dorsal rays, XI, 14; anal rays, II, 8; branched caudal rays, 15; pectoral rays, 12–12.

Depth, 5.2. Greatest width, 1.5 into projection of greatest depth. Head length, 3.2. Least suborbital width, 1.40 in head. Least interorbital width, 2.7 in eye. Eye, 4.6 in head, 1.1 in snout. Snout, 4.6 in head. Upper jaw, 3.4 in head. Angle of muzzle (not including the truncated lips), 57°; of mouth, 37° with the horizontal; of gill-membranes, 52°. Eye, 2.9 in distance from tip of mandible to union of gill-membranes; latter distance, 1.8 in head and 0.8 times interspace between union of membranes and insertion of pelvic fin. Highest dorsal spine, 2.7 in head, 2.6 in first dorsal base, and 1.4 in the highest dorsal soft ray, which enters the head 2.1 times and the second dorsal base 1.6 times. Length of caudal fin, 1.5 in head. Highest anal ray, 2.0 in head and 0.8 in the anal base, which enters the head 2.4 times, and the second dorsal base 1.8 times. Longest pectoral ray 1.3 in head; length of pelvic fin, 1.3. Interspace between pelvic fins, 2.0 in pelvic base.

The record of Palestine, Texas, first given by Jordan and Evermann (1896: 1094), was based on a specimen (U.S.N.M. No. 34712) of P. whipplii madl:osus sent to the National Museum by E. L. Yoakum of that city, without a definite statement that it was caught in the vicinity of Palestine, Texas. It was probably obtained locally, and the record has recently been verified by the collection of another specimen in the Neches River system, 6.3 miles southeast of Nacogdoches, Texas. The Palestine specimen has the following characters: standard length, 54 mm.; eye in snout, 1.1; dorsal, XI, 13; anal, II, 8; scales, 52 + 7 = 59. The one from near Nacogdoches has: standard length, 28 mm.; eye in snout, 1.0; dorsal, XI, 14; anal, II, 8; scales, 45 + 12 = 57 (the counts for this specimen are not included in Tables I–VI). The species whipplii is not listed by Evermann and Kendall (1894) in their review of the fishes of Texas, although Jordan and Gilbert gave the range of Pocci-
ichthys punctulatus (which name they wrongly used for P. whipplii) as "Missouri to Texas." Without doubt the Missouri record referred to true punctulatus. The reason for including Texas in the range was obviously the unpublished identification, as "Etheostoma whipplei (Texas variety)," of a specimen of Pecosichthys jessiae collected by Jordan and Gilbert in Sabine River at Longview, Texas (examined in the National Museum).

A highly successful darter with a wide range of habitat tolerance, this subspecies ascends headwaters even above the limit of Sernotilus and Campostoma in the colder, more torrential streams of the Ouachita region, and at the same time is a common form in the muddy lowland bayous along with Hololepis and Gambusia.

The name radiosus refers to the large number of soft dorsal rays.

3. Pecosichthys whipplii whipplii (Girard)

Western Redfin Darter

Bolechthys whipplii.—Girard, 1859: 103 (original description; "Coal creek, Arkansas" [= Coal Creek, a southern tributary of the Arkansas River in eastern Oklahoma]).

Bolechthys whipplii.—Vaillant, 1873: 96-97 (after Girard).


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Clariola whipplii.—Jordan, 1929: 168 (range, in part; description).


Pratt, 1935: 127 (description; lower Arkansas basin).

Catonotus whipplii.—Schrencksen, 1938: 232 (description; lower Arkansas basin).

Poecilichthys punctulatus (erroneous synonymizing).—Jordan and Gilbert, 1883: 516 (range, in part; description).

In 17 specimens from 20 to 61 mm. in standard length the head enters the standard length 2.8 to 3.5 times; the depth, 4.7 to 6.2 times; the eye enters the head 4.4 to 6.0 times; the snout, 4.2 to 5.2 times. The distance from the union of the gill-membranes measures 1.6 to 1.9, usually about 1.8 times in the head. The nape consistently is completely scaled, but about half the scales are embedded. The scales on the cheeks and on the opercles vary from a few embedded ones to a complete set of exposed ones.

Observations on live and freshly preserved material show that the life colors of this subspecies are essentially like those described for radiosus and montanus. Pilsbry's notes on the life colors of this subspecies (Fowler, 1904: 249) are incorrect, since the fins of no form of P. whipplii are ever bordered with red, and since no specimen that we have examined shows "green spines and rays." The anal border is blue, not green.

Apparently this form is not so well adapted to the lowland habitat as is P. w. radiosus, but it is common in most small tributary creeks of the Arkansas River within its range and likewise ascends the headwaters into the smallest of mountain brooks.

4. Poecilichthys whipplii montanus, new subspecies

Mountain Redfin Darter

(Pl. I, Fig. 2)

The holotype is an adult male 75 mm. in standard length, collected by John D. Black and Jack Yerton on June 17, 1939, near the head of Blue Hole Creek, a tributary of Clear Creek, one mile south of Winslow, Washington County, Arkansas; U.M.M.Z. No. 127777.
There are 499 paratypes, as follows: 7 with the holotype; 227 from East Branch of Blue Hole Creek; 100 from the lower part of Blue Hole Creek; 107 from Railroad Creek just below the mouth of Blue Hole Creek; 53 from 1 mile below the junction of these streams; 4 from Schaberg Creek (of which Railroad Creek is the main tributary) at Schaberg, Crawford County; and 1 from Jones Fork of Clear Creek, near Winfrey, Crawford County. The other headwaters of Clear Creek have not been explored, nor have those of adjacent tributaries of the Arkansas River. Map 1 shows the location of these collections.

The principal characteristics by which \( P. w. montanus \) is separated from \( P. w. whipplii \), its nearest relative, have been given on pp. 6–8, in Tables I–V, and on Plate I. The characters common to this and the other subspecies of \( P. whipplii \) are given on pp. 4–6. In 50 specimens from 22 to 75 mm. in standard length the head enters the standard length 3.2 to 3.6 times; the depth, 4.9 to 5.5 times; the eye enters the head 4.3 to 6.8 times; the snout, 4.1 to 5.1 times. The distance from the union of the gill-membranes to the tip of the mandible measures 1.7 to 2.0, usually 1.8 to 1.9 times in the head.

The nape is always well covered with small, embedded scales. The opercles vary from one-half to well scaled, and most of the scales are embedded. The invariably embedded cheek scales vary from a few to a complete investment and are often limited to two or three rows just back of the eye.

The color pattern of the body, as in the other subspecies of \( P. whipplii \), is extremely variable. The remarks on this subject given above in the account of \( P. w. radiosus \) apply almost as well to \( P. w. montanus \), except that the tendency toward the transformation of the main row of blotches into an interrupted lateral band, often evident in \( radiosus \), is not seen in \( montanus \).

The principal patterns are (1) a rather uniform mottling, most characteristic of the larger individuals, and (2) a series of about 12 dark but hollow-centered crossbars, typical of the young. These bars tend to disappear in larger specimens, the transition from the barred to the mottled pattern progressing
from the head backward, with much variation in the rate and completeness of the change. The general ground color appears lighter than in any of the other subspecies; the dark mottlings tend to be brown rather than blackish, and the body is less intensely dusted with melanophores than in the other subspecies.

On the basis of a color photograph of the holotype, taken when captured, and of other color notes made on live and freshly preserved material, the life colors of the adult males of this form are described as follows: The general body color is mottled, as described above for adults. The brilliant crimson spots become more numerous posteriorly, to form irregular vertical bands, 2 to 4 scales wide, behind the origin of the soft dorsal fin. There are more red spots below than above the lateral line. A very high male is almost solid red along the sides. The abdomen and the lower side of the caudal peduncle appear to be suffused with orange-red, but this color is largely confined to the scale margins. The middle of the opercle, the top of the head, and the sides of the snout are bluish. The branchiostegals are margined with dusky blue, and there are blue specks on the breast. The spinous dorsal is marked with a row of irregular blocks of crimson, one at the base of each membrane; then a wide clear band; a strong band of crimson; a submarginal clear band; and a dusky blue marginal stripe. The soft dorsal is dusky cream, with 3 to 4 rows of crimson spots on the membranes, running into a band of crimson, bordered distally with a clear band and then margined by a narrow blue band. The caudal has a crimson basal bar, followed successively by a wide band of dusky cream, a wide crimson bar, and a narrow band of bright caerulean to royal blue. The anal is brilliant, opaque crimson on the basal three-fourths, and is bordered by blue (rarely by cream). The pectoral and pelvic rays are orange-red on their basal three-fourths; otherwise these fins are clear, save for minute dusky flecks along the edges of the rays. There is a faint dusky blue bar at the base of each pectoral and pelvic fin, visible only when the fish is dry.
The females have the soft dorsal and caudal checkered with red and dusky, as in the other subspecies. They show less red than the males (often none on the body), and the blue borders on the fins are faint or lacking.

The holotype agrees with the species description already given and has the following special features: Scales 11—(60 + 10 = 70)—13. Opercles with partially embedded scales on posterior half; cheeks with embedded scales anteriorly; nape well covered with embedded scales. Dorsal rays, XII, 14; anal rays, II, 9; branched caudal rays, 15; pectoral rays, 13-15.

Depth, 4.9. Greatest width, 1.6 into projection of greatest depth. Head length, 3.6. Least suborbital width, 14.0 in head. Least interorbital width, 1.9 in eye. Eye, 6.6 in head; 1.5 in snout. Snout, 4.6 in head. Upper jaw, 3.4 in head. Angle of muzzle, 68°; of mouth, 25° with the horizontal; of gill-membranes, 68°. Eye, 3.7 in distance from tip of mandible to union of gill-membranes; latter distance, 1.9 in head and 0.9 times interspace between union of membranes and insertion of pelvic fin. Highest dorsal spine, 2.5 in head, 3.2 in first dorsal base, and 1.4 in the highest dorsal soft ray, which enters the head 2.3 times and the second dorsal base 1.7 times. Length of caudal fin, 1.7 in head. Highest anal ray, 2.2 in head and 1.5 in the anal base, which enters the head 1.7 times, and the second dorsal base 1.5 times. Longest pectoral ray, 1.4 in head; length of pelvic fin, 1.6. Interspace between pelvic fins, 1.6 in pelvic base.

This subspecies is not unlike *P. w. whipplii* in its habitat preferences, except that it becomes relatively more abundant in headwater brooks. It is the only species of fish which penetrates to the extreme source of certain tributaries of Clear Creek. It is particularly abundant in small streams. In a single dip with a 3-foot seine, 26 adults were caught in a pool only 3 feet in diameter. The headwater brooks commonly inhabited by this darter dry up completely every few summers, but seem to be repopulated quickly by migrants from farther downstream, where the form is also common.
This subspecies is named montanus as it inhabits mountain streams.

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JORDAN, DAVID S., AND CHARLES H. GILBERT


MEEK, SETH EUGENE

No. 429 The Subspecies of Poecilichthys Whippii 21


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* Including one specimen, from the Penagula River system, with 49 scales.
TABLE II
COUNTS OF PORED SCALES IN LATERAL LINE IN SUBSPECIES OF Poecilichthys whipplii

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Average ..................... 42.16 43.50 41.15 49.38 57.75
Standard error .............. ± 0.45 ± 0.40 ± 0.43 ± 0.53

* Including one specimen, from the Pascagoula River system, with 39 pored scales.
TABLE III
COUNTS OF UNPORED SCALES IN THE LATERAL LINE SERIES IN SUBSPECIES OF POCILIOPTHYS WHIPLII

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Average: 9.65
Standard error: ±0.46

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### TABLE IV

**Pin-ray Counts in Subspecies of *Pecilichthys whippii***

<table>
<thead>
<tr>
<th></th>
<th>artesiae Alabama R. System*</th>
<th>artesiae Miss. R. System</th>
<th>radiatus</th>
<th>whippii</th>
<th>montanus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dorsal spines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td></td>
<td>20</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>27</td>
<td></td>
<td>46</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td></td>
<td>6</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>62</td>
<td></td>
<td>16</td>
<td>61</td>
<td>50</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>10.58</td>
<td></td>
<td>11.00</td>
<td>11.13</td>
<td>11.14</td>
</tr>
<tr>
<td><strong>Standard error</strong></td>
<td>± 0.08</td>
<td></td>
<td>± 0.07</td>
<td>± 0.08</td>
<td>± 0.08</td>
</tr>
<tr>
<td><strong>Dorsal soft rays</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>31</td>
<td></td>
<td>9</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>24</td>
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<td>24</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td></td>
<td>4</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>41</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>59</td>
<td></td>
<td>16</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>12.39</td>
<td></td>
<td>12.44</td>
<td>13.69</td>
<td>13.92</td>
</tr>
<tr>
<td><strong>Standard error</strong></td>
<td>± 0.08</td>
<td></td>
<td>± 0.09</td>
<td>± 0.08</td>
<td>± 0.10</td>
</tr>
<tr>
<td><strong>Anal spines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td></td>
<td>16</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>62</td>
<td></td>
<td>16</td>
<td>68</td>
<td>50</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>7.38</td>
<td></td>
<td>7.31</td>
<td>7.84</td>
<td>7.96</td>
</tr>
<tr>
<td><strong>Standard error</strong></td>
<td>± 0.08</td>
<td></td>
<td>± 0.08</td>
<td>± 0.07</td>
<td>± 0.07</td>
</tr>
</tbody>
</table>

* Including one specimen, from the Pascagoula River system, with XI, 13 dorsal rays and II, 9 anal rays.
TABLE V

<table>
<thead>
<tr>
<th>Size Group</th>
<th>artesiae Alabama R. System*</th>
<th>artesiae Miss. R. System</th>
<th>radiolus</th>
<th>whippeli</th>
<th>montanus</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 to 29 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>30 to 39 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>7</td>
<td>4</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>17</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>40 to 49 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>1.0</td>
<td>12</td>
<td>1</td>
<td>7</td>
<td>10</td>
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</tr>
<tr>
<td>1.1</td>
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<td>1</td>
<td>2</td>
<td>11</td>
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<td>1.2</td>
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<td>9</td>
<td>5</td>
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<tr>
<td>1.3</td>
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<td></td>
<td></td>
<td>2</td>
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<tr>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
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<td></td>
<td>1</td>
</tr>
<tr>
<td>50 to 59 mm.</td>
<td></td>
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</tr>
<tr>
<td>1.0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
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<tr>
<td>1.3</td>
<td>5</td>
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<tr>
<td>1.4</td>
<td></td>
<td></td>
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<td>4</td>
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</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>60 to 74 mm.</td>
<td></td>
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<tr>
<td>1.0</td>
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<td>1.1</td>
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<td>1.2</td>
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<tr>
<td>1.3</td>
<td>1</td>
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<td></td>
<td></td>
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<tr>
<td>1.4</td>
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<td>2</td>
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<tr>
<td>1.5</td>
<td></td>
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<td></td>
<td>4</td>
</tr>
</tbody>
</table>

* Including one specimen, from the Pasagoula River system, 58 mm. long, with eye 1.3 in snout.
TABLE VI
DIFFERENCES BETWEEN MEANS FOR SCALE AND FIN-RAY COUNTS OF THE
FOUR SUBSPECIES OF Pecilichthys Whipplii, COMPARED WITH
THE STANDARD ERROR OF THE DIFFERENCES

In these computations we have used the formulas stated by Hubbs and
Kuhse (1937: 7).

<table>
<thead>
<tr>
<th>Subspecies</th>
<th>Lateral line scales</th>
<th>Pored scales</th>
<th>Unpored scales</th>
<th>Dorsal spines</th>
<th>Dorsal soft rays</th>
<th>Anal soft rays</th>
</tr>
</thead>
<tbody>
<tr>
<td>articulata* and whipplii</td>
<td>articulata* and whipplii</td>
<td>articulata* and mon-tealanus</td>
<td>articulata* and whipplii</td>
<td>articulata* and mon-tealanus</td>
<td>articulata* and whipplii</td>
<td>articulata* and mon-tealanus</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>2.70</td>
<td>10.43</td>
<td>15.85</td>
<td>7.73</td>
<td>13.15</td>
<td>5.42</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>4.7</td>
<td>18.6</td>
<td>26.9</td>
<td>16.4</td>
<td>26.3</td>
<td>11.1</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>1.61</td>
<td>7.22</td>
<td>15.29</td>
<td>8.23</td>
<td>16.60</td>
<td>8.37</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>2.66</td>
<td>11.6</td>
<td>22.3</td>
<td>13.9</td>
<td>25.2</td>
<td>12.3</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>3.64</td>
<td>3.13</td>
<td>0.24</td>
<td>0.51</td>
<td>3.49</td>
<td>2.89</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>6.7</td>
<td>5.5</td>
<td>0.4</td>
<td>1.1</td>
<td>6.9</td>
<td>5.6</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>0.23</td>
<td>0.55</td>
<td>0.56</td>
<td>0.32</td>
<td>0.23</td>
<td>0.61</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>2.1</td>
<td>5.0</td>
<td>5.1</td>
<td>2.9</td>
<td>3.0</td>
<td>0.1</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>1.30</td>
<td>1.30</td>
<td>1.53</td>
<td>0.00</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>10.8</td>
<td>11.8</td>
<td>11.8</td>
<td>0.9</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>0.14</td>
<td>0.26</td>
<td>0.28</td>
<td>0.40</td>
<td>0.52</td>
<td>0.12</td>
</tr>
<tr>
<td>$\Delta + \text{SE}_\Delta$</td>
<td>0.11</td>
<td>0.13</td>
<td>0.11</td>
<td>0.13</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>1.3</td>
<td>2.4</td>
<td>3.5</td>
<td>2.6</td>
<td>4.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

* The data for P. w. articulata apply only to the specimens from the Alabama River system plus one from the Pascagoula River system.
Subspecies of *Poecilia thys whipplii*

**FIG. 1.** *Poecilia thys whipplii radiosa.*
From the holotype, an adult male 50 mm. in standard length, from Sugar Loaf Creek, Hot Spring County, Arkansas.

**FIG. 2.** *Poecilia thys whipplii montanus.*
From the holotype, an adult male 75 mm. in standard length, from Blue Hole Creek, Washington County, Arkansas.
CONTRIBUTION TO THE Ichthyology OF ALASKA, WITH Descriptions OF TWO NEW FISHES

By CARL T. HUBBS AND LEONARD P. SCHULTZ*

In studying fish collections made by and for the senior writer during 1939, and specimens in the United States National Museum, we have identified certain species of marine fishes which do not appear to have been previously recorded from the Territory. One species, *Arctiodus delacyi*, is described as new. The others have been known either from more southerly waters on the North American coast, or from the Commander Islands off the coast of Kamtchatka. The supposedly Asiatic genus *Crossias* is shown to occur in Alaska, and its status is discussed at some length. *Sebastodes swifti* is recorded for the second time and indicated as probably distinct from *Sebastodes aurora*. The range of *Sebastodes walgeri* is extended to Prince William Sound. Correct fin-ray counts are given for the three species of *Bothrocara* which occur in Alaska.

The burbot of interior Alaska and adjacent fresh waters in North America and Siberia is named as a new subspecies, *Lota lota leptura*.

*Sebastodes swifti* Evermann and Goldsborough

*Sebastodes swifti.—Evermann and Goldsborough, 1907: 285-86, Fig. 36 (original description; Yes Bay and Kasaan Bay, Alaska).

* Curator of Fishes, United States National Museum.
One half-grown fish, the third specimen referable to this species, was taken by the senior author by shrimp trawl in Frederick Sound, between Frederick Point and Coney Island, Alaska, on September 1, 1939, at a depth of 45 to 80 fathoms. Since this specimen corresponds rather well with the descriptions of *Sebastodes aurora*, it was compared with the types of *S. aurora* and *S. swifti*, and with data from a large specimen of *S. aurora* examined at Stanford University. The following cranial spines are present on all 5 specimens: nasal, preocular, supraocular, postocular, tympanic, parietal, coronal, and nuchal. The peritoneum is always blackish or dusky, the mandible is scaly, the interorbital space is flattish with concavities between the ridges, and the lower jaw does not enter the profile. Other features are presented in Table I. The data in this table indicate that *Sebastodes swifti* has 18 or 19 pectoral fin rays (8 or 9 of which are unbranched), instead of 17 or 18 (8 or 7 unbranched) as in *S. aurora*. The number of gill-rakers (counting the one at the angle as on the lower limb) are 9 or 10 : 21 in *swifti*, instead of 6 to 8 : 16 to 19 in *aurora*. There are 7 soft anal rays instead of 6. Although the series of specimens is small, the characters seem sufficiently distinctive to warrant the continued recognition of *S. swifti* as a species distinct from *S. aurora*.

In life the specimen from Frederick Sound was a rather clear red over the body and fins. The dark markings were brown on the body and black on the side of the face.

*Sebastodes maliger* (Jordan and Gilbert)

The range of this rockfish (see Hubbs and Schultz, 1933: 29) is extended to the Prince William Sound region, on the basis of a half-grown specimen taken by Walter J. Eyedam in a herring net, during the summer of 1940, in the vicinity of Thumb Bay, Alaska. It deviates from descriptions of the species and of the subgenus *Piceropodus* to which *maliger* is referred, in having embedded scales on the posterior and outer parts of the mandible. Some specimens from Puget Sound, however, are also scaled in this region.
<table>
<thead>
<tr>
<th>Species</th>
<th>S. aurora</th>
<th>S. swifti</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurements</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Standard length in mm.</strong></td>
<td>260</td>
<td>171</td>
</tr>
<tr>
<td><strong>Greatest depth of body</strong></td>
<td>357</td>
<td>368</td>
</tr>
<tr>
<td><strong>Length of head</strong></td>
<td>410</td>
<td>415</td>
</tr>
<tr>
<td><strong>Diameter of eye</strong></td>
<td>117</td>
<td>112</td>
</tr>
<tr>
<td><strong>Width of interorbital space</strong></td>
<td>64</td>
<td>68</td>
</tr>
<tr>
<td><strong>Length of upper jaw</strong></td>
<td>187</td>
<td>191</td>
</tr>
<tr>
<td><strong>Least depth of caudal peduncle</strong></td>
<td>99</td>
<td>102</td>
</tr>
<tr>
<td><strong>Longest gill-raker</strong></td>
<td>47</td>
<td>61</td>
</tr>
<tr>
<td><strong>Longest dorsal spine (3rd)</strong></td>
<td>152 (4th and 5th)</td>
<td>163 (4th and 5th)</td>
</tr>
<tr>
<td><strong>Length of second anal spine</strong></td>
<td>154</td>
<td>197</td>
</tr>
<tr>
<td><strong>Least preorbital distance</strong></td>
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<td>2</td>
</tr>
<tr>
<td><strong>Gill-raker formula</strong></td>
<td>7 +17</td>
<td>8 +20</td>
</tr>
<tr>
<td><strong>Scale formula</strong></td>
<td>7 to 14</td>
<td>7 to 16</td>
</tr>
<tr>
<td><strong>Pores in lateral line</strong></td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td><strong>Pectoral fin rays</strong></td>
<td>17 to 18</td>
<td>17 to 17</td>
</tr>
<tr>
<td><strong>Unbranched pectoral fin rays</strong></td>
<td>7 to 9</td>
<td>7 to 7</td>
</tr>
<tr>
<td><strong>Anal soft rays</strong></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Dorsal rays</strong></td>
<td>XIII, 13</td>
<td>XIII, 13</td>
</tr>
</tbody>
</table>

*The data are as follows:

S.U. (Stanford University), No. 3490: "Albatross," Station 289, 34° 25' 06" N. Lat., 122° 42' 08" W. Long.
U.M.M.Z. (University of Michigan Museum of Zoology) No. 126297: Frederick Sound, between Frederick Point and Coney Island.
Artedius delacyi, new species

This new cottid, from Kodiak Island, Alaska, is very closely related to Artedius lateralis, which has been reported as ranging from Point Conception, California, to southern British Columbia (Hubbs, 1926a: 7; Schultz and DeLacy, 1936: 127). We are able to extend the range of A. lateralis to the northern end of the Queen Charlotte Islands, where 3 large specimens (U.S.N.M. Nos. 163544–45) were collected by Allan C. DeLacy and Wilbert M. Chapman, on December 12, 1934, at Cox Island, which is located in the eastern end of Parry Passage between Langara Island and Graham Island. It hardly seems probable, however, that the two species will be found to overlap in their distribution. Jordan and Gilbert’s (1899: 456) record of Artedius lateralis from Unalaska now proves to have been based on specimens of Astrolytes fenestratis, as shown by a re-examination of their specimen (U.S.N.M. No. 23934) as well as other examples from the same region. The false record of Artedius lateralis from Bering Island has been treated elsewhere (Hubbs, 1926a: 7).

The outstanding apparent distinction of the new species, as compared with Artedius lateralis, lies in the thicker lips and the less depressed and more declivous, more rounded, and blunter muzzle. The width of the upper lip, measured sagittally, and the least width of both lips below the suborbital margin, are each as great or almost as great as the least suborbital width, instead of being 0.6 to 0.8 as wide (as in adults of A. lateralis). The head averages shorter, measuring 2.75 to 2.85 rather than 2.5 to 2.8, usually 2.6 or 2.7 times in the standard length.

Artedius delacyi has none of the distinctive features which led to the generic separation of Parartedius hankinsoni, Allartedius corallinus, and other species (Hubbs, 1926a).

The holotype, a mature male 79 mm. in standard length (99 mm. total length), was collected in a tide pool in Uvak Bay, Kodiak Island, Alaska, by Allan C. DeLacy, on September 26, 1939, with 2 paratypes, a mature male and a mature female, respectively 88 and 90 mm. long (total lengths, 106 and
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The body is rather robust anteriorly, with a dorsal contour which slopes in a weak curve from the origin of the dorsal fin forward to the tip of the muzzle and backward to the slender caudal peduncle. Greatest depth of body, 4.2 (4.7, 4.9); least depth of caudal peduncle, 5.1 (5.0, 5.0) in head to end of opercular membrane and 1.7 (2.0, 1.8) in length of peduncle. Length of head, 2.75 (2.85, 2.8). The depth of the head is about two-thirds the width of the head, which is approximately one-fourth greater than the depth of the body. The angle of the muzzle in side view is 56° to 59°. Length of snout in head, 3.4 (3.5, 3.8); length of orbit, 4.7 (5.0, 4.7); length of upper jaw, 1.85 (2.0, 2.1); distance from orbit to tip of pre-opercular spine, 2.75 (2.8, 2.85); from orbit to upper angle of gill opening, 2.5 (2.3, 2.3). Least suborbital width in orbit, 1.95 (2.0, 1.9); least fleshy interorbital width, 2.0 (2.0, 1.8); least bony interorbital width, 3.0 (2.8, 2.9). The fleshy interorbital is almost flat, with a slight median crease but without definitely elevated rims.

The rather short preopercular spine is bifid and covered with skin, as in *Arctedius lateralis*; below this is a blunt, completely embedded tubercle. The nasal spines are short and covered with skin, and each bears a slender cirrus (either a cirrus or a fringed flap in *Arctedius lateralis*). The teeth are in villiform bands on the jaws, vomer, and palatines, and are of uniform size; none is canine-like. The anterior nostril opens as a short tube with a posterior cirrus; the posterior nostril is in a simple tube half as high as the pupil. There are 2 or 3 cirri near the upper posterior angle of the premaxillary. A small cirrus is present or absent on the orbit. The supraorbital cirrus is simple or fringed. The few cirri on the top of the

1 The measurements of the 3 types are listed in the following order: holotype (male paratype, female paratype).
head are irregularly arranged in 3 transverse rows and in 2 longitudinal series, with a very few cirri near the midline, including one just in front of the first dorsal spine. There are 3 or 4 cirri along the preopercular margin, and 1 near the tip of the bony opercle. On the upper and lateral surfaces of the head there are numerous pores.

The lateral line pores number 34 or 35, plus 2 on the caudal fin. The first 16 or 17 pores bear 1 to 3 cirri, of which those on the light areas before and behind the second main dark crossbar, and sometimes those in the light area behind the first bar, are enlarged and flaplike; an isolated cirrus may occur on one or more of the light areas on the posterior part of the body and a flap is either present or absent on the light spot at the caudal base. The lateral line plates are embedded anteriorly and medially and obsolete posteriorly; a few of the least concealed plates bear 1 or 2 minute spines, but none could be described as denticulate.

The head is wholly scaleless. The dorsal band of serrate scales extends from above the first pore in the lateral line to the base of the last soft dorsal ray, thus not nearly to the end of the last dorsal membrane. The lowermost scales in each row tend to coalesce basally. There are 26 (27, 30) scale rows, and a maximum of 9 or 10 scales in a row.

Fin rays: dorsal, VIII (IX, IX)—16 (16, 15); anal, 12; pectoral, 14—15 (15—14, 15—15); pelvic, 1, 3. The dorsal fins are barely connected at the base. The spinous dorsal is especially high in the holotype, but in all 8 specimens the first 2 spines are noticeably shorter than are the third to the sixth, which are of subequal height. Only the female, however, agrees closely with Arius lateralis (Hubbs, 1926: 6) in having the first 2 spines subequal and about 0.7 as high as those which follow. The height of each spine in percentage of the height of the highest one is as follows: I, 78 (75, 64); II, 86 (82, 69); III, 99 (97, 100); IV, 100 (98, 93); V, 96 (100, 98); VI, 96 (98, 93); VII, 84 (97, 90); VIII, 58 (79, 82); IX — (57, 53). Measurements into the head of the longest ray in each fin: first dorsal, 2.5 (2.8, 3.1); second dorsal, 2.1
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(2.0, 2.0); anal, 2.4 (2.5, 2.3); pectoral, 1.25 (1.3, 1.3); pelvic, 2.5 (2.9, 2.5). The pectoral fin extends to above the base of the fourth (or third) anal ray. The pelvic reaches two-thirds (or little more than half) the distance to the origin of the anal fin.

In coloration this species agrees closely with *Arctedius lateralis* and its closest relatives. In the holotype, however, the pattern is considerably obscured by the general darkening of the whole body (no doubt a feature of the nuptial male). The top of the head is blackish, and the bars and light blotches of the back do not contrast sharply. The darkened color of the lower sides of the urosonic extends nearly to the anal fin, instead of leaving a wide translucent band, and the ventral light spots tend to be small and complete, rather than being markedly enlarged and cut off into semicircles, as in the female type. The belly is dusky instead of clear, and the ground color of the lower side of the head is sooty blackish, instead of purplish gray. The anal is sooty black, with little trace of the dark and light checkering on the rays. The caudal and pectoral fins are also darkened and show only a trace of the light spots on the dusky rays. The pelvic is blackish rather than whitish. Instead of being light with dusky vermiculations, the dorsals are sooty, with light spots arranged in rows which do not reach the upper margin of the fins. Between the first 2 spines is a conspicuous transparent area, separated by a concave edge from the black upper part of this membrane (the female shows these markings very faintly). One paratype, a less highly developed male, somewhat approaches the female in its coloration.

The first dark crossbar extends from the fourth to seventh (or fifth to eighth) dorsal spines downward and forward to the axil of the pectoral fin. The second bar is weaker than is the first or the third. The third bar extends downward and slightly forward from the base of the third to fifth (or second to fifth) dorsal soft rays to the lateral line, so as to partially enclose a prominent light spot on the lateral line. Only mottled traces, best indicated by paired blotches on the lateral
Carl L. Hubbs and Leonard P. Schultz

line, represent 2 dark bars lying between the third bar and the
dark half-ring which encloses ventrally the prominent light
semicircle around the end of the dorsal base. A dark bar at
the caudal base is deflected forward on the axial line to par­
tially surround a bright oval spot. Traces of the dark bars
are evident below the lateral line. The 3 or 4 blotchy dark
bars below the eye are scarcely discernible in the males.

When received fresh in formaldehyde, the types showed life
colors much like those of _Artedius lateralis_. Especially
noticeable in the males was the transparent salmon-ocher color
on the side of the abdomen and the lower part of the tail region.
The head was reddish; the dark bars on the back, bright coral­
line (that is, pinkish lavender, like coralline algae); the light
bars, olive. The first dorsal fin was boldly marked with deep
red spots, and with a brilliant red wedge between the first 2
spines (as in _A. lateralis_). The markings on the second dorsal
and anal were greenish black in one male, reddish brown in the
other.

The adult female, as in _A. lateralis_, was greenish on the lower
part of the head, and the flesh of the belly region and above the
anal fin was tinted with the same color. There was a strong
overwash of ochre on the posterior sides of the abdomen. The
light areas along the lateral line and between the dorsal
blotches were bright coralline.

We take pleasure in naming this species for its collector, our
former student and collaborator, Allan C. DeLacy.

_Radulinus aspellus_ Gilbert

The following specimens, collected in Alaska, appear to pro­
vide the most northerly and westerly records of this species,
which has hitherto been known to occur from "Burrard Inlet,
B. C., to Farallon Islands, California" (Schultz and DeLacy,
1936: 127). In the United States National Museum there are
3 collections made by the "Albatross" in 1887–88 as follows:
No. 53651, from Station 2882, at 46° 09' 00" N. Lat., 124° 22'
30" W. Long.; No. 53652, from Station 2870, at 46° 44' 00" N.
Lat., 124° 32' 00" W. Long.; and No. 53653, from Station 2872,
at 48° 17' 00" N. Lat., 124° 52' 00" W. Long. One specimen, U.S.N.M. No. 60433, is from Kasaan Bay, Prince of Wales Island. The most westerly record for this species is for two specimens, U.S.N.M. No. 103684, trawled by the Zaprora, on June 15, 1932, at 56° 10' N. Lat., 153° 38' W. Long., which is somewhat south of Kodiak Island. Another example, U.M.M.Z. No. 127696, was trawled with shrimp in the general vicinity of Petersburg, in 1939; it was received from Earl N. Ohmer.

*Myoxoccephalus parvulus* Gilbert and Burke

*Myoxoccephalus parvulus*—Gilbert and Burke, 1912: 59-60, Fig. 12 (original description; Medni and Bering Islands). Schmidt, 1929a: 411-14 (as probable synonym of *Poroctonus sellaris*). Soldatov and Lindberg, 1930: 236-38 (comparisons). Hensdil, 1933a: 44 (genus); 1931b: 46-49 (Avatcha and Anchorage bays, eastern Kamchatka; description and critical notes).

Of this species the senior author collected 3 specimens, 54 to 59 mm, in standard length, in rocky tide pools at Sea Lion Neck and at Palevina Reef on St. Paul Island of the Pribilof group. They are the first to be recorded for the North American side of Bering Sea—if *M. parvulus* is distinct from *M. sellaris*. The St. Paul specimens agree with the distinctive features of *M. parvulus* as pointed out in the original description. There are no prickles behind the pectoral (perhaps, as Schmidt thinks, because all examples of *parvulus* are young from tide pools). There are no pores above the anal fin. As Schmidt intimated, however, the value of this character needs checking. The idea that *M. sellaris* has such pores may have been drawn from the small light spots shown on Bean’s plate (1887: Pl. 18) of “*Cottus quadrimaris*.” These spots probably represent the position of prickles which become well developed only in adult males, as stated for the nominal subspecies *Poroctonus sellaris ochotensis* Schmidt (1929a: 411). The coloration agrees in full detail with that of the holotype of *M. parvulus*, as described and figured. The criterion of the more numerous dorsal spines (9 instead of 8) does not hold, as 2 of our fish have 8 and only 1 has 9 spines. The eye varies from
about 0.07 to 0.08 of the standard length. Rendahl (1931b: 47-49) indicated a similar variation in the number of dorsal spines, and gave measurements of the eye in small specimens as 0.085 and 0.088.

The Alaskan specimens of *M. parvulus* certainly belong to a species different from *M. sellaris*, as represented by an example 53 mm. in standard length, collected in Peter the Great Bay, Siberia, and sent to the University of Michigan by the Museum of Zoology of the Academy of Sciences at Leningrad. The specimen has 4 well-developed, sharp preopercular spines; a large eye (0.12 of the standard length); 2 ridges behind the eye instead of only 1; fine cirri in place of broad supraorbital and occipital flaps; 2 cirri instead of none between the 2 just mentioned; and a thin instead of leathery skin. The fin rays number: dorsal, VIII-12; anal, 9; pectoral, 16-17.

The fin rays of our specimens vary as follows: dorsal, VIII or IX-13 or 14; anal, 11 or 12 (last ray of dorsal and anal counted as a double ray); pectoral, 17.

It seems certain that the St. Paul specimens are identical with *M. parvulus*, but the status of the species of "Porocottus" is so confused that we do not here attempt a final decision as to whether *parvulus* is a valid species. In these fish the extra preopercular spine, often held to be diagnostic of *Porocottus* (the third spine from above), is either absent or weakly developed. This evidence confirms the treatment of Gilbert and Burke and of Rendahl (1931a: 43-44; and 1931b: 46), who synonymized *Porocottus* with *Myoxocephalus*. Further confirmation is furnished by an adult of *Myoxocephalus polyacanthocephalus* from near King Cove, Alaska, for this specimen has 4 spines on each side, rather than the usual number, 3.

An examination of pertinent material in the United States National Museum does not negate the conclusion that *M. parvulus* is probably a valid species.

The specimens from St. Paul Island were described in the field as follows: The markings are bold. The main light saddle varies; it may be creamy and olive-brown, bright coralline (pinkish lavender), or variegated with coralline; it may be
followed by a smaller, coralline blotch. The saddle on the caudal peduncle is creamy to olive, or olive-white, or dusky pinkish. The bright speck at the caudal base is bright rosy, silver-rose, or silver-white. The head and nape are variegated with cream, rosy, and green, or are very deep olive. The narrow bar below the middle of the first dorsal may be greenish black, becoming bright red near and on the fin. Most of the rest of the back is deep dusky. The dark saddles become blackish near a light margin. The spinous dorsal is irregularly marked, but is mostly dark medially and paler fore and aft. The dull soft dorsal is barred with deep olive, but the anal is crossed by bright pink or red bars. The caudal fin has a yellow lower margin and in one or two specimens a yellowish posterior edge, and its deep greenish bars lie on a blotched base of bluish gray, becoming pink toward the margin of the fin. The lower part of the body may be boldly spotted with silver, or finely speckled with blue-gray. The main, curved light bar on the pectoral fin is almost white, becoming cream below; or brownish, grading to watery orange on lower part; or largely pink. Posteriorly this fin is blotched with greenish black and pink or orange.

Genus Grossias Jordan and Starks

This genus, now reported for the first time for North America, was based by Jordan and Starks (1904: 296) on a new species, Grossias allisi, from Japan. It was indicated as related to Pseudoblepharus and Bero, though differing in having 3 pelvic soft rays, no palatine teeth, and no penis. The resemblance of Grossias to those genera is probably superficial, and correlated with a rock-reef habitat; the species of Grossias also look very much like the members of the American tide-pool group Oligocottinae (Hubbs, 1926; and Schultz, 1938).

The genetic relationships of Grossias obviously lie with Myoxocephalus and Porocottus, as stated by Schmidt (1929b: 503). In fact, the distinction of Grossias from Myoxocephalus is not trenchant. The supposedly diagnostic features of Grossias, as pointed out by Schmidt, are as follows:
. . . . on the second and third ray in the male 1-2 rows of short spine-
like appendages. On the lower side of the pectoral rays of the male
osses tubercles. Cutaneous flaps over the eyes (supraorbital flaps) and
on the occiput. Cirri on the tips of spines of the first dorsal fin. Lateral
line consisting of two rows of pores, one above the other below the central
channel, which is closed, without scales and pores. Small sculpins . . .

The clasping structures on the pelvic fins are apparently
developed in all species of Crossias, though evident only in
nuptial males. Similar structures, however, are developed in
at least one species of Myoxocephalus. In a mature male of
M. axillaris from near King Cove, Alaska, the second pelvic ray
carries a trace of tubercular enlargements and the third ray
bears strong bony processes in 1 row branching into 2 irregu-
lar rows. Nuptial tubercles are developed on the inner side of
the pectoral fins of males in several species of Myoxocephalus,
for instance in M. polyacanthocephalus (Jordan and Ever-
mann, 1898: 1977, footnote; also in a specimen at hand from
near King Cove, Alaska) and in M. verrucosus ochotensis
(Schmidt, 1929a: 418, Fig. 4).

The tentacles on the head and spiny dorsal fin are none too
distinctive, because they are occasionally or even characteristi-
cally simple in some forms of Crossias, according to the Rus-
sian ichthyologists cited. When simple, they are not very
sharply distinguishable from the cirri developed on the top of
the head and from the filamentous tips of the dorsal spines,
which are developed in some species of Myoxocephalus, par-
ticularly in M. niger (which was taken with Crossias albo-
maculatus in reef pools on the Pribilof Islands).

An examination of the material at hand shows that the
characters of the lateral line are also differences of degree. In
Crossias allisi the axial pores are obsolete even in the half-
grown, and the regularly arranged, paired lateral pores, one
above and one below each obsolescent lateral line plate, are at
the end of relatively long side tubes. In adult specimens of
C. albomaculatus, these structures are similar, except that very
small axial pores are developed anteriorly, where the lateral
pores are increased in number and tend to lose their regular
arrangement. In the species of Myoxocephalus the plates vary
from weak to strong, and from concealed to exposed, but the axial pores remain open, and the lateral pores are typically less distant from the axis of the lateral line (large adults of *M. polyacanthocephalus*, *M. jaok*, *M. axillaris*, and *M. niger* were examined).

In the young of *Crossias albomaculatus* about 25 mm. long the lateral line (undeveloped toward the caudal) is a conspicuous tube opening by large axial pores, and the paired lateral pores have been developed only near the head. The process of lateral line formation in *C. albomaculatus* is apparently as follows: the main tube with its pores develops from the head backward; before the tube and line reach the caudal fin, paired lateral pores develop near the head, and again this process continues backward (these pores when first formed are small, but they gradually enlarge); later each lateral pore near the head becomes multiple, and this change proceeds backward; in the meantime the axial pores become reduced in size and then obliterated, from the tail region forward (the retrogression reversing the direction of the progressive development). The same sequence of events takes place in *Myxocephalus*, but at a slower rate.

All forms of *Crossias* appear to be small fishes, but the adult size varies greatly in *Myxocephalus*. They tend to be more compressed and more brightly colored, but in these respects too there is much variation in *Myxocephalus*.

Further study of various species of the two groups will be needed to judge the advisability of maintaining *Crossias* as a genus distinct from *Myxocephalus*. Pending such an investigation, the *status quo* should probably be maintained. Tarametz (1935b: 88) has synonymized *Crossias* with *Porocottus*, although recognizing *Porocottus* as distinct from *Myxocephalus*.

The resemblance between *Crossias beringi* Soldatov (1916) and *Argyrocottus* may be more than superficial and suggests the possibility that *Crossias* as now constituted is a polyphyletic group.

It may be noted that *Crossias beringi*, in violation of the
International Rules of Zoological Nomenclature, has been divided into two formae, neither of which bears the name of the species (Soldatov, 1916; Schmidt, 1929b: 504-5; Soldatov and Lindberg, 1930: 231-32, Figs. 39-40). Rendahl restricted the name Crossias beringi to "Crossias beringi forma meridionalis," which therefore became a synonym. Until intergradation between the two forms is proved, Crossias borealis Soldatov should probably rank as a full species.

Crossias albomaculatus Schmidt

A series of young to adult specimens of this sculpin, the first to be reported from North America, were collected by the senior author and H. D. Gray in a tide pool on the black lava reef of Sea Lion Neck, near the north end of the east side of St. Paul Island, Pribilof Islands, in Bering Sea, on July 23, 1939. A young example was found in a large collection made by shrimp trawl at a depth of 10 to 20 fathoms, at the junction of Frederick Sound and Dry Strait in Southeastern Alaska, on September 1, 1939 (circumstances make it seem almost impossible that this specimen was inadvertently mixed with the trawl collection).

Hitherto the species has been known only from Medni Island of the Commander group, off the Kamchatka coast opposite the end of the Aleutian chain, and from the east coast of Kamchatka. It is of interest that Myoxocephalus niger and M. parvalis, taken in the same pool on St. Paul Island, are also reported from Medni Island.

The specimens at hand correspond well with the published accounts of Crossias albomaculatus. The one nuptial male shows the clasper-like appendages on the pelvic rays, just as described and figured, but the processes on the pectoral rays are rudimentary. On the top of the head there are 3 pairs of multifid tentacles and numerous simple cirri, as in no other
species of the genus. The tips of the dorsal spines and the adjacent edge of the interspinal membranes bear clusters of cirri (the figure of *C. albomaculatus* shows, by artist’s error, a single cirrus on each spine).

Counts of dorsal and anal rays in the St. Paul specimens average lower than those assigned the species (Table II), but this discrepancy is probably due to our practice of counting the last soft ray in these fins as a double ray.

**TABLE II**

<table>
<thead>
<tr>
<th></th>
<th>Number of Fin Rays</th>
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<tbody>
<tr>
<td>Dorsal spines</td>
<td>8</td>
</tr>
<tr>
<td>Dorsal soft rays</td>
<td>9</td>
</tr>
<tr>
<td>Anal rays</td>
<td>10</td>
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<tr>
<td>Pectoral rays (right)</td>
<td>11</td>
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<tr>
<td></td>
<td>12</td>
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<td>13</td>
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<td>15</td>
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<td>16</td>
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The specimen from Frederick Sound corresponds with young of like size from St. Paul Island. The fin rays number: dorsal, 1X–16; anal, 12; pectoral, 15–14. The upper part of the body as well as the top of the head is covered with papillae (these later develop into cirri on the top of the head). On the pectoral there are 2 characteristic blackish blotches, one large and submedian, the other ventral.

The following life-color description was based on the nuptial male, with variations as shown by other specimens in parenthesis. The large, light diamond on the nape is dusky coralline (often brown or olive but generally with more or less coralline—that is, lavender-pink; the diamond is olive-brown in the largest fish, which has dark saddles and a brick-red occiput). The 4 (rarely 3 or 5) light areas behind the nuchal one are more or less coralline, and slightly (to strongly) vermiculated with brown (sometimes leaving the ground color in round spots). The last of the light bars forms a rounded saddle (which is generally the most strongly tinted with coralline, and is similar in color to the round spot on the caudal base; the
latter spot is sometimes greenish). The dark bars are deep brown (deep olive to brick-red). The lower sides are marked with rather round and regular, coralline to greenish spots (sometimes reddish-centered and green-edged; few, irregular and more or less silvery in the young). In the one mature male these spots become intensely silvery on the sides of the belly (as in only a few of the other specimens); and in this male only, these silver spots are set off by a blackish edge. The sides of the abdomen are salmon; the lower parts, creamy white; the breast, silvery; the throat, whitish (in most of the females and in all the young the abdomen and the lower sides of the head are watery green). The spinous dorsal bears an anterior and a posterior reddish black bar (sometimes scarcely reddish; bright red inside dusky edges in the largest specimen; uniformly reddish in young). The soft dorsal is variously barred with reddish; the anal is finely barred with pink and blackish green. The caudal is variously marked with reddish (red to brown) crossbars.

**Bothrocara pusilla** (Bean)

Two Alaskan specimens referable to this species were collected in 1939, one by the senior author at a depth of 45 to 80 fathoms in Frederick Sound between Frederick Point and Coney Island, and the other by Earl N. Ohmer, in the general vicinity of Petersburg. When checked with published accounts, they were found to differ in having a greater number of rays in the vertical fins. They were therefore compared directly with the types of all three species usually referred to the genus *Bothrocara*, and the fin rays in the types were recounted. The type of *Maynella pusilla* Bean (U.S.N.M. No. 45360) has 110 dorsal rays + 7 on the upper half of the caudal fin, and 99 anal rays + 7 on the lower half of the caudal; the type of *Bothrocara mollis* Bean (U.S.N.M. No. 45359) has 110 + 6 or 7 dorsal rays and 94 + 6 or 7 anal rays (these counts were made with great difficulty, owing to the poor condition of the types). The type of *Bothrocara remigera* Gilbert (U.S.N.M. No. 78820, in good condition) has 14 pectoral rays, and 110 + 7
dorsal rays and 99 + 7 anal rays, and rather strong teeth on the palatines. The teeth in the jaws of *B. mollis* are weaker than in *remigera* or *pusilla*, but otherwise similar; there are a few on the vomer, but none occur on the palatines of the partially destroyed type. The mouth cavities of *mollis* and *remigera* are brownish and the snout is longer than in *pusilla*. Otherwise the three species look remarkably alike. Certainly one must doubt the validity of the separation of *mollis* and *remigera*, but *pusilla* is obviously a distinct species. A definite determination of the status of these species as well as that of the genus must await the study of ample fresh material.

Chapman (1940: 39–40) has recently recorded and discussed a specimen of *Bothrocara*, referred to *B. mollis*, from off Queen Charlotte Islands. However, since his fin ray counts differ from those of the types of *Bothrocara*, Dr. Chapman kindly sent the specimen to the National Museum and upon comparison with types it turned out to be a specimen of *Lycocepitus mandibularis* Gilbert, which has been reported from off California. Thus the range is extended considerably to the northward. Our counts are: dorsal, 86; anal, 76; pectoral, 8.

*Lota lota leptura*, new subspecies

*Gadus Lota* (identification correct to species).—Richardson, 1823: 20 ("every river and lake in the country," that is, along "the shore of the Polar Sea"); natural history; account may refer entirely to intergrades, *leptura x maculosa*; probably excluding references to Pennant's account).

*Lota lota*.—Regan, 1911: 218–21 (range, in part; size in Alaska).

*Lota vulgaris* (synonym of *Lota lota*).—Günther, 1862: 309–60 (synonymy, range, and records, in part).

*Gadus (Lota) maculosa* (misidentification as to subspecies).—Richardson, 1836: 248–51 ("every river and lake from Canada to the northern extremity of the continent"); Fort Good Hope, lower Mackenzie River; detailed description; account may refer entirely to intergrades, *leptura x maculosa*; natural history).


\textit{Lota lota maculosa}.—Berg, 1933: 750-51, Fig. 721 (diagnostic characters; synonymy and range, in part; the pertinent material refers to the ‘‘American album’’ as an inhabitant of eastern Siberia; references to other treatises on this form in Russian).

The burbot of the Yukon River system in Alaska and Canada, and of other streams and lakes in Alaska, are obviously separable, at least subspecifically, from \textit{Lota lota lota} of Europe and most of Siberia and from \textit{Lota lota maculosa} of eastern North America. The work of Berg (1933: 747-51, Figs. 718-21) and the examination of young specimens in the United States National Museum show that the same hitherto unnamed form inhabits the streams of Siberia (‘‘Anadyr and to the south to the Kurfa Bay region’’), north and east of the range of \textit{L. l. lota}, which occurs southeastward to Sakhalin. This zoogeographical pattern finds a partial parallel in the distribution of \textit{Dallia pectoralis}, \textit{Catostomus catostomus}, and certain salmonoids.

Limited material in the United States National Museum suggests that intergrades between the subspecies \textit{leptura} and \textit{maculosa} inhabit the Mackenzie and Fraser river systems and the Rocky Mountain waters tributary to Hudson Bay (but apparently not the lakes and streams near Hudson Bay). The few specimens at hand from the Missouri River system also appear somewhat intermediate between the two subspecies, though they are probably referable to \textit{L. l. maculosa}. Material from the Columbia River system has not yet been measured.
### Table III

**Distance from Notch at End of Dorsal Fin to End of Vertebral Column, Divided by Distance from Dorsal Fin Notch to Anal Fin Notch, in Lota lata**

The data are taken from Tables V to VIII, with additional figures for adults of L. l. maculosa.

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<td><strong>Lota lata leptura</strong></td>
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* The averages were computed from the base data.
The most diagnostic feature of *Lota lota leptura* seems to be the slender, long, and acute posterior end of the isocerale caudal region. This character is expressed as a ratio: distance from notch at end of dorsal fin to end of vertebral column, divided by the distance between the notches at the ends of the dorsal and anal fins (Table III). There is little overlap and no apparent age variation in the measurements. The two published figures of *leptura*, based respectively on an Alaskan and a Siberian specimen (Bean, 1887, Pl. 14, Fig. 2; Berg, 1933, Fig. 721) accurately portray this distinctive character, by which *leptura* differs from the European subspecies, *lota*, as well as from the common American form, *maculosa*.

In other respects *L. l. leptura* appears to agree closely with *L. l. maculosa*. On the average both American forms have shorter pectoral fins than the typical, European subspecies (Tables V to VIII), partially confirming the distinction pointed out by Jordan and Evermann (1898: 2551). The distance from the tip of the snout to the origin of the dorsal fin probably averages slightly greater in *leptura* and *maculosa* than in *lota* (Tables V to VIII), though the difference does not deserve the emphasis accorded by Berg (1933: 750–51). Because of the slightly shorter pectoral fin and longer predorsal space in *leptura* and *maculosa*, the pectoral fin in the adults usually fails to reach the vertical from the origin of the dorsal fin. In *L. l. lota*, the pectoral reaches approximately to below the origin of the first dorsal fin, varying some in either direction. This difference is brought out in Berg’s excellent figures (1933: Figs. 718–21) of *L. l. lota* and *L. l. leptura*, in Jordan and Evermann’s cut (1900: 3308, Pl. 364, Fig. 897) of *L. l. maculosa*, and in most of the drawings of the European form, for instance the one given by Regan (1911: 220, Pl. 20, Fig. 1). A few of the figures for *L. l. lota* by European authors show a pectoral as short as in a typical example of *leptura* or *maculosa*, but these illustrations are rather crude. The criterion under discussion is expressable as a ratio, distance from tip of snout to origin of dorsal fin divided by distance from tip of snout to end of pectoral fin (Table IV). It will be noted that
<table>
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<th>General locality*</th>
<th>Sahb.</th>
<th>Europe</th>
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<td>4 5</td>
<td>6 7-8</td>
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<td>11-12</td>
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<td>14-15</td>
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<td>Standard length, mm.</td>
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<td>Thousandths of standard length</td>
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<td>77</td>
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<tr>
<td>Dorsal fin notch to anal fin notch (A)</td>
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<td>83</td>
</tr>
<tr>
<td>Dorsal fin notch to end of vertebrae (B)</td>
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<td>351</td>
</tr>
<tr>
<td>Tip of snout to origin of dorsal (C)</td>
<td>333</td>
<td>351</td>
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<tr>
<td>Tip of snout to end of pectoral (D)</td>
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<td>146</td>
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<tr>
<td>Length of pectoral</td>
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<tr>
<td>First dorsal base</td>
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<tr>
<td>Ratio, B</td>
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<tr>
<td>Total</td>
<td>160</td>
<td>165</td>
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</table>

* More exact locality and other data are given in the text.
TABLE VII
Measurements and Counts of Possible Intergrades,
*Lota lutea* \*leptura\* \*maculosa\*

<table>
<thead>
<tr>
<th>Locality*</th>
<th>Fort Simpson (MacKenzie R.)</th>
<th>Yellowhead L. (Fraser R. system)</th>
<th>Waterton L. (Glacier National Park)</th>
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<tbody>
<tr>
<td>Specimen number*</td>
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<td>85</td>
<td>86</td>
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<tr>
<td>Standard length, mm.</td>
<td>190</td>
<td>310</td>
<td>skin</td>
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<tr>
<td>Thousandths of standard length</td>
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</tr>
<tr>
<td>Dorsal fin notch to anal fin notch (A)</td>
<td>56</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Dorsal fin notch to end of vertebra (B)</td>
<td>97</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Tip of snout to origin of dorsal (C)</td>
<td>368</td>
<td>374</td>
<td></td>
</tr>
<tr>
<td>Tip of snout to end of pectoral (D)</td>
<td>340</td>
<td>363</td>
<td></td>
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<tr>
<td>Length of pectoral</td>
<td>127</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>Length of head</td>
<td>213</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>Ratio, $\frac{D}{A}$</td>
<td>1.73</td>
<td>1.63</td>
<td>1.75</td>
</tr>
<tr>
<td>Ratio, $\frac{C}{D}$</td>
<td>1.08</td>
<td>1.03</td>
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<tr>
<td>Fin rays</td>
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<tr>
<td>First dorsal</td>
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<td>13</td>
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<tr>
<td>Second dorsal</td>
<td>73</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Anal</td>
<td>72</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>156</td>
<td>174</td>
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</table>

* Other data are given in the text.

In this respect the young of the American forms tend to agree with the adults of *L. l. lutea*.

To judge from our limited material and from the numerous figures which have been published, the European form has a more rounded as well as a longer pectoral fin. The longest rays are the eighth and ninth, rather than the sixth, seventh, or eighth (*leptura*) or the fifth to seventh (*maculosa*). In this character *maculosa* closely resembles Pietschmann's figures (1934; Pl. 3) of the pectoral fins of the fossil species, *Lota bucki*.

Bean (1884) discussed various possible criteria, but concluded, in agreement with Goode and Bean (1879: 42), that the
prime difference between the European and American forms lies in the number of vertebrae (60 or 61 in *lota*; 64 in *maculosa*). Some new vertebral counts in *maculosa*, *lota*, and *leptura* are listed:

Counts for *Lota l. maculosa*—
- Potsdam, New York: $25 + 38 = 63$.
- North Branch of Flambeau River, Wisconsin: $25 + 39 = 64$; $26 + 38 = 64$; $27 + 38 = 65$.
- Missouri River system, Wyoming: $25 + 38 = 63$.

Counts for *Lota l. lota*—
- Europe: $24 + 36 = 60$; $24 + 39 = 63$.

Counts for *Lota l. leptura*—
- Alaska: $25 + 38 = 63$; $25 + 39 = 64$; $26 + 39 = 64$; $26 + 40 = 66$.
- Siberia: $26 + 40 = 66$; $26 + 38 = 64$; $26 + 40 = 66$; $26 + 40 = 66$; $25 + 39 = 64$.

These data on the number of vertebrae indicate that the European and common American forms of *Lota* possess approximately the same number of vertebrae, but that the Alaskan and Siberian form (*leptura*) has on the average more vertebrae. An adequate number of counts might indicate an average of one or two more vertebrae in *leptura* than in *lota* and *maculosa*.

Certain counts and measurements for the three subspecies of *Lota lota* as here recognized are given in Tables V to VIII. We find no acceptable basis for the separation of other subspecies, though we have studied material from various parts of the ranges of the three forms here recognized. No adequate material is at hand, however, to check on the status of *Lota lota kamensis* Markun (1936), from the Kama River of the Volga system. Markun thought that this form may be intermediate between the European subspecies and the "*Lota lota maculosa*" (= *L. l. leptura*) of northeastern Siberia. Fortunately, Markun made a statistical study of the characters of the Kama River form. In comparing our counts with his, it would seem that on the average *L. l. leptura* has fewer fin rays, a slenderer
tail region, and a longer distance from the tip of the snout to the origin of the dorsal fin. A great difference appears in the measurements for the distance from the tip of the snout to the end of the pectoral fin, but here either a slip in translation or a typographical error seems evident in Markun’s figures.

Description.—The following description is based on the holotype, U.S.N.M. No. 29916, a specimen 535 mm. from tip of snout to end of last vertebra, collected by E. W. Nelson at Kotlik, Alaska, June 20, 1881. Kotlik is near one of the mouths of the Yukon River, on Norton Sound. In addition certain measurements and counts of 22 paratypes are recorded in Table VIII. Locality and other data for each specimen are given in the list which follows this description.

Sixty-nine paratypes (U.S.N.M. No. 76848), from 28 to 63 mm. in standard length, were caught in a linen trap at a lake near Nijni Kolymsk, Siberia, by N. W. Widding, in September, 1914. In the same month he took 134 paratypes (U.S.N.M. No. 76847), 23 to 64 mm. long, from a pond near Kolyma, Siberia, in a cloth trap.

The measurements of the holotype are expressed in thousandths of the standard length. Length of head, 221; length of snout, 65.5; diameter of eye, 23; fleshy interorbital width, 64; tip of snout to rear edge of maxillary, 97; postorbital length of head, 135; greatest depth of body, 122; distance from notch at posterior end of second dorsal to similar notch at rear of anal fin, 43; distance from notch at posterior end of second dorsal to tip of last vertebra, 89; distance from tip of snout to origin of first dorsal fin, 389; distance from tip of snout to posterior tip of pectoral fin, 351; length of pectoral fin, 135; length of longest ray in first dorsal fin, 52; longest ray of second dorsal, 67; longest ray of anal fin, 60; longest ray of pelvic fin, 122; length of base of first dorsal, 71; the sixth and seventh pectoral rays are longest.

The number of fin rays in the holotype are as follows: dorsal, 12–73; anal, 75; pectorals, 20–20.

Nine gill-rakers were counted on the first gill-arch.
DATA FOR SPECIMENS OF *Lota lota*, FOR WHICH COUNTS AND MEASUREMENTS ARE GIVEN IN TABLES V TO VIII

These specimens are in the collections of the United States National Museum (U.S.N.M.), University of Michigan Museum of Zoology (U.M.M.Z.), and the University of Wisconsin (U.W.). Other specimens were measured for the critical ratios.

*Lota lota lota* (Table V)
1. — U.S.N.M. No. 105233: Tyn River, Sakhalin; July 26, 1929.
2. — U.S.N.M. No. 24188: France; M. Goldsmith.
3. — U.S.N.M. No. 28427: Lago di Como, Italy; Italian Commission, Berlin Fishery Exhibit.
11–12. — U.S.N.M. Nos. 41110 and 41102: Lake of Morat, Switzerland; Department of Interior and Agriculture, Switzerland.
13. — U.S.N.M. No. 10096; Europe; Bonaparte collection.
14–15. — U.S.N.M. 17333; Sweden; Uddevalla.

*Lota lota maculosa* (Table VI)
21. — U.M.M.Z. No. 126771; Otter Brook, at Grange, Coos County, New Hampshire; Bailey and Oliver, August 18, 1939.
Carl L. Hubbs and C. Willard Green, July 11, 1925.


37.—U.M.M.Z. No. 57000: Bear Creek, 5 miles south of Houghton Lake, Michigan; Charles W. and Edwin P. Creaser, August 10, 1922.

38—40.—U.M.M.Z. No. 117693: Otsego Lake, near headwater of Blanche River, at Swastika, Ontario; Carl L. and Laura C. Hubbs, August 23, 1930.

41.—U.M.M.Z. No. 66083: Black River, just above junction with East Branch, Montmorency County, Michigan; Jan Metzelaar and T. H. Langlois, August 13, 1925.

42.—U.M.M.Z. No. 67163: Porcupine Lake, Presque Isle County, Michigan; Carl L. Hubbs, September 17, 1925.

43.—U.M.M.Z. No. 68303: Bear Creek, 5 miles south of Houghton Lake, Michigan; Creaser, August 10, 1922.

44.—U.M.M.Z. No. 127653: Otsego Lake, near headwater of Blanche River, at Swastika, Ontario; Carl L. and Laura C. Hubbs, August 23, 1930.

45—46.—U.M.M.Z. No. 100103: Lake Siskiwit, Isle Royale, Michigan; Creaser and party, July 17, 1927.

47—48.—U.M.M.Z. No. 88920: Big Stone Bay, Marquette County, Michigan; Walter Koelz, August 26, 1924.

49.—U.S.N.M. No. 20977: Outer Island, Lake Superior; J. W. Milner, November 12, 1917.

50.—U.M.M.Z. No. 8154: Crystal Lake, Benzie County, Michigan; R. Kennicott, August 26, 1924.


52.—U.M.M.Z. No. 8131: Crystal Lake, Benzie County, Michigan; Charles W. Creaser, June 7, 1927.

53.—U.M.M.Z. No. 53684: Lake Minkemoya, Manitoulin Island (in Lake Huron), Ontario; Walter Koelz, November 12, 1917.

54.—U.M.M.Z. No. 68033: Lake Huron, off Alpena 14 miles SE.; S., Michigan; Walter Koelz, October 7, 1917.


58.—U.S.N.M. No. 21911: tributary to James Bay; C. Drexler.

59.—U.S.N.M. No. 64865: White Oak Lake, at Deer River, Minnesota; A. J. Woolman.

60.—U.S.N.M. No. 20392: Port Ripley, Minnesota; R. Kennicott.

61—66.—U.M.M.Z. No. 76618: North Branch of Flambeau River, 4 miles west of Fifield, Wisconsin; Edwin P. Creaser and Samuel Jones, August 24, 1923.

69—71.—U.W., collections 133, 135, and 136: North Turtle Lake, Wisconsin; George Wagner, August 1–9, 1867.

72.—U.M.M.Z. No. 86539: Trout Lake, Vilas County, Wisconsin; Stillman Wright, July 7, 1927.
Possible Intergrades, *Lota lota: leptura × maculosa* (Table VII)

- U.S.N.M. No. 21195: Fort Simpson [on Mackenzie River]; R. Kennicott, August 20, 1859.
- U.S.N.M. No. 70450: Yellowhead Lake [Fraser River drainage, near Continental Divide], British Columbia; Ned Hollister, September 1, 1911.
- U.S.N.M. No. 76847: pond near Kolyma, Siberia; N. W. Wredling, September, 1914.
- U.S.N.M. No. 76848: lake near Nijii Kolymak, Siberia; Wredling, September, 1914.
- U.S.N.M. No. 29916 (holotype) and 29915: Kotlik, Alaska [near mouth of Yukon River]; E. W. Nelson, January 20, 1881.
- U.S.N.M. No. 104429: Naknek River, Alaska; Claude Flock, June 12, 1931.

*Lota lota leptura* (Table VIII)

- U.S.N.M. Nos. 23456-58: Kedik, Alaska; Wm. J. Fisher, January 10, 1886.
- U.S.N.M. No. 29916 (holotype) and 29915: Kotlik, Alaska [near mouth of Yukon River]; E. W. Nelson, January 20, 1881.
Supplementary Statement

As this paper passes through page proof we receive a publication by Andriashev (1939) which bears on the status of the species of Cottidae here discussed. He lists *Myoxocephalus parvaus* on page 43, with a question mark, presumably as to its validity. Following Taranetz (1935a) Andriashev (1939: 43 and 66) synonymizes *Crossias* with *Porocottus* (see also p. 13), erroneously regards *Crossias albomaculatus* as a western subspecies of *Porocottus bradfordi*, and records *albomaculatus* from Attu and Agattu Islands of the Aleutian Chain. Therefore our records of *Crossias* are not the first for North America. *Porocottus bradfordi* Butler (in Jordan and Evermann, 1896: 2862-63) is described as having the pelvic rays serrate in the male, and should perhaps be referred to *Crossias* rather than *Myoxocephalus*.

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The description of "Arizonichthys psammophilus, new genus, new species" (Nichols, 1940: 1-2) induces us to list and discuss the cyprinodont fishes which inhabit the waters of the Colorado River system. The four genera and species, representing the Cyprinodontidae and the Poeciliidae, are to be treated by us in more detail in subsequent publications.

**GENUS CRENICHTHYS HUBBS**

*Crenichthys.*—Hubbs, 1932: 1-4 (original description; comparisons and relationships; type, *C. nevadae* Hubbs).

Our field studies of 1934 and 1938 have demonstrated that this remarkable derivative of *Empetrichthys* has a rather wide distribution in the springs and creeks of southern Nevada, including one of the present tributaries of the Colorado River.

1. *Crenichthys baileyi* (Gilbert)

Cyprinodon macularius baileyi.—Gilbert, 1893: 233 (original diagnosis; Pahranagat Valley, Nevada).

Cyprinodon baileyi.—Jordan and Evermann, 1896: 671, 675 (diagnosis, after Gilbert).
Although long confused with *Cyprinodon*, this species agrees with *Crenichthys nevadae* in all essential respects, including the invariable lack of pelvic fins and the bifid rather than trifid teeth. It is obviously to be referred to *Crenichthys* (our conclusions in this regard have received preliminary notice in the paper by Sumner and Sargent). The chief apparent difference between *baileyi* and *nevadae* lies in coloration, for the lateral dark spots are arranged in two rows rather than in a single series.

*Crenichthys baileyi* does not occur in Railroad Valley, Nevada, where *C. nevadae* abounds in warm springs, but replaces that species in the White River and Pahranagat valleys. It also occurs in the warm-spring headwaters of Moapa or Muddy River, which still flows into the Colorado River (the lower course of Moapa River is now flooded by Lake Mead), and is therefore to be included in the present Colorado River fauna. It is now confined to a chain of isolated warm-spring waters, all of which were formerly connected with one another, and with the Colorado River, through Quaternary White River (Carpenter, 1915: 53). The former course of this now extinct river can thus be traced by its relict fish populations as well as by its continuous terraces and dry canyons (Hubbs, 1941: 68, Fig. 7).

The now isolated populations of *Crenichthys baileyi* show indications of partial differentiation and will probably be treated as subspecies. Several thousand specimens have been preserved for the analysis of this speciation.

**GENUS CYPRINODON LACEPEDE**

2. *Cyprinodon macularius* Baird and Girard

As we have in preparation a revision of the genus *Cyprinodon*, we will not attempt to give here any synonymy or critical discussion of its Colorado River representatives. Several forms of other river systems, at least subspecifically distinct, have
been confused with *macularius*, which in turn shows local differences that will likely prove of subspecific significance. The partial confusion of *Crenichthys baileyi* with *Cyprinodon macularius* is mentioned above.

Regan's (1907: 85) record of this species from "Colorado (Eigenmann)" was doubtless based on specimens from the Colorado Desert, which is in southeastern California.

**GENUS GAMBUSIA POEY**

3. *Gambusia affinis affinis* (Baird and Girard)

This fish has been widely introduced and established through the Colorado River system, as elsewhere through the West, in mosquito-control work. Its nomenclature will be treated by the senior writer.

**GENUS POECILIOPSIS REGAN**

*Poeciliopsis.*—Regan, 1913: 980, 996-7, Fig. 170D (original description; in part; no type designated; synopsis of species). Heen, 1916: 119 (type, *Poecilia presidionis* Jordan and Culver; in part). Meek and Hildebrand, 1916: 314, 324 (diagnosis; type, *Poecilia presidionis*; in part). Hubbs, 1924: 10 (characters; type, *Poecilia presidionis*, not *Poeciliopsis kuhmacensis* as indicated by Jordan, 1920); 1926: 62-66 (characters; comparisons; species; *Leptorhaphis* as synonym); 1936: 232; 235 (characters; comparisons; possibly a complex; species). Hildebrand, 1938: 307 (division into smaller genera by Hubbs not accepted; in part).

*Leptorhaphis.*—Regan, 1913: 980, 998 (original description; haplotype, *L. in/fasiae*). Hubbs, 1924: 10 (characters; comparisons).


Large series of poeciliopsines from the Pacific drainage of Mexico are available for a prospective revision of this group. For present purposes it will suffice to say that the status of the genus *Poeciliopsis* as a unit (see Hubbs, 1936: 235) remains somewhat uncertain.

*Arizonichthys* is to be quoted in the synonymy of *Poeciliopsis*, since its haplotype, *Arizonichthys psammophilus*, is clearly a synonym of *Poeciliopsis occidentalis* (Baird and Girard).
Even if *occidentalis* be segregated generically from *Poeciliopsis* (as it well may), the name *Arizonichthys* will almost surely remain a synonym, for *occidentalis* seems to be separable on only very trivial characters from *Poeciliopsis infans*, the type species of *Leptorhaphis* (see Hubbs, 1926: 65). These species, *occidentalis* and *infans*, are geographically connected by a chain of related forms, as we shall indicate in a later publication.

On technical, nomenclatorial grounds it is not certain that *Arizonichthys* was validly proposed. We do not wish to stress this point, however, in view of the uncertain acceptability of the provisions that new generic names proposed after 1930 are invalid unless accompanied by a definite description and a definite designation of type species.

*Arizonichthys* was proposed not only without any formal generic diagnosis or comparison, but even without allocation to family. It may be pointed out that the ovarian structure differs in the viviparous and oviparous cyprinodonts, providing a means for family identification of series which do not include males.

4. *Poeciliopsis occidentalis* (Baird and Girard)


*Poecilia occidentalis*—Garman, 1895: 61, Pl. 5, Fig. 5 (synonymy; description; San Bernardino Creek, Mexico; Nickson, Ari-
Mollencia occidentalis.—Regan, 1913: 1010, 1013 (characters; synonymy and range, in part). Fowler, 1921: 399 (Santa Cruz River at "Tucson").


Arizonicthys psammophilus.—Nichols, 1940: 1-2 (original description; 34 miles east of Tanque Verde, Pima County, Arizona).

This is one of the commonest fishes in the southern part of the Colorado River drainage basin, particularly in the Santa Cruz River system, from which Arizonicthys psammophilus has recently been described. The types of occidentalis came from the Santa Cruz River in Mexico, and numerous toptotypes are at hand, as well as hundreds of other specimens from various tributaries of the Santa Cruz in Arizona. No series precisely toptotypic of psammophilus (that is, from Tanque Verde Creek) has been seen, but there is no reason to doubt its identity with occidentalis. Comparing the description of the 48-mm. type of psammophilus with an example of occidentalis of the same relatively large size, we find the agreement complete.
The type habitat of *Arizomichthys psammophilos*—pools on the sandy bed of a hill stream which nearly disappears in the dry season—is a characteristic abode of *Poeciliopsis occidentalis*. The local belief that these fish can dig into the sand to survive periods of desiccation is a natural but implausible explanation of the seasonal reappearance of the stock (no doubt from more permanent spring-fed waters upstream).

Creeks like Tanque Verde Creek, which dry up seasonally but at times flow normally to river courses, do not provide the locus for the development or survival of peculiar forms. There is truth in Nichols' statement that "the occurrence of peculiar cyprinodont fishes in isolated desert environments of the West is not without precedent," though the examples of *Empetrichthys* and *Crenichthys* have a wider distribution than at first indicated, and "*Arizomichthys*" is definitely not to be included among the isolated types.

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POECILICHTHYS KANAWHAE, A NEW DARTER
FROM THE UPPER NEW RIVER SYSTEM IN
NORTH CAROLINA AND VIRGINIA

By EDWARD C. RANEY

On a recent collecting trip in North Carolina, Ernest A. Lachner, L. James Kezer, and the author were so fortunate as to take numerous specimens of a new percid fish of the genus *Poecilichthys*. This new darter is closely related to both *P. variatus* and *P. osburni*. It is named *Poecilichthys kanawhae* for the Kanawha River system, of which the New River is a main tributary.

The 45 available specimens of the new species have all been taken in the New River drainage of North Carolina and Virginia, where it is largely limited to riffles. It appears to prefer large streams, although a few specimens were taken in a small tributary within 100 feet of the New River. Thus another interesting species is added to the distinctive fauna of the Kanawha River system above the Kanawha Falls, and it is to be considered a relict form. Discussions of the fish fauna of this region have been published by Hubbs (1931), Hubbs and Trautman (1932), and Hubbs and Raney (1939). Since little is known of the distribution of the fishes in the head-

*The trip to North Carolina upon which this new species was found was made possible through a grant from the Faculty Research Committee of Cornell University.*
waters of the New River (see Breder and Breder, 1923), lists of the species collected at 9 localities are included in Table I. Several species not hitherto recorded from North Carolina were found.

The holotype (U.M.M.Z.1 No. 131837), an adult male 71.5 mm. in standard length, and 20 paratypes, which include several adult males and females as well as many juveniles, were taken in the North Fork of the New River at Crumpler, Ashe County, North Carolina, on April 1, 1940. Here the river, averaging close to 300 feet in width, consists of long, deep pools with occasional long riffles. These darters were collected in a moderately fast riffle in water from 6 to 18 inches in depth over a bottom of small rubble and gravel. A few were taken by overturning large rocks, but most were obtained by holding a 10-foot seine stationary and scuffing the area of gravel and rubble on the upstream side. The adult females were swollen with eggs, an indication that the breeding season was near. The adult males were in brilliant nuptial dress. In and above this riffle, 14 other species, including 3 species of darters, were taken. The fishes which were collected at this and at the other localities are listed in Table I.

Two paratypes, both small males, were collected in the North Fork of the New River, 1 mile north-northeast of Warrensville, Ashe County, North Carolina, on April 1, 1940. Both specimens were captured in a riffle over a rubble bottom.

Five paratypes, 2 adult males in breeding color and 3 juveniles, were taken in the North Fork of the New River, 1 mile north-northeast of Creston, Ashe County, North Carolina, on the same day. The specimens were taken in a rather swift riffle 70 feet wide and 2 feet deep at the deepest point, over a gravel bottom.

Seven paratypes—3 adult males, 2 females with eggs, and 2 juveniles—were collected in the South Fork of the New River at Index, Ashe County, North Carolina, on April 2, 1940. Four were seined in a wide riffle in the main channel, and 3 specimens, including a large, adult male, were taken in the mouth of a small tributary within 100 feet of the river.

1 University of Michigan Museum of Zoology.
TABLE I
DISTRIBUTION OF THE FISHES COLLECTED IN THE NEW RIVER DRAINAGE, ASHE AND WATAUGA COUNTIES, NORTH CAROLINA, APRIL 1-2, 1949. THE PRESENCE OF A SPECIES IS INDICATED BY AN X.
Those species found in the same riffle habitat as Poeciliichthys kanawhae are followed by an asterisk.

<table>
<thead>
<tr>
<th>Species</th>
<th>North Fork New River</th>
<th>South Fork New River</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Crumpler</td>
<td>1 mi. NNE of Warneville</td>
</tr>
<tr>
<td>Salvelinus f. fontinalis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmo gairdneri iridus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Catostomus c. commersonnii</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Hypentelium nigromarginum</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Xyotheca micropogon*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rhinichthys atratulus obtusus*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rhinichthys cataractae*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Notropis scabriceps</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Notropis gilberti*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Notropis pharopus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Notropis reidelli*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Phoxocephalus teretulus*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Parapercis laurac*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Hypororhinchus notatus</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Comstockia anomala*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Hedropterus maculatus*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Poeciliichthys kanawhae</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Catostomus f. tubellatus*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Etheostoma b. brennioides*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cottus bairdii*</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Five paratypes, all juveniles, were obtained in the South Fork of the New River, 1 mile southwest of Fleetwood, Ashe County, North Carolina. All were found in a long, wide riffle in water less than 1 foot deep, for the most part, over rubble bottom.

The holotype and numerous paratypes have been deposited in the University of Michigan Museum of Zoology. The other paratypes listed above are in the Cornell University Museum.

Two paratypes (U.M.M.Z. No. 93371), both juveniles, were captured in Big Reed Island Creek, Carroll County, Virginia, on May 17, 1931, by Carl L. Hubbs and Edwin P. Creaser. Hubbs and Trautman (1932: 37) recognized that these were different from typical *Poecilichthys osburni*, but since they had only 2 small specimens they described them as large-scaled variants. In their recent revision of the *Poecilichthys variatus* group, Hubbs and Black (1940: 11) also mentioned these as variants of *P. osburni*.

Three paratypes (U.S.N.M. No. 107679), including an adult male and two females, were obtained in Crooked Creek 4 miles east of Galax, Carroll County, Virginia, on July 13, 1938, by Leonard P. Schultz and Earl D. Reid. Some characters of these specimens were listed by Hubbs and Black (1940: 11), who considered them also as large-scaled variants of *Poecilichthys osburni*.

Dr. Carl L. Hubbs has kindly examined all the specimens of *Poecilichthys kanawhae* mentioned above and is in agreement with the diagnosis presented here. He has also loaned me specimens of *kanawhae* and *osburni* from the collection of the University of Michigan Museum of Zoology and has made available to me scale and fin counts of the specimens of *osburni* in the University of Michigan collection. In addition, he has examined the manuscript critically and has made a number of suggestions for its improvement. Dr. Leonard P. Schultz, Curator of Fishes in the United States National Museum, has loaned me 3 specimens of *kanawhae*, designated above as paratypes, and several series of *variatus* from Virginia, which were...
### TABLE II

**Number of Scale Rows and Fin Rays in Three Species of Pocilloichthys**

<table>
<thead>
<tr>
<th></th>
<th>Lateral-line Scale Rows (to End of Hypural)</th>
<th>Scales Above Lateral Line</th>
<th>Scales Below Lateral Line</th>
<th>Anal Rays</th>
<th>Dorsal Spines</th>
<th>Dorsal Soft Rays</th>
<th>Dorsal Spines + Soft Rays</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48</td>
<td>49</td>
<td>50</td>
<td>51</td>
<td>52</td>
<td>53</td>
<td>54</td>
<td>55</td>
</tr>
<tr>
<td><em>P. kanawhae</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. variatus</em></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>P. oasburni</em></td>
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</tr>
</tbody>
</table>

*Types: see Table IV for localities.
†Specimens from Pennsylvania, West Virginia, and Virginia.
‡Specimens from the upper Kanawha River system in West Virginia and Virginia.*
used in making comparisons. The measurements and counts included in this paper were obtained in the manner described by Hubbs and Black (1940: 9).

*Poecilichthys kanawhae*, new species (Pl. I)

Although this darter is related to both *P. variatus* and *P. osburni*, it appears to be closer to *variatus* in many characters. Both *kanawhae* and *variatus* are rather robust and heavy-shouldered species as compared to the more terete *osburni*. The squamation (Table II) is almost identical; there are from 48 to 57 lateral-line scale rows, with a mean of 53 in each, whereas in *osburni* there are from 59 to 70, with a mean of 63. Furthermore, both may be separated from *osburni* by the other scale counts as may be seen in Table II. In addition to differences in body shape and in squamation, *osburni* is more darkly banded, especially anteriorly. This character is especially striking in adult males at the height of the breeding season (see Hubbs and Trautman 1932: 35, Fig. 2). In *kanawhae* and *variatus* the dark, vertical bands are pronounced on the posterior half of the body. There are usually 6, and they become entirely invisible in some adult males of *variatus* which, as portrayed in Hubbs and Black (1940, Pl. 2), may appear very dark. The breeding colors are in general almost identical in *kanawhae* and *variatus*. However, in the large, adult, male *kanawhae* near the breeding season, there are usually 10 vertical red-orange bars along the side. In this respect *kanawhae* resembles *osburni* rather than *variatus*, since in the latter the red-orange bars are fewer (5 or 6) and are limited to the posterior half of the body. Whereas *kanawhae* and *variatus* correspond in the several above-mentioned characters, such as general body shape, number of scale rows, and general coloration, *kanawhae* differs from *variatus* in the characters given in Table III. In several respects *kanawhae* and *osburni* are closer to each other than to *variatus*. Each has 5 dark saddles (6 in 65 per cent of the specimens of *kanawhae*) on the back, whereas *vari-
Poecilichthys kanawhae, a New Darter

The coloration along the sides is similar, in that the transverse red-orange bars occur along the anterior half of the body (in variatus these bars are limited to the posterior half). Both have a large yellowish mark on the cheek.

### TABLE III

A COMPARISON OF SOME CHARACTERS OF Poecilichthys kanawhae AND Poecilichthys variatus

<table>
<thead>
<tr>
<th>Character</th>
<th>P. kanawhae</th>
<th>P. variatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black saddles on back</td>
<td>5 or 6</td>
<td>4</td>
</tr>
<tr>
<td>Vertical red-orange bars on sides in breeding males</td>
<td>10</td>
<td>5 or 6</td>
</tr>
<tr>
<td>Eye</td>
<td>Smaller; greatest diameter less than snout (about equal to snout in a few cases); eye in snout, 1.1-1.4</td>
<td>Smaller; greatest diameter equal to or greater than snout; eye in snout 0.8-1.0</td>
</tr>
<tr>
<td>Snout</td>
<td>Snout somewhat produced; angle of muzzle 70° to 90°</td>
<td>Snout somewhat produced; angle of muzzle 55° to 75°</td>
</tr>
<tr>
<td>Gill-membranes</td>
<td>More broadly joined; angle, 100° to 128°; few or no pigment flecks in adult</td>
<td>Less broadly joined; angle, 61° to 90°; heavily dotted with pigment flecks in adult</td>
</tr>
<tr>
<td>Head</td>
<td>Shorter; in standard length, 3.8 to 4.1 in adults; narrower behind eyes</td>
<td>Longer; in standard length, 3.4 to 3.7 in adults; broader behind eyes</td>
</tr>
<tr>
<td>Light mark on cheek</td>
<td>Large and well defined in adult</td>
<td>Small and ill-defined in adult</td>
</tr>
<tr>
<td>Breast</td>
<td>Scaleless (at times with several embedded scales)</td>
<td>Scaled (naked in a few individuals)</td>
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</table>

and little or no pigment on the gill-membranes, and, furthermore, the breast is scaleless (occasionally with a few embedded scales). In variatus the breast is almost always well scaled.

The structural evidence, considered in the light of the known distributional facts, indicates that kanawhae and oxburh have evolved from the variatus type as they were left isolated in the upper Kanawha River system above the great Falls of the Kanawha River in West Virginia. As far as is now known,
kanawhae is limited to the extreme headwaters of the New River in North Carolina and some of its tributaries in Carroll County, Virginia. In Carroll County osburni also has been taken in Reed Creek. This stream enters the New River almost opposite the mouth of Big Reed Island Creek, where Hubbs and Trautman (1932: 37, and Fig. 1) collected kanawhae. The 2 species have not been taken together, however—at least, up to the present. Lower in the Kanawha River system (but still above the Falls) osburni has been taken in a number of localities. No variatus has been taken above the Falls in the Kanawha River. The distribution of variatus, as given recently by Hubbs and Black (1940: 7), includes the “Ohio River drainage basin in New York, Pennsylvania, West Virginia, Ohio, Indiana, and Kentucky, exclusive of the Upper Kanawha, Wabash, Kentucky, and Tennessee River systems.”

Hubbs and Black (1940: 9), in their recent revision of the group, have included a key to the darters related to P. variatus. P. kanawhae could be included, in part, under item 2b of their key, since the snout is more declivous (angle to muzzle from 70° to 90°) and the gill-membranes are broadly joined. However, as may be seen by an examination of Tables II and IV, kanawhae does not agree with blennius in all other characters given in 2b. Under 3c in the key, the presence of 6 (often 5) dark saddles in kanawhae distinguishes it trenchantly from P. blennius, which has 4. Furthermore, the dark dorsal saddles in blennius are set off by a creamy white posterior border, not seen in kanawhae.

The counts and measurements of the types included in Tables II, III, and IV, the photograph of an adult male in Plate I, and the comparisons with related forms have portrayed most of the characteristics of kanawhae.

In the adult, the form of the body is rather robust and the snout is very blunt. In the holotype, the angle of the muzzle, especially when the anterior half of the snout is considered, is close to 90°, but the snout is more produced in smaller specimens. The snout, viewed from the side, is somewhat rounded. The dorsal contour of the body, beginning at the top of the
<table>
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<tr>
<th>Measurements and Counts of the Types of Pecidichthys kanawhae</th>
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<tr>
<td><strong>TABLE IV</strong></td>
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<tr>
<td>North Fork, New River, at Cumber, N.C.</td>
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<tr>
<td>C.U.M. 7673</td>
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<td>North Fork, New River, at Index, N.C.</td>
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<td>C.U.M. 7088</td>
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<tr>
<td>South Fork, New River, near Pleatwood, N.C.</td>
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<td>Big Reed Island Creek, Va.</td>
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<td>U.M.M.Z. 95371</td>
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<td>Galax, Va.</td>
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<td>U.M.M.Z. 107879</td>
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<td>Holotype Paratypes Paratypes Paratypes Paratypes Paratypes Paratypes Paratypes Paratypes</td>
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<tr>
<td>Number of specimens 1 20 5 2 7 7 2 3 46.8-58.5</td>
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<td>Standard length (in mm.) 39.5-60 33.70 48.5-52.5 44.60 39.44 30.44 46.8-58.5</td>
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<td>Scales above lateral line 7 6-8 6-7 6-7 8 7-8 7-8 7-8 8</td>
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<td>Scales below lateral line 7 6-8 6-7 6-7 8 7-8 7-8 7-8 8</td>
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<td>Head in length 1 1 1 1 1 1 1 1 1 1</td>
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<td>Least interorbital width in eye 2 2 2 2 2 2 2 2 2 2</td>
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<td>Eye in head 4 4 4 4 4 4 4 4 4 4</td>
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C.U.M. = Cornell University Museum.
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<td>Angle of muzzle</td>
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<td>72-86</td>
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<td>79-80</td>
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<td>Angle of gill-membranes</td>
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<td>109-126</td>
<td>110-134</td>
<td>106-128</td>
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<td>Eye into distance from tip of mandible</td>
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<td>Latter distance into head</td>
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<td>Interspace between insertion of pelvic fin and union of gill-membranes, in distance thence to tip of mandible</td>
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<td>Highest dorsal spine in head</td>
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<td>2.1-2.4</td>
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<td>Highest dorsal spine in first dorsal base</td>
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Edward C. Raney
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<td>Highest anal ray in head</td>
<td>1.5-1.9</td>
<td>1.5-1.9</td>
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<td>1.6-1.9</td>
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<td>0.7-1.0</td>
<td>0.8-1.0</td>
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<td>1.7-1.8</td>
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<td>Paratypes</td>
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<td>1.3-1.4</td>
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<td>Longest pectoral ray in head</td>
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<td>0.8-0.9</td>
<td>0.8-0.9</td>
<td>0.8-0.9</td>
<td>0.8-0.9</td>
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<td>Length of pelvic fin in head</td>
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<td>1.2-1.3</td>
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<td>Paratypes</td>
<td>Interspace between pelvic fins in pelvic base</td>
<td>1.4</td>
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<td>1.3-1.5</td>
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head, is slightly inclined upward to just beyond the origin of the first dorsal. The slope of the back is somewhat rounded beneath the first dorsal, but gradually declines posteriorly to the end of the second dorsal base, where it levels off. The ventral margin of the body is nearly horizontal anteriorly, but curves upward sharply at the origin of the anal and levels off again just behind the base of the anal. The caudal peduncle is rather stout.

Yearlings and small juveniles about 30 to 40 mm. in standard length are more elongate and have a body shape very much like that of *Etheostoma blennioides blennioides*.

The genital papilla (see Hubbs and Cannon, 1935: 11) of adult females is much better developed than that of adult males (in the type series, collected near the breeding season). In the female it is an unpigmented, subconical structure, somewhat flattened on the dorsal side and lying rather closely against the first spine of the anal fin. In adult females it is more than half as long as the first anal spine. In the adult male it is more flap-like and is much flattened, especially on its dorsal side. It has numerous, small, dark spots, which are more concentrated near the base, and is rather short, averaging about \( \frac{1}{2} \) as long as the first anal spine. The females are less brightly colored and differ in pattern, especially along the posterior side of the body, as is pointed out below.

In breeding or near-breeding adults the anal rays are heavily edged with tissue on either side. Nonbreeding adults and small specimens do not have this thickened tissue.

The spine on the posterior edge of the opercle is rather blunt. In *P. variatus* it is much longer and sharper. In the holotype the cheeks, opercle, breast, and angle between the supratemporal and lateral head canals are scaleless. In a small number of the paratypes there are a few embedded scales on the breast but the cheeks and opercle are scaleless.

The lateral-line system of the head is similar to that of the other fishes related to the *P. variatus* group discussed in detail by Hubbs and Black (1940: 5). The terminology here used is that employed by Hubbs and Cannon (1935: 10-11, Pl. II).
The lateral canal gives off 5 pores. The supratemporal commissure is complete; the median pore opens at the end of a tube which extends posteriorly a short distance. On either side is a lateral pore which opens directly over the canal. The coronal pore lies about on a line with the posterior border of the eye, whereas in *P. variatus* it is well in advance of the same line. The 2 anterior nasal pores are mesad and slightly in advance of the anterior nostrils; the 2 posterior nasal pores lie mesad and usually slightly in advance of the posterior nostrils. The infraorbital canal has 8 pores in some specimens, but the next to the last pore of one or both sides is lacking in several others; the holotype has such a pore on the right side only. The anterior series of 4 pores is rather strongly set off from the posterior group of 4, which open at the end of downward or backward extending tubes. The posteriormost pore of the anterior series presents an appearance very different from that of *P. variatus* or *P. osburni*, in which this pore lies at the end of an upward extending tube which reaches nearly to the eye. In *kanawhae* the tube is short; it extends upward only slightly in certain specimens, but downward for a short distance in others; in still other examples the pore opens on the canal. On the right side of the holotype the tube extends upward for a short distance and the pore opens upward. On the left side, however, the pore is lacking. In this character *kanawhae* appears to resemble *P. blennius* and *P. tetrazonus*. There are 10 pores in the operculomandibular series.

The holotype is a brilliantly colored male. The dorsal background of olivaceous brown is crossed by 6 prominent dark saddles, which are sharply set off from the adjacent olivaceous-brown scales. The first bar is located just in front of the first dorsal, the second is slightly in front of the middle of the first dorsal. It is the least pronounced of all the saddles and does not reach as far down on the sides as the others. The third saddle is at the posterior fifth of the first dorsal; the fourth is at the middle of the second dorsal; the fifth is immediately behind the second dorsal; the sixth crosses the caudal peduncle
near the base of the caudal fin. In about $\frac{3}{4}$ of the specimens the fifth and sixth are fused and thus form but 1 saddle. All the saddles except the second, which crosses the middle of the dorsal fin, extend below the lateral line on the side. The posterior sides have 6 prominent, transverse green bars with red-orange bars between. These more or less complete transverse red-orange bars (10, in all) are also found on the anterior sides. The bar just behind the pectoral base is more pronounced than are the 3 immediately posterior to it. These bars are not as well developed in younger males and are not found in females. Anteriorly, the lower sides are of a red-orange that merges into yellow above. The belly is pearl white. In the holotype, as in other males which are near the breeding season, the scales on the belly and lower sides are tipped with pearl white. The gill-membrane is red-orange, and the branchiostegals are yellow. The top of the head is dark; the snout is dusky with a yellow tinge. The opercle is dusky, and the cheeks have a large orange-yellow blotch. A dusky green, vertical band extends downward from the eye to the gill-membrane and is bordered in front by a yellow band. The chin is yellow-orange. An oval orange spot extends from the ventral end of the pectoral base to the anterior part of the pelvic base.

The first dorsal is strongly banded. At the base on the membrane is a row of greenish-yellow spots. This is bordered outwardly by a clear band, which in turn is bordered by a broad, green band. Next to the green band is another clear band and beyond that a bright orange-red band bordered on the extreme edge of the fin by a narrow clear area. The second dorsal is more somber, as the rays are relatively clear. The membrane near the base is dusky green with orange spots. Two-thirds of the distance from the base the membrane is orange, bordered on the outer edge by a clear area, and at the extreme edge of the fin is a narrow dusky-green band. The caudal fin has a green bar at its base, and the remainder of the fin is edged by a narrow green band. The main part of the caudal fin is slightly dusky, with four narrow, vertical, wavy
No. 434  *Poeciliichthys kanawhae*, a New Darter

red bands. The anal fin is dark green at the base and fades to pearl white at the edge, and has a few scattered orange spots on the membranes. The pelvic fins are green at the base and pearl-white at the edge, with a tinge of red-orange just inside the pearl edging. The pectorals are dusky at the base, greenish-yellow in the center, and clear on their outer borders. Four rows of wavy red spots parallel the posterior edge of the fin.

Adult females have the 6 (occasionally 5) dark saddles across the back, but the dark transverse bars on the posterior sides are not strongly developed. The general effect is rather that of a scattered mottling with an irregular or zigzag ventral border. The most anterior dark bar is better developed, extending downward from the first dorsal saddle behind the pectoral fins. They lack the bright orange and reds which are prominent on the body of the male. The pelvic and anal fins are white; there are a few dark spots on the anal fin. Both dorsals, the caudal, and the pectorals are dark-spotted. These spots appear in from 2 to 3 vertical rows on the caudal fin. There are also red-orange spots in the second dorsal, caudal, and pectoral fins, and those in the latter 2 fins are arranged more or less in rows. There is a row of faint, dusky spots near the base of the first dorsal, and a row of red-orange spots near the edge.

The yearlings are banded somewhat like *Etheostoma blennioides blennioides*. There are usually 10 irregular dark bars along the side. With the exception of the anal and pelvic fins are dark-spotted, somewhat as in the female.

**Supplementary Records.**—On April 4, 1941, many additional specimens of *Poeciliichthys kanawhae* were collected in southwestern Virginia in the tributaries of the New River. It was found in Carroll County in Little Reed Island Creek, 1 mile northwest of Hillsville; Crooked Creek, 1 mile southwest of Woodlawn; Snake Creek, 7 miles southeast of Hillsville; Big Reed Island Creek, 5.5 miles northeast of Hillsville. Specimens were also collected in Chestnut Creek, 1 mile south of Galax, Grayson County, and in the West Fork of Little River,
5.5 miles northeast of Willis, Floyd County. It was the most common darter in the riffles. No specimens of *P. osburni* were taken in the same streams.

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1923 A List of Fishes, Amphibians and Reptiles Collected in Ashe County, North Carolina. Zoologica, 4: 3-23, Figs. 1-8.

HUBBS, CARL L.

HUBBS, CARL L., AND JOHN D. BLACK

HUBBS, CARL L., AND MOTT DWIGHT CANNON

HUBBS, CARL L., AND EDWARD C. RANEY

HUBBS, CARL L., AND MILTON B. TRAUTMAN

**PLATE I**

Paratype of *Percichthys incisa*, an adult male in breeding dress, 70 mm. in standard length, from North Folk of New River, near Creston, Ashe County, North Carolina.
POEILACTYHS KANAWHAKE

PLATE 1
HADROPTERUS NASUTUS, A NEW DARTER FROM ARKANSAS

BY REEVE M. BAILEY

It has long been apparent that the Ozarkian upland is a region of marked endemism for fishes, particularly among the Cyprinidae and Percidae. Another species, presumably confined to this area, is herein described from the White River basin in Arkansas under the name H. nasutus. It is allied to the recently described H. oxyrhynchus Hubbs and Raney (1939) from the Cheat and New rivers in Virginia and West Virginia.

Employing ratios based upon differences in snout length and other head proportions among several species of Hadropterus, Hubbs and Raney (1939: 3) stated that, "in respect to these ratios, as well as in certain other characters, the species maculatus, macrocephalus, phoxocephalus, and oxyrhynchus form a graded series, in which oxyrhynchus stands at the extreme end of the line of specialization." In the elongation of the head and snout nasutus is even more specialized than oxyrhynchus, and should follow that species if inserted in the above sequence. Essential similarities in coloration, especially the uniform possession of a subterminal orange band in the spinous dorsal fin, and various common structural characters,
Reeve M. Bailey

indicate a close interrelationship of *phoxocephalus*, *oxyrhynchus*, and *nasutus* as contrasted with other species of *Hadropterus*. *H. oxyrhynchus* and *nasutus* are both upland forms, each with an apparently restricted geographic range, whereas *phoxocephalus* occurs at lower elevations and is more widely distributed, ranging from western Pennsylvania and Tennessee to Wisconsin, Iowa, Kansas, and Oklahoma. It seems probable that the marked similarity between *oxyrhynchus* and *nasutus* is due to common ancestry, but possibly they were independently derived from *phoxocephalus* or a *phoxocephalus*-like form.

The presence of seven branchiostegal rays in *nasutus* is a remarkable feature. Six branchiostegal rays have heretofore been considered characteristic of the Etheostomatinae. In an examination of all other species of *Hadropterus* and of many species of other darter genera variations in branchiostegal-ray counts from the normal number, six, were found in only two species. One of thirteen specimens of *H. roanoka* had five rays on each side; the others 6-6. In twenty-three specimens of *H. oxyrhynchus* one had 7-7, one 6-7, and twenty-one 6-6. The presumably normal presence of seven rays in *nasutus* and the occasional occurrence of this number in *oxyrhynchus* may be considered as genetic holdovers from the condition in the ancestral Percinae, and thus as further evidence of the generalized or primitive condition of *Hadropterus* among the Etheostomatinae. On the other hand, the transition from six rays in *phoxocephalus*, to six or seven in *oxyrhynchus*, and finally to seven in *nasutus* may represent a specialization independent of the condition in the Percinae. The additional ray is of obvious adaptive significance because the region of the branchiostegal membrane is unusually elongated. The latter view, which appeals to me as the more plausible, tends neither to prove nor to disprove the primitiveness of *Hadropterus*. In recognition of the close similarity between *nasutus* and certain species of *Hadropterus* and in view of the observed variation

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2 Dr. Carl L. Hubbs has examined several species not available to me and has offered suggestions in the preparation of this paper.
in branchiostegal-ray count in *oxyrhynchus*, it seems unwise to erect a new genus for the reception of *nasutus*.

**Hadropterus nasutus**, new species

(Pl. I, Figs. 1 and 3)

Longnose Darter

**Typ**es.—The holotype is an adult male (U.M.M.Z. No. 132-898), 65.5 mm. in standard length, collected in the Middle Fork of the Little Red River (tributary to the White River) near the bridge at U. S. Highway 65, 1.5 miles southeast of Leslie, Searcy County, Arkansas, on August 17, 1940, by Reeve M. Bailey and Max E. Davis (field number B40: 37). The single paratype (I.S.C. No. 2), an adult female, 63.0 mm. long, was taken with the holotype.

**Diagnosis**.—A slender species of *Hadropterus* allied to *phoxocephalus* and *oxyrhynchus*, and, like those species, with a conspicuous submarginal orange band in the spinous dorsal. Snout very long and narrow, 3.05 in head (including opercular membrane) and 1.7 times length of orbit. Head longer than in other species of *Hadropterus*, 3.0 to 3.2 in standard length. In the excessive prolongation and compression of the snout *nasutus* (for comparative photographs with *phoxocephalus* see Pl. I) is approached only by *oxyrhynchus*. From that species *nasutus* differs in several proportionate measurements: the upper jaw is contained 3.0 to 3.05 times in the head length in *nasutus*, 3.2 to 3.5 in *oxyrhynchus*; the least depth of the caudal peduncle is contained 3.7 times in the head length in *nasutus*, 3.0 to 3.4 in *oxyrhynchus*; the median fins are proportionately lower and the paired fins relatively shorter in *nasutus* (compare values in following description with those given in Hubbs and Raney’s Table II); the snout and the head are relatively longer in *nasutus*; and the midventral scales of the belly are less well developed. The scales are rather small, 73 to 83 along lateral line; nape and cheek with small scales,

* Nasutus = long nose.
Reeve M. Bailey

opercle with rather large, ctenoid scales; midventral scales of belly moderately enlarged in males, not differentiated in females. Dorsal XIII–12 or 13; anal II, 8 or 9; pectorals 13 or 14. Preopercle entire, the lower limb much longer than upper. Gill-membranes moderately united; the distance from their union to insertion of pelvic fins 1.8 to 1.9 in distance from tip of mandible to union of gill-membranes. Branchiostegals rays 7, a number characteristic of no other darter so far as known.

DESCRIPTION.—Many features of form and coloration are illustrated in Plate I, Figures 1 and 3. The body is slightly compressed and elongate, width 2.7 (2.9) in head length and depth 6.0 (6.5) in standard length. The head (including opercular membrane) is longer than in any other species of Hadropterus, 3.0 (3.2) in standard length. The caudal peduncle is rather slender, its least depth 3.7 in head length. The median fins are low: highest dorsal spine 4.0 (3.4) in head; highest dorsal soft ray 2.75 (2.8) in head; longest caudal ray 2.0 (1.9) in head; and highest anal ray 2.45 (2.3) in head. The short pectoral fin extends back as far as the tip of the pelvic fin, its longest ray 1.6 (1.55) in head, and the pelvic fin extends about half the distance from its insertion to origin of anal, its length 1.85 (1.8) in head. The depth of the elongate head is contained 2.3 (2.2) times in its length, and its width 2.6 (2.7) in the length. The eye is not unusually small for a species of Hadropterus, but because of the great length of the head the orbital length is contained 5.3 (5.0) times in the head length. The greatly produced snout presents a gently sloping lateral profile and a sharply angulate outline from above (see Pl. I, Figs. 1 and 3); its length is contained 3.05 times in the head length. The mouth is large: the maxilla extends to below

5 Body proportions and numerical counts are those of the holotype; if the paratype differs from the holotype the figure is given in parenthesis.

The length of the orbit is obtained by placing the tips of the dividers at the edges of the eye and spreading them with a gentle pressure. The orbital measurement is not comparable with the eye length employed by Hubbs and Raney.
the anterior margin of the orbit, and the upper jaw length is contained 3.0 (3.05) times in the head length. The orbit is contained 1.7 times in the snout length; the narrow, fleshy interorbital, 2.1 (1.9) times in the orbital length. The orbital length is received 3.4 (3.3) times in the distance from the tip of the mandible to the union of the gill-membranes, a measurement reflecting the great length along the lower side of the head and the wide connection of the gill-membranes. The distance from the insertion of the pelvic fins to the union of the gill-membranes is contained 1.8 (1.9) times in the distance from the tip of the mandible to the union of the membranes. The comparable measurement ratios are 0.8 to 0.95 in palmaris (Bailey, 1940), 0.5 to 1.0 in maculatus, 0.8 to 1.2 in macrocephalus, 1.1 to 1.5 in phoxocephalus and 1.5 to 1.8 in oxyrynchus.

The spinous and soft dorsals are slightly separated. The dorsal rays number XIII–12 (13). The two anal spines are subequal in length, but the first is considerably stronger than the second; there are 9 (8) anal soft rays. The caudal is slightly emarginate, with 17 principal rays, of which 15 are branched. The pelvic fins are separated by a space about equal to four-fifths of the pelvic base. The pectoral rays (both sides) number 13–13 (14–14).

There are 11 (12) scale rows as counted from the soft dorsal downward and backward to the lateral line, 76–73 (83–77) scale rows along the complete lateral line to base of caudal on left and right sides respectively, and 16 (15) rows as counted from the origin of anal upward and forward to the lateral line. The minimum enumeration of scale rows around the caudal peduncle is 29 (27). The nape is completely covered with minute scales. The upper portions of the cheeks are clearly scaled, but the lower parts appear to be scaleless, because the few, small, cycloid scales are embedded. The opercles are completely covered with ctenoid scales comparable in size to those of the body. The breast is naked except for a single, en-

1 The last ray of the soft dorsal and anal fins was counted as double at the base.
larged scale near its center. Between the pelvies there is a single, enlarged, median scale, followed posteriorly by an area of undifferentiated, embedded scales for half the length of the pelvic fins. In the holotype, a male, the remainder of the mid-line of the belly is provided with a series of moderately enlarged and strongly ctenoid scales. In the adult female of *H. nasutus* these scales are not differentiated. In the female of *H. pheroxephalus* these scales are hardly modified, and in other species they are weaker in that sex than in the male.

The preopercle is entire, and smoothly curved; the horizontal arm is almost twice the length of the vertical arm. The broad premaxillary frenum is much wider than the fleshy, terminal, upper lip, and equal to the length of the pupil. The slender mandibles diverge narrowly but regularly, forming a very sharp angle. The mandibular frenum is about half the width of the premaxillary frenum. Both upper and lower lips are greatly expanded and flaplike. The lower jaw is slightly included within the upper lip. The vomer bears a strong cluster of teeth, and the palatines are strongly toothed. The dentigerous surfaces of the premaxillae and dentaries are greatly expanded anteriorly. The branchiostegal rays number 7 on each side of both specimens.

The sensory pores and canals of the head agree with the description of those structures in *oxyrhynchus* (Hubbs and Raney, 1939: 4). Eleven operculomandibular pores were counted on the right side of the holotype, but only 10 in the other three counts. The complete lateral line is almost straight.

The genital papilla of the adult male is a subquadrate, depressed, longitudinally rugose flap; that of the adult female is slightly shorter and more rounded posteriorly.

COLORATION.—The most conspicuous character of the living specimens was the bright orange submarginal band on the spinous dorsal. The entire dorsal surface was dull yellow-orange. In preservation there is an enlarged, dark humeral spot, and a small but distinct black spot at the base of the caudal fin. Along the side there is a series of from 10 to
14 vertically elongate, dark lateral blotches, which are mostly narrower than the interspaces and tend to be narrower and higher anteriorly and more quadrate along the caudal peduncle. On the dorsal surface there are many irregular but distinct blotches and crossbands of brownish black (in preservation; see Pl. I, Fig. 3). A pronounced dark streak extends backward from the snout through the eye; it continues across the upper part of the cheek and opercle, but is here less intense and more diffuse. There is no trace of a subocular dark bar (such a bar is present in *phoxocephalus*).

The spinous dorsal is thickly sprinkled with dark chromatophores except in the area of the orange band. The soft dorsal and anal are faintly dusky in preservation and the caudal is crossed by three irregular vertical bars. A trace of pale yellow is still visible at the caudal base in the preserved specimens.

**Habitat.**—*H. nasutus* is known only from the type locality. The Middle Fork of the Little Red River at this point presented a diversity of habitats, and yielded twenty-seven species of fish. The water was clear, colorless, and warm; the current varied from almost stagnant backwaters to swift riffles, and the width, from twenty-five to seventy-five feet. The bottom was composed largely of gravel and rubble, but there was some silt in quiet-water areas. The flow was estimated at ten cubic feet per second.

The two specimens of *nasutus* were seined in quiet water where there was an abundance of vegetation (*Potamogeton*, yellow pond lily, and algae). The bottom was of silt and the depth was about three feet. Associated species included *Erimyzon oblongus claviformis*, *Hyborynchus notatus*, *H. salmoides*, *Lepomis macrochirus*, *Lepomis megalotis*, and *Ambloplites rupestris*. An excellent rubble riffle nearby contained an abundance of darters of four other species.
LITERATURE CITED

BAILEY, REEVE M.
1940 *Hadropterus palmaris*, a New Darter from the Alabama River System. Journ. Wash. Acad. Sci., 30: 524-30, Fig. 1.

HUBBS, CARL L., AND EDWARD C. RANEY

PLATE I

Comparative photographs of *Hadropterus nasutus* and *H. phoxocephalus*.

Fig. 1. *Hadropterus nasutus*, new species. The holotype.

Fig. 2. *Hadropterus phoxocephalus*, a specimen 46.5 mm. in standard length; from the Raccoon River, Dallas County, Iowa.

Fig. 3. *Hadropterus nasutus*, the anterior portion of the holotype viewed from above, to show the slender, tapering snout and the color pattern of the dorsum.

Fig. 4. *Hadropterus phoxocephalus*, anterior portion of the specimen shown in Figure 2 viewed from above, to show the broader and more rounded snout and the characteristic color pattern of the dorsum. (Photographs by Max E. Davis.)
Among the most incompletely known of the fresh-water fishes of the eastern United States are the small, venomous catfishes, popularly referred to as "madtoms." In the present paper we present data on the nomenclature and characters of four species, listed below in terms of current usage as well as of the proposed nomenclature:

<table>
<thead>
<tr>
<th>NAME IN CURRENT USE</th>
<th>PROPOSED DESIGNATION</th>
</tr>
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<tbody>
<tr>
<td>Schilbeodes or Rabida insignis</td>
<td>1a. <em>S. marginatus marginatus</em></td>
</tr>
<tr>
<td></td>
<td>1b. <em>S. marginatus atrorus,</em> new subspecies</td>
</tr>
<tr>
<td>Schilbeodes or Rabida ensis</td>
<td>2. <em>Schilbeodes insignis</em></td>
</tr>
<tr>
<td>Schilbeodes or Rabida gilberti</td>
<td>3. <em>Schilbeodes gilberti</em></td>
</tr>
<tr>
<td>Schilbeodes pyrius</td>
<td>4. <em>Schilbeodes mollis</em></td>
</tr>
</tbody>
</table>

This report is based on a study of material in the Museum of Zoology of the University of Michigan (U.M.Z.), Cornell University (C.U.), and the United States National Museum (U.S.N.M.). We are particularly grateful to Dr. Leonard P. Schultz, Curator of Fishes, United States National Museum, for permission to study and report on the specimens in the National Museum collection. Much of the material used in
this study was collected by the junior author during the course of field explorations, which were supported by a grant from the Faculty Research Fund of Cornell University.

Genus *Schilbeodes* Bleeker


Prior to 1930 it had not been noticed by American ichthyologists, nor has it been noted by the compilers of *Nomenclators*, that LeSueur introduced the name *Pimelodon*, for a species of *Schilbeodes*. LeSueur’s name has priority over Bleeker’s. A question might be raised as to whether LeSueur proposed a new name or merely a substitute spelling for *Pimelodus Lacépède*. In his 1819 paper, however, LeSueur used *Pimelodus* as the equivalent of *Piméclose* for his first species, then abbreviated this name for the subsequent species, until he came to the one which he called “*Pimelodon livré*.” This name has been listed wrongly as “*Piméclose livré*” in all synonymies from the time of Valenciennes (1840: 144), except those of Vaillant (1896: 28) and of Jordan, Evermann, and Clark (1930: 156). We interpret *Pimelodon* as unavailable prior to 1896, because until that time it was nonbinomial. The species name was given by LeSueur in the French vernacular, and the Latin equivalent, *Pimelodus insignarius*, was not published until 1896. *Schilbeodes* was available proposed in the meantime, it is retained. We regard *Pimelodon LeSueur*
as available as of 1896, when republished by Vaillant. If the genus should be divided, a problem would arise as to whether this name would have priority over Rabida Jordan and Evermann (1896).

We prefer, however, to follow Jordan and Evermann in referring all of the species of Ameiuridae with an adnate adipose fin, other than the stonecat, Noturus flavus, to one genus, Schilbeodes Bleeker. There appears to be no clear-cut line of demarcation between the species having a smooth pectoral spine (Schilbeodes) and those with a serrated pectoral spine (Rabida), because the species that are extreme in this character, namely S. leptocanthus and S. furious, are connected by a virtually unbroken chain of forms showing intermediate degrees of pectoral-spine serration. The other characters which were used by Jordan and Evermann to distinguish Rabida, either as a subgenus or a genus, are even less tangible.

EASTERN MADTOM

1. Schilbeodes marginatus (Baird)

The eastern madtom has long been known as Schilbeodes insiginis, or by some authors, recently, as Rabida insiginis. It now becomes evident (see p. 22) that the name insiginis belongs with the related species of the Mississippi Valley, currently known as Schilbeodes or Rabida exilis. Hence the next available name, marginatus, is resurrected for the eastern madtom. This species is divisible into at least two subspecies. The synonymy is given in full under the subspecies headings.

Schilbeodes marginatus (the "insignis" of recent authors) has generally been interpreted as the exclusively Atlantic coast representative of S. exilis (the true insignis). It was recorded long ago, however, from the upper Kanawha or New River system by Cope, whose Sinking Creek record has been repeated by Fowler (see synonymy). Cope's report was apparently the basis for the early records of the Atlantic coast form from "upper Ohio valley," "Ohio River," and finally "Ohio." We, too, have collected madtoms of the insignis group in the New River system in Virginia. They prove to be
related more closely to *S. marginatus* than to the true *S. insignis*. They seem, however, to be distinct enough to warrant subspecific separation and are here referred to the new subspecies, *Schilbeodes marginatus atrorus*, characterized by the sharply bicolored, black-bordered fins (especially the caudal fin). The more widespread subspecies takes the name *S. m. marginatus* (p. 6).

*S. m. atrorus* occurs also in the Atlantic coast drainage basin, for the same type—though not quite so extreme—occupies the Roanoke River system. Except for this insertion of *S. m. atrorus* in the middle of its range, *S. marginatus* is relatively consistent in its characters. From the northern limit of the species in the Merrimack River system of New Hampshire (Hoover, 1936: 239; Bailey, 1938: 151, 172, 182) southward to the Susquehanna River drainage basin in Pennsylvania and Maryland, and again in the stream systems of the Carolinas and Georgia south of the Neuse, the fins are rather evenly pigmented, grading outward to weakly blackish margins or dusky submarginal bands.

In the Potomac, James, and Chowan systems north of the Roanoke and in the Tar and Neuse systems to the south, the coloration approaches that of *atrorus*. A gradient in color pattern is thus indicated:

1. Fins consistently approaching a unicolor pattern, merely dusky or blackish toward margin: *S. m. marginatus*, in the northern and southern but not in the central part of the Atlantic coast drainage.

2. Fins in some fish nearly unicolor but often more sharply marked, yet without a definitely black border, except in a few individuals: *S. m. marginatus*, in the Potomac, James, Chowan, Tar, and Neuse river systems (to the north and south of the Roanoke system).

3. Fins sharply bicolor, often very sharply so, occasionally rather indefinitely bicolor: *S. m. atrorus*, slightly atypical, in the Roanoke River system.

4. Fins consistently very sharply bicolor: typical *S. m. atrorus*, in the upper Kanawha (New) River system.
Each category in this gradient shows some intergradation with the adjacent ones, because of extensive individual variation.

A peculiar type of intergradation is thus indicated. For some distance on either side of the centrally located Roanoke River system (where the range of *S. m. atrorus* splits the distributional territory of *S. m. marginatus* into two parts), some of the individuals in certain irregularly scattered localities closely approach *S. m. atrorus* in coloration. This is true in the Potomac drainage about Washington, and in the James River system. Thus, out of 52 specimens collected in the Catawba River of the James system, north of Fincastle, Virginia, 2 or 3 have the caudal and first dorsal fins quite as sharply bicolored as in *S. m. atrorus* from the Roanoke, with black margins and almost no melanophores elsewhere; many have the fins almost uniformly dusky, darkening somewhat outward; still others provide a transition. From the Chowan system, separated from the Roanoke only by tidal inlets, we have seen one series, from Waqua Creek, Brunswick County, Virginia, which almost equals *atrorus* in the bicoloration of the fins, and 2 specimens, from the Blackwater River at Zuni, Virginia, which are very definitely of the *S. m. marginatus* type (with almost uniformly dusky fins). Many of the Neuse River fish are like typical *marginatus* or merely approach *atrorus*, but two specimens, collected long ago by J. W. Milner at Kinston, North Carolina, might, in the absence of contrary evidence of geographical variation, be referred to *S. m. atrorus*.

It is barely possible that these specimens from Kinston, North Carolina, may represent a local population of *S. m. atrorus* that exists, or that formerly existed, in the lower Neuse River. Both have 17 anal rays (a rather low number). For comparison with the data in Tables I–III, we give the proportions for these specimens. Measurements in standard length (94 and 99 mm.): body depth, 5.4–6.2; predorsal length, 2.9–3.0; head length, 3.8–4.1. Measurements in head length: head depth, 2.3–2.4; head width, 1.3–1.4; fleshy interorbital, 2.5–2.7; snout length, 2.8–2.9; dorsal spine, 3.1–3.3; pectoral spine, 1.6–1.8; pectoral fin, 1.3–1.5. Pectoral spine in pectoral
fin, 1.3 in both; orbit length in snout length, 2.0-2.4; caudal ratio 1, 1.7-1.8; caudal ratio 2, 2.6-2.7.

Two misuses of the name marginatus caused some confusion in the early literature: (1) The name Noturus marginatus was listed by Nelson (1876: 50), with the range "Wabash valley and south (Jordan)," for a species which Jordan (1878b: 68) soon afterward identified as Noturus micrus. (2) Noturus occidentalis Gill (1862: 45-46), from the Platte River, an obvious synonym of Noturus flavus, has been confused with Schilbeodes marginatus. Günther (1864: 105) described, as Noturus occidentalis, some specimens sent to the British Museum by the Smithsonian Institution, but his description applied to Schilbeodes marginatus, as Jordan (1877a: 372; 1877b: 99) noted, on the advice of Gill. Günther's locality, Platte River, was presumably taken from Gill's account rather than from his own specimens. The fact that Günther associated this locality with a description of Schilbeodes marginatus led to the inclusion of "Nebraska" and "Platte River" in the range of Noturus insignis as given by Swain and Kalb (1883: 640).

Key to the Subspecies of Schilbeodes marginatus
1a.-Vertical fins dusky, bordered with darker (except for a fine whitish edge); entire caudal fin rendered more or less dusky by widespread melanophores. Dorsal and pectoral spines averaging shorter (in the typical, northern race), Atlantic coast drainages, from the Merrimack in New Hampshire to the Oconee in Georgia (exclusive of the Roanoke) ... S. m. marginatus
1b.-Vertical fins strongly bicolored, pale toward base but blackish to jet-black in an outer band; caudal fin almost clear of pigment in the light part. Dorsal and pectoral spines averaging longer than in the typical, northern race of S. m. marginatus. Basins of the Roanoke and upper Kanawha systems, Virginia ...... S. m. atroris

COMMON EASTERN MADTOM
1a. Schilbeodes marginatus marginatus (Baird)

Fishes of the Genus Schilbeodes.


Noturus occidentalis (misidentification).—Günther, 1884: 105 (description only).

Noturus flavus (misidentification).—Uhler and Lugger, 1876: 151 (description; ecology; Maryland records). Nelson, 1890: 671 (description; Vermont to Virginia and westward; in New Jersey catalogue).


Jordan, 1890: 101, 109, 114, 125, 127, 133, 134, 136 (coloration; habitat; records, Virginia and North Carolina). Bean, 1892: 19-20, Pl. 19, Fig. 26 (description; use as bait; synonymy, etc., in part; range). Evermann and Cox, 1895: 204, 308-9 (records, Neuse River system). Jordan, 1899: 42 (diagnosis; range).

Schilbeodes insignis.—Jordan and Evermann, 1896a: 145, 147 (comparisons; synonymy, and nomenclature in part; designation of type series of N. marginatus from Pennsylvania); 1896b: 234 (range; synonymy); 1900: 3236, Pl. 28, Fig. 66 (Consy Creek, Bainbridge, Pennsylvania). Bean, 1903: 95-96, 489, 740 (synonymy in part; description; range). Fowler, 1904: 173, Pl. 15 (description; Crosswicks Creek near Trenton, New Jersey). Smith, 1907: 70 (diagnosis; range, especially in North Carolina). Fowler, 1915: 208-9 (records—except those For Virginia and Missouri). McAtee and Weed, 1915: 5-7, 10, and Radcliffe and Welsh, 1916: 40-41 (Potomac River system and Maryland records). Welsh, 1916: 54 (records, Poconos systems). Fowler, 1917a: 110, 117 (Harlinsake Creek, New Jersey; Pennsylvania records); 1917b: 54-56, 1 pl. (breeding habits; coloration; associated species; Tohickon Creek, Pennsylvania); 1918: 90, and 1919: 57 (Pennsylvania records); 1920a: 299 (Pampeck Lake outlet, Pennsylvania); 1920b: 150 (New Jersey records); 1921a: 287, and 1921b: 63 (Pennsyl-


**Rhabdia gilberti** (misidentification).—Fowler, 1935: 19, Fig. 37 (South Carolina records).

**Habom.—Odell, 1935: 132 (Delta Lake, New York).**

Margined madtom.—Odell and Senning, 1936: 85, 86 (lake records, Delaware and Susquehanna river systems, New York); 1938: 99 (Waneta Lake, New York).

RANGE (Map 1) AND GEOGRAPHICAL VARIATION.—As already noted (p. 4) the range of the typical subspecies, *S. m. marginatus*, is the Atlantic coast drainage, from the Merrimack River system in New Hampshire southward to Georgia, with a break in the Roanoke system, which is occupied by *S. m. atrorus*. Average differences can be detected in comparing samples of *S. m. marginatus* from north and south, respectively, of the range of *S. m. atrorus*. The chief difference so far noticed lies in the length of the pectoral spine. This spine, measured from its extreme base, enters the head 2.1 to 2.8 (average, 2.35) times in 14 specimens from the north; 1.6 to
2.5 (average, 2.06) times, in 20 fish from south of the Roanoke. In 13 specimens of each form the dorsal spine enters the head 3.0 to 4.3 (average, 3.35) times in the north, and 2.4 to 3.6 (average, 3.08) times in the south. Some of the overlap is probably due to age and sex rather than to geographical variation. Eventually, the subspecies *S. m. marginatus* as here delimited may be further subdivided, but the data at hand hardly warrant such action.

The populations of *S. m. marginatus* north and south of the Roanoke also differ a little in the average number of anal rays (Table I). The average number is slightly higher in the south than in the north. Thus, in respect to both the length of the spines and the number of anal rays, *Schilbeodes marginatus* follows the trend of geographic variation that is characteristic of the Amiaulidae (Hubbs, 1940: 209-10).

The southern limit of *S. m. marginatus* seems to be the Oconee River system in eastern Georgia. Jordan (1878c: 414)

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>NUMBER OF ANAL RAYS IN FIVE FORMS OF SCHILBEODES</th>
</tr>
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<tbody>
<tr>
<td>All rays were enumerated. The skin was slit at the front of the fin to make sure of an accurate count.</td>
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</table>

<table>
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<tr>
<th>Form</th>
<th>Number of Anal Rays</th>
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<tr>
<td></td>
<td>14 15 16 17 18 19 20 21 22 No. Ave.</td>
</tr>
<tr>
<td><em>S. m. marginatus</em></td>
<td></td>
</tr>
<tr>
<td>N. of Roanoke R. system</td>
<td>1 10 9 2</td>
</tr>
<tr>
<td>S. of Roanoke R. system</td>
<td>2 6 7 4</td>
</tr>
<tr>
<td><em>S. m. atrorus</em></td>
<td></td>
</tr>
<tr>
<td>Kanawha River system</td>
<td>1 6 11 9 2</td>
</tr>
<tr>
<td>Roanoke River system</td>
<td>3 6 7 4 2</td>
</tr>
<tr>
<td><em>S. marginis</em></td>
<td></td>
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<tr>
<td>Mississippi R. system</td>
<td>1 1 2 10 2 2</td>
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<tr>
<td><em>S. leptocomius</em></td>
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<td></td>
</tr>
<tr>
<td>S. New York and New Jersey</td>
<td>4 6 8 2</td>
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</table>
listed the range of the eastern madtom as Pennsylvania to Georgia, but subsequent authors (other than Hubbs and Lagler, 1941: 64) have indicated South Carolina as the southern end of the distribution. Two small series from Georgia, in the University of Michigan Museum of Zoology, were collected on November 12, 1931, by Donald Ameel, in South Fork of Broad River near Danielsville, Madison County, and in Aliens Creek, of the Oconee River system, north of Talmi. These and the other record stations are charted on Map 1.

MEASUREMENTS.—Additional measurements made on 10 specimens of *S. m. marginatus*, 5 from north and 5 from south of the Roanoke basin, indicate no definite geographic trend, but are given (combined) for comparison with the data on *S. m. atrorus* and *S. insignis*:

Measured into standard length:
- Body depth, 5.8 to 6.9 (average, 6.3)
- Preadoral length, 2.7 to 3.0 (average, 2.9)
- Head length, 3.7 to 3.9 (average, 3.75)

Measured into head length:
- Head depth, 2.9 to 3.3 (average, 2.2)
- Head width, 1.2 to 1.5 (average, 1.3)
- Fleshy interorbital, 2.2 to 3.0 (average, 2.7)
- Snout length, 2.6 to 3.0 (average, 2.8)
- Pectoral fin length, 1.3 to 1.5 (average, 1.45)

Measured into pectoral fin:
- Pectoral spines, 1.3 to 1.5 (average, 1.4)

Measured into snout length:
- Orbit length, 2.0 to 2.7 (average, 2.3)

Measured into distance from origin of dorsal to adipose notch:
- Distance from adipose notch to end of caudal fin, 1.3 to 1.7 (average, 1.5)

Measured into distance from origin of anal to base of caudal:
- Distance from origin of lower procurent caudal rays to base of caudal, 2.5 to 2.9 (average, 2.7)

BLACKBORDERED EASTERN MADTOM

*Schilbeodes marginatus atrorus*, new subspecies

(Plate I)

*Noturus marginatus* (identification correct to species only).—Cope, 1868: 237 (characters, in part; "Sinking Creek of the Kanawha").
No. 487

Fishes of the Genus Schilbeodes


Noturus insignis (misidentification).—Jordan, 1878a: 368 ("Upper Ohio river"—basin understood); 1889: 353 (comparison; Roanoke River at Roanoke, Salem, and Alleghasy Springs); 1890: 118, 121-22 (same material; habitat; color).

Schilbeodes insignis.—Fowler, 1915: 9 (Sinking Creek, Virginia). Hubbs and Lagler, 1941: 65 ("the Kanawha River system of West Virginia [sic] (subspecies)").


Range (Map 1).—The typical race of this subspecies occupies the upper Kanawha or New River system, above the Kanawha Falls. The known specimens are all from Virginia, but the form no doubt occurs also in West Virginia and probably in North Carolina, in the same drainage basin. The same form, not quite so extreme in its characters, inhabits the Roanoke River system in Virginia. The habitat of S. m. atrorus is thus interpolated in the middle of the range of S. m. marginatus; an example of medial (as opposed to peripheral) differentiation. By individual variation specimens from several river systems to the north and to the south of the Roanoke exhibit a partial intergradation between the subspecies—as already pointed out.

Schilbeodes marginatus atrorus takes its place among the few members of a fauna that transgresses the Alleghenian divide to occur also in the upper Kanawha system. As this montane fish fauna has not been well defined in the literature, we list here the component species (excluding fishes, like Salvelinus fontinalis and Rhinichthys cataractae, which are widespread in the north and range southward along the two sides of the mountain divide):

1. Thoburnia rhodanea (Thoburn).—This sucker was described (Thoburn, in Jordan and Evermann, 1896a: 183) as probably from the French
Hubbs and Raney. Oco., Papers 8

Broa.d River at Wolf Creek, Tennessee. It has never been retaken in the Tennessee River system, but was rediscovered in the James system (Hubbs, 1930: 43-44), to which it was then thought to be confined. It has since been taken in the Roanoke system, and one specimen in Cornell University is included in a collection made by Dr. A. H. Wright near White Sulphur Springs, West Virginia, in the upper Kanawha system. In our collecting we have failed to find it in that region. Thorius bathos is, therefore, doubtfully included in the present list.

2. Chromosoma orca Cope.—This dace has been regarded as confined to the Roanoke and James river systems of the Atlantic drainage, but has also been taken by the junior writer in the upper Kanawha basin (in West Fork of Little River, 5.5 miles east northeast of Willis, Floyd County, Virginia; April 4, 1941).

3. Noemis leptocephalus (Girard).—When it was revalidated (Hubbs, 1926: 28-29, Pl. 1, Fig. 2; Pl. 2, Fig. 2), this chub was thought to be confined to the coastal drainage. Recently, however, it has been found to live also in the upper Kanawha River system. The junior author took it with Chromosoma orca in the West Fork of Little River, and George W. Burton collected it in Spruce Run, a tributary of New River in Giles County, Virginia.

4. Notropis albicollis Jordan.—This shiner is listed as confined to the Atlantic coast drainage, from the Roanoke system southward, but we have also indentified it from the upper Kanawha basin, at several localities in Virginia and West Virginia. We suppose that Goldsborough and Clark’s record (1908: 35) of Notropis cornutus from Horsepen Creek, Virginia (in the Kanawha system) must have been based on the similar species, N. albicollis, for N. cornutus is one of the common Mississippian species that is seemingly absent in the upper Kanawha waters.

5. Comprocosoma anomale, subspecies.—This is a fine-scaled montane subspecies that transgresses the Alleghenian divide at several points. In the south Notropis rubricorpus occurs on both sides of the divide (Jordan and Evermann, 1896a: 286).

On the Mississippi Valley side of the mountains most of these species conform with S. marginatus in being confined to the distinctive upper Kanawha fauna, which is separated by the Kanawha Falls from the Ohio River fauna (Hubbs, 1931; Hubbs and Trautman, 1932; Hubbs and Raney, 1939; Raney, 1941).

The Mississippi Valley species, Schilbeodes insignis, occurs in the Ohio River system below the Kanawha River. Material from Indiana and from the Tennessee River system is essentially typical of the Mississippi Valley species (exilis = insignis),
as here distinguished. The record station of *S. insignis* which most closely approaches the range of *S. m. atror* is the Guy­andotte River, a tributary of the Ohio River, in West Virginia. On being re-examined in the National Museum, the single specimen from this locality (first reported by Evermann and Goldsborough, 1908: 33) is found to be referable to *insignis*. The borders of the anal and caudal are merely dusky. Traces are retained of the dark blotch about the front of the first dorsal fin. Most of the proportions are also typical of *insignis* as listed in Table III: caudal ratio, 1.7; caudal ratio 2, 3.0; pectoral spine in head, 3.1 (shorter than in any other specimen of *insignis* measured); pectoral fin in head, 1.75; pectoral spine in pectoral fin, 1.7; predorsal length in standard length (80.5 mm.), 3.15; head length, 3.8. The head is about as large and deep as in *marginatus*, suggesting either a slight tendency toward intergradation with *marginatus*, or an independent local differentiation.

**MATERIAL.**—The holotype, 112 mm. in standard length, was seine by Carl L. Hubbs and family on August 22, 1936, in Wolf Creek, at U. S. Highway 52, between Bastian and Novis, Bland County, Virginia; U.M.M.Z., No. 139452.

Fifteen paratypes, like the holotype from the upper Kanawha (New) River system in Virginia, bear the following data:

- U.M.M.Z., No. 139453: 8 specimens, taken with the holotype.
- U.M.M.Z., No. 138523: 5 specimens, obtained by E. C. Rousey, E. A. Lauchner, and L. J. Kezer, on March 31, 1940, in Reed Creek, 1 mile southwest of Wytheville, Wythe County.
- U.S.N.M., No. 104091: 2 juveniles, collected by L. P. Schultz and Earl D. Reid, on June 17, 1937, in Sinking Creek, 3 miles above its mouth in the New River, Giles County. This is the stream from which Cope first recorded the subspecies (under the name, *Noturus marginatus*).

Specimens from the Roanoke River system are not designated as paratypes. The following series, all from the Roanoke basin in Virginia, were studied:

- U.S.N.M., No. 40194: 8 specimens (1 now in Cornell University collection), 63-116 mm. long, secured by Jordan in the Roanoke River, at Roanoke.
Hubbs and Raney

U.S.N.M., No. 100182: 4 specimens, 37 to 79 mm. long, collected by Stuart Abraham on April 22, 1935, in West Branch of Cub Creek, 11 miles south of Appomattox Court House.

U.S.N.M., No. 101323: 2 specimens, 46 to 49 mm. long, taken by George S. Myers and Abraham on September 15, 1935, in Wards Fork Creek at Wards Fork, between Madisonville and Callen, Charlotte County.

U.S.N.M., No. 104096: 2 specimens, 49 to 52 mm. long, seized by Schultz and Reid on June 13, 1937, in Spoon Creek, between Martinsville and Stuart.

U.S.N.M., No. 104110: 2 adults, 100 and 122 mm. long, secured by Schultz and Reid on June 18, 1937, in Roanoke River at Bennett’s Mills.

C.U., No. 83235: 4 specimens, 52 to 103 mm. long, collected by Crosswell Henderson, in October or November, 1940, in Roanoke River near Roanoke.

C.U., No. 9415: 1 specimen, 97 mm. long, taken by Raney, Lauchner, and Keser, on March 31, 1940, in Roanoke River at Glauraz, Roanoke County.

C.U., No. 9534: 1 specimen, 79 mm. long, seized by Raney, Lauchner, and R. A. Pfeiffer, on April 3, 1941, in Angling Creek, 1 mile west of Patrick Springs, Patrick County.

U.M.M.Z., No. 94522: 1 specimen, 39 mm. long, obtained by Donald Ameg on November 10, 1931, in Shiner Creek at Forksville, Mecklenburg County.

U.M.M.Z., No. 95151: 1 specimen, 21 mm. long, secured by Carl L. and Laura C. Hubbs, on September 9, 1928, in a tributary of Little Calf-pasture River just above Bell Valley, Rockbridge County.

U.M.M.Z., No. 95323: 7 specimens, 33-97 mm. long, collected by Hubbs and Edwin P. Creaser, on May 16, 1931, in Tinker Creek, just above Cloverdale, Botetourt County.

U.M.M.Z., No. 95346: 2 specimens, 108 and 127 mm. long, secured by Hubbs and Creaser, on May 16, 1931, in the Roanoke River at Salem, Roanoke County.

U.M.M.Z., No. 95401: 12 specimens, 31-107 mm. long, collected by Hubbs and Creaser, on May 17, 1931, in North Mayo River at State Highway 13, Henry County.

U.M.M.Z., No. 95408: 8 specimens, 34-82 mm. long, taken by Hubbs and Creaser, on May 17, 1931, in Blackwater River, 1 mile south of Gogginville, Franklin County.

U.M.M.Z., No. 126243: 1 specimen, 123 mm. long, seized by George W. Burton, on May 5, 1939, in Horsepasture Creek, Henry County.

NOMENCLATURE.—Some doubt exists as to whether the name marginatus should be applied to this subspecies rather than to the form occurring farther north in the Atlantic Coast drainage. The brief original proposal of the name marginatus (in Cope, 1869: 257) was as follows:
Three species of this genus are in the museum of the Academy, and may thus be distinguished:

- No palatine teeth; head four times to basis caudal; dorsal higher than long; maxillary barbels reaching beyond basis pectoral; brownish, fins black-edged. **MARGINATUS**

**NOTURUS MARGINATUS BAIRD**

One specimen from Sinking Creek of the Kanawha, and one from the head of James River; similar specimens from the Susquehanna.

The name *marginatus* was obviously taken from a manuscript, by Baird, who has been regarded as responsible for the name. Baird's material came from the Susquehanna. The diagnosis, in the key, applies better to *atrorus* than to typical *marginatus* (as this name is here used), but does not wholly exclude either. Jordan and Evermann, by the method they followed in synonymies, restricted the type locality to Pennsylvania and designated [U.S.N.M.] No. 1571 as the type. An 81-mm. specimen from Carlisle, Pennsylvania, collected by S. F. Baird, originally from Smithsonian Institution, No. 1571, and received by the University of Michigan in 1859 (Anonymous, 1861: 23), is obviously a cotype. Fowler (1915: 208) reported that other cotypes, collected by Baird at Carlisle, are in the Academy of Natural Sciences of Philadelphia. It is our opinion that Jordan and Evermann legally restricted the type and that the name *marginatus* must go with the Susquehanna River form.

**Diagnosis.**—Vertical fins sharply bicolor, pale at base but broadly bordered with black (with a trace of a light edge on extreme margin); caudal fin largely devoid of pigment on basal part; black on caudal especially extensive toward upper and lower posterior angles (see Plate I). Body waxy yellow, without a definite pattern. Anal rays (Table I), counting anterior rudiments, 16 to 20, averaging 18.17. Pectoral spine long and strong; its length from extreme base 1.6 to 1.9 in head, and 1.2 to 1.6 in pectoral fin length (in the typical race).
DESCRIPTION.—An extended description of this form is not deemed necessary, for its characters are indicated in the comparisons, in Plate I, and in the proportional measurements (Table II). It agrees with S. m. marginatus in the proportional measurements by which marginatus differs from insignis (Table III). There is little overlap between atrorus and insignis in the relative length of the pectoral spine. There is virtually no intergradation between specimens of similar size.

This subspecies resembles marginatus and differs from insignis in that it typically instead of rarely attains an adult size of more than 100 mm. (standard length).

Another important character in which atrorus agrees with marginatus and contrasts with insignis is the lack of the color pattern of the anterior back that characterizes the Mississippi Valley species.

The life colors of the holotype, and of the paratypes taken with it, were thus described: “Intense sooty black margins on dorsal, anal, and caudal. Soft dorsal, adipose, and caudal olive yellow inside the black margins. Translucent olive with a blue tinge on back; a yellow streak along lateral line.” Specimens taken in Reed Creek, also in the Kanawha system of Virginia, were described as follows, after preservation for a night in formalin: “Yellow brown, with the edge of the dorsal, caudal, and anal fin blackish (one lacked the margin on the anal).” The specimen from Roanoke River at Glenvar was orange yellow at the base of the dorsal fin. Jordan (1890: 121) described Roanoke River specimens: “In life, pale yellow, nearly uniform; all specimens, large and small, with the dorsal, anal, and caudal broadly edged with jet-black, the basal part of the fin pale.”

That this species agrees with the other madtoms in carrying a pain-producing venom about the pectoral spine was demonstrated beyond doubt by a field experiment, at the type locality.

Like the related forms, S. m. atrorus is, according to our experience, a riffle species. The holotype and paratypes from Wolf Creek were collected under stones on a riffle. The Reed Creek paratypes were taken on a rubble and boulder bottom.
in water 1.5 to 2 feet deep, where the stream breaks over the remains of an old dam. The specimens taken by the junior author in the Roanoke River, and its tributary Angling Creek, were caught on the stony riffles. The Roanoke was 150 feet wide where a specimen was seined at Glenvar; at Roanoke, where the subspecies also occurs, the river is much larger. Angling Creek, a mountain stream, was only 2 to 10 feet wide. The water inhabited varied from very clear to very silty. Jordan (1890: 121) wrote of the habitat of this form in Roanoke River: “Very common, especially in grassy places.”

Etymology: ater, black; orus, border.

**TABLE II**

**Proportional Measurements of Schilbeodes marginatus stroma**

Minimum, maximum, and average values are given for specimens other than holotype.

<table>
<thead>
<tr>
<th>River system</th>
<th>Kanawha</th>
<th>Kanawha</th>
<th>Roanoke</th>
</tr>
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<tbody>
<tr>
<td>Specimens</td>
<td>Holotype</td>
<td>10 paratypes</td>
<td>10 specimens</td>
</tr>
<tr>
<td>Standard length</td>
<td>37-127 (96)</td>
<td>68-124 (87)</td>
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<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tr>
<td>In standard length</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Body depth</td>
<td>5.6</td>
<td>5.2-6.4 (5.86)</td>
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<tr>
<td>Predorsal length</td>
<td>2.8</td>
<td>2.8-3.0 (2.91)</td>
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<tr>
<td>Head length</td>
<td>2.8</td>
<td>2.8-3.9 (3.74)</td>
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<tr>
<td>In head length</td>
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<td>Head depth</td>
<td>2.1</td>
<td>2.1-2.3 (2.18)</td>
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<td>Head width</td>
<td>1.3</td>
<td>1.2-1.4 (1.30)</td>
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<tr>
<td>Fleshy interorbital</td>
<td>3.1</td>
<td>2.7-3.5 (2.82)</td>
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<td>Snout length</td>
<td>2.8</td>
<td>2.5-2.7 (2.63)</td>
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<tr>
<td>Dorsal spine</td>
<td>3.1</td>
<td>2.5-3.3 (2.86)</td>
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<td>Pectoral spine</td>
<td>1.9</td>
<td>1.6-2.2 (1.90)</td>
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<tr>
<td>Pectoral fin</td>
<td>1.5</td>
<td>1.2-1.6 (1.41)</td>
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<td>In pectoral fin</td>
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<tr>
<td>Pectoral spine</td>
<td>1.4</td>
<td>1.2-1.6 (1.45)</td>
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<td>Inmost length</td>
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<td>1.7-3.4 (2.28)</td>
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<tr>
<td>Caudal ratio</td>
<td>1.7</td>
<td>1.4-1.7 (1.54)</td>
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<tr>
<td>Caudal ratio 21</td>
<td>2.5</td>
<td>2.0-2.8 (2.46)</td>
<td></td>
</tr>
</tbody>
</table>

* Origin of dorsal to adipose notch
† Origin of anal to base of caudal
* Origin of lower precurrent C. rays to base of C.
SLENDER MAITON

2. Schilbeodes insignis (Richardson)

Pimelodon livrei (French vernacular).—LeSueur, 1819: 155 (description). Pimelodus insignis.—Richardson, 1836: 132 (name only, as follows: "Pimelodus . . . insignis (livré, Le Sueur)").


Schilbeodes insignis.—Jordan, Evermann, and Clark, 1930: 156 (copied synonymy, in part).

Pimelodus lenniscatus.—Valenciennes, in Cuvier and Valenciennes, 1840: 144-45 (original description; name from LeSueur, MS; no locality). De Kay, 1842: 187, and Storer, 1845: 405 (characters, range—"Southern States," assigned by fancy).


1This record, overlooked by Hubbs, 1926: 53, and Greene, 1935: 145-46, was obviously the basis for the "Lake Michigan" and "Lake" records of 1877-78 (see also legend of Map 1).
and Gilbert, 1883: 100 (description; range). Forbes, 1884: 84
(Illinois records). Cragin, 1885: 107 (Kansas). Graham, 1885:
71 ("Neosho, Osage, etc.," Kansas). Jordan, 1885: 892 (range;
classnobir as synonym). Eigenmann and Ford, 1886: 410 (Bean
Blossom Creek, Indiana). Call, 1887: 79 (Hinkson Creek, Mis-
souri). Evermann and Jenkins, 1888a: 44, 52, 54, and 1888b:
110, 120, 123 (Tippecanoe River, Indiana). Jordan, 1889: 353 (com-
parison). Meek, 1890: 168 (characters; range); 1891: 117, 120,
124, 126, 129, 141 (description; records, Ozark region). Gilbert,
1891: 146 (records). Call, 1892: 46 (Raccoon River, Perry, Iowa).
Meek, 1892a: 12; 1892b: 223, 225; and 1892c: 108 (Iowa rec-
ords); 1894: 75, 86, 95 (Arkansas records). Hay, 1894: 172, 174
(description; Indiana records compiled). Evermann and Kendall,
1895: 470 (records, vicinity of Neosho, Missouri). Kirch, 1895:
357, 354-35 (Tiffin River, Manitou Beach, Michigan). Jordan,
1899: 42 (diagnosis; range).

Schizostoma caulis.—Eigenmann and Beeson, 1894a: 81, and 1894b: 44
(Indiana records). Eigenmann and Evemann, 1896a: 145, 147 (comparisons; description;
range); 1896: 243, 244 (range; synonymy). Evermann and Cox,
1886: 365, 373, 388 (records compiled, Missouri River basin).
Cox, 1886: 608 (Blue Earth River at Mankato, Minnesota);
1897: 20 (same record; characters). Jordan and Evermann,
1900: 3236, Pl. 28, Fig. 65 (Oxart Fork of Gasconade River,
Marshfield, Missouri). Evermann, 1902: 95 (Great Lakes re-
region). Large, 1903: 9-10 (characters; Illinois records).
Eigenmann and Beeson, 1905: 120 (Indiana records reprinted).
Michael, 1906: 9 (misprinted "caulis"; range; Tiffin River,
Michigan). Goldsborough and Clark, 1908: 33 (Guyandotte
River, West Virginia). Meek, 1908: 141 (Indiana records re-
peated). Forbes, 1909: 367, 398, 404 (range; distribution in
Meek and Hildebrand, 1910: 246, Fig. 21 (descrip-
tion; range; Hickory Creek, New Lenox, Illinois). Hanksin,
Pratt, 1923: 96 (compiled). Hubbs, 1926: 31-35 (comparisons;
Tiffin River, Michigan, record doubted). Cahm, 1927: 45, 57, 59
(food and habits; records, Waukesha County, Wisconsin).
Hubbs and Greene, 1928: 390 (Great Lakes basin). Potter and
Jones, 1928: 355 (Iowa records compiled). Thompson and
Hurst, 1930: 27 (habitats, Champaign County, Illinois).
Greene, 1935: 145-46 (distribution; Wisconsin records). Alt-
ubida exilis.—Jordan, 1929: 92 (characters; Wisconsin to Kansas).

Jordan, Evermann, and Clark, 1930: 156 (range; synonymy).


Pinneledon insignarius.—Vaillant, 1896: 28, Pl. 24 (name and plate from LeSueur, MS; synonymy; nomenclature; plate first published).

Range and Geographical Variation.—Schilbeodes insignis, as we now call the species which has generally been known as S. exilis, has a wide range in the Mississippi Valley system (Map 1). It is the only representative of this species group in the interior basin, excluding the upper Kanawha system which is occupied by S. marginatus atros.dus. It probably ranges (or has probably ranged) from the southern part of the Great Lakes basin, in Wisconsin and Michigan, and from southeastern Minnesota, southward through Indiana, Illinois, and Iowa to the Tennessee River system in Alabama and the Arkansas River system in Arkansas and Oklahoma. One specimen is known from the upper Ohio system, from Guyandotte River, tributary to the Ohio River below the mouth of the Kanawha (p. 13). Throughout most of its range this species seems to be rare or local, perhaps on the verge of extinction. Over much of this territory it is represented only by old literature records. Its present center of abundance is the Ozark Upland of southern Missouri, northwestern Arkansas, northeastern Oklahoma, and southeastern Kansas. In that well-consolidated region it is usually common under stones and dead leaves and is represented by a large number of recent records.
That this species is subject to geographical variation was early noted by Jordan (1877b: 100) and recently by Hubbs and Lagler (1941: 65). The Ozark population is particularly flat-muzzled, the specimens appearing to have been pinched between thumb and forefinger. In this respect they are quite unlike *S. marginatus*. In some regions, however, as in the Guyandotte River of West Virginia, *insignis* has the head shaped much like that of *marginatus*. There is considerable variation in the intensity of the dark fin borders. The differences are not very tangible, however, and further study is needed before any subspecific separations should be attempted.

Hubbs and Lagler (1941: 65) suggested that *exilis* (= *insignis*) might be a complex of subspecies referable to *insignis* (= *marginatus*). We now find evidence, however, that the two named forms are specifically distinct.

**COMPARISON.**—The Mississippi Valley species, here called *S. insignis*, differs from *S. marginatus* (both subspecies) in several characters:

1. Instead of being unicolor the back bears a definite though rather faint color pattern: about the base of the dorsal fin there is a dark blotch, preceded and followed by a light saddle. In some poorly preserved specimens these features of coloration are not apparent.

2. The adult size is smaller, very seldom instead of typically more than 100 mm. in standard length. The largest known specimen, from the Tennessee River system, is only 108 mm. long, whereas a considerable number of *marginatus* at hand are longer than 120 mm., and that form is reputed by some authors to reach the over-all length of 12 inches.

3. The caudal fin is usually more rounded, with less evident posterior angles.

4. The procurent caudal rays are less developed, the adipose notch is more posterior, and the caudal fin is smaller. These differences, showing little or no overlap, are expressed as caudal ratios 1 and 2 in Table III. On the average the pectoral fin and the pectoral spine are shorter as compared with the head. The pectoral spine is definitely shorter, as
measured into the pectoral fin, and on the average the head is shorter. The predorsal length is less, with a little overlap. These differences are also indicated in Table III. As the differential measurements are not very closely correlated, it is easy to identify each specimen by the ensemble of its measurable characters.

NOMENCLATURE.—As already mentioned we are compelled by the evidence to shift the name insignis from the eastern species, marginatus, to the western form, exilis. The sole basis for the name Pimelodus insignis Richardson (for references see synonymy) was LeSueur’s account of “Pimelodon livrée,” described without locality. The description of the fins as having a very black border indicates that he had either marginatus or exilis. This item fits S. m. atrorus best, but it is unlikely that LeSueur would have encountered that subspecies; it fits exilis better than S. m. marginatus. The description of the caudal as rounded and of the pectoral spine as short point toward exilis. So also does the number of anal rays (20), which LeSueur would hardly have counted in S. m. marginatus, for he surely would have missed at least one rudimentary ray (see Table I).

In describing Pimelodus lemniscatus on the basis of LeSueur’s drawing and of a specimen furnished by LeSueur, Valenciennes further indicated that LeSueur described exilis rather than marginatus. Valenciennes attributed the scien-

The paper by LeSueur (1819), in which this name was proposed, has apparently not been seen by most ichthyologists. The failure of authors to note LeSueur’s use of the generic name Pimelodon has already been noted (p. 2). Other items in this paper have been misquoted. Thus, the type locality for Pimelodus nebulosus was given as Lake Ontario by Jordan and Evermann (1896: 140), whereas LeSueur mentioned only Philadelphia and the Delaware. Pimelodus aeneus (synonym of Plecostus olivarie) was accredited by Jordan and Evermann (1896a: 143) to Cuvier and Valenciennes (1840: 155), with the type locality of New Orleans, but it was well described by LeSueur (1819: 152-53), who gave the habitat as “l’Ohio.” Jordan and Evermann (1896a: 135) quoted Pimelodus caudascoratus in the synonymy of Ictalurus punctatus, with the localities, “Wabash River, Mississippi River,” but LeSueur (1819: 153) cited only “l’Ohio” and “Pittsburgh” for his P. caudascoratus.
tific name to LeSueur and quoted his name, *Pimelode* [sic] *livrée*. Since Richardson’s *Pimelodus insignis* had in the meantime been proposed on the basis of LeSueur’s name, Valenciennes’ action helped fix the status of Richardson’s name, too. Valenciennes obviously had *exilis* rather than *marginatus*. He described the fins as bordered with blackish, the caudal as rounded, the pectoral spine as short (“de moitié plus courtes que les nageoires”), and the anal rays as 21. Even more diagnostic is his remark that the procurent caudal rays occupy the

**TABLE III**

**Differences between Schilbeodes *marginatus* and *S. insignis* in Proportional Measurements**

Based on half-grown to adult specimens from various parts of the range of each species. Both subspecies of *marginatus* included. Numbers measured: 20 of *insignis*, 31 of *marginatus* (64 for the ratio, pectoral spines in head). Averages in parentheses.

<table>
<thead>
<tr>
<th></th>
<th><em>S. marginatus</em></th>
<th><em>S. insignis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Caudal ratio 1*</td>
<td>1.3-1.7 (1.5)</td>
<td>1.6-2.4 (2.0)</td>
</tr>
<tr>
<td>Caudal ratio 2†</td>
<td>2.3-2.9 (2.6)</td>
<td>3.0-3.9 (3.4)</td>
</tr>
<tr>
<td>Pectoral spine in head</td>
<td>1.6-2.8 (2.0)</td>
<td>1.9-2.8 (2.5)</td>
</tr>
<tr>
<td>Pectoral spine in pectoral fin</td>
<td>1.5-1.6 (1.4)</td>
<td>1.4-1.8 (1.65)</td>
</tr>
<tr>
<td>Pectoral spine in head</td>
<td>3.6-3.9 (3.8)</td>
<td>3.8-4.3 (4.05)</td>
</tr>
<tr>
<td>Predorsal length</td>
<td>2.7-3.0 (2.9)</td>
<td>2.9-3.3 (3.1)</td>
</tr>
</tbody>
</table>

* Origin of dorsal to adipose notch
† Adipose notch to end of caudal

posterior third of the length of the tail. LeSueur’s figure, reproduced by Vaillant, confirms these interpretations. It shows the dorsal, caudal, and anal fins with a black margin (fitting *exilis* better than either *marginatus marginatus*, which has less sharply bicolored fins, or *marginatus atrorus*, which has the border wider, particularly toward the angles of the fins). All of the critical measurements (Table III) made on the figure check much better with *exilis* than with either subspecies of *marginatus*; caudal ratio 1, 1.7; caudal ratio 2, about 3.3; pectoral spine in head, about 3.3 (too short even for
exilis—far too short for a three-inch marginatus); pectoral fin in head, 1.8; pectoral spine in pectoral fin, 1.8; head length, 4.0; predorsal length, 2.8 (from side-view figure) or 3.1 (from top-view figure). We assume that Le Sueur obtained the type specimen of Pimezodon lividus and hence the type of Pimelodus insignis, Pimelodus lemniscatus, and Pimelodon insignarius, at some locality in the Mississippi River system, rather than in the "Southern States" as supposed by De Kay (1842: 187), or in Pennsylvania as suggested by Girard (1859: 159).

ROANOKE MADTOM

3. Schilbeodes gilberti (Jordan and Evermann) Noturus gilberti.—Jordan and Evermann, in Jordan, 1888: 351-53, Pl. 43, Fig. 2 (original description; comparisons; Roanoke River at Roanoke, Salem, and Alleghany Springs). Jordan, 1890: 87, 125, Pl. 13, Fig. 2 (Roanoke River records). Schilbeodes gilberti.—Jordan and Evermann, 1896a: 145, 148 (comparisons; description; range); 1896b: 234 (range; synonymy); 1900: 3256, Pl. 28, Fig. 67 (type from Roanoke River, Salem, Virginia). Schrenkiesen, 1958: 167 (characters; Virginia). Pratt, 1923: 97 (characters; range). Babida gilberti.—Jordan, 1929: 95 (characters; range; statement "widely distributed" unwarranted). Jordan, Evermann, and Clark, 1930: 156 (range). Pratt, 1935: 90, and Driver, 1942: 254 (compiled).

This species, of the Roanoke River system, has been known only from the original types of Noturus gilberti. Fowler (1935: 19, Fig. 36) did report and figure "Babida gilberti," from South Carolina, but the figure certainly does not represent gilberti, and the 2 young from Great Cypress Swamp prove on re-examination to be S. m. marginatus (Director E. Milby Burton of the Charleston Museum kindly loaned these specimens for study). We therefore synonymize Fowler's Babida gilberti with S. m. marginatus.

Four specimens of S. gilberti were collected by E. C. Raney, E. A. Lachner, and L. J. Kezer, on March 31, 1940, in Roanoke River at Glenvar, Roanoke County, Virginia. They were secured with S. m. atrorus on a rubble riffle. These specimens agree well with the types, which have been examined in the National Museum.
S. gilberti is a species of very distinctive appearance. The characters by which it differs from marginatus are as follows: the head is short and broad; the pectoral spine is extremely short; the adipose fin is very low and short (it is developed along much less than half the distance between the rudimentary caudal rays and the end of the dorsal base); the first dorsal fin has a blackish base, but is otherwise pale (marginatus on the contrary has a pale fin with a blackish border); the caudal fin has an orange border, which is broader above than below; the tail fin is truncate and slightly emarginate; the barbels are unusually short and stubby; the eye is extremely small.

4. Schilbeodes mollis (Hermann)

It seems necessary to change the name of Schilbeodes gyrinus (for synonymy see Jordan and Evermann, 1896a: 146) to S. mollis (Hermann, 1804: 309). Attention has been called (Hubbs, 1936) to a generally overlooked volume by Johannes Hermann in which names were given in proper binomial form to several American fishes. Among these was Silurus mollis, which was treated as follows:

SILURUS MOLLIS. Nobis.
Pinna dorsali postica adiposa, cirris maxillae superioris quatuor, pinna anali radiis duodecim, radio primo dorsali pectoraliumque adjacenti spineae capitit similium mollibus candidis.
Venter valde mollis et fuscidis.
Ex America. Musei Humphrediani p. 131. No. 33.

It was first thought that this description was unrecognizable, but on further consideration it seems reasonably sure that Hermann had the species generally known as Schilbeodes gyrinus (Mitchill, 1818). The name Silurus, the locality "America" (to be considered in connection with the brief description, according to Opinion 52 of the International Commission on Zoological Nomenclature), and especially the statement that there are four superior maxillary barbels, renders it undeniable that Hermann had a species of the Ameiuridae. An ameiurid described in 1804 would almost certainly have
come from the Atlantic coast. Among the species occurring there the only ones in which 12 anal rays could conceivably have been counted are the species of *Schilbeodes*: a larger number would surely have been seen and recorded for any species of *Ictalurus* or *Ameiurus* occurring on the Atlantic coast. *Schilbeodes marginatus* has 15 to 20 anal rays, very seldom fewer than 17 (Table I), and of these all but 2 or 3 are readily visible. Therefore it would be extremely improbable that one would count only 12 anal rays in this madtom. The species heretofore known as *Schilbeodes gyrinus* is the only one in which the 12 count would likely have been made. In 20 specimens from southern New York and New Jersey the anal ray count averages only 15.50 (Table I). If rudiments are excluded, a count of 12 or 13 would be obtained in most of the specimens. A very diagnostic feature of *gyrinus* is stated by Hermann, "venter valde mollis et flaccidus." *S. marginatus* could hardly be said to have a very soft and flabby belly. The trim *S. leptacanthus*, which ranges north to South Carolina and has about as few anal rays as *gyrinus* (Table I), would certainly never have been so characterized.

The conclusion seems inescapable that Hermann described the tadpole madtom as *Silurus mollis* 14 years before Mitchill named it *Silurus gyrinus*. The name should therefore stand as *Schilbeodes mollis* (Hermann).

Greeley (1936: 84) used the trinomial, *S. gyrinus gyrinus*, for the Eastern form, "because of the probable validity of the form *sialis*." It remains to be proved, however, that this species breaks up into definable subspecies over its wide range.

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PlATE I

Schilbeodes marginatus atrorus, new subspecies

Holotype, 112 mm. in standard length, collected by Carl L. Hubbs and family on August 22, 1936, in Wolf Creek, New River system, between Bastian and Nokie, Bland County, Virginia.

Photographed by Clarence Flaton.
Mar 1. Distribution of Schilbeodes insignis and Schilbeodes marginatus, as indicated by record stations.

Solid marks represent localities of specimens examined. Hollow symbols are unconfirmed locality records.

The Rappahannock River system of the coastal drainage in Virginia and North Carolina and the Upper Kanawha (New) River system, in the Mississippi drainage adjacent to the Rappahannock system, are outlined, to enclose the known range of Schilbeodes marginatus atrorus. Otherwise all records for the Atlantic coast drainage are referred to S. marginatus marginatus, and all those for the Mississippi River system are allocated to S. insignis. From the Potomac system to the Nene River some specimens approach and a few equal S. m. atrorus.

Some doubt is attached to the two records for the Great Lakes drainage assigned to S. insignis. The record for "Root River, Wisconsin" (Jordan, 1878a: 47), obviously the basis for 1877-78 records for Lake Michigan (see synonymy and footnote on p. 18), is unconfirmed, and was possibly a slip for Oromocto River at Lae La Belle, Wisconsin, for there is an old specimen in the National Museum from that locality, collected by Hoy and identified as *exilis* by Jordan, and no material from Root River seems to be preserved. The one Michigan record (Keinath, 1885: 327, 334-35) has been accepted with much doubt (Hubbs, 1926: 51-52, and subsequent treatises). Efforts to confirm this record by examining museum series and by collecting at the same locality have failed.

The one record for Minnesota (Cox, 1896: 608; 1897: 20; Surber, 1920: 21) has been doubted by "Eddy and Surber (1943: 162-63), who have not collected any specimens in the state.

The largest circle in Illinois covers the streams of McLean County, the type locality of *Noturus exilis* Nelson (1876: 51). Forbes and Richardson (1909 and 1920: 298) indicated that the original specimens came from "Illinois River," but perhaps they meant Illinois River system. The two circles of intermediate size in Illinois refer to two other county records for *exilis*, namely De Kalb and Woodford counties. A few other records without precise location, like that of Graham (1885: 71) for Neosho River, Kansas, are approximately spotted on the stream named. Fowler's (1915: 308) record for "Brook River, Iowa," could not be located. A few reports for Atlantic coast streams, in regions well represented by other records, are not included. Probably some of Fowler's papers have been missed. The numerous collections of the New York Biological Survey, which have not been reported in detail, are mostly represented by single dots arbitrarily placed on the states' streams.

The far eastern record for *S. insignis* is for the Geyanonde River, West Virginia (Goldborough and Clark, 1908: 53). The exact location on the river is unknown. The type specimen taken is discussed on p. 12.

The record stations were spotted by Clark, Hubbs and Laura C. Hubbs.
RELATIONSHIPS OF **ALEPIDOMUS**, A NEW GENUS OF AThERININE FISHES FROM THE FRESH WATERS OF CUBA

By CArL L. HUBBS - SWiFFER INSTI tuTIO N OF SAFARI

In his fascinating little book *The Migration of Animals from Sea to Land*, Pearse (1936) has pointed out that animals have seldom surmounted the great physiological difficulties involved in a change of habitat from sea water to fresh water. It is not surprising, therefore, to note that isolated fresh-water representatives of marine groups are often so strongly differentiated from their supposedly remote marine ancestors as to justify generic or greater separation. That this is true as a rule of the Atherinidae can be seen by a perusal of the systematic monograph on this family (Jordan and Hubbs, 1919). Another example of the trenchant distinctness of a fluvial atherine becomes apparent when one considers in detail the characters of the Cuban fresh-water species which was described by Eigenmann (1903: 222, Fig. 9) as *Atherina evermanni*. In this paper I treat the relationships of that species, discuss the genera into which *Atherina* and the related *Hepsetia* have been divided in recent years, and then erect a new genus, *Alepidomus*, for the sole reception of *Atherina* or *Hepsetia evermanni*. 
Despite its close superficial resemblance to certain species of the New World group Atherinopsinae this tiny little silverside of Cuban fresh waters obviously belongs to the essentially Old World and largely marine subfamily Atherininae. I have already indicated (Hubbs, 1936: 249) that it agrees with the Atherininae in the structural features by which that group has been separated (by Jordan and Hubbs, 1919: 14-15, 29, 48) from the Atherinopsinae: the premaxillaries are not dilated posteriorly; the gape is nearly straight and scarcely restricted at the corner of the mouth by the membranes between the jaws; the anus opens far in advance of the normal position just in front of the anal fin (nearer pelvic insertion than anal origin); the belly is rather long (though less elongate than usual in the Atherininae); the pelvic fins are inserted much nearer the pectoral insertion than the anal origin; and the anal fin is short (though longer than in most Atherininae).

A newly observed character clinches the evidence that "Atherina" evermanni should be referred to the Atherininae rather than the Atherinopsinae. This character involves the dentition of the premaxillary. In evermanni the dentigerous surface is reflected outward so as to cover the whole outer face of the premaxillary with shagreen. In all available species of Atherina and Hepseta (in the sense of Jordan and Hubbs), whether from the New World, Europe, or the Indo-Pacific region, I find that a shagreen of minute teeth more or less completely covers the exposed part of the premaxillary. A survey of nearly the entire gamut of the Atherinopsinae, on the other hand, discloses no dentition of this type. In certain atherinopsines with weakly developed mandibles, notably in the marine Membras and the Mexican fluviatile Archomenidia (Jordan and Hubbs, 1919: 54-56) the teeth which occur in a uniserial file along the extreme edge of the premaxillary are exposed, but they are directed downward and do not simulate the villous band on the outer surface of the bone, as developed in Atherina and its relatives.
This distinction in premaxillary dentition appears to provide a usual but not invariable subfamily criterion. In a few small aberrant genera of the Atherininae the character breaks down. Thus, in the Australian fluviatile genus *Craterocephalus* (Jordan and Hubbs, 1919: 14, 44-47; Weber and De Beaufort, 1922: 277; Whitley, 1943: 132, 135) the teeth are described as being “microscopic” or “very small” in the jaws and apparently do not extend over the outer surface of the premaxillary. Although also referred to the Atherininae by Jordan and Hubbs (1919: 15, 47, Pl. 3, Fig. 10) the excessively compressed Indo-Pacific genus *Iso* Jordan and Starks (1901: 204-6, Fig. 4) has the outer face of the premaxillary smooth and edentulous.

In this connection it is interesting to note that the *Iso*-like but even more bizarrely specialized Chilean atherine recently described by Clark (1937: 88-90, 1 fig.) as *Notocheirus hubbsi*—presumably a parallel offshoot, from the Atherinopsinae—has the small teeth in the jaws “more or less concealed by the numerous spines of the snout” and the head “from snout to nape velvety or bristly with spines like those on the scales.” These head spines are more plausibly interpreted as hypertrophied scale ctenii than as jaw teeth which have become extended over the surface of the head and body. These alternative explanations seem distinct even if one favors the idea that ctenii and teeth are homologous, in that they have both been derived from denticles.

The suggestion that spines on the outer surface of the head may represent teeth extroverted from their normal position in the jaws is not purely theoretical, for this is certainly true of the armature of the free surface of the premaxillary in *Atherina* and other fishes. The process seems to have been carried to an excessive extreme in the western Pacific atherine genus *Atherion* (Jordan and Starks, 1901: 199, 203-4, Fig. 3; Jordan and Hubbs, 1919: 14, 30). Counteracting the principle of irreversible evolution as it applies to the extent of development over the body surface, what are obviously true teeth (rather than “tooth-like spines” or “fine spinules”)
thickly cover in *Atherina* not only the premaxillary but also the lower lip, the entire exposed bony surfaces of the mandible, interopercle, preopercle and anterior part of subopercle, various ridges on the muzzle and around the eye, the postorbital ridge, and even the margin of the scapular process.

The teeth extend over the outer surface of the lips in some but not all species of the Melanotaeniinae, a subfamily of Atherinidae occurring in the fresh waters of Australia and New Guinea (Regan, 1914: 276–84, Pl. 31; Weber and De Beaufort, 1922: 286–311, Figs. 77–83). The same character is exhibited by certain genera in other families of teleost fishes.

Returning to the Cuban fresh-water silverside I conclude that it has properly been classified in the Atherininae. Its source is, therefore, not to be sought in the fresh waters of any New World land, for all other fresh-water atherines of the Western Hemisphere are classed in the Atherinopsinae. It shows no particular approach toward either of the two known New World Atlantic species of Atherininae, nor toward any of the numerous other marine members of that subfamily. Its ancestry must be traced to some remote, presumably marine progenitor.

**Recent Generic Divisions of Atherina**

To provide a basis for a consideration of the generic status of "*Atherina*" evermanni it is desirable to consider the genera that have recently been proposed for species which had previously been referred to a large genus *Atherina*.

Fowler (1903: 730) first based a new subgenus, *Atherinomorus*, on the western Atlantic marine species *Atherina laticeps*, with the prime character, "rami of mandibles not elevated inside of mouth." Noting that this character is also a feature of *Atherina boyeri* Risso, the European type species of *Hepsetia* Bonaparte, Jordan (1919: 310–11) and Jordan and Hubbs (1919: 31) synonymized *Atherinomorus* with *Hepsetia*. We recognized *Hepsetia* as a genus, because the species with the low mandibular rami "usually differ from those of typical *Atherina* in their shorter and blunter premaxillary
spine, the shorter and more rounded snout, the larger eye, wider interorbital, longer head, deeper body, and larger scales." The general facies strongly suggest two distinct phyletic lines.

Believing that we held an inaccurate conception of *Hepsetia*, Whitley (1930: 9-10) proposed a new genus, *Pranesus*, "practically identical with *Hepsetia* as defined by Jordan & Hubbs."

Not having at hand a copy of Bonaparte's book, Whitley based his belief on the fact that "Sherborn, in his Index Animalium, considers *Hepsetia* Bonaparte as a possible error for *Hepsetus* Swainson." The two names, however, have little but spelling in common, and are nomenclatorially distinct (Hubbs, 1939).

Bonaparte (1832-41) specifically states that he is erecting two subgenera. Under *Hepsetia* he mentions only the "esempio l'unica europea *Atherina Boyeri* (*Hepsetus*, Rond.)"; under the other subgenus ("*Atherina*, Rond." ) he cites only *A. hepsetus*. Bonaparte's indications of the type species were made clear by Jordan (1916). The type species of *Pranesus* is *Pranesus ogilbyi*, which was based on the description of Australian examples of "*Atherina pinguis*" by Ogilby (1912: 38-40, Pl. 12, Fig. 1, and Fig. a). Whitley proposed the new name because Ogilby thought that the wide-ranging nominal *pinguis* might be a complex. Incidentally, one might be inclined to raise a voice of protest against the naming of new genera and species on the basis of a suspicion that they may be unnamed. In a later paper Whitley (1934) named two other new genera for Australian fishes of the *Atherina* type, namely *Pranesella* and *Atherinason*, without offering trenchant generic diagnoses. More recently (1943) he has proposed still further generic separations.

Not mentioning the new "genera" proposed by Whitley, Fowler (1941: 249-51, Fig. 1) has lately erected the new genus *Thoracatherina* for the Hawaiian species, *Atherina* or *Hepsetia insularum*, and in the same paper recognized *Atherinomorus* as a valid genus for the Atlantic American species (*laticeps* = *stipes*). He separated the two genera from *Hepsetia* (*boyeri*) of Europe primarily on the basis of the greatly enlarged
"infra-pectoral" scales, on the shoulder girdle below the base of the pectoral fin. He stated that the scales of that region are small in *Hepsetia boyeri*, and they are so indicated on the excellent plates in the monographs by Bonaparte (1832-41) and Borsieri (1904). The type species of Atherina (*A. hepsetus*), also European, is shown by an examination of specimens as well as figures to have these scales similarly small. All other species of the *Atherina* and *Hepsetia* type at hand, with the exception of *evermanni*, have these scales more or less notably enlarged. Species found to be so characterized are *Atherinomorus stipes* and *Atherina harringtonensis* of the New World, and a number of species each of the *Atherina* and *Hepsetia* types of eastern Asia (Japan, Philippines, Java). The type species of *Pranesus* is figured by Ogilby as having these scales not enlarged, but I suspect an error. If *Pranesus ogilbyi* has enlarged scales on the shoulder girdle I see no valid grounds for separating *Thoracatherina* from *Pranesus*. Other characters assigned to *Thoracatherina* do not appear, after an examination of East Indian species, to be of generic significance.

There are better grounds for the generic separation of the Atlantic American species *stipes*. As Fowler (1941: 249, Fig. 2) indicated in establishing *Atherinomorus* as a genus, this species differs from *Hepsetia boyeri* in having scales on the dorsal, anal, and pectoral fins (these scales are thin and deciduous, and apt to be overlooked unless well-preserved specimens are carefully examined). *Atherina*, as represented by *A. hepsetus*, agrees with *Hepsetia* and *Thoracatherina* in totally lacking scales on these fins. Nor are such scales developed in *Atherina harringtonensis*, "*Atherina* evermanni", or in any of the eastern Pacific species examined. I therefore recognize *Atherinomorus* as a distinct genus, but hold in abeyance the question of any further generic division of *Hepsetia* or of *Atherina*. These open problems are not vitally concerned in the treatment of the Cuban fresh-water species, for which I now propose the name
A New Genus of Atherine Fishes

Alepidomus, new genus

Type species.—Atherina evermanni Eigenmann.

The characters in which this genus agrees with Atherina, Hepsetia, and Atherinomorus (and with the similar Pacific genera Pranesus, Thoracatherina, etc., if these are valid) have already been stated. Its most trenchant feature is, perhaps, the lack of scales on the shoulder girdle below the pectoral. As correctly shown in the type figure this region, instead of being covered with either small or large scales, is totally and abruptly naked (hence the name Alepidomus, from α, privative, λεπίς scale, and ὁμός, shoulder). The abdomen is shorter and the urosonse consequently longer than in typical atherinines; the origin of the anal fin is much nearer the head than the caudal base. The scales are relatively larger than in any near relative, numbering about thirty-two along the axial line, and the exposed field of the individual scales is normally shaped; that is, the scales are less elevated and less extensively imbricated than is usual in the group. The adult size is much smaller than that of the species in related genera. In an aquarium it is seen to be a very delicate, semitranslucent fish. Alepidomus differs from Atherina and agrees with Hepsetia and Atherinomorus in having the mandibular rami scarcely elevated within the mouth and in other less trenchant features. It deviates from Atherinomorus but agrees with other related genera in lacking scales on the dorsal, anal, and pectoral fins.

Only one species of the genus is known.

Alepidomus evermanni (Eigenmann)

Atherina evermanni.—Eigenmann, 1903: 222, Fig. 9; Hubbs, 1936: 249. Hepsetia evermanni.—Jordan and Hubbs, 1919: 35, Pl. 2, Fig. 2.

In the preparation of this account I have had at hand a paratype from San Cristóbal, Cuba, and a specimen collected by Merino in August, 1935, in Laguna la Canoa, Artemisa, Cuba. Through the courtesy of Arthur Greenberg of the Everglades Aquatic Nursery I have had live specimens in an aquarium. They were mid-water swimmers, moving about
rather jerkily with much fluttering of the high-set pectoral fins.

The Atherininae of the New World may now be listed as follows. For synonyms see Jordan and Hubbs (1919).

Genus **Atherinomorus** Fowler

*Atherinomorus stipes* (Müller and Troschel): shores of western Atlantic from Florida to Brazil; also reported (Hubbs, 1920: 1), perhaps erroneously, from the Pacific coast of Colombia.

Genus **Thoracatherina** Fowler

*Thoracatherina insularum* (Jordan and Evermann): Hawaiian Islands; also New Caledonia and Galápagos Islands, according to the questionable records by Borodin (1932: 76).

Genus **Atherina** Linnaeus

*Atherina harringtonensis araus* (Jordan and Gilbert): western Atlantic from Florida Keys to Puerto Rico and Panamá; also reported (Hubbs, 1920: 2), perhaps erroneously, from the Pacific coast of Colombia.

*Atherina harringtonensis karringtonensis* Goode: Bermuda Islands.

Genus **Alepidomus** Hubbs

*Alepidomus evermanni* (Eigenmann): fresh waters of Cuba.

All other New World Atherinidae are referred to the Atherinopsinae.

**LITERATURE CITED**

**BONAPARTE, CARLO L.**

**BORODIN, N. A.**
No. 488  A New Genus of Atherinine Fishes

Borbiere, Olemintina


Clark, H. Walton


Eigenmann, Carl H.


Fowler, Henry W.


Hubbs, Carl L.


Jordan, David Starr


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1934 New Fish from Victoria. Victoria Nat., 50: 241-42, 1 fig.
The taxonomy of the Goodeidae, a family of exclusively Mexican viviparous fishes, was thoroughly revised by Hubbs and Turner (1939). In the revision the following 4 subfamilies were set up: Ataeniobiinae, Goodeinae, Characodontinae, and Girardinichthyinae. Eighteen genera and 24 species were described. Analytical keys for both males and females were constructed, and all of the known distributional records of each species were included. A complete synonymy was presented, and outline drawings of ovarian and trophotaenial structures were introduced. De Buen (1940, 1941a, 1941b, 1941c) described a new genus, Hubbsina, and 2 new species, *Hubbsina turneri* and *Allodoca vivipara*. He also reviewed the classification of *Skiffia lemae* and *Skiffia variegata* and furnished new distributional records of a number of species. In the revision of Hubbs and Turner the classification of the genus *Allodonichthys* was made with some hesitation, because females and embryos of this genus were not available for a study of the critical ovarian and trophotaenial structures.

In April, 1939, I made extensive collections in the streams of Colima, in the Río Purificación and some of its tributaries in the state of Jalisco, and in the Río Tamazula above the town...
of Tuxpan. Females of *Allodontichthys zonistius* were secured and also specimens of a new species of *Allodontichthys*. A new genus and new species of the subfamily were taken in the Río Resolana, a tributary of the Río Purificación.

The present paper is intended as a brief supplement to the revision of Hubbs and Turner to present the following data and suggestions: a description of the character of the ovary and trophotaeniae of *Allodontichthys zonistius* and a correction of the taxonomic position of this genus, a description of a new species, *Allodontichthys tamaululae*, from the Tamaulula River, a description of the characters of males, females, and embryos of a new genus and species, *Xenotaenia resolanae*, and some suggestions concerning the zoogeography and morphological evolution of the different genera of the subfamily Girardinichthyinae, particularly of those genera occurring outside of the plateau to the south and southwest.

**Classification of Allodontichthys zonistius**

*Allodontichthys zonistius* was first described as *Zoogneticus zonistius* by Hubbs (1932) from a male specimen collected in a tributary of the Río Colima near the city of Colima. In the revision by Hubbs and Turner the new genus *Allodontichthys* was erected on the basis of certain external characters and peculiarities of the teeth, but the genus was retained in the subfamily Goodeinae because it possesses certain superficial characters common to this subfamily. The possibility that the genus might be closely related to *Balsadichthys* and *Ilyodon* was recognized. It was impossible to determine definitely the relationships of the genus because no females or embryos were available. It was stated in the revision (1939: 49) that “it would not be surprising, when females of *Allodontichthys* are obtained, to find that this genus possesses the ovarian and trophotaenial characters of the Girardinichthyinae rather than of the Goodeinae to which *Allophorus*, *Zoogneticus*, and *Allotoca* are referred, and therefore that *Allodontichthys* may be regarded as ancestral to *Ilyodon*. Until these characters of the female and embryo are discovered, the position of *Allodontichthys* in the system will remain uncertain.”
On April 2, 1939, I obtained 4 female specimens of Allodontichthys in the vicinity of Colima. One female which had been gravid recently, but contained no embryos, was collected in a stream tributary to the Rio Tuxpan at Villa Alvarez; U.M.M.Z. No. 143020. Three mature females, 1 of which was gravid, were taken in the Rio Colima about 300 yards from the Colima railway station; U.M.M.Z. No. 143021. The critical ovarian characters were observed in the non-gravid females, and the diagnostic trophotaenial features were studied in the embryos dissected from the gravid female.

The study of the new material confirms the prediction of Hubbs and Turner that the genus possesses the ovarian and trophotaenial characters of the subfamily Girardinichthyinae. A cross section of the ovary (Pl. I, Fig. 1) shows that the ovary consists of a muscular wall surrounding an internal cavity which is divided by a single dorsoventral septum, except at the posterior end, and is partly filled by paired, folded masses attached to the walls of the ovary in dorsolateral positions. Ovigerous tissue is confined to the folded masses. All other genera of the subfamily Girardinichthyinae possess these characters in the ovary. The trophotaeniae are much like those of Balsadichthys. The flattened ribbons are attached to the anal lip along the sides and posterior margin (Fig. 3). All are directed posteriorly. The ribbons are branched, and there are 9 to 13 termini. The longest trophotaeniae extend to the caudal end of the embryo.

There is a pronounced sexual dimorphism in the color markings. The females are like the males in having the part of the body above the lateral line spotted with dark brown, the scales blackened posteriorly, a black comma-shaped spot behind the opercle, and the black bars crossing the dorsal fin. All females have wide, dark, and fairly regular bars beginning well above the lateral line and extending well below the lateral line. There are 10 to 12 of these bars, the first just back of the eye and the last at the anterior end of the caudal fin. These bars are present in older females, but they are not as distinct as in younger specimens. In size there does not seem to be any
TABLE I

PROPORTIONS AND STRUCTURES IN TWO NEW SPECIES OF THE GLAUCOMOSITIDAE AND IN CLOSELY RELATED SPECIES

The proportionate measurements and fin-ray counts for *Xenotaenia resolanae* and *Allodontichthys tamaulae* are those of the holotypes.

<table>
<thead>
<tr>
<th></th>
<th><em>Xenotaenia resolanae</em></th>
<th><em>Allodontichthys tamaulae</em></th>
<th><em>Allodontichthys costatus</em></th>
<th><em>Hyodon furcatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length</td>
<td>41 mm.</td>
<td>33 mm.</td>
<td>35 mm.</td>
<td>78 mm.</td>
</tr>
<tr>
<td>Length of head</td>
<td>12 mm.</td>
<td>8 mm.</td>
<td>8.3 mm.</td>
<td>16 mm.</td>
</tr>
<tr>
<td>Depth of body in total length in per cent</td>
<td>28.8</td>
<td>24.2</td>
<td>23.4</td>
<td>20.5</td>
</tr>
<tr>
<td>Predorsal length in total length in per cent</td>
<td>29.0</td>
<td>18.2</td>
<td>21.4</td>
<td>20.5</td>
</tr>
<tr>
<td>Preanal length in total length in per cent</td>
<td>56.1</td>
<td>48.4</td>
<td>51.4</td>
<td>48.4</td>
</tr>
<tr>
<td>Preventral length in total length in per cent</td>
<td>58.5</td>
<td>50.2</td>
<td>52.7</td>
<td>52.8</td>
</tr>
<tr>
<td>Length of caudal peduncle in total length in per cent</td>
<td>41.5</td>
<td>35.5</td>
<td>36.8</td>
<td>37.7</td>
</tr>
<tr>
<td>Height of caudal peduncle in total length in per cent</td>
<td>23.2</td>
<td>24.2</td>
<td>22.8</td>
<td>25.6</td>
</tr>
<tr>
<td>Width of body at opercle in total length in per cent</td>
<td>12.2</td>
<td>12.1</td>
<td>12.8</td>
<td>12.8</td>
</tr>
<tr>
<td>Length of gut in total length in per cent</td>
<td>17.3</td>
<td>14.8</td>
<td>14.6</td>
<td>14.0</td>
</tr>
<tr>
<td>Width of orbit in length of head in per cent</td>
<td>85.1</td>
<td>66.6</td>
<td>70.1</td>
<td>141.0</td>
</tr>
<tr>
<td>Interorbital distance in length of head in per cent</td>
<td>29.1</td>
<td>25.0</td>
<td>26.8</td>
<td>29.4</td>
</tr>
<tr>
<td>Gape of mouth in length of head in per cent</td>
<td>41.7</td>
<td>42.5</td>
<td>42.7</td>
<td>46.9</td>
</tr>
<tr>
<td>Length of snout in length of head in per cent</td>
<td>33.3</td>
<td>25.0</td>
<td>26.6</td>
<td>35.6</td>
</tr>
<tr>
<td>Base of dorsal in length of head in per cent</td>
<td>16.6</td>
<td>25.0</td>
<td>26.2</td>
<td>23.2</td>
</tr>
<tr>
<td>Base of anal in length of head in per cent</td>
<td>20.8</td>
<td>50.0</td>
<td>54.1</td>
<td>53.1</td>
</tr>
<tr>
<td>Base of caudal fin in length of head in per cent</td>
<td>16.6</td>
<td>43.8</td>
<td>46.3</td>
<td>37.5</td>
</tr>
</tbody>
</table>
The Goodeid Fishes

TABLE I—(Cont.)

<table>
<thead>
<tr>
<th></th>
<th><em>Xenotrias</em></th>
<th><em>Allodontichthys tamazulae</em></th>
<th><em>Allodontichthys zonistius</em></th>
<th><em>Hyodon furcidens</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Base of pectoral in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>length of head in</td>
<td>12.5</td>
<td>21.2</td>
<td>22.5</td>
<td>25.0</td>
</tr>
<tr>
<td>per cent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base of pelvic in</td>
<td>4.2</td>
<td>6.7</td>
<td>7.2</td>
<td>12.5</td>
</tr>
<tr>
<td>length of head in</td>
<td>36-40</td>
<td>40-43</td>
<td>40-43</td>
<td>50-54</td>
</tr>
<tr>
<td>per cent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scales in lateral line.</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>No. of rays in dorsal</td>
<td>16</td>
<td>15</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>fin</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>No. of rays in anal</td>
<td>35</td>
<td>28</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>fin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of rays in pectoral</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of rays in caudal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

notable difference between males and females. For other external characteristics see Table I.

*Allodontichthys tamazulae*, new species

The holotype, U.M.M.Z, No. 143022, an adult female 33 mm. in total length (27 mm. in standard length) was collected on April 3, 1939, in the Rio Tamazula, a tributary of the Rio Tuxpan, just above the town of Tamazula, Jalisco, Mexico. Eight paratypes, 5 males and 3 females, U.M.M.Z. No. 143023, were taken with the holotype. The characters of the ovary were studied in the holotype which was mature, but, unfortunately, none of the females was gravid, and it was impossible to determine the character of the trophotaeniae. The size, body form, and other external characters, except for the coloration (Table I), indicate that the specimens belong to the genus *Allodontichthys*, and the characters of the teeth are decisively diagnostic. The species is named for the town of Tamazula.

In general the coloration of *A. tamazulae* is much lighter than that of *A. zonistius*, and the entire portion above the lateral line is more lightly mottled with dark brown. About 12 heavy, dark, vertical bars extend in the females of *A. zonistius*
from well above the lateral line to well below the lateral line, and a black comma-shaped patch is present just back of the pectoral fin. In *A. tamazulae* there are 18 to 22 very short dark bars along the lateral line. Only in the part anterior to the dorsal fin and behind the head is there any considerable extension of the bars below the lateral line. In this area 7 to 10 irregular bars extend downward upon the belly. The comma-shaped patch behind the pectoral fin is present in *A. tamazulae*, but is much lighter than it is in *A. zonistius*. Three light vertical bars occur upon the caudal fin in *A. tamazulae*. There are none in *A. zonistius*. All males are more heavily marked than the females, particularly in the vertical bars below the lateral line upon the belly.

The teeth of *A. tamazulae* resemble those of *A. zonistius* in being conical and shouldered instead of bifid. In *A. zonistius* there are 16 teeth in the main row of the upper jaw and 20 in the lower jaw. The teeth are long, fairly sharp, and firmly set in the jaws in a single, curved row, with smaller conical teeth forming a second irregular row behind. In *A. tamazulae* the teeth are definitely conical and shouldered, but they are shorter and more blunt than they are in *A. zonistius*. In both the upper and lower jaws there are 12 teeth in the main row. The teeth are crowded and somewhat uneven, but they are not in alternating rows. Only the middle half of each jaw is occupied, leaving the lateral part of each jaw toothless. In both jaws there is a second row of small, conical teeth, irregular in position and loosely set in the jaws. The teeth of this second row are larger than those in *A. zonistius*.

The gut in both *A. zonistius* and *A. tamazulae* is two-thirds to three-fourths of the total body length. A carnivorous habit is indicated by the short gut and by the presence in the gut of some large (5 mm.) insect larvae.

*Xenotaenia*, new genus


The genus *Xenotaenia* is distinguished from other genera of the Girardinichthyinae by a number of well-defined characters.
The Goodeid Fishes

The trophotaeniae are in the form of a flattened rosette (Pl. I, Fig. 4) with 2 wide processes emerging from the posterior lip of the anus and a truncated mass attached to the anterior lip. The 2 posterior extensions are short and extend only to the posterior end of the anal fin of an embryo. All of the flattened processes have numerous small, bulbous masses upon the dorsal and ventral surfaces and the lateral margins. Since these trophotaeniae are unlike any others in the subfamily, the genus is named for the character.

Other distinguishing features of the genus are: (1) the great length and breadth of the head in relation to the total body length, 28.8 per cent (Table I), (2) the short and weak dorsal and anal fins, (3) the small number of scales in the lateral line, 36 to 40, (4) the small number of bifid teeth in the main row of the upper and lower jaws.

*Xenotaenia resolanae*, new species

The holotype of this species is a female 41 mm. in total length (34 mm. in standard length) taken in the Rio Resolana, a tributary of the Rio Purificación about 25 miles southwest of the town of Autlán in the state of Jalisco, Mexico, on March 29, 1939; U.M.M.Z. No. 143024. Two paratypes, a second and smaller female and a mature male, were taken in the same locality; U.M.M.Z. No. 143025. The holotype was gravid, and the character of the trophotaeniae was determined from embryos contained in her ovary.

Most of the measurements and numbers of rays in the fins are listed in Table I, together with those of *Ilyodon furvidens* and of the 2 species of *Allodontichthys* for comparison.

It will be noted that the head is unusually long in proportion to the total length and that the caudal peduncle differs little from the other species in proportion to the length. These facts taken together indicate that the region of the body between the posterior end of the head and the anterior end of the caudal peduncle is much shorter than it is in other species. The predorsal and the preanal lengths are greater than in other species because of the relatively greater length of the
head in *Xenotaenia resolanae*. The height of the body in relation to the total length is much greater than in other species. The interorbital distance in relation to the length of the head is about the same as in *Allodontichthys*, but not as great as it is in *Ilyodon*. The head is thick, and though it becomes narrower anteriorly, it is not as pointed as it is in *Allodontichthys* nor as bluntly rounded as it is in *Ilyodon*. The snout is short, and the eye is relatively large. The gape of the mouth is relatively narrower than that of *Ilyodon* and wider than that of *Allodontichthys*

All fins except the caudal are short and weak. The dorsal and the anal fins are set well back upon the body. The caudal fin is relatively high and contains fewer rays than does that of *Ilyodon* and more than does that of *Allodontichthys*.

There are 36 to 40 rows of scales on the lateral line of *X. resolanae*, considerably fewer than in *Allodontichthys* and many fewer than in *Ilyodon*.

The teeth are arranged in both jaws in an anterior row with several scattered rows behind. The teeth of the anterior (main) row are large, strong, bident, and firmly set in the jaws. The gut is relatively short, about 65 per cent of the total body length. As in *Allodontichthys* the short gut is indicative of a carnivorous habit in contrast to the omnivorous food habit of *Ilyodon*, in which the gut is much longer than is the body.

The swollen area in the male between the anus and the genital pore is rather flat and is as wide as it is long. There is no extension of the swollen area upon the thin membrane which envelopes the bases of the anterior rays of the anal fin. This backward extension of the swollen area is characteristic of the males of *Ilyodon*. The first 6 rays of the anal fin in the male are only slightly differentiated from the other rays of the anal fin in contrast to the condition in some other species of the Girardinichthyinae in which the first 6 rays are well separated from the other rays in the form of a lobe and are much shorter. In *X. resolanae* the margin of the fin is only slightly indented between the anterior and posterior parts of the fin, and the longest rays of the anterior group of 6 rays are 80 per cent as long as the longest ray of the posterior group.
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In color, specimens of *X. resolanae* are much lighter than are those of *Ilyodon* or *Allodontichthys zonistius*. In younger specimens the posterior halves of the scales are darkened by brown and black pigment cells above the lateral line for the entire length of the body and in the belly region for some distance. Along the lateral line there are about 15 irregular patches. In older specimens these dark patches along the lateral line often become broken up or disappear, whereas the markings upon the individual scales dorsal to the lateral line become more conspicuous. There are 3 irregular, vertical brownish bars on the caudal fin. The posterior margin of the dorsal fin is edged sparsely with light brown.

Zoogeography and Morphological Evolution of the Genera of the Subfamily Girardinichthyinae

A survey of the geographical distribution of the genera and species of the subfamily Girardinichthyinae and of the morphological differentiation in each brings one to the conclusion that there has been an ancient division in the subfamily and that the members of the 2 divisions have differentiated along somewhat different lines. The geographical barrier between the groups is the mountain range extending in an east-west axis from Mount Popocatepetl to Mount Colima. The evidence points to the region of Colima as the one in which the subfamily originated. After the origin of the subfamily, presumably there was some dispersal so that the range was increased. Some differentiation would have accompanied the dispersal. With the throwing up of the mountainous barrier, there was a separation of the group into that part of the subfamily included in the plateau and the other part excluded from the plateau and occurring south of the barrier. The part included within the plateau increased its range to the north and east, and at the same time new genera arose. The group excluded from the plateau and remaining in the Colima region increased its range in part by emigration up the coast to the northwest, northward up the rivers to the southern edge of the plateau and eastward and southeastward up the
Rio Balsas to its headwaters. Those genera outside of the plateau usually retained primitive characters, whereas those within the plateau usually have become more differentiated.

The hypothetical ancestral form would have had viviparity already established. The ovary would have had the characteristic features of the subfamily, and the trophotaeniae of the embryos would have been finger- or ribbon-shaped, rather numerous and rather long. There would have been little sex differentiation in size or color, and in the male the anal fin would have been only slightly changed from the condition in the female in the direction of the extreme lobation and shortening of the 6 anterior rays present in some species within the plateau. The teeth would have been conical, at least not bifid, fairly few in number, and arranged in one or more complete rows.

The living species which most nearly resembles the ancestral form is *Allodontichthys zonistius*. This species qualifies in all regards except for sex dimorphism in color. *Allodontichthys tamaulipe* has emigrated northward from the ancestral site, going up the Rio Tuxpan, but it has not yet passed the mountain barrier so as to reach the plateau. This species has changed somewhat in color markings, but in general it has retained the primitive characters of the ancestor, including the lack of sex dimorphism in color. There have been some changes in the teeth. The conical shape has been retained, but the number of teeth in the first row has been reduced by the dropping out of teeth at the outer margins of the jaws. *Balsadichthys xanthus* and *Ilyodon furcidens* probably arose from the ancestral form while still in the Colima region. These 2 species hybridize readily, and it is likely that there was a common ancestor for them in fairly recent times. In producing these species the ancestral form would have developed a larger size, a bifid condition of the teeth, and in the male a reduction of the first 6 rays of the anal fin together with a greater thickening of the swollen region between the anus and the genital pore and of the membrane enveloping the bases of the first 6 rays of the anal fin. In *Balsadichthys* there has
been an increase in the number of teeth by the formation of a second main row, the teeth of which alternate roughly with those of the first main row. Both genera have increased their ranges so that they are present now not only in the Colima region in which they originated but also to the north in the upper Río Tamazula. *Balsadichthys* has emigrated also to the east and the southeast using the Río Balsas as a highway, and during the emigration it has given rise to the new species *Balsadichthys whitei*. This species is present in the headwaters of the Río Balsas at Cuautla and Yauatepec southeast of Mexico City and at Tlapa in the eastern part of the state of Guerrero. *Xenotaenia resolanae* has arisen from another stock of the ancestral form during its emigration from the ancestral site northwestward up the coast. Few of the streams in this region have been explored, and it is likely that other species will be found. *Xenotaenia* has changed from the ancestral form in some important structures, but in some other characters it is very primitive. It has developed strong bifid teeth, suggesting that it has arisen from a stock closely related to the one which gave rise to *Ilyodon* and *Balsadichthys*. This, however, may have been an instance of independent and parallel evolution. The head has become longer and wider and the body deeper than they are in the ancestral form. The body color has become generally lighter. The trophotaeniae are shorter and fewer, and the membrane connecting them to the anal lip has become wider. It has retained a more primitive type of male anal fin than has any other species, and in this respect it probably resembles the ancestor closely.

The division of the subfamily which was cut off within the plateau, while retaining the basic characters of the subfamily, has become divided into 2 main stocks identified by the character of the trophotaeniae. One stock, including *Skiffia*, *Ollentodon*, and *Neotoca*, has 3 long posteriorly directed trophotaeniae, whereas the other, including *Lermichthys* and *Girardinichthys*, has a short pair anterior to the anus and a longer pair posterior to the anus. The first group has become differentiated in sexual dimorphism in size and color, the
climax being reached in *Neotoca*. Shortening of the first 6 rays of the anal fin of the male has become most extreme in *Skiffia*. *Lermichthys* and *Girardinichthys* probably represent geographically isolated genera which arose from a common ancestor no longer living. The withdrawal of water from the Mexican and Toluca basins has probably destroyed an old communication between the basins, and each of the isolated genera has evolved independently. In *Lermichthys* a very long dorsal fin has developed as the most conspicuous external feature. In *Girardinichthys* extreme sexual dimorphism in color has developed, and in the male there has arisen a thick straplike muscle just beneath the skin and lying in a vertical position, attached to the bases of the anterior rays of the dorsal and anal fins.

To recapitulate, it is assumed that the subfamily *Girardinichthyinae* originated in the Colima region and after a period of dispersal the members of the subfamily were divided into 2 groups by the rise of the mountain range on the southern edge of the plateau. Those excluded from the plateau increased their range by extensions up the Pacific coast to the northwest, up the Rio Tuxpan to the northward and up the Rio Balsas to the east. The genera *Balsadichthys*, *Allodontichthys*, *Hyodon*, and *Xenotaenia* are the living representatives of this subdivision. The subdivision which was included within the plateau at its southwestern corner became divided into 2 stocks, each of which spread to the north and east through the waters of the plateau and in some instances became isolated within relatively small ranges by physiographic changes in the plateau. One of the stocks is represented at present by the genera *Lermichthys* and *Girardinichthys* and the other by *Skiffia*, *Ollentodon*, and *Neotoca*.

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**Buex, Fernando de**


No. 495

The Goodeid Fishes


HUBBS, CARL L.


HUBBS, CARL L., and TURNER, C. L.

PLATE I

Fig. 1. Diagrammatic cross section of ovary of Allobrontichthys zonistius.
O. C., ovarian cavity.
O. S., ovarian septum.
O. T., ovigerous tissue.

Fig. 2. Diagrammatic cross section of ovary of Xenotaenia resolanae.
Abbreviations as in Fig. 1.

Fig. 3. Trophotaeniace of Allobrontichthys zonistius.

Fig. 4. Trophotaeniace of Xenotaenia resolanae.
A REVIEW OF MICROGLANIS, A GENUS OF SOUTH AMERICAN CATFISHES, WITH NOTES ON RELATED GENERA*

BY A. LOURENÇO GOMES

The genus Microglanis was proposed by Eigenmann (1912: 155) to include pimelodid catfishes previously referred to Pseudopimelodus but without backward projecting extensions of the premaxillary tooth patch. Microglanis poecilus Eigenmann, from British Guiana, was selected as the type of the genus, which was considered to include also Pseudopimelodus parahybae Steindachner (1880: 60) and Pimelodus (Pseudopimelodus) pulcher Boulenger (1887: 276). The description of M. variatus Eigenmann and Henn (in Eigenmann, Henn, and Wilson, 1914: 14), M. ater Ahl (1936: 109), and M. zonatus Eigenmann and Allen (1942: 89) increased the size of the genus, and Gosline (1941: 85) added still another species when he referred Pimelodus (Pseudopimelodus) cottoides Boulenger (1891: 233) to Microglanis. Pseudopimelodus Bleeker (1858: 196), having as genotype Pimelodus raninus Valenciennes (in Cuvier and Valenciennes,

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was restricted to those species with backward projecting extensions of the premaxillary tooth patch (as in \( P. \) raninus; cf. Eigenmann, 1912: 154) by the action of Eigenmann (1912: 130, 151, and 155). The genus \( \text{Pseudopimelodus} \) as then understood included \( \text{Pimelodus raninus} \) Valenciennes, \( \text{Pimelodus bifrons} \) Valenciennes (in Cuvier and Valenciennes, 1840: 154), \( \text{Pseudopimelodus acanthochirus} \) Eigenmann and Eigenmann (1888: 122), \( \text{Pimelodus (Pseudopimelodus) cot-}

\text{toides} \) Boulenger, \( \text{Pseudopimelodus villoso} \) Eigenmann (1912: 152), and \( \text{P. albomarginatus} \) Eigenmann (1912: 153). Eigenmann and Allen (1942: 90), however, defined \( \text{Pseudopimelodus} \) as "without angle projecting backward" in the premaxillary tooth patch, even though still referring to \( P. \) raninus as genotype. In this same work, \( \text{Zungaro} \) Bleeker (1858: 196; genotype \( \text{Pimelodus zungaro} \) Humboldt and Valenciennes, 1811: 170, from the Rio Marañon) is characterized by the "occipital process short and notched at the tip for the reception of the much longer dorsal plate". \( \text{Microglanis} \) is maintained on the basis of the very short occipital process not approximating the dorsal plate. Eigenmann and Eigenmann (1890: 109 and 110) gave as a character of \( \text{Pseudopimelodus parahybae (Microg} \text{lanis)} \) the occipital process meeting the much longer dorsal plate. Schultz (1944: 197) pointed out the differences between \( \text{Pseudopimelodus} \) and \( \text{Zungaro} \), but doubted the validity of \( \text{Microglanis} \).

In identifying a collection of fishes from Rio Grande do Sul, Brazil, I found it necessary to investigate the status of \( \text{Pimelodus (Pseudopimelodus) cottoiles} \) Boulenger, and the present paper is the result of the study which ensued. An attempt is made to determine the limits of the three genera involved. I am indebted to Dr. Reeve M. Bailey, of the Museum of Zoology of the University of Michigan (U.M.M.Z.), for help in all phases of the preparation of this paper. For the loan of specimens in their respective institutions, I wish to acknowledge the kindness of the late Dr. Thomas Barbour, of the Museum of Comparative Zoology (M.C.Z.), Dr. Wilbert M.

\( ^1 \)This species has frequently been referred to \( \text{Pseudopimelodus} \).
Chapman, of the California Academy of Sciences (C.A.S.), Miss Francesca La Monte, of the American Museum of Natural History (A.M.N.H.), Dr. George S. Myers, of the Natural History Museum of Stanford University (N.H.M.), M. Graham Netting and Dr. Arthur Henn, of the Carnegie Museum (C.M.), Karl P. Schmidt, of the Chicago Museum of Natural History (C.M.N.H.), and Dr. Leonard P. Schultz, of the U. S. National Museum (U.S.N.M.).

MATERIAL STUDIED AND METHODS

There is insufficient material of *Zungaro, Pseudopimelodus*, and *Microplanis* to permit a thorough revision of these genera. The material available is perhaps sufficient to establish the main characters by which they may be distinguished. In addition to the specimens of *Microplanis* reported below, the following material was examined.

*Zungaro zungaro* (Humboldt and Valenciennes).—Nine specimens: C.M. No. 6671a, 118 mm. in standard length, from Canal del Dique, Soplaviento; No. 6672, 600 mm., from Río Magdalena, Honda; and No. 6673a, 211 mm., from Río Magdalena, El Blanco; all collected in Colombia, by C. H. Eigenmann; C.A.S. No. 17974 (3), ranging from 97.4 to 144 mm., from Ríos Popoi and Huachi; and No. 17037 (3), 120 to 195 mm., from Río Colorado, tributary to Río Bopi; all collected in Bolivia, upper Beni basin, by N. E. Pearson. These specimens are labeled *Pseudopimelodus zungaro*, and were so reported by Eigenmann (1922: 32) and Pearson (1924: 10—Indiana University Museum Nos. 17036 and 17037).

*Pseudopimelodus acanthochirus* Eigenmann and Eigenmann.—Nine specimens, C.M. No. 7119, ranging from 24.0 to 41.0 mm. in standard length, from Río Guaporé, near Santo Antonio do Guaporé, Mato Grosso, Brazil, Amazon basin, collected by J. D. Haseman. The lateral line is seen with difficulty in most of the specimens; in two it is complete to the base of the caudal fin. All have lateral backward projecting extensions in the premaxillary tooth patch, rounded posteriorly in the smallest specimens and pointed in the others.
Pseudopimelodus albomarginatus Eigenmann.—Two specimens: C.M. No. 1680 (holotype), 75.0 mm. in standard length, from Tukeit; and No. 1682c (paratype), 69.0 mm., from Waratuk; both collected in the Potaro River, tributary to the Essequibo River, British Guiana, by Eigenmann (1912: 153). Lateral line with large conspicuous pores to midway between dorsal and adipose fins and then with very small pores to base of caudal fin.

Pseudopimelodus pulcher (Boulenger).—One specimen, C.A.S. No. 17973, 88.0 mm. in standard length, from Tingo de Pauca, at the mouth of Río Crisnejas in Río Marañon, Peru, collected by Pearson. Premaxillary tooth patch with lateral backward projecting extensions not as long as in the other species of the genus.

Pseudopimelodus roosevelti Borodin.—Five specimens; C.M. Nos. 7120a,b, and 7064a,b (4—labeled Pseudopimelodus pulcher), 21.1 to 54.4 mm. in standard length, from Río Tieté, Salto do Avanhandava; and 7118a (labeled Pseudopimelodus zugaro), 135 mm., from Río Piracicaba, Piracicaba; all collected in São Paulo, Brazil, Paraná basin, by Haseman. Predorsal plate nearly touching occipital process, not fitting into a notch in largest specimen, closer to occipital process in those 52.2 and 54.4 mm. long (No. 7064), fitting into a notch in occipital process in smallest specimens. All have lateral backward projecting extensions in the premaxillary tooth patch; in the smallest specimen (21.1 and 33.0 mm.—No. 7120) the caudal fin is deeply forked, the lobes pointed.

Pseudopimelodus transmontanus Regan.—Two specimens: C.M. No. 5331, 75.0 mm. in standard length, from Río Telembi; and C.A.S. No. 17977 (Ind. Univ. Mus. No. 13007), 80.0 mm., from a creek; both collected near San Lorenzo, Colombia, Patía basin, by A. Henn and C. Wilson (Eigenmann, 1922: 33). Pores on lateral line posterior to adipose fin minute.

Pseudopimelodus villorus butcheri Schultz.—Three specimens, U.M.M.Z. No. 142493 (paratypes), 37.0 to 119 mm. in standard length, from Río San Juan, near bridge south of Mene Grande, Venezuela, Maracaibo basin, collected by L. P.

The methods of taking measurements and counts are those described by Hubbs and Lagler (1941: 12-20). In the enumeration of fin rays the unbranched soft rays are represented by lower case Roman numerals (Hubbs, 1944: 76); the spines are represented by small capitals.

THE GENERA ZUNGARO, PSEUDOPIMELEODUS, AND MICROGLANIS

These pimelodid catfishes have the following characters in common: body stout, head broad, covered with skin; eye without free orbital rim; no palatine or vomerine teeth; teeth villiform in each jaw forming a patch on the premaxillary and one on mandible; small fontanel on top of head extended backward to level of posterior margin of eye; snout not produced; barbels flattened; adipose small; dorsal anterior to pelvic insertion; dorsal and pectoral fins with a well-developed pungent spine.

The three genera are contrasted in the following key.

KEY TO THE PIMELODID CATFISHES OF THE GENERA ZUNGARO, PSEUDOPIMELEODUS, AND MICROGLANIS

1a.—Premaxillary band of teeth with backward projecting extensions; distance from tip of snout to last well-developed pore on lateral line, 1.0 to 1.1 in standard length; caudal fin forked, more deeply in the young; posterior edge of dorsal spine sometimes serrate or crenulate, sometimes smooth; species of moderate to large size .... 2

2a.—Posterior nostril about equidistant from eye and anterior nostril; anterior edge of pectoral spine smooth, weakly serrate or serrate only at the base; humeral process short and strong, triangular, 2.0 or more in the length of pectoral spine, not reaching its middle; predorsal plate meeting and fitting into a notch of the occipital process; lower jaw slightly projecting Zungaro

2b.—Posterior nostril closer to eye than to anterior nostril; anterior edge of pectoral spine strongly serrate; humeral process elongate, 1.5 or less in the length of pectoral spine, reaching its middle; predorsal plate meeting or failing to join occipital process, sometimes fitting into a notch in the young; jaws usually subequal Pseudopimeleodus

1b.—Premaxillary band of teeth without backward projecting extensions; distance from tip of snout to last well-developed pore on lateral
line, 1.3 to 1.9 in standard length; caudal fin emarginate, or forked; posterior edge of dorsal spine smooth; species of small size. 

Microplanus

TENTATIVE LIST OF THE SPECIES OF ZUNGARO AND PSEUDOPIMELODUS

Zungaro Bleeker, 1858 (tautotype Pimelodus zungaro Humboldt and Valenciennes, 1811); Bleeker, 1862; Eigenmann, 1910; Eigenmann and Allen, 1942.

= Pseudopimelodus Eigenmann and Eigenmann, 1890, partim; Eigenmann, 1922, partim.

1.—Z. mangurua (Valenciennes, in Cuvier and Valenciennes, 1840) Eigenmann, 1910 and 1912. Type locality, "dans les eaux douces du Brésil et du Paraguay." The validity of this species is doubtful (Eigenmann, 1912: 151); Gosline (1941: 85; 1945: 27) included it in Cephalosilurus.

2.—Z. zungaro (Humboldt and Valenciennes, 1811) Bleeker, 1858 and 1862. Type locality, "la rivière des Amazones." 

=Pseudopimelodus butonis Steindachner, 1880, non Valenciennes.

Pseudopimelodus Bleeker, 1858 (tautotype Pimelodus raninus Valenciennes, in Cuvier and Valenciennes, 1840, designated by Bleeker, 1862); Eigenmann and Eigenmann, 1890, partim; Eigenmann, 1910 (P. butonis incorrectly cited as genotype) and 1912; Eigenmann, 1922, partim; Eigenmann and Allen, 1942.

=Pseudopimelodus butonis Steindachner, 1880, non Valenciennes.

1.—P. aoanthocharus Eigenmann and Eigenmann, 1888. Type locality, Tupana and Tajapuru, Para.; Tefe and Jutai, Amazonas, Brazil, Amazon basin.

2.—P. albornargi 1latus Eigenmann, 1912. Type locality, Tukeit, Potaro River, British Guiana.

3.—P. silicencrustatus Eigenmann, 1912. Type locality, Tukeit, Potaro River, British Guiana.

4.—P. butonis (Valenciennes, in Cuvier and Valenciennes, 1840) Bleeker, 1858. Type locality, Cayenne, French Guiana. The validity of this species is doubtful (cf. Eigenmann, 1912: 151); Gosline (1941: 85; 1945: 27) included it in Cephalosilurus.

5.—P. charus (Valenciennes, in Cuvier and Valenciennes, 1840) Bleeker, 1858. Type locality, Rio Sabará, Minas Gerais, Brazil. The validity of this species is in need of verification. Gosline (1945: 23) included it in Zungaro.

6.—P. pulcher (Boulenger, 1887) Eigenmann and Allen, 1942. Type locality, Casarao, Ecuador, upper Marañon basin. Boulenger described this species as without backward projecting extensions in the premaxillary tooth patch. Eigenmann included it
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in *Batrachoclinus* (1910: 383) and later in *Microplanius* (1912: 155), probably on the basis of this character. Eigenmann and Allen (1942: 91) placed it in *Pseudopimelodus*, after studying the specimen which I subsequently examined.

6.—*P. ruxius* (Valenciennes, in Cuvier and Valenciennes, 1840) Blochier, 1858. Type locality "Mana," French Guiana (Gosline, 1941: 81; 1945: 28). Eigenmann and Eigenmann (1890) and Eigenmann (1912) gave as type locality "Mana, Rio Janeiro."

7.—*P. rosei* Borodin, 1927. Type locality, Rio Moge-guará, São Paulo, Brazil.

8.—*P. transmontanus* Regan, 1913. Type locality, Rio San Juan and Patín, Colombia.

9.—*P. variolosus* Ribeiro, 1914. Type locality, Rio Taquiri, Mato Grosso, Brazil, Paraguay basin.

10.—*P. villosus* Eigenmann, 1912.

10a.—*P. v. villosus* Eigenmann, 1912. Type locality, Potaro landing, British Guiana, Essequibo basin.

10b.—*P. v. schultzi* Schultze, 1944. Type locality, Rio San Juan, near bridge south of Mene Grande, Veneculol, Maracaibo basin.

11.—*Pseudopimelodus* sp.

12.—*Pseudopimelodus* vargaro Eigenmann and Eigenmann, 1888 and 1890, see Humboldt. Goias, Brazil. Eigenmann (1912: 151) referred to specimens from Goias, previously reported by Eigenmann and Eigenmann as *P. vargaro*, as perhaps representing a different species. In the event those specimens are distinct from other known species a new name will be needed, since *vargaro* is not available.

*MICROGLANIS* EIGENMANN, 1912

*Pseudopimelodus*—Eigenmann and Eigenmann, 1880: 108, partim.

*Batrachoclinus*—Eigenmann, 1910: 383, partim.


This genus includes small Pimelodid catfishes which differ from the related genera *Zungaro*, *Pseudopimelodus*, *Lophiosilurus*, and *Cephalosilurus* principally in the lack of lateral backward projecting extensions in the premaxillary tooth patch. *Lophiosilurus* and *Cephalosilurus* have the head very broad and much depressed and the lower jaw strongly pro-
jecting. In Microglanis the head is narrower anteriorly and not as greatly flattened; M. variegatus is the only species in the genus in which the lower jaw protrudes and the head is broader than long. Zungaro and Pseudopimelodus are compared with Microglanis in the key given above. In contrast to Zungaro, Microglanis and Pseudopimelodus have the nostrils similarly placed, the anterior edge of the pectoral spine strongly serrated, the predorsal plate meeting or failing to join the occipital process, and the humeral process elongate, contained two or less than two times in the pectoral spine. Microglanis is believed to be more closely related to Pseudopimelodus than it is to Zungaro.

Schultz (1944: 197–98) has questioned the validity of the genus Microglanis, and George S. Myers has suggested (in correspondence) the possibility that the species here referred to Microglanis are only the young of Pseudopimelodus. In young specimens of Pseudopimelodus villosus butcheri and P. roosevelti even at a size comparable to that of Microglanis the premaxillary tooth band has well-developed backward project­ing extensions, not essentially different from those of large indi­viduals. Large specimens of Microglanis differ not at all from small ones; at all sizes the premaxillary teeth are in an almost transverse band, rounded laterally and without back­ward extensions. The discovery of developed eggs in the ovaries of a specimen of M. iheringi only 52 mm. in standard length provides conclusive evidence that this species is in real­ity of small size—not the young of another fish.

The genus Microglanis has an extensive geographic range, but its species constitute a closely knit unit. There doubtless are excellent color characters in the group, which I believe will provide clear-cut specific differences. Nevertheless, color char­acters were neglected in the present study, because most of the available specimens were pale, some completely discolored, and therefore not suitable to the study of color features.

KEY TO THE SPECIES OF Microglanis

1a.—Lower jaw projecting; head very wide, broader than long. Pacific slope of Ecuador (near Vinces) ........................................ M. variegatus
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1b.—Jaws subequal; head longer than broad. Atlantic slope

2a.—Distance from tip of snout to last well-developed pore on lateral line, 1.3 to 1.4 in standard length. Colombia and Venezuela (Rio Turmero, Aragua, and Carabobo).

M. heringi, new species

2b.—Distance from tip of snout to last well-developed pore on lateral line, 1.5 to 1.9 in standard length

3a.—Mouth large, the gape (greatest width across opening of mouth) less than 1.6 in head length. British Guiana, Venezuela (Rio Orinoco basin), and Amazon.

M. poroibus

3b.—Mouth small, the gape more than 1.7 in head length

4a.—Maxillary barbel long, reaching beyond tip of the short humeral process. Peru (Rio Morena) — M. zonatus

4b.—Maxillary barbel short, not reaching or hardly reaching tip of the elongate humeral process

5a.—Anal rays, 10 to 12. Southeastern Brazil (Rio de Janeiro to Rio Grande do Sul) — M. cottoides

5b.—Anal rays, 14. Middle Brazil — M. ater

Microglanis variegatus Eigenmann and Henn

Microglanis variegatus.—Eigenmann and Henn, in Eigenmann, Henn, and Wilson, 1914: 14 (original description; type locality, near Vincos, Ecuador). Eigenmann, 1922: 33, Pl. 2, Figs. 3 and 4 (description; same locality). Gosline, 1941: 85; 1945: 28 (listed only).

Three specimens examined: C.A.S. No. 13971 (three—types, Indiana University Museum No. 13106), two, 36.5 mm. in standard length (one is the holotype), and one, 29.5 mm.; and C.M. No. 5418a (paratype), 29.5 mm.; all from a shallow, plant grown, forest pool near Vinces, Provincia Rios, Ecuador, collected by A. Henn.

Microglanis heringi, new species

Holotype, Chicago Museum of Natural History, No. 35350, 35.0 mm. in standard length, from Rio Turmero, near Turmero, Aragua, Venezuela, collected by Y. Barnes, Jr., on September 24, 1937. Eight paratypes: C.M.N.H. Nos. 35349, 35347, 35351, and U.S.N.M. No. 121985 (2), 26.2 to 31.0 mm., taken with the

3 Named for my former teacher, the late distinguished Brazilian ichthyologist, Dr. Rodolfo von Ihering.
### TABLE I

**Proportional Measurements in Microglandus Fairugi, New Species**

The proportions are expressed as thousandths of the standard length or of the head length.

<table>
<thead>
<tr>
<th></th>
<th>Paratypes</th>
<th>Holotype</th>
<th>Paratypes</th>
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<td>Distance from tip of snout to pelvic insertion</td>
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<td>Distance from tip of snout to anal origin</td>
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<td>Distance from tip of snout to adipose origin</td>
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<td>Length of dorsal base</td>
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<td>Distance from dorsal to adipose (excluding fin base)</td>
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Proportions of head length

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* The width of the mandibular tooth patch was taken from the middle obliquely to the posterior extremity.
holotype; A.M.N.H. No. 8665a,b (2), 49.0 and 31.5 mm., collected in the state of Carabobo, Venezuela; M.C.Z. No. 32124, 52.0 mm., from Colombia, collected by Niceforo Maria, in 1929.

DESCRIPTION.—For proportionate measurements see Table I. Body compressed, especially toward caudal peduncle, its cross section at dorsal origin roughly triangular, the depth and width progressing decreasing to the tail. Body depth, 4.6 in standard length; body width at tip of humeral process, 4.9. Standard length, 1.3 in total length. Head broad, with a few scattered pores on top and side, the dorsal profile straight, inclined downward to tip of snout; head length, 3.5 in standard length; head width, 1.2 in head length. Eye minute, superior, its length, 13 in head length, 5.7 in the interocular width; interocular width, 2.2 in head length. Nostrils far apart, the anterior tubular, close to margin of snout, the posterior near eye, with a flap; distance from posterior nostril to anterior margin of eye about twice in the distance between nostrils. Snout short, rounded, sharp, its length, 2.5 in head length, 1.2 in interocular width. Frontal fontanel small, ovoid, extended backward to the level of posterior margin of eye. Occipital with minute, circular fontanel, smaller in largest specimens, just in front of base of occipital process. Occipital process strong, short, in contact with the much longer dorsal plate. Mouth rather wide, anterior, the gape more or less horizontal, 1.7 in head length. Premaxillary tooth patch without backward projecting extensions, rounded laterally, with a small notch in the middle of the rear edge. Mandibular tooth patch much longer than premaxillary one, crescent shaped, very narrow posteriorly. Maxillary barbel long, reaching at least the middle of humeral process, sometimes extended beyond tip of humeral process and middle of pectoral spine, as in the holotype. A groove extends backward from the origin of maxillary barbel to level of eye. Outer mental barbel reaching beyond insertion of pectoral spine, its origin posterior to origin of inner mental barbel. Inner mental barbel short, roughly two-thirds the length of the outer. Gill-rakers fli-
form, 2 + 5 on first branchial arch of a paratype 29.6 mm. in standard length; longer on lower ramus than on upper ramus.

Dorsal rounded, slightly higher than long, the spine short and smooth, its origin somewhat anterior to level of tip of depressed pectoral spine, its distance from tip of snout, 2.7 in standard length; last dorsal ray above insertion of pelvic fin or a little anterior to it; distance from dorsal to adipose (excluding fin bases), 4.9 in standard length. Humeral process elongate, pointed, extended to level of middle of pectoral spine, its length, 2.0 in head length. Pectoral truncate, its first branched ray the longest, the distance from its insertion to tip of snout, 3.9 in standard length. Pectoral spine longer and stronger than dorsal spine, slightly recurved near tip, 1.4 in head length, with hooks along both the anterior and the posterior edges, those on posterior edge stronger. On the proximal part of the anterior edge the hooks are small and more or less perpendicular to the spine; those distal are stronger, slightly curved and retrore, except for a few near the tip, which are antrorse or perpendicular to the spine. In one specimen (52 mm.) the distal third of the pectoral spine bears antrorse hooks. Posterior hooks slightly curved, retrore, except near the tip of the spine where they are more or less perpendicular to the spine. Pelvic rounded, its insertion situated at middle of body. Adipose free posteriorly, the distance from its origin to tip of snout, 1.4 in standard length; adipose base, 5.8 in standard length; length of adipose fin, 7.0 in standard length. Anal rounded, deep, the distance from its origin to tip of snout, 1.4 in standard length. Distance from tip of snout to last well-developed pore on lateral line, 1.3 in standard length. Caudal slightly forked, the lobes pointed. Caudal peduncle relatively long, 5.8 in standard length; caudal peduncle depth, 7.1 in standard length, 1.2 in caudal peduncle length. Dorsal rays, 1, 6; anal rays, 4 or 5, 7 or 8 (v, 8 in holotype); pectoral rays, 1, 5; pelvic rays, i, 5.

Coloration of body variegated, the light areas minutely stippled with dark and the dark areas with light. Upper part

4 First two soft unbranched rays difficult to count unless good illumination and high magnification are used.
of head and body dark brown, in largest specimens darker between the nape and posterior base of dorsal fin; upper part of head with a few whitish points in some specimens; snout somewhat lighter; a transverse light band from the insertion of pectoral fin of one side, across nape, to the other side; an elongate, more or less elliptical spot, wider posteriorly, in front of and at the origin of adipose fin. Side of head lighter than top, with two light spots, very distinct in the holotype, but not as well marked in all specimens. Side of body mostly lighter than the upper part, with a dark brown band from between pectoral and pelvic fins of one side to the other, confluent on top with the dark brown of the back; another band, which is very narrow inferiorly and much wider superiorly, extends from the anterior part of anal to adipose, and a dark wide crossband across peduncle and base of caudal rays; both are confluent with the dark coloration of the back. Lower surface uniformly whitish, stippled with dark brown, much darker on largest specimens. Dorsal fin mostly dark brown, with a large light spot on the posterior four or five rays; tips of rays light. Adipose dark brown in the middle, light anteriorly and posteriorly. Other fins mostly light, with spots of dark brown, which form one or two indistinct irregular bands, lacking in part in some small specimens, including the holotype, more distinct in largest specimens, which have the fins darker. Caudal fin with a broad, dark band parallel to the posterior edge. The specimen from Colombia is darker than are the others, and the contrast between dark and light areas is not as well marked as in the holotype and paratypes collected in Aragua; the specimens from Carabobo are intermediate in color between those from Colombia and from Aragua. 

*M. iberingi* is the only species in the genus known from northwestern South America. The coloration of the body is more similar to that of *M. cottoides* and *M. sonatus* than to that of the other species of *Microglanis*. The chief characteristics of *M. iberingi* are the typical coloration, the relatively narrow width of the head and body, the gently rounded contour of the snout, the rather well-developed lateral line, and the relatively long caudal peduncle.
The two largest specimens are adult females; in one of them (the 52 mm. specimen from Colombia) the ovaries are full of ripe eggs.

*Microplanis poecilus* Eigenmann

*Microplanis poecilus*.—Eigenmann, 1912: 155, Pl. 12, Fig. 2 (original description; type locality, below Pacaeo Falls, Essequibo River, British Guiana). Capitoeco, 1935: 58 (Rupununi River, British Guiana, Essequibo basin; listed only). Gosline, 1941: 85; 1945: 28 (listed only).

Forty-six specimens examined: C.M. No. 1676a,b (two-labeled *Batrachoglanis raninus*, but the largest specimen is the holotype and the smaller a paratype of *M. poecilus*), 27.5 and 17.0 mm. in standard length, from below Pacaeo Falls in Essequibo River, British Guiana, collected by C. H. Eigenmann; A.M.N.H. No. 14658a,b (2), 68.0 and 69.0 mm., from the Amazon basin; N.H.M. Nos. 40189 (30) and 40190 (12), 21.0 to 28.0 mm., from Caño de Quirobana, some 34 kms. north of the mouth of Río Apure into Río Orinoco, Venezuela, collected by Carl Ternetz.

*Microplanis zonatus* Eigenmann and Allen

*Microplanis zonatus*.—Eigenmann and Allen, 1942: 89, Pl. 3, Figs. 1 and 2 (original description; type locality *Río Morona, Peru*). Gosline, 1945: 29 (listed only).

One specimen examined: C.A.S. No. 17970 (holotype, Ind. Univ. Mus. No. 15890), 19.5 mm. in standard length, from *Río Morona, Peru*, collected by W. R. Allen.

*Microplaniscottoides* (Boulenger)

*Pseudopimelodus chirua*.—Steindachner, 1876: 622, see Valenciennes (description; Rio Parahyba and Santa Cruz, Río de Janeiro, Brazil).

*Pseudopimelodus paranahoe*.—Steindachner, 1888: 60, Pl. 3, Figs. 2 and 2a (original description; type locality, Rio Parahyba and Santa Cruz, Río de Janeiro, Brasil). Eigenmann and Eigenmann, 1888: 123 (listed only); 1890: 110 (description; same locality).

*Pimelodus (Pseudopimelodus) paranahoe*.—Boulenger, 1891: 233, see *Pimelodus (Ekandia) paranahoe* Steindachner, 1876: 615.

*Batrachoglanis paranahoe*.—Eigenmann, 1916: 383 (listed only).
As a consequence of Boulenger's action (1891: 233) in uniting Steindachner's species, *Pimelodus (Rhamdia) parahybae* (1876) and *Pseudopimelodus parahybae* (1880) in the genus *Pimelodus*, the latter specific name becomes a homonym, and is not available even though the species was subsequently placed in *Microglanis*. Boulenger correctly indicated that the name *cottoides* was necessary even if the nominal species *parahybae* and *cottoides* should prove to be identical. It is now apparent, after the study of the specimens indicated below, that *Pseudopimelodus parahybae* Steindachner, 1880, and *Pimelodus (Pseudopimelodus) cottoides* Boulenger, 1891, are the same, and the species must be known as *Microglanis cottoides* (Boulenger).

Seventy-four specimens examined: C.A.S. No. 17969 (fifty-nine, 1 paratype), ranging from 18.5 to 42.0 mm, in standard length, from Rio Grande do Sul (probably Rio Camaquã), Brazil, collected by H. von Ihering; and No. 17972 (two, 1 paratypes of *M. parahybae*), 27.0 and 29.0 mm, from Santa Cruz, Rio de Janeiro, Brazil; U.M.M.Z. No. 145295, 36.0 mm, from the Laguna dos Quadros basin, Conceição do Arroio County, Rio Grande do Sul, Brazil, collected by H. Kleerekoper; U.S.N.M. No. 94298 (2), 22.0 and 32.5 mm, from Rio Paraíba, Rio de Janeiro, Brazil; C.M. No. 71104, 56.0 mm, from Rio Ribeira, São Paulo, Brazil, collected by J. D. Haseman; and C.M. No. 6931-a-g (9), 21.0 to 51.0 mm, from Uruguaiana, Rio Grande do Sul, Brazil, collected by Haseman.

*Microglanis ater* Ahl

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PLATE I

*Microglanis iberingi*, new species

Fig. 1.—Holotype from Rio Turunoro, Aragua, Venezuela; 35 mm. in standard length; C.M.N.H. No. 35350. Lateral view.

Fig. 2.—The same. Dorsal view.
**Plate I**

*Microglanis sheringi*

**Fig. 1**

**Fig. 2**
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NOTROPIS ALBORUS, A NEW CYPRINID
FISH FROM NORTH CAROLINA AND VIRGINIA

BY CARL L. HUBBS AND EDWARD C. RANEY

The most speciose group of eastern North American freshwater fishes is the complex that has generally, and we think wisely, been classed in a single genus *Notropis*. There seems to be no end in sight to the new species that are being added to this already large genus. We here define *Notropis alborus*, a new species from the coastal drainage basins of southern Virginia and of North Carolina. It is a Piedmont form, of the Roanoke, Cape Fear, and Pee Dee river systems. Its distribution (Map 1) corresponds interestingly with that of *Notropis sequiens* and of *N. altipinnis* (Hubbs, 1941: Fig. 1).

WHITEMOUTH SHINER

*Notropis alborus*, new species

(Pl. 1; Fig. 1; Map 1)

*Notropis proese* (misidentification).—Jordan, 1890: 332 (size; color; near Greensborough, North Carolina).

The only specimens of this species that seem to have been recorded in the literature were taken by Jordan near Goldsborough, North Carolina (Jordan, 1890: 191). These were
collected in South Buffalo Creek about 5 miles southeast of Greensborough and in Little Allemanee Creek about 9 miles southeast of the same town. The collection from Goldsborough in the United States National Museum 1 contains 25 specimens of *Notropis alborus* (No. 40347) and 1 specimen of *N. procne longiceps* (No. 117390). Pending further information we assume that most of Jordan's series of "procne" from near Goldsborough comprised *alborus*. His specimens from Fulk's Mills were not located.

**RELATED SPECIES OF ATLANTIC COAST**

Among all species of *Notropis* known to occur in the Atlantic drainage south of the St. Lawrence River system, there are only 5 with 4–4 pharyngeal teeth, and *alborus* is one of these. The others are *N. heterolepis*, *N. volucellus*, *N. procne*, and *N. bifrenatus*. Recent discussions of the status and characters and figures of these species are as follows:

*N. heterolepis*—Hubbs, 1926: 36–37, 41–42; Greeley, 1934, Pl. 8; Hubbs and Lagler, 1941: 52, 59–60, Fig. 75.

*N. volucellus*—Hubbs and Greene, 1928: 375–80; Hubbs and Ortenburger, 1929: 67–70; Hubbs and Brown, 1929: 31–32; Trautman, 1931; Greeley and Greene, 1931: Pl. 7; Hubbs and Lagler, 1941: 52, 59, Fig. 74.


*N. bifrenatus*—Fowler, 1906: 138–40, Pl. 2; Hubbs, 1926: 36, 40–41; Hubbs and Brown, 1929: 30; Greeley and Greene, 1931, Pl. 6; Bailey, 1938: 169; Hubbs and Lagler, 1941: 52, 60.

The known Atlantic Coast distribution of these 4 species (in large part indicated by Hubbs and Lagler, 1941: 59–60) is as follows:


*Notropis volucellus volucellus* (Cope): Roanoke and Neuse river systems. These records are based on our collections.

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1 Specimens examined by courtesy of Curator Leonard P. Schultz.
Notropis Alborus, a New Cyprinid Fish

made respectively in the Roanoke River at Salem, Roanoke County, Virginia (May 16, 1931), and in Flat River 3 miles north-northeast of Timberlake, Person County, North Carolina (April 2, 1941).

MAP 1. Record stations for types of Notropis alborus. The type locality is ringed.

Notropis procne (Cope): from the Delaware and Susquehanna river systems to the James River basin of Virginia (N. p. procne), and from the Roanoke system in Virginia to the Santee drainage in South Carolina (N. p. longiceps).

Notropis bifrenatus (Cope): from southern Maine to the Potomac River drainage of Virginia, generally in sluggish waters.

Thus, N. alborus occurs south of the southern limit of the range of N. bifrenatus and far south of any heterolepis record for the Atlantic drainage. It overlaps the distribution of N. v. volacellus, though the two have not yet been taken together. The range of N. alborus lies within that of N. procne longiceps, and these forms have been taken together, as in Morgan Creek, near Chapel Hill, North Carolina.

COMPARISONS.—Notropis alborus differs from N. heterolepis
and *N. volucellus* in having 7 instead of 8 anal rays. It contrasts further with *heterolepis* in having the dorsal fin larger (depressed length equal to or nearly as long as distance between dorsal and occiput, instead of being about two-thirds that distance). The dorsal is more sharply pointed, and is situated farther forward; its origin lies over instead of behind the pelvic insertion, nearer the tip of the snout than the base of the caudal (the reverse is usually true of *heterolepis*). *N. alborus* lacks the elevated lateral line scales and the black pigment about the anus that characterize *N. v. volucellus* and it is much more strongly black-banded.

Close comparison discloses numerous characters by which *alborus* can be distinguished from *N. procne* and from *N. bifrenatus*, the 2 Atlantic Coast species with 4—4 teeth and 7 anal rays. These differences are brought out in the following comparisons (supplemented by Figs. 1-3). We add comparative statements for *Notropis atrocaudalis* Evermann, a species of Texas with 4—4 teeth and 7 anal rays, and otherwise very similar to *alborus, procne, and bifrenatus*. Most of the material of *atrocaudalis* was collected and made available by Kelshaw Bonham.

**LATERAL LINE**

- *N. alborus, procne, and atrocaudalis*: complete or very nearly so.
- *N. bifrenatus*: typically incomplete, but becoming nearly or quite complete at southern end of range.

**DORSAL CONTOUR AT NAPE**

- *N. alborus*: slightly convex to almost straight.
- *N. procne*: almost straight.
- *N. atrocaudalis*: definitely convex.
- *N. bifrenatus*: slightly concave (sometimes nearly straight).

**DORSAL CONTOUR AT FRONT OF DORSAL**

- *N. alborus and bifrenatus*: rather sharply elevated.
- *N. procne*: very little elevated.
- *N. atrocaudalis*: intermediate in elevation.
CURVATURE OF DORSAL CONTOUR IN REFERENCE TO VENTRAL CONTOUR

_N. alborus_: much greater.
_N. procne_ and _atrocaudalis_: somewhat more curved.
_N. bifrenatus_: about equally curved.

BODY DEPTH IN HEAD
_N. alborus_: 0.8–1.1.
_N. procne_: 1.1–1.3.
_N. atrocaudalis_: 0.9–1.3.
_N. bifrenatus_: 0.8–1.0.

EYE IN SNOUT
_N. alborus_: 1.2–1.5.
_N. procne_: about 1.0.
_N. atrocaudalis_: 1.0–1.3.
_N. bifrenatus_: 0.7–0.9.

EYE IN POSTORBITAL
_N. alborus_: 1.4–1.7.
_N. procne_: 1.4–1.6.
_N. atrocaudalis_: 1.7–2.0.
_N. bifrenatus_: 1.4–1.7.

MOUTH
_N. alborus_: nearly horizontal, not rising anteriorly to above lower border of orbit. Angle measurements, taken with an arm protractor (Hubbs, 1946) in 10 specimens, vary as follows: angle between edge of upper lip and line joining middle of caudal base with tip of snout, 18° to 26° (average, 22°); angle between edge of upper lip and line tangential to top of head, 39° to 52° (average, 43°).
_N. procne_: slightly sloping, rising anteriorly to between levels from lower border of orbit and lower border of pupil.
_N. atrocaudalis_: mouth moderately oblique, rising anteriorly to level from lower part of pupil.
_N. bifrenatus_: rather strongly oblique, rising anteriorly to above level from lower margin of pupil.
SNOUT IN SIDE VIEW

*N. alborus*: blunt and gibbous, projecting a little beyond upper lip.

*N. procne* and *atrocaudalis*: moderately blunt, scarcely projecting beyond upper lip.

*N. bifrenatus*: very bluntly pointed, scarcely or not at all projecting beyond upper lip.

NUPTIAL TUBERCLES ON HEAD

*N. alborus*: weak, rather evenly distributed over top and sides of head, but nowhere much enlarged; scarcely developed about either jaw or on adjacent edge of snout.

*N. procne*: moderately coarse over top and sides of head, but weak on opercles, except on uppermost part; rather strong on cheeks and preorbital; moderately developed about jaws.

*N. atrocaudalis*: developed over top and most of sides of head, becoming strengthened on region behind upper half of eye and obsolete on middle of parietal region, cheek, and mandible.

*N. bifrenatus*: tubercles very few and scattered; a patch above each eye; a band between anterior nostrils on front of snout; a patch in front of eye on lachrymal; a few on cheek; some on upper part of opercle; almost none on mandible.

NUPTIAL TUBERCLES ON BODY SCALES NEAR HEAD

*N. alborus*: lacking.

*N. procne* and *atrocudalis*: more or less developed in a row near each scale margin.

*N. bifrenatus*: lacking.

DARK MARGIN OF EACH SCALE POCKET

*N. alborus*: forming a conspicuous streak down to lateral line; contrasting sharply with the light center and edge of scale; conspicuous dark spots formed where the lines cross.

*N. procne*: rather conspicuous down to lateral line, but appearing more like bands of dots than pigment.
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streaks; spots at intersection of lines weaker; scale centers conspicuously lighter.

*N. atrocaudalis*: rather indistinct; whole scale tending to be evenly peppered with dots becoming indistinct toward lateral line; without prominent spots at intersections of lines.

*N. bifrenatus*: strongly developed, but whole scale with lightly stippled scale centers; streaks extending to lateral line; spots at intersections of lines rather large, but diffuse.

**MID-DORSAL STREAK**

*N. alborus*: obsolescent.

*N. procne*: moderately strong with intensifications at front of dorsal, at base of caudal, and often at nape.

*N. atrocaudalis*: weak except toward head, where intensified.

*N. bifrenatus*: very weak.

**COLOR OF DORSAL FIN BASE**

*N. alborus, N. atrocaudalis, and N. bifrenatus*: a little intensification along base of each membrane.

*N. procne*: strong black streak with pale area near origin of dorsal and about end of fin.

**PIGMENT ON LIPS (Figs. 1-3)**

*N. alborus*: lacking except in concealed area about symphysis of upper lip.

*N. procne*: developed on both exposed and concealed parts of entire length of upper lip and weakly in a row on tip of chin.

*N. atrocaudalis*: developed on exposed part and on concealed part near symphysis, but not on lower lip.

*N. bifrenatus*: upper lip blackish on both exposed and concealed parts except near edge of gape, becoming black on forward extension of lateral band; a streak of pigment on middle of lower lip, but never, as far as observed by us, with a black chin tip as described and figured by Fowler (1906: 140, Pl. 11).
DARK BAND ON SIDE OF SNOUT (Figs. 1–3)
N. alborus: ringing tip of snout, entirely above upper lip.
N. procne: confined to preorbital blotch, the whole tip of snout evenly pigmented.
N. atrocaudalis: ringing snout and encroaching upon exposed part of upper lip.
N. bifrenatus: ringing snout in a narrow band on upper lip and extreme edge of rostral fold.

PIGMENTATION ON TOP OF SNOUT (Figs. 1–3)
N. alborus: no pigment or very little behind nostrils and in a terminal ring just above the dark band; evenly stippled between nostrils.
N. procne: some stippling behind nostrils; no light band ringing snout; pigment between nostrils mostly concentrated in a pair of lateral crescents.
N. atrocaudalis: reduced stippling behind nostrils and in light ring above dark stripe anteriorly; pigment between nostrils evenly stippled.
N. bifrenatus: pigment somewhat reduced behind and before nostrils, but without a definite light ring; region between nostrils darkened and somewhat blotched, but without a definite pair of dark crescents.

BAND OF PIGMENT ON SIDE OF HEAD POSTERIORLY (Figs. 1–3)
N. alborus and atrocaudalis: moderately broad, subcontinuous.
N. procne: moderately broad to narrow, more or less disrupted (blackest on anterior part of opercle).
N. bifrenatus: broad and continuous.

PIGMENT ON AND JUST BEHIND SHOULDER GIRDLE
N. alborus: well developed or intense on shoulder girdle, still more intensified just behind in a streak which is not definitely continued downward.
N. procne: weak or lacking on shoulder girdle; typically intensified just behind girdle in a streak extending more than half way to pectoral base.
N. atrocaudalis: band rather evenly continuous across this region.
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Figs. 1-3. Heads of Notropis alborus (Fig. 1), Notropis procne procne (Fig. 2), and Notropis bifrenatus (Fig. 3), to show form and pigmentation. Drawings by Edwin Buda.

*N. bifrenatus*: broad streak across shoulder girdle and region just behind, more or less disrupted by an oblique light streak.

**LATERAL BAND ON BODY**

*N. alborus*: narrower than pupil; moderately diffuse and weakly intensified about lateral line pores.

*N. procne*: rather narrow and diffuse, but strongly marked by black pigment about pores.

*N. atrocaudalis*: about as narrow as pupil, blackish, and strongly set off by light area above; concentration of pigment about lateral line pores conspicuous.
Hubbs and Roney  
Occ. Papers

N. bifrenatus: much wider than pupil and very intense, especially near base of scale pockets (1 row of these blotches is made up of the dark pigment around the lateral line pores).

Caudal Spot and Adjacent Pigment

N. alborus and bifrenatus: conspicuous, black, and conjoined with lateral band; several median caudal rays rather inconspicuously dark edged.

N. procne: much smaller than pupil, disconnected from lateral band; several median caudal rays inconspicuously dark edged.

N. atrocaudalis: about as large as pupil, very intense, disconnected from lateral band; two median caudal rays boldly bordered with black so that the spot appears to be continued backward.

Melanophores on Lower Edge of Caudal Peduncle

N. alborus and procne: more or less definitely triserial; tending to form a chainlike pattern with 3 subequal loops.

N. atrocaudalis and bifrenatus: biserial or nearly so; little tendency to form a chainlike pattern of three links.

Pigment about Anus

N. alborus: moderately conspicuous on either side of anus.

N. procne: scarcely developed, except in moderate intensity behind anus.

N. atrocaudalis: moderately developed behind and on sides of anus.

N. bifrenatus: conspicuous around entire region of anus and often also in area between anus and pelvic bases.

It will be seen that a large proportion of the diagnostic characters in this group of shiners is made up of details of pigmentation. This is true also of 2 other species of the same region, and of their relatives elsewhere (Hubbs, 1941), and of certain other minnows (Hubbs, 1942). Insufficient attention has been given such pigmentary characters in the systematics of the American cyprinids.

Material.—The holotype, 42 mm. in standard length, was
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collected by E. C. Raney and Ernest A. Lachner on March 6, 1940, in Brush Creek, a tributary of Deep River, 5 miles west of Siler City, Randolph County, North Carolina. U. M. M. Z., No. 138489. (The dot for the type locality, on Map 1, is ringed.)

Nineteen paratypes, 28 to 45 mm. long, were taken at the same locality. U. M. M. Z., No. 138490; Cornell University, No. 10074.

Additional paratypes bear the following data:

U. M. M. Z., No. 132797: 1 specimen, 49 mm. long, collected by Joe F. Wilson in May, 1939, in a tributary of Rocky River 2 miles south of Davidson, Mecklenburg County, North Carolina.

U. M. M. Z., No. 138332: 8 adults, 38 to 49 mm. long, collected by A. McLaren White on April 28, 1933, in Morgan Creek 2 miles below bridge on the Pittsboro-Chapel Hill Highway, Orange County, North Carolina.

U. M. M. Z., No. 138333: 3 adults, 47 to 48 mm. long, collected by A. McLaren White on June 3, 1933, in Morgan Creek 1 mile above the Pittsboro-Chapel Hill Highway, Orange County, North Carolina.

U. M. M. Z., No. 138488: 8 specimens, 31-36 mm. long, collected by Raney and Lachner on April 5, 1940, in a tributary of the Yadkin River 11 miles southeast of Lexington, Davidson County, North Carolina.

U. S. N. M., No. 40847: 25 specimens, collected by David Starr Jordan in 1888 at Greensboro, Guilford County, North Carolina.

U. S. N. M., No. 33227: 16 adults, 42 to 50 mm. long, collected by L. L. Williams in February, 1930, in Bolins Creek, Chapel Hill, North Carolina.

U. S. N. M., 107615: 48 specimens, 21 to 44 mm. long, collected by L. P. Schultz and Earl D. Reid on July 11, 1938, in Little Buffalo Creek about 5 miles west of Clarksville, Mecklenburg County, Virginia.

Cornell University, No. 3538: 5 specimens, 32 to 45 mm. long, collected by Elmer E. Brown on December 25, 1934, in a tribu-
tary of Buffalo Creek 5 miles southwest of Greensboro, Guilford County, North Carolina.

C. U. No. 9619: 2 specimens, 40 and 41 mm. long, collected by Raney, Laehner, and R. A. Pfeiffer on April 2, 1941, in a tributary of the Roanoke River at Clarksville, Mecklenburg County, Virginia.

DESCRIPTION.—Many of the features of this species have been described in the preceding comparisons, or are indicated in the illustrations (Pl. I and Fig. 1). Scale and ray counts comprise Table I. Measurements taken according to the directions given by Hubbs and Lagler (1941: 12-20, Figs. 2-3), and corresponding with those recently given for *Notropis scepticus* and *Notropis altipinnis* (Hubbs, 1941), are recorded in Table II. A few supplementary items follow.

The teeth are constantly 4-4, without room on the arch for an outer row. They are hooked and have a rather broad, flat grinding surface. The uppermost tooth is weakly crenate on the lower edge of its grinding surface.

In the breeding male the anteriormost pectoral ray is arched outward. The tuberculate part of each of the following several rays is arched upward. The tubercles on these rays form a rather fine shagreen. In these respects *albosius* agrees with *deliciosus, procne, atrocaudalis*, and *bifrenatus*, but contrasts with *volucellus volucellus*, which has the tubercles larger, in a single series that branches once.

The life color was described by Jordan (1890: 132) as follows: "The jet-black lateral band distinct; fins slightly yellowish." No bright colors were noted by us on live or on freshly preserved material.

HABITAT.—As already noted, this is a Piedmont species. It apparently avoids not only the "black-water" streams of the Coastal Plain but also the swift mountain streams. The ecological records for the collections indicate a considerable diversity in habitat. The streams inhabited varied from small (with the maximum width 10 feet) to medium-sized (30 to 60 feet wide). The water was described as "white," and as clear to turbid; the vegetation, none; the bottom, sand, rubble, bed-
rock; the current, generally rather swift, or pools and riffles. In one pool-and-riffle stream, these minnows were taken in a pool. Elsewhere, the niche was not recorded.

The name alborus, derived from albus, white, and os (genitive oris), refers to the unpigmented lips.

<p>| Table I |
|-----------------|-------------|-------------|-----------|
| <strong>Scale and Ray Counts in Notropis alborus</strong> |
|               | Holo-types | Paratypes   | Total Specimens | Average |
| <strong>Scale counts</strong> |            |             |           |          |
| Along lateral line | 33         | 33-35       | 49         | 33.8     |
| Above lateral line  | 6-6        | 49          | 5.0        |          |
| Below lateral line  | 4          | 49          | 4.3        |          |
| Predorsal rows      | 11         | 12-16       | 30         | 13.5     |
| Predorsal scales    | 17         | 13-19       | 39         | 15.4     |
| Around body         |             |             |            |          |
| Above lateral line  | 11         | 16-11       | 22         | 16.9     |
| Below lateral line  | 11 (in all)| 22          | 11.0       |          |
| Total               | 24         | 25-24       | 39         | 23.9     |
| Around caudal peduncle |             |             |            |          |
| Above lateral line  | 5          | 5 (in all)  | 20         | 5.0      |
| Below lateral line  | 5-5        | 20          | 4.9        |          |
| Total               | 12         | 11-12       | 20         | 11.9     |
| <strong>Ray counts</strong>      |            |             |           |          |
| Dorsal fin          | 8          | 8 (in all)  | 20         | 8.0      |
| Anal fin            | 7          | 7 (in all)  | 21         | 7.0      |
| Pectoral fin        | 14-14      | 13-13 to 15 | 35         | 13.9     |
| Pelvic fin          | 8-8        | 8-8 to 9-9  | 36         | 8.1      |</p>
<table>
<thead>
<tr>
<th>Stream system</th>
<th>Roanoke</th>
<th>Cape Fear</th>
<th>Yadkin</th>
<th>Total Range and Grand Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum and catalogue number</td>
<td>U. S. N. M. 107615, C. U. 9019</td>
<td>U. M. M. Z. 138489 (Holotype), U. S. N. M. 92227</td>
<td>U. M. M. Z. 132797</td>
<td>All series</td>
</tr>
<tr>
<td>Specimens measured</td>
<td>8</td>
<td>1</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Standard length, mm.</td>
<td>38.65-44.1 (40.47)</td>
<td>43.1 (46.30)</td>
<td>48.75 (43.51)</td>
<td>38.65-49.7 (43.51)</td>
</tr>
<tr>
<td>Predorsal length</td>
<td>485-502 (491)</td>
<td>498 (498)</td>
<td>512 (498)</td>
<td>485-516 (499)</td>
</tr>
<tr>
<td>Dorsal to occiput</td>
<td>255-307 (295)</td>
<td>287 (305)</td>
<td>313 (300)</td>
<td>293-315 (300)</td>
</tr>
<tr>
<td>Prepelvic length</td>
<td>463-601 (484)</td>
<td>497 (498)</td>
<td>491 (499)</td>
<td>475-515 (491)</td>
</tr>
<tr>
<td>Body depth</td>
<td>213-340 (228)</td>
<td>234 (230)</td>
<td>216 (228)</td>
<td>213-240 (228)</td>
</tr>
<tr>
<td>Body width</td>
<td>119-138 (130)</td>
<td>155 (128)</td>
<td>143 (132)</td>
<td>114-147 (132)</td>
</tr>
<tr>
<td>C. peduncle, depth</td>
<td>91-105 (90.5)</td>
<td>115 (110)</td>
<td>105 (105)</td>
<td>108-111 (105)</td>
</tr>
<tr>
<td>C. peduncle, length</td>
<td>251-275 (231)</td>
<td>237 (248)</td>
<td>219 (247)</td>
<td>240-254 (247)</td>
</tr>
<tr>
<td>Head length</td>
<td>231-279 (259)</td>
<td>235 (257)</td>
<td>245 (255)</td>
<td>247-274 (255)</td>
</tr>
<tr>
<td>Head depth</td>
<td>153-167 (160)</td>
<td>161 (164)</td>
<td>159 (162)</td>
<td>154-177 (162)</td>
</tr>
<tr>
<td>Stream system</td>
<td>Roanoke</td>
<td>Cape Fear</td>
<td>Yadkin</td>
<td>Total Range and Grand Average</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>-----------</td>
<td>--------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Saout length</td>
<td>70-85</td>
<td>70-85</td>
<td>71</td>
<td>70-85</td>
</tr>
<tr>
<td></td>
<td>(77)</td>
<td>(80)</td>
<td>(78)</td>
<td>(77)</td>
</tr>
<tr>
<td></td>
<td>74-81</td>
<td>70-88</td>
<td>68</td>
<td>66-88</td>
</tr>
<tr>
<td></td>
<td>(77)</td>
<td>(77)</td>
<td>(77)</td>
<td>(77)</td>
</tr>
<tr>
<td>Eye length</td>
<td>63-79</td>
<td>72-88</td>
<td>93</td>
<td>55-99</td>
</tr>
<tr>
<td></td>
<td>(69)</td>
<td>(78)</td>
<td>(74)</td>
<td>(74)</td>
</tr>
<tr>
<td>Interorbital, least fishy</td>
<td>68-72</td>
<td>65-78</td>
<td>64</td>
<td>64-78</td>
</tr>
<tr>
<td></td>
<td>(71)</td>
<td>(71)</td>
<td>(71)</td>
<td>(71)</td>
</tr>
<tr>
<td>Upper jaw, length</td>
<td>131-142</td>
<td>140-149</td>
<td>128</td>
<td>128-149</td>
</tr>
<tr>
<td></td>
<td>(136)</td>
<td>(141)</td>
<td>(140)</td>
<td>(140)</td>
</tr>
<tr>
<td>D. origin to lateral line</td>
<td>86-116</td>
<td>87-106</td>
<td>96</td>
<td>87-116</td>
</tr>
<tr>
<td></td>
<td>(106)</td>
<td>(95)</td>
<td>(101)</td>
<td>(101)</td>
</tr>
<tr>
<td>P, insertion to lateral line</td>
<td>240-277</td>
<td>245-284</td>
<td>262</td>
<td>246-284</td>
</tr>
<tr>
<td></td>
<td>(265)*</td>
<td>(265)*</td>
<td>(265)*</td>
<td>(265)*</td>
</tr>
<tr>
<td>Anal length</td>
<td>195-228</td>
<td>224</td>
<td>212</td>
<td>195-253</td>
</tr>
<tr>
<td></td>
<td>(215)</td>
<td>(216)</td>
<td>(216)</td>
<td>(216)</td>
</tr>
<tr>
<td>Anal, basal length</td>
<td>82-85</td>
<td>81-92</td>
<td>93</td>
<td>81-100</td>
</tr>
<tr>
<td></td>
<td>(88)</td>
<td>(88)</td>
<td>(88)</td>
<td>(88)</td>
</tr>
<tr>
<td>Caudal, longest ray</td>
<td>272-300</td>
<td>269-326</td>
<td></td>
<td>269-326</td>
</tr>
<tr>
<td></td>
<td>(285)*</td>
<td>(285)*</td>
<td>(283)</td>
<td>(283)</td>
</tr>
<tr>
<td>Pectoral, length</td>
<td>195-212</td>
<td>188-219</td>
<td>198</td>
<td>188-219</td>
</tr>
<tr>
<td></td>
<td>(200)</td>
<td>(200)</td>
<td>(200)</td>
<td>(200)</td>
</tr>
<tr>
<td>Pelvic, length</td>
<td>169-203</td>
<td>178-205</td>
<td>183</td>
<td>169-205</td>
</tr>
<tr>
<td></td>
<td>(180)</td>
<td>(180)</td>
<td>(188)</td>
<td>(188)</td>
</tr>
</tbody>
</table>

* 6 specimens.
† 4 specimens.
‡ 7 specimens.
16

Hubbs and Raney

Occ. Papers

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HUBBS, CARL L., AND KARL F. LAGLER
No. 498  *Natropis Alborn*, a *New Cyprinid Fish*  

HUDDS, CARL L., AND A. I. ORTENBURGER  

JORDAN, DAVID  

TRAUTMAN, MILTON B.  
1931 *Natropis volucellus wickliffi*, a New Subspecies of Cyprinid Fish from the Ohio and Upper Mississippi Rivers. *Ohio Journ. Sci.*, 31: 468-74, Fig. 1.  

**ADDENDUM**  
As this paper was passing through the press two additional lots of *Natropis alborn* were received by the Museum of Zoology, as follows:  

U.M.M.Z. No. 147606: 3 adults, 45 to 49 mm. long, collected by Joseph R. and Reeve M. Bailey on August 30, 1946, in Sugartree Creek, tributary to the Dan River, at U. S. Highway 158, 3 miles east of Leansburg, Person County, North Carolina.  

U.M.M.Z. No. 147628: 2 adults, 41 and 42 mm. long, collected by Bailey and Bailey on August 31, 1946, in Deep River, tributary to the Cape Fear River, at Randlemann, Randolph County, North Carolina.—REEVE M. BAILEY.
PLATE I

Notropis alborsus new species. Photographs by Art Smith.

Fig. 1. Side view of an adult male paratype, 48 mm. in standard length, from Bolina Creek, Chapel Hill, North Carolina.

Fig. 2. Top view of an adult female paratype, 43 mm. in standard length, from Brush Creek, a tributary of Deep River, 3 miles west of Siler City, North Carolina.
BLIND CATFISHES FROM ARTESIAN WATERS OF TEXAS*

By CARL L. HUBBS and REEVE M. BAILEY

DURING the course of a collecting trip to the western and south-western United States in 1938, the senior author visited the Witte Memorial Museum at San Antonio, Texas. Mrs. Ellen S. Quillin, the director of that institution, made available for his examination two blind catfishes (Amciuridae) which had been pumped from deep artesian wells in the vicinity of San Antonio. Subsequently, these specimens were loaned to the Museum of Zoology. We are greatly indebted to Mrs. Quillin for placing these specimens in our hands for study. Both are now in the Witte Memorial Museum.

One of the specimens is the second known example of the remarkably specialized Trogloglanis pattersoni Eigenmann. The other proves to represent a distinct new genus and species apparently allied to Pilodictis olivaris. Other blind catfishes have been taken, but are not available. One from the artesian well of the Alamo Dressed Beef Company was presented to Witte Memorial Museum (Accession No. 25.193.37.G) but could not be found. Still others appear not to have been preserved. Thus, a blind fish from an artesian well was reported

*Contributions from the Scripps Institution of Oceanography, New Series, No. 318, and from the Museum of Zoology, University of Michigan.
by Mrs. R. P. Persyn in the *San Antonio Light*, September 7, 1929. Mr. Josef Boecke, who collected one of the specimens described below, told us on June 3, 1938, that he had seen about twenty blind, pink catfish in the irrigation ditches fed by his artesian well, which is 1000 feet deep. Very sluggish, they were easily caught by hand. The last one seen by him was caught in June, 1934. He knew of another that came from an artesian well 1250 feet deep, west of San Antonio. It is much to be hoped that additional specimens will be preserved.

The two blindcats now known from the subterranean waters about San Antonio are completely devoid of external eyes and skin pigment. That both belong to the catfish group confirms the view (Norman, 1926: 325–29; Hubbs, 1938: 266) that catfishes are particularly well represented in the subterranean fauna. *Satan erystomus* adds not only a new genus and species to the list of blind, depigmented cave fishes, but also another line of evolution of such types. It seems to have been derived from an ancestor of *Ploidoichis olivaris*, whereas *Trogloglanis pattersoni* appears to have been evolved from the *Ameiurus* type. *Satan* and *Trogloglanis* are clearly members of the North American fresh-water catfish family Ameiuridae.

The habitat of the blindcats of the San Antonio region is amazing. The specimens have come from artesian wells 1000 to 1250 feet deep. It is virtually certain that they have been derived from the chief water-bearing stratum of the region. This is the Edwards Limestone Formation of Comanche (Lower Cretaceous) age (Livingston, Sayre, and White, 1936). In the vicinity of San Antonio the top of this formation lies 400 to 1000 feet underground. Like the other formations of the region the Edwards Limestone dips toward the coast. In the southernmost part of Bexar County it lies about 3000 feet below the land surface. Farther northwest, on the Edwards Plateau, it lies at the surface. There are obviously open channels through the limestone for the artesian head closely follows precipitation. The population of the great subterranean depths by the ancestors of these catfishes is, therefore, explicable. Livingston, Sayre, and White (1936: 73) wrote:
No. 499  

Blind Catfishes from Texas

Extensive exploration by wells in this reservoir in Bexar County has shown that under large areas the limestone is traversed by an intricate system of openings. In some places the openings are small, apparently being confined to joint planes and fissures. In others they consist of solution channels of varying sizes, the largest good-sized caverns.

Since, prior to the drilling of the wells, the water in the Edwards Limestone reached the surface in large springs along Balcones Fault, and since the water in the wells now reaches to or nearly to the surface, it is obvious that the blindcats live under great hydrostatic pressure. In correlation with this habitat condition the air bladder in both species appears to have become obsolete.

Artesian waters in three prefectures of Japan have yielded a fish that is unrelated to the blindcats of Texas but parallels them in its modifications for subterranean existence. It is a member of the essentially marine family Gobiidae. Along with a similar cave form, it appears to be closely related to a common Japanese littoral goby, *Luciogobius guttatus*. The 2 subterranean, presumably fresh-water forms were very briefly described by Tomiyama (1936: 51-52, Figs. 10C-D) as variations of what he called *Luciogobius guttatus guttatus*. Regan (1941) more plausibly treated them, on the basis of Tomiyama's account, as distinct species, which he named *Luciogobius pallidus* (from the artesian wells) and *L. albus* (from a cave). They might be regarded as comprising a special genus, for they differ from the littoral gobies of the genus *Luciogobius* not only in characters associated with their dark habitats but also in an apparently trenchant feature, the lack of free pectoral rays. The cave form was described as an albino with more or less degenerate eyes. The artesian form was said to be paler and to have the eyes covered by skin. The 2 differ sharply from one another as well as from the 2 known littoral species of *Luciogobius* in body, head, and fin proportions.

This artesian-water goby and the 2 blindcats of Texas are apparently the only blind fishes that are known to inhabit artesian waters. Various other species have been reported from the outflows from artesian wells, particularly in arid
regions. Some of the published accounts (listed on pages 406 and 423 in Volume III of Dean’s *Bibliography of Fishes*), as well as a number of verbal reports from residents in the Great Basin, claim that the fish issued from the ground. The species concerned, with the exception of the 3 kinds under discussion, are, however, eyed and pigmented. It seems probable that their isolated distribution is attributable to some channel of dispersal other than an underground connection. Occasional surface flows of flood water readily explain some of the cases investigated afield.

*Satan*, new genus


This genus is sharply differentiated from other genera of ameirurid catfishes except *Trogloglanis* by the complete absence of eyes, the obsolescence of the air bladder, and the lack of pigmentation. Despite their similarity in degenerative and adaptive features associated with subterranean life, *Satan* and *Trogloglanis* are strikingly different in many characters (Table I). Although the relationship of neither genus is fully certain, it is apparent that they represent separate evolutionary lines and that their similarities are due to convergence rather than to a common origin from a cave-adapted ancestor. *Satan* is much less modified from the surface-living ameirurids than is *Trogloglanis*. From *Ameirus*, the presumed ancestor of *Trogloglanis*, *Satan* differs in the absence of eyes, of pigmentation, and of air bladder, in the increased size and development of the lateral line canals and pores on the head, in the reduced size of the narial apertures, in the excessive development of the adipose fin, in the reduced length of the intestine, in the more flattened and trapezoidal shape of the head, and in the broad overlapping of the branchiostegal membranes.

In superficial characters *Satan* is most closely approached by *Pilodictis*. These genera have a very similar body form, with a greatly depressed head, wide transverse mouth, slender body, and a long and flaring adipose fin. The branchiostegal mem-
### TABLE I

**Comparison of the Two Blind Catfishes from Texas**

<table>
<thead>
<tr>
<th>Character</th>
<th>S. eurytomus</th>
<th>T. pattersoni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teeth on jaws</td>
<td>Well developed, in villi-form bands</td>
<td>None</td>
</tr>
<tr>
<td>Jaws</td>
<td>Arched, horizontal, covering premaxillary teeth</td>
<td>Papery thin</td>
</tr>
<tr>
<td>Lower jaw</td>
<td></td>
<td>Straight and transverse, curved upward into mouth, entirely behind broad premaxillaries</td>
</tr>
<tr>
<td>Mouth</td>
<td>Transverse</td>
<td>Greely inverted</td>
</tr>
<tr>
<td>Mouth, as seen from below</td>
<td>A gently arched slit</td>
<td>Open, semicircular</td>
</tr>
<tr>
<td>Mouth opening inside</td>
<td>Scarcely restricted, more than half width of head</td>
<td>Greatly restricted, less than one-third width of head</td>
</tr>
<tr>
<td>End of gape</td>
<td>Horizontal, entirely below base of maxillary barbel</td>
<td>Sharply curved upward behind base of maxillary barbel</td>
</tr>
<tr>
<td>Lip at corner of gape nasal and maxillary barbels</td>
<td>Thick, exposed</td>
<td>Thin, concealed</td>
</tr>
<tr>
<td>Mental barbels</td>
<td>Maxillary barbel very much the thicker and longer</td>
<td>Subequal in thickness and length</td>
</tr>
<tr>
<td>Anterior nostril</td>
<td>Outer much thicker and longer than inner</td>
<td>Outer little thicker or longer than inner</td>
</tr>
<tr>
<td>Posterior nostril</td>
<td>A narrow tube</td>
<td>Broader, with a posterior flap</td>
</tr>
<tr>
<td>Gular fold</td>
<td>Broadly overlapping</td>
<td>Large, about one-fourth internarial space; lateral rim scarcely elevated</td>
</tr>
<tr>
<td>Branchiostegal membranes</td>
<td>About 50°</td>
<td>Obsolescent</td>
</tr>
<tr>
<td>Angle of shoulder girdle, from below</td>
<td>Scarce archd</td>
<td>Not overlapping</td>
</tr>
<tr>
<td>Edge of shoulder girdle in front of scapular process</td>
<td>Finely dilute</td>
<td>About 110°</td>
</tr>
<tr>
<td>Outer edge of testis</td>
<td>Volvety, easily rubbed off in preservation; hairlike cilia scarcely developed</td>
<td>Strongly arched</td>
</tr>
<tr>
<td>Epidermis</td>
<td>To below first dorsal or interdorsal space</td>
<td>Weakly and sparsely lobinate</td>
</tr>
<tr>
<td>Extent of visible lateral line</td>
<td></td>
<td>Heavily bestr with fine cilia and scattered coarse ones</td>
</tr>
<tr>
<td>Character</td>
<td>Satan eurytomus</td>
<td>Troplognathus plectrodon</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Lateral line</td>
<td>In segments with pores at either end</td>
<td>Forming a keel (sub-continuous anteri­orly), without well-defined pores</td>
</tr>
<tr>
<td>Lateral line pores on head</td>
<td>Medium to large, averaging about as large as posterior nostril; none tubular</td>
<td>Minute, very small, smaller than either nostril; mostly in tubelets</td>
</tr>
<tr>
<td>Pore at front base of each nasal barbel</td>
<td>Lacking</td>
<td>Present</td>
</tr>
<tr>
<td>Anterior pair of mandibular pores</td>
<td>Opening into a common fossa</td>
<td>Widely separated</td>
</tr>
<tr>
<td>Snout</td>
<td>Greatly depressed and flat</td>
<td>Little depressed, broadly rounded in contour</td>
</tr>
<tr>
<td>Form of head contours from above</td>
<td>Isosceles trapezoid</td>
<td>Semioval</td>
</tr>
<tr>
<td>Free edge of rays at front margin of anal and pelvic fins</td>
<td>With very fine anterose spinulations, several per segment</td>
<td>Smooth</td>
</tr>
<tr>
<td>Rays in dorsal, anal, pectoral, and pelvic fins</td>
<td>More numerous</td>
<td>Less numerous</td>
</tr>
</tbody>
</table>

Branes are well separated and often overlap in Pilodictis, which in this respect furnishes, with Ictalarius, the closest approach to the wide overlap seen in the blind genus. Satan and Pilodictis differ trenchantly, not only in those features that adapt Satan to life underground but also in the lack of the backward projections of the premaxillary tooth band in Satan, a well-developed feature in Pilodictis. This character varies, too, in the surface forms, since in addition to Pilodictis such projections occur in Noturus, a relative of Schilbeodes and, to a less extreme degree, in Ictalarius, which is related to Ictalurus. In the Pimelodidae also some genera have and others lack the projections. In Satan the lower jaw is slightly included, whereas in Pilodictis it projects beyond the upper jaw, but Satan approaches Pilodictis in this character more closely than do other ameirids.
Because of these similarities, it is suggested that Satan and Pilodictis may have had a distant common ancestry. Pilodictis olivaris is widely distributed in the rivers of Texas today. It is a secretive, negatively phototropic species that seeks retreat in undercut banks or beneath flat boulders, stumps, logs, or other objects. A species of such habits and with well-developed tactile senses would be expected to work into underground waters if available. The abundance of small creatures in the subterranean waters of the San Antonio area (Eigenmann, 1919: 397) would provide an adequate food supply, and subsequent modification of such an invading population would, as usual, result in depigmentation, loss of vision, and increased development of some sense organs.

The backward projections of the premaxillary tooth band are probably to be regarded as primitive. In this respect Pilodictis may be more generalized than Satan, as it assuredly is in pigmentation, in the development of eyes and air bladder, and in the structure of the sensory system on the body. The wide separation and broad overlap of the branchiostegal membranes in Satan is more extreme than in other genera of ameiruids and is probably to be considered a generalized character. A seemingly parallel situation—the retention by a specialized cave fish of a primitive character that has become modified in recent surface-living relatives—has been noted by Eigenmann in the Amblyopsidae. Pelvic fins are retained in the cave-living Amblyopsis, whereas its closest relative in surface waters, Chologaster, has lost them. Satan, in all probability, was derived from some now extinct surface-living ameiruid not greatly different in fundamental characters from Pilodictis.

Certainly, neither Satan eurystomus nor Trogloglanis pattersoni is to be regarded as an immediate derivative or subspecies of its eyed ancestor, as Typhlobagrus kromeri is supposed by Pavan (1946) to be related to Pimelodella transitoria or P. lateristriga.
WIDEMOUTH BLINDCAT

Satan eurystomus, new species

(Plate I, Figs. 1-3)

The holotype (Witte Memorial Museum, San Antonio, Texas, Accession No. 31.P.16.5) is an immature male, 68.7 mm. in standard length. It was collected near San Antonio and came from an artesian well 1250 feet deep. It was the gift of William Kempin.

Proportional measurements of the holotype, the only known specimen, are presented in Table II, and most features of body form and external anatomy are beautifully illustrated in the drawings (Plate I) prepared by Miss Grace Eager, accomplished staff artist of the Museum of Zoology. Many of the salient structural characters are indicated in the comparison with Trogloglanis pattersoni (Table I).

In common with most other blind, subterranean fishes, the lateral line canals and pores of the head are excessively developed. Two large pores open just behind the head, at the origin of the lateral line. The upper, more anterior one is almost level with the 2 pores comprising the straight part of the lateral line on the posterior part of the head. There are 12 large operculomandibular pores. The anteriormost pore on the mandible opens close to its fellow of the opposite side in a median transversely oval pit. A pore lies behind the eye position. Another is situated above and behind this pore. Of the 5 or 6 pores in the infraorbital series, the anterior 3 or 4 form a nearly horizontal line behind the anterior nostril. On each side there are 1 interorbital, 2 nasals, and 1 prenasal. No supratemporal canal or pore are visible. The lateral line extends to below dorsal or to below interdorsal space. It has 3 elongate pores in a short anterior tube, and behind this 5 to 9 short separated sections of tube, each with a pore on either end. Sense organs in the form of low cones are conspicuous, particularly on the head and anterior trunk regions.

The nostrils are minute. The diameter of the anterior one is about 0.4 mm., only two-fifths the size of that in T. pattersoni. There are 10 branchiostegal rays. The gill-rakers on the
TABLE II

**PROPORTIONATE MEASUREMENTS OF SATAN CURYSTOMUS (HOLOTYPE) AND TROGLOPLANIS PATTERSONI FROM NEAR SAN ANTONIO, TEXAS, EXPRESSED AS THOUSANDS OF THE STANDARD LENGTH.**

For paired structures measurements were taken on both sides and averaged.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Satan curystomus</th>
<th>Trogloplanis pattoneri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body depth below dorsal origin</td>
<td>0.687</td>
<td>0.683</td>
</tr>
<tr>
<td>Body depth above anal origin, to top of adipose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caudal peduncle depth (over-all)</td>
<td>0.174</td>
<td>0.172</td>
</tr>
<tr>
<td>Caudal peduncle depth (muscle mass only)</td>
<td>0.083</td>
<td>0.085</td>
</tr>
<tr>
<td>Caudal peduncle length</td>
<td>0.154</td>
<td>0.194</td>
</tr>
<tr>
<td>Predorsal length</td>
<td>0.343</td>
<td>0.319</td>
</tr>
<tr>
<td>Length to adipose origin</td>
<td>0.254</td>
<td>0.299</td>
</tr>
<tr>
<td>Dorsal base</td>
<td>0.133</td>
<td>0.110</td>
</tr>
<tr>
<td>Interdorsal distance</td>
<td>0.044</td>
<td>0.038</td>
</tr>
<tr>
<td>Adipose fin, basal length</td>
<td>0.0271</td>
<td>0.0307</td>
</tr>
<tr>
<td>Adipose fin, length to tip</td>
<td>0.0381</td>
<td>0.0338</td>
</tr>
<tr>
<td>Adipose notch to caudal base</td>
<td>0.0127</td>
<td>0.0115</td>
</tr>
<tr>
<td>Anal origin to caudal base</td>
<td>0.00453</td>
<td>0.00376</td>
</tr>
<tr>
<td>Anal base</td>
<td>0.00234</td>
<td>0.00196</td>
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<td>0.00202</td>
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<td>Length to pelvic insertion</td>
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<td>Anal to anal origin</td>
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<td>Dorsal fin height</td>
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<td>Dorsal spine length</td>
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<td>Longest dorsal ray</td>
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<td>0.00225</td>
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<td>Adipose fin, vertical height</td>
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<td>Caudal fin length</td>
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<td>0.000244</td>
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<tr>
<td>To upper angle</td>
<td>0.000245</td>
<td>0.000212</td>
</tr>
<tr>
<td>To end of shortest ray</td>
<td>0.000238</td>
<td>0.000245</td>
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<td>Anal fin, depressed length</td>
<td>0.000284</td>
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<tr>
<td>Longest anal ray</td>
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<td>Pelvic fin length</td>
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<td>Pectoral fin length</td>
<td>0.000228</td>
<td>0.000219</td>
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<tr>
<td>Pectoral spine length</td>
<td>0.000105</td>
<td>0.000174</td>
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<tr>
<td>Length first pectoral branched ray beyond tip of spine</td>
<td>0.000113</td>
<td>0.000045</td>
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<tr>
<td>Between pectoral insertions</td>
<td>0.0000224</td>
<td>0.0000255</td>
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<tr>
<td>From inside of shoulder girdle to tip of humeral process</td>
<td>0.000047</td>
<td>0.000039</td>
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<tr>
<td>Between pelvic insertions</td>
<td>0.0000108</td>
<td>0.0000102</td>
</tr>
<tr>
<td>Between pelvic fins</td>
<td>0.000028</td>
<td>0.000033</td>
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<tr>
<td>Head length</td>
<td>0.0000309</td>
<td>0.0000371</td>
</tr>
<tr>
<td>Head width</td>
<td>0.00002235</td>
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<tr>
<td>Head depth at operculum</td>
<td>0.0000162</td>
<td>0.0000174</td>
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### TABLE II (Cont.)

<table>
<thead>
<tr>
<th>Measurement</th>
<th><em>Evan</em> eurystomus</th>
<th><em>Tragulus</em> patternus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head depth at end of first third of projection of head length</td>
<td>94</td>
<td>132</td>
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<tr>
<td>Mouth width</td>
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<tr>
<td>Gape, exterior</td>
<td>159</td>
<td>131</td>
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<tr>
<td>Least interior width</td>
<td>120</td>
<td>81</td>
</tr>
<tr>
<td>At base of maxillary barbels, behind upper lip</td>
<td>154</td>
<td>139</td>
</tr>
<tr>
<td>Snout tip to mandible tip</td>
<td>8</td>
<td>49</td>
</tr>
<tr>
<td>Snout tip to front of gill opening</td>
<td>104</td>
<td>129</td>
</tr>
<tr>
<td>Front of gill opening to line joining pectoral insertions</td>
<td>146</td>
<td>78</td>
</tr>
<tr>
<td>Length of barbels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>86</td>
<td>210</td>
</tr>
<tr>
<td>Maxillary</td>
<td>229</td>
<td>202</td>
</tr>
<tr>
<td>Outer mental</td>
<td>142</td>
<td>145</td>
</tr>
<tr>
<td>Inner mental</td>
<td>88</td>
<td>137</td>
</tr>
<tr>
<td>Distance between posterior nostrils</td>
<td>81</td>
<td>61</td>
</tr>
<tr>
<td>Snout to posterior nostril</td>
<td>78</td>
<td>58</td>
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<tr>
<td>Mandibular tooth patch, length</td>
<td>9</td>
<td>*</td>
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<tr>
<td>Premaxillary tooth patch</td>
<td></td>
<td></td>
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<tr>
<td>Length</td>
<td>11</td>
<td>*</td>
</tr>
<tr>
<td>Width</td>
<td>126</td>
<td>*</td>
</tr>
</tbody>
</table>

* No teeth on jaws.

outer arch number $4 + 15 = 19$. They are slender and moderately long. The longest is about one-third as long as the distance between the posterior nostrils.

The premaxillaries bear a well-developed patch of villiform teeth which form a transverse band without backward projecting processes. The length of the band is 9 per cent of the width; there is no separation or constriction at the midline. The palate is toothless.

The first dorsal fin is high and somewhat pointed, with 1 rather weak spine and 7 branched rays (counting the last 2 elements as 1 ray). The anal is long and low, with 6 unbranched and 14 branched rays. Along the front margin of the anal fin the anterior rays bear several weak antrorse spinules per segment. Except for the marginal principal rays the caudal fin is mutilated distally, but the form of the remaining part of the fin suggests that it may have been slightly emarginate. There are 17 principal caudal rays; 13 procu-
rent rays above, of which at least 5 are segmented; and 16 pro-
current rays below, of which at least 4 are segmented. Each
pectoral fin has 10 branched rays and a single spine, which is
smooth along its anterior edge and bears 8 to 10 serrations
posteriorly. Each pelvic fin has 9 branched rays and 1 simple
ray on its outer edge, which bears spines like those at the
front of the anal fin.

The intestine is relatively thick-walled and rather short,
with one extra coil about one-third as wide as the mouth. The
outer edge of the testis is finely fringed, as is usual in the
family. No trace of an air bladder could be found. The body
cavity is largely filled with adipose tissue.

Several notable differences in form between *S. eurytomus*
and *T. pattersoni* are best indicated by angle measurements
(taken as described by Hubbs, 1946). In *S. eurytomus* lines
joining the insertions of the pectoral fins with the point of
union of the branchiostegal membranes intersect at an angle
of 71°; those joining the pectoral insertion with the tip of the
snout, at 51°. The angle formed by the edges of the shoulder
girdle, as seen from below, is about 50°; by the edges of the
gular groove, 63°; by lines joining the insertion of the pec-
torals and the corners of the mouth, 15°; by the dorsal and
ventral contours of the head, just behind the barbels, 25°; and
by the muzzle, in lateral profile, 21°.

*Satan eurytomus* signifies "wide-mouthed prince of dark-
ness."

*Trogloplanus* Eigenmann

Orthotype.—*Trogloplanus pattersoni* Eigenmann.

This, the only previously known genus of the Ameiuridae
that is wholly blind, depigmented, and subterranean, is the
most sharply differentiated genus of the family. Most of its
salient characteristics are given in Table I. The weak tooth-
less mouth, much modified jaws, greatly restricted and in-
ternally situated mouth opening, foreshortened head, and
obsolete air bladder, together with the modifications of the
sensory system and of pigmentation, set this genus off as the
most highly specialized of the Ameiuridae. Its distinctness
was not fully appreciated by Eigenmann.
Eigenmann (1919: 398) suggested that Trogloglanis is a derivative of Schilbeodes. The similarity in form, in shortness of anal fin, and in certain other characters accords with this interpretation, but differentiation has proceeded so far that it is perhaps impossible to be certain of the relationships. In agreement with Ameiurus, as contrasted with Schilbeodes, the venom pore in the pectoral axil is lacking (it is present in the young only of Ameiurus) and the adipose fin, although large, is separated from the procurent caudal rays. Derivation from Ameiurus appears to be most plausible.

Gronias nigrilabris Cope (1864: 231-32) has also been regarded as a blind cave catfish related to Ameiurus. The specimens, however, were caught in Conestoga Creek, Pennsylvania, and were assumed to have issued from limestone caves merely because the specimens had defective eyes. They were well pigmented and had an air bladder. We see no reason for thinking that the types of Gronias nigrilabris were other than specimens of Ameiurus nebulosus nebulosus (Le Sueur) with eyes defective due to injury or some other cause. Such fish are not infrequently encountered. The serrated pectoral spine as well as the locality precludes the relationship with Ameiurus melas postulated by Jordan and Evermann (1896: 142). A figure of the type of Gronias nigrilabris, recently published by Fowler (1945: 55, Fig. 160), confirms our reference of Gronias nigrilabris to the synonymy of Ameiurus nebulosus nebulosus.

TOOTHLESS BLINDCAT

Trogloglanis pattersoni Eigenmann

(Plate I, Fig. 4)


The second known specimen of this species (Witte Memorial Museum, Accession No. 34.20.7.G) is an immature male, 68.3 mm. in standard length. It was caught in June, 1934, by Josef Boecke in a ditch fed by an artesian well on his ranch, 2½ miles east and 1½ miles north of the Alamo in San Antonio,
No. 499  Blind Catfishes from Texas

Texas. Proportional measurements of this specimen are presented in Table II, and the peculiar mouth structure is shown in Plate I, Figure 4. Most of the more striking characters are indicated in the comparison with *Satan eurytomus* (Table I).

Though well developed, especially on the head, the lateral line system is much less conspicuous than in *Satan eurytomus*. Between a slender tube at the front of the lateral line and the uppermost pore of the opicular series, but at a distinctly higher level, are 2 similar tubules. The more posterior of the 10 or 11 small operculomandibular pores are at the tips of minute tubes. The anteriormost pore on the maxilla is well separated from its fellow of the other side. There is one similar pore behind the eye position, another above and slightly behind this, 5 or 6 in the infraorbital series, 2 interorbitals, 2 nasals, 1 prenasal, and 1 more at the front base of each nasal barbel. All these pores are very minute. Most of them open in small tubules. No supratemporal canal or pores are visible. The lateral line is developed to near the posterior end of the adipose fin, but is much interrupted posteriorly. Anteriorly, it consists of an irregularly lobate dermal keel, with mere traces of open tubes and pores.

The nostrils are of moderate size. The diameter of the anterior is about 1.0 mm. It is notably larger than in *S. eurytomus*.

There are at least 8 branchiostegal rays. The gill-rakers on the outer arch number $4 + 15 = 19$. They are slender, but very short. The longest is about one-seventh as long as the distance between the posterior nostrils.

The very delicate jaws as well as the bones of the palate are toothless.

The dorsal fin is high and somewhat pointed, with 1 long, well-developed spine and 5 branched rays. The anal, more or less semicircular in outline, has 4 unbranched and 11 branched rays. The outer ray is smooth. The caudal fin is weakly truncate, not convex posteriorly as shown in Eigenmann’s figure (1919: 298, Fig. 1). In addition to the 17 principal caudal rays there are 19 procurent rays above, of which 1 is
segmented, and 15 procurent rays below, of which 3 are segmented. Each pectoral fin has 9 branched rays and a single strong spine, which is smooth along its anterior edge and bears 8 or 9 prominent serrations posteriorly. The pelvic fin of the right side has 1 simple ray on its outer edge, which is smooth, and 7 branched rays.

The intestine is rather thin-walled and is somewhat more coiled than it is in S. eurystomus. The outer edge of the testis bears a few weak, lobulate projections, rather than the fine fringe that is usually developed in the Ameiuridae. No air bladder could be found. The body cavity is largely filled with adipose tissue.

Lines joining the insertions of the pectoral fins with the point of union of the broadly connected branchiostegal membranes intersect at an angle of 108°; those joining the pectoral insertions with the tip of the snout, at an angle of 68°. The angle formed by the edges of the shoulder girdle, as seen from below, is about 110°. The gular groove is obsolete. The angle formed by the lines joining the insertions of the pectorals and the corners of the mouth is 34°; by the dorsal and ventral contours of the head, just behind the barbels, 24°; and by the muzzle, in lateral profile, 46°.

LITERATURE CITED


1946 An Arm Protractor for the Precise Measurement of Angles in Systematic Ichthyology. Copeia, pp. 79–80, Fig. 1.
No. 499

Blind Catfishes from Texas

JORDAN, DAVID STARR, and BARTON WAREN ETHERMANN

LIVINGSTON, PERN, A. N. SAVIT, and W. N. WHITE

NORMAN, J. R.

PAYAN, C.

REGAN, C. TATE

TOMIYAMA, ITTÔ
PLATE I

FIGS. 1-3. *Satan eurytousus*, holotype, in lateral, anterior and ventral aspects; standard length, 69 mm.

Fig. 4. *Tropiloglanis patternsei*: anteroventral aspect of the second known specimen; standard length, 68 mm.
THE METAMORPHOSIS OF THE CALIFORNIA RIBBON FISH, TRACHYPTERUS REX-SALMONORUM

CARL L. HUBBS

TRACHYPTERUS REX-SALMONORUM Jordan & Gilbert


Trachypterus sp. Holder, Fishes of the Pacific Coast, 1912, p. 70, Fig. 27; Thompson, Calif. Fish and Game, 5, 1919, p. 95.

An examination of ten specimens of Trachypterus from California indicates that T. seleniris is merely the adult of Trachypterus rex-salmonorum. These specimens vary in length from 10 to 1520 mm., and illustrate very well the remarkable changes which this species undergoes with age.

The measurements of the ten specimens used in this study are listed in Table 1. Specimen I, only 10 mm. long (when the body flexure is straightened out), is a larva still retaining a large yolk sac; it was collected December 20, 1905, having been washed ashore at La Jolla, California, during a northwest wind; it was turned over to the writer by the Scripps Institution for
Biological Research. Specimen 2, 25 mm. in axial length, was taken by the California State Fisheries Laboratory in a trawl hauled at an intermediate depth of forty fathoms over deep water, 8 miles S.S.W. of the west end of Santa Catalina Island, California. Specimen 3, 102 mm. long, is the one from near Monterey reported on by Sette (1923); the proportionate measurements for this specimen are computed from the absolute values given by Sette, in the table on p. 94 of his paper. Specimen 4 and 8 are young fishes 130 and 145 mm. long taken at Avalon, Santa Catalina Island; these and the adults (Nos. 8 and 9) from the same locality, apparently served as the basis for the records of Regalius from Catalina Island. Specimen 6 probably came from Pacific Grove, California. Specimen 7, 285 mm. long, is the type of Trachypterus rex-salmonorum, collected off San Francisco; the proportionate measurements, like those for Specimen 3, are computed from the values given by Sette (1923). Specimens 8 and 9 are adults, 860 and 1000 mm. long, from Avalon. Specimen 10 is the large type, 1520 mm. long, of Trachypterus seleniris Snyder (1908), from Monterey.

It seems clear that all these specimens represent a single species. As shown by the tables and the curves, the extremely wide variations in proportions, finding their extreme divergence between the larval specimen and the largest adult, are well connected by intermediates. Similarly structural and color features show an intergradation between the two extremes. The number of fin rays is approximately alike in all the material examined. In Specimens 3, 4, 5, 6, 7, 8, 9 and 10, the dorsal rays are 5, 171; 5, 161; 5, 170; 6, 166; 5, 170; 5, 178; 5, 179; —, 168, respectively.

The larva shows a strong downward flexure of the body, and the anterior dorsal is carried on a narrow fleshy lobe extending forward and upward, from the nape, well above the transversely rounded occipital region. No such structure is shown by Emery for Trachypterus toenia of the Mediterranean, but a somewhat similar although probably not homologous developmental modification occurs in the postlarvae of many flat fishes (Heteroso-
The postlarva still shows a considerable body flexure, and retains the interneural-containing lobe at the base of the first dorsal. The larva is particularly extreme in proportions, the tail region being but slightly developed compared with the head and trunk (Table I); the head is relatively larger in reference to the trunk (Table II), and the eyes, jaws, etc., relatively larger in reference to the head (Table III), than in later stages. The postlarva in these respects affords a complete transition between the larval and juvenile stages (Tables I–III). These changes in proportions are discussed later in the paper.

The body in the young is naked, but in the adult becomes covered with pad-like scales. In the adult, also, the lateral line posteriorly becomes armed with antrorse spines. The spinules (later granulations) on the fin rays, on the contrary, disappear with age.

The excessively long and flexible pelvic fin and anterior dorsal of the young — probably much longer than the body and serving as flotation organs in the larvae and postlarvae — become both proportionately and absolutely shorter with increased size, finally with age becoming obsolete. The main dorsal becomes gradually lower throughout its length. The lower lobe of the caudal, fairly well developed and with one strengthened and doubtless greatly produced ray in the larvae and postlarvae, becomes relatively small in the young and obsolete in the adult. The upper caudal lobe, scarcely evident in the larvae, becomes moderately developed in the postlarvae, then greatly elongate, like the pelvic and anterior dorsal fins, in the young, and finally very short in the adult. This lobe at first extends horizontally backward, but gradually rotates to assume an antrorse direction. Essentially similar changes in the fins take place in *Trachypterus taenia*, as outlined by Emery.

Metamorphosis as determined from the changes in structure and in the fins takes place later in development than the metamorphosis in proportions. The length of the fins, when little or not at all broken, is indicated in proportionate terms in Table I.
TABLE I

MEASUREMENTS OF TRACHYPTERUS REX-SALMONORUM FROM CALIFORNIA

This table illustrates the changes which the species undergoes with age. Measurements expressed in thousandths of total length to caudal base.

<table>
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<th>Specimen No.</th>
<th>1</th>
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<th>4</th>
<th>5</th>
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<th>8</th>
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<th>10</th>
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<td>100</td>
<td>100</td>
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<td>300</td>
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<td>300</td>
</tr>
<tr>
<td>Length of head</td>
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</tr>
<tr>
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<td>55</td>
<td>55</td>
<td>55</td>
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<tr>
<td>Length of upper jaw</td>
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<tr>
<td>Length of lower jaw</td>
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<tr>
<td>Height of dorsal</td>
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<td>250</td>
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<tr>
<td>Length of caudal</td>
<td>250</td>
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<td>250</td>
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<td>250</td>
<td>250</td>
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<tr>
<td>Length of pelvic</td>
<td>450</td>
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<td>450</td>
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</table>

The form of the body also changes greatly with age, the depth being much the greatest between the origin of the dorsal and the sharp lower angle of the mandible in the very young, but greatest near the middle of the total length in the large adults. As Sette has shown, the change in the proportionate depth of the head and trunk is not regular throughout the length of this region, the depth posteriorly increasing in reference to the depth anteriorly.

The coloration also exhibits changes with age, becoming gradually more uniform. The posterior and finally the anterior spots of both dorsal and ventral series slowly disappear. *Trachypterus rex-salmonorum*, presumably like other species of
the genus,\(^1\) provides an exception to the general rule that, in fishes, the proportions of the head and body do not change after the postlarval period, or change proportionately to the increase in size, so that, mathematically expressed, the dimensions of any part of the body form a linear function of the total length. From Table I and Figure 26 it will be seen that the dimensions of the parts measured are not linear functions of the total length. In this species the development as regards form and proportions is of a greatly retarded type, and entails a protracted metamorphosis, the postlarval features being gradually lost during juvenile life. This situation is graphically shown in the Figure.

The remarkable changes in the proportions of the body which Trachypterus undergoes with age are due, of course, to the differential growth rate of the several parts of the body. From the graphs it is very clear that this differential growth rate is most extreme in the young, decreasing with age. The differential growth consists chiefly in the more rapid growth of the tail than of the trunk, as Sette\(^2\) has already suggested in his study of two young specimens of this species. In the larva the anus is near the end of the body; in the young, still in the posterior half, but in the adult, in the anterior half of the total length.

There is also a differential growth in the anterior regions, the trunk growing more rapidly than the head, and the posterior portion of the head faster than the eyes, jaws, etc., these structures being relatively large in the larval and to a lesser degree so in the postlarval stages. The differential growth rate in the head-trunk region, however, characterizes chiefly the larval and postlarval stages, changes in proportions within these regions being scarcely evident in the young to adult fishes. The data are given in Tables II and III.


\(^2\) Copeia, No. 122, 1923, pp. 93–96.
Trachypterus rex-salmonorum

TABLE II
MEASUREMENTS IN HUNDREDTHS OF LENGTH TO ANUS

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>9</th>
<th>9</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Length to caudal, mm.</td>
<td>10</td>
<td>25</td>
<td>130</td>
<td>145</td>
<td>173</td>
<td>860</td>
<td>1000</td>
<td>---</td>
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</tr>
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</table>

Greatest depth | 59 | 48 | 31 | 28 | 29 | 27 | 27 | --- | --- |
Length of head | 35 | 32 | 24 | 25 | 29 | 23 | 24 | --- | --- |
Length of orbit | 14 | 15 | 11 | 9 | 8 | 7 | 8 | --- | --- |
Interorbital | 6 | 8 | 5 | 9 | 5 | 4 | 5 | --- | --- |
Length of upper jaw | 19 | 16 | 11 | --- | 9 | 8 | 9 | --- | --- |
Length of lower jaw | 21 | 20 | 13 | --- | 12 | 12 | 12 | --- | --- |

TABLE III
MEASUREMENTS IN HUNDREDTHS OF LENGTH OF HEAD

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length to caudal, mm.</td>
<td>10</td>
<td>25</td>
<td>102</td>
<td>130</td>
<td>145</td>
<td>173</td>
<td>285</td>
<td>860</td>
<td>1000</td>
<td>1520</td>
</tr>
</tbody>
</table>

Length of orbit | 40 | 48 | 34 | 44 | 35 | 37 | 34 | 31 | 34 | 29 |
Interorbital | 18 | 26 | --- | 22 | 23 | 16 | --- | 17 | 21 | 14 |
Length of upper jaw | 33 | 50 | 29 | 44 | --- | 32 | 42 | 37 | 36 | --- |
Length of lower jaw | 60 | 64 | --- | 56 | --- | 42 | --- | 52 | 52 | --- |

SUMMARY

Trachypterus seleniris is merely the adult of the California ribbon fish, Trachypterus rex-salmonorum, representing the end-stage in a development replete with structural and proportional changes.

The larvae and postlarvae show a flexure of the body, and possess a peculiar isolated nuchal lobe containing the interneurals supporting the five elongated dorsal rays. The larvae exhibit one extreme of the age variations in proportions, the tail region being but slightly developed, the head, and especially the eyes
and mouth, relatively very large. The postlarvae afford a transition to the juvenile stages.

The young are naked, the adult becoming covered with pad-like scales. The lateral line becomes armed posteriorly with anterorse spines, but the granulations on the fin rays disappear with age. The fin rays all become shorter with age; the excessively long pelvic fin and anterior dorsal, — probably flotation organs in the young, gradually become shorter with age — eventually obsolescent; the lower lobe of the caudal does not persist in the adult, while the upper lobe, inordinately elongate in the young, becomes very short with age and gradually rotates to assume an anterose direction. The metamorphosis as determined by changes in structure and in the fins takes place later in development than the metamorphosis in proportions.

The form of the body changes greatly with age, the depth at the nape greatly decreasing with age; the depth posteriorly increasing in reference to the depth anteriorly. The coloration also changes, becoming more uniform with age.

The dimensions of the various parts of the body in Trachipterus are not, as usual among fishes, linear functions of the total length. The development is of a greatly retarded type, and entails a protracted metamorphosis, the postlarval features being gradually lost during juvenile life.
OBSERVATIONS ON THE FLIGHT OF FISHES, WITH A STATISTICAL STUDY OF THE FLIGHT OF THE CYPSELURINAЕ AND REMARKS ON THE EVOLUTION OF THE FLIGHT OF FISHES

CARL L. HUBBS

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I. INTRODUCTION

Perhaps too much ink has already been used in discussing the flight of fishes. Certainly too much of what has been written has been unduly deductive. Many have argued from preconceived ideas of the flight of birds, or from generally erroneous conceptions of the mechanics of flight, just how fishes must fly. A few
hours of close observation of fishes flying would often have shown the resulting deductions to be erroneous. No attempt is made in this paper to review the very extensive, though mostly incidental and trivial, literature on the flight of fishes. This has in part been done by Ahlborn (1895), Gill (1905), Hankin (1914), and others. A large but by no means complete list of references is indexed in Dean’s Bibliography of Fishes.

Few of those who have written on the flight of fishes have made really critical field studies. Realizing this regrettable fact and being already interested in the subject (Hubbs, 1918; quoted by Nichols and Breder, 1928), I naturally took advantage of extremely favorable opportunities in 1929 to make some detailed studies.

Some of my observations of that year were made in the East and South China seas, about western Java, and around the entire main island of Japan, but most of the studies were carried out during the first half of June, when I chanced to journey from Java through Java Sea, Straits of Macassar, Celebes Sea, among the Philippine Islands, and on to southern Japan. The small size of the steamer on which the trip was made and its slow speed of only eight to ten knots were very favorable for observations. Still more fortunate was the circumstance that most of the seas traversed were exceptionally calm, usually with a glassy surface scarcely perturbed even by a ground swell. The details of flight were then very easily observed and tabulated. We had, however, enough rough weather to make possible a statistical study of flight over stormy as contrasted with calm seas. After we passed out from the Philippines into the open Pacific, the sea became increasingly rough as the wind developed into a gale.

Some of the observations were made by the unaided eye, but a larger number, including most of those on the positions of the fins at the various stages of flight, were made with the aid of good binoculars, which were continually kept at hand. The timing of flights was accomplished rather crudely, since there was no stop watch on board, by recording the number of ticks of an ordinary watch elapsing while a fish was in the air. Seemingly practical arrangements to measure the length of flights by the
simultaneous use of two sextants were made too late, for the sea had then become too rough to carry out the observations.

The extreme abundance of flying fishes in the calm seas and straits of southeastern Asia and their moderate though decreasing abundance in the open ocean provided ample material for the study. On day after day thousands of individuals, often singly, often in flocks, rose near the ship to sail away, in plain sight from a vantage point on the navigation deck.

By the rarest good fortune there once rose at very close range a school of that most primitive of flying fishes, Oxynotus micropterus, the flight of which has never been recorded. Several times the two-winged or monoplane flying fishes, Exocoetus proper, flitted out into observability. But by far the greatest number of observations were made on the four-winged or biplane flying fishes, the Cypselurinae. This is the group which, among fishes, has attained the ultimate in flight.

These observations on the flight of the true flying fishes (Exocoetidae) were supplemented by a few views of the air movements of Tylosurus and Hemiramphus, which belong to the same general group Synentognathi, but are more primitive than the Exocoetidae. The air leaps of such fishes as the tuna (Thunnus) and mullet (Mugil) were also seen.

Of the many thousands of fishes which I have observed in real flight, not one was suspected of belonging to any family other than the Exocoetidae. Certainly none was a "flying" gurnard (Dactylopteridae), another type of marine fish still held by some to be capable of flight (most recently by Beebe, 1928a, 1928b). I was, however, within the range of that family and obtained a considerable number of specimens. On my own brief negative observations I lay no great stress, but I am deeply impressed by the opinion of Lo Bianco, which has been quoted by several of the writers on the flight of fishes. This man, the famous collector and preparator of the Naples Zoological Station, after a lifetime of field work in the Gulf of Naples, where Dactylopterus is common, emphatically denied that this fish ever flies. He claimed it to be (as adult) essentially a bottom fish, and all its characters confirm this view.
Scrutinizing the massive bony helmet with long spines, the thick scales, unmodified caudal fin, the highly modified dorsal and pelvic fins, and the detached hooklike pectoral lobe of Dactylopteridae, I find nothing even to suggest that these fishes could possibly attain the consummate speed necessary to hurl their heavy, ungainly bodies for any distance through the air. It is true that the pectoral fins of the dactylopterids, like those of the scorpaenoid Pterois volitans, are so immense as to give one on casual inspection the idea that these fishes can fly. But a critical investigation shows that these great pectoral fins could not possibly maintain so heavy a body in the air. They are so flexible that they will support the body horizontally between them only when they are grasped very close to their bases. Their outer portions are positively raglike. The thin, exerted, unbranched pectoral rays, graduated and unthickened and unsharpened along what would have to be the sharp, strong cutting edge of the plane if these fishes really could fly, contrast sharply with the structure of the pectoral rays in the Exocoetidae. The pectoral of the “flying” gurnard may well sustain the body weight in the dense medium of water, when the fish volplanes downward, as Beebe describes it as doing, but it is assuredly utterly insufficient to hold the fish in the air, even for a moment. Möbius’ claim (1878), that he had seen Dactylopterus supporting itself in air by taut and non-vibrating wings was, therefore, erroneous. The flight of the “flying” gurnard may, I believe, be confidently added to the long list of sea myths.

The only structure in Dactylopterus, except the expanded pectorals, which has been held as adapted to flying is the air bladder (Calderwood, 1891). But it seems clear that this structure is particularly designed as a sound-producing organ. Its dorsal position I would relate rather to the constriction of the coelom by the body armature than to any aérostatic function. In regarding the heavy muscular wall of the air bladder as adapted to a sudden release of external pressure when the fish leaves the water, the author quoted must have forgotten his physics.

Sailors’ yarns aside, nearly all the claims that dactylopterids fly seem to rest chiefly on Moseley’s (1879, p. 571) observations,
which were made on the Challenger Expedition. Meeley thought he recognized species of "flying gurnets" in the air, supporting themselves grasshopper-like by buzzing their wings. But he observed small fish, which probably did not have greatly enlarged pectorals. How he could have made quite sure of the flapping of such tiny "wings" while its bearer dashed for an instant out of the water, I cannot understand. Though he claimed that he chased and caught one or two, he netted the fish out of the sargasso weed. I suppose that he chased a young flying fish and saw it alight near a mass of weeds, but failed to see it dart away, as is the habit of such fish; then netted a gurnard out of the vegetation and thus fooled himself and hundreds of others into believing that such a fish can fly, and that it does fly by buzzing its wings!

Flight has also been attributed to certain fresh-water fishes. The African butterfly fish, Pantodon, has almost as little in body form or fin structure to suggest real flight as has the "flying" gurnard. I know of no actual record of observations on its flight, although it has often been kept in aquaria (as is attested by numerous articles in aquarium journals). The statement or guess of one French explorer that Pantodon is a "petit poisson volant," expressed on a label in an exhibit in Paris, and the statement of another French explorer that he had observed a small flying fish about Lake Chad, appear to be the only bases for the hundred-times repeated claim that this fish can fly. This traveler's description of the air movements of Pantodon, repeated by Pellegrin (1906), along with a fanciful picture of the fish in activity which seems quite out of harmony with its form, is very brief and indicates some form of skimming rather than flight. The account states that the pectorals beat the water surface, which would seem to indicate that the fish does not leave the water, although we certainly have no reason to think that an untrained observer could see the individual fin movements. There is, furthermore, no proof or even good indication that the fish observed was a Pantodon rather than, as would seem more probable, a characin. Certainly there is no good reason to align Pantodon among the flying fishes.

The South American "fresh-water flying fishes," characins of
the subfamily Gasteropelecinae, are reputed by means of an actual flapping of the "wings," to accomplish their well-authenticaed long skimming movements and short flights. The structure of these fishes, especially of their muscles, as Ridewood (1913) has pointed out, very strongly supports these observations.

Flight has also been accredited to certain fossil fishes (Landois, 1894; Abel, 1906, 1912; Lull, 1906; Young, 1915). On this question I have nothing to say.

II. THE FLIGHT OF THE MOST PRIMITIVE FLYING FISH

No observation has been published on the flight of Oxyporhamphus micropterus, which is of critical interest because this rare species is apparently the most primitive of all the flying fishes, certainly the least specialized in respect to wing development. It was, therefore, a piece of real good fortune that I saw a flock of about twenty-five adult individuals of this genus take a flight in Bohol Strait, Philippine Islands, on June 7.

They rose near the boat, in fact almost below me and only 10 meters distant, and made away at right angles with the boat. They flew only 5 to 8 meters and rose but a few decimeters above the surface. Possibly with a longer start beneath the surface they would have flown farther, but they cannot be regarded as capable of really long soars. They merely volplaned like other flying fishes, for the pectorals were clearly neither flapped nor vibrated, even at the start of the short air journey. The simple wave-rings emanating from the points of origin and end of flight

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1 This genus has almost universally been known of late as Evolantia Heller and Snodgrass, 1903. It was based on Exocoetus micropterus Valenciennes. But the name Oxyporhamphus Gill, 1863, was obviously based on the half-beaked young of the same genus. A comparison of Valenciennes' figure of Hemiramphus cuspisatus (Cuvier and Valenciennes, Histoire naturelle de poissons, 18 [1846]: 55, Pl. 55), the type species of Gill's genus, with Nichols and Breder's figure (1928) of the beaked young of Evolantia microptera, indicates that they are based on the same genus if not the same species. The only discrepancy of moment is in the number of dorsal rays (Valenciennes gives 18 for cuspisatus and 15 for micropterus). It is possible that the two species are distinct, but more likely that the count for cuspisatus is too high. The fact that the two types of cuspisatus were taken from the stomach of a bonito might explain a miscount of the rays. Since the generic name Oxyporhamphus is older than Evolantia, it should replace the latter name.
Flight of Fishes

confirmed my visual impression that none taxied at the surface at the beginning of the flight, and that none attempted a second soar. The flight of the primitive *Oxyprohamphus* is, therefore, much simpler and shorter than that of the more specialized flying fishes, the Cypselurinae.

That the fishes observed really were *Oxyprohamphus* seems certain. I clearly distinguished their slender form, lack of beak, and relatively short pectorals, which are only long enough to reach approximately the rather small pelvic fins. The pectoral fins, though much shorter than those of any other Asiatic flying fish, were much longer proportionately than those of any other surface-swimming Asiatic fish.

III. THE FLIGHT OF THE MONOPLANE FLYING FISHES

The genus *Exocoetus* (*Halicyprisinae* of Jordan and Evermann, and of Nichols and Breder) has also a distinctive type of flight. This the late Charles Henry Gilbert, one of the most acute of fish observers, told me years ago. He related having frequently seen on the high seas of the tropics flocks of this genus making simple leaps of about 10 to 20 meters, a long flight for a fish, though a relatively short one for a typical flying fish (Cypselurinae).

My clearest and surest observations on the flight of *Exocoetus*, made in the Pacific Ocean east and northeast of Luzon (at Lat. 20° to 21° N., Long. 127° to 128° E., surface temperature 26.5°C., and at Lat. 24° N., Long. 128°30' E., surface temperature 26.5°C.), confirm these remarks of Dr. Gilbert. Often singly, but frequently in loose to compact groups of about twenty-five, these little flying fishes were there seen to catapult themselves directly out of the water, clearly without undertaking any initial surface-skimming. At times they shot forth at a small angle with the surface, and then their flight did not differ notably from that of the more primitive *Oxyprohamphus*. Often, however,

2 No flying fishes were identified as *Exocoetus* in the passages among the Philippine Islands, where the Cypselurinae so notably abounded. *Exocoetus* is apparently a fish of the open seas. It has been recorded hundreds of miles from the nearest land.
and probably more typically, they came out at an angle of about 45°, or even more, with the surface. They were then caught by the wind, which when strong wafted them about like pieces of paper, so that at times they were carried 2 to 4 meters above the surface. This high and passive flitting, the lack of initial surface-skimming or taxi movements, the shortness of the flight (not more than 20 meters), and the constant failure to repeat a flight before reentering the water, all feature the flight of *Exocoetus*, and contrast it strikingly with the low, accurately controlled, long and often compound air movements of the Cypselurinae, in which each flight is induced by a taxi.

The flight of *Exocoetus*, however erratic, like that of *Oxyporhamphus* and the Cypselurinae, is merely a soar. The pectoral fins were clearly seen to be held taut and were neither flapped nor vibrated.

These erratically flying exocoetids were identified as *Exocoetus* because the pelvic fins were not observable. In this genus these fins are small and placed far forward, and are not modified as organs of flight. In the Cypselurinae the pelvics as well as the pectorals are much enlarged, and form conspicuous planes when a fish is soaring. In the large size of the pectoral fins these fishes referred to *Exocoetus* rivaled the Cypselurinae and contrasted strongly with the short-winged *Oxyporhamphus*.

IV. THE FLIGHT OF THE TYPICAL OR BIPLANE FLYING FISHES

In the Cypselurinae, comprising four genera in the classification of Breder (1928), the aerial locomotion of fishes reaches its

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4 The high, flitting flight of fishes of the genus *Exocoetus* doubtless accounts for the circumstance that during storms especially they are often cast upon the decks of large vessels.

5 Hankin (1920) has indicated a difference in the flight of the "two-winged" and "four-winged" flying fishes which I did not appreciate. He believed that the former lacked the power to check their speed before ending their flight, thus contrasting with the "four-winged" species which he thought slackened their flight by movements of their enlarged pelvic fins just before alighting.

6 The remarkable analogy of the flight of cypselurine flying fishes to that of airplanes has lately been stressed by a number of authors, most definitely by Breder (1931).
Flight of Fishes

ultimate expression. The manner of flight in these “four-winged” or biplane fishes is not only highly specialized, but appears also to be strikingly uniform throughout this speciose and obviously successful group, which includes all the species of the Exocoetidae, with the exception of Oxyporhamphus micropterus, Exocoetus evolans, Exocoetus obtusirostris, Fodiator acutus, and the few species of Parexocoetus (Breder, 1928). I have observed in flight the large California flying fish, Cypselurus californicus, and at least ten species in the western Pacific, from Java to Japan. In all these I have found the movements in the air to be surprisingly alike. This similarity in flight methods through the group decreases the importance of my inability to distinguish in flight the species observed in Asia.

To illustrate the variety of species of Cypselurinae observed in Asia and to present evidence for their possible future identification, I describe the appearance of some of the forms seen. Most of the notes and records in Celebes Sea on June 3 were based on a very robust species estimated to be 20 to 25 cm. long (over all), with blackish wings. On the next day the same type was observed, but one not quite so robust and with colorless pectorals was perhaps commoner; still another, slenderer and smaller, but distinctly of the biplane type, was flying after the same fashion, though usually in more compact schools (sometimes nearly one hundred would dash out almost simultaneously); rarely, another type, with a wide yellow streak near the outer edge of the otherwise blackish pectoral, was seen on June 4 and subsequently. In the Strait of Basilan, on June 6, most of the flying fishes seen were about 19 to 25 cm. long, without marked color on the pectoral fin. Later that day, out in Sulu Sea, at least four species, mostly larger, 25 to 45 cm. long, were studied, for the coloration of the pectoral fins was of four types: clear, blackish, blackish with a yellow band, yellow. In Bohol Strait, on June 7, the Cypselurinae were mostly 22 to 32 cm. long and fairly robust; the pectorals of some were without noticeable color, but most of them were blackish, and the pelvics of some were also dark. In the Pacific east and northeast of Luzon most of the fishes of the group under consideration were rather large and robust; a few
FIG. 66. Four stages in the flight of a cypselurine flying fish (see explanation at bottom of opposite page)
had yellow-brown pectorals (these were seen from just off San Bernardino Strait, where they were rare, and northward in increasing commonness almost to Kyūshū); others were similar, but had clear pectorals. About Japan I observed *Cypselurus agoo* and at least two related species, and also one with black-blotched pectorals.

The cypselurine flying fishes were especially abundant in the passages among the Philippine Islands, where the water was as placid as that of a little lake on a calm day and where the surface temperature varied from 28° to 30° C. They had also been common in the similarly smooth Celebes Sea (32° C.) and Java Sea. They remained rather common in the open ocean east and northeast of Luzon, as long as the temperature remained high (27° to 29°), although they were not so excessively abundant here as among the Philippines. They became scarcer at 24° N. latitude, where the surface temperature was 26.5°, and relatively very few (only 11 seen in three hours) at about 30° N. latitude, where the temperature was 24° to 25° C.

These flying fishes showed a marked tendency to congregate, not only in general regions, but also in schools. At times more than one species would be seen in the air simultaneously, but often whole flocks were clearly of a single species, distinct from another just previously flushed.

The flying fishes swim with great speed in the water, as I long ago saw clearly for *Cypselurus californicus*. I observed that when that species is under water the wings are held tightly against the body (Fig. 66 a), and I assume that this fin position must hold true for all the species. On reaching the surface the

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**EXPLANATION OF FIGURE 66**

a. The fish approaches the surface; both pairs of fins folded

b. The fish breaks the surface and spreads the pectoral fins (upper or anterior planes) to support the anterior part of the body

c. The fish gains speed by the taxi or surface-skimming. The caudal beats the water; the body shakes; and the wing tips flutter in response, giving a false illusion of wing beating

d. The fish takes off by spreading the pelvic fins, thus lifting the tail out of the water. The planes are now held taut and rigid as the flying fish dashes through the air
pectoral fins are at once spread, so quickly indeed that my eye never caught the movement. Since the supporting planes lie well in advance of the center of gravity and since the lower posterior planes, the enlarged pelvic fins, must at first remain folded against the belly, the fore part of the body is held up at a slight angle with the surface of the water, while the elongated and strengthened lower lobe of the caudal fin is partially submerged in the water (Fig. 66 b).

The "taxi"

In obtaining this position at the surface of the water there may be some slackening of the speed of the fish. They actually appeared almost to balance themselves for a split second at the inception of the surface movements which are characteristic of this group of flying fishes and which may be termed the "taxi" stage of the flight. At least we may be sure that at the start of the taxi sufficient velocity is not yet attained to carry the fish on a very long soar through the air. That this is true was evident from actual observations. When the taxi was misgoverned, much abbreviated, or even eliminated, on account of some condition of wind, wave, or obstacle, the fish was sustained in the air for only a few feet. And when a very short taxi was employed, the first flight was not much longer.

I believe that I was able to observe the acceleration in speed which I assume is produced by the taxi. In compound flights it was obvious that the slackened speed at the end of one flight was greatly accelerated by the taxi intervening directly between this soar and the following one. At the end of each taxi the fish appears to be catapulted into the air at a very high speed. What this actual speed is would be very interesting to know. I assume that it is not less than about 55 kilometers (35 miles) per hour, my very rough estimate of the average speed of the whole flights (drawn up from guesses of the distance traversed in timed

7 The folding back of the pectoral fins while the fish swim under water and their spreading only on coming to the surface were observed by Adams (1906, p. 145), who placed some live flying fish in a bathtub on board ship. I suppose that these observations are correct, although this author's account of the actual flight is very peculiar and no doubt erroneous.
That an acceleration takes place during the taxi may also be concluded from the fact that my estimate of the speed of the entire taxi is only 10 meters per second (about 35 kilometers per hour), which is less than my estimate for the whole flight and which is almost certainly less than the speed attained at the end of the taxi and the beginning of the actual flight. The taxi may, therefore, be assumed to accelerate the speed to a degree sufficient to carry the fish for a considerable distance through the air.

The propulsive power by which this acceleration is accomplished is derived solely from a violent side-to-side vibration of the tail, as the fish skims along with only the strengthened lower caudal lobe in the water. The even wave-ring disturbance on the quiet sea surface indicated that such a movement takes place, and the actual track which I once saw left on a dust-covered surface proves the point.

The retention of the propelling organ in the dense medium of water and the supporting of the moving body in the rare medium of air permit the attaining of a very high speed. This is the principle of the speed boat.

The rapid shaking undergone by the stiff body clearly follows from the tail movement. The slight movement of the taut pectoral fins (Fig. 66 c) during the taxi has been mistaken by uncritical observers to be an actual flapping of the wings, but this rapid vibration of the fins, like the less obvious but still observable shaking of the whole body, is solely a response to the violent tail movements. The vibration of the wing tips, having an amplitude of only a centimeter or two and usually lasting a bare second, is certainly insufficient to give so heavy a body speed enough to carry it through the air. The hazy outline of the planes becomes transformed into knifelike rigidity, as I have observed hundreds of times for many species and as most other trained observers have indicated, at the instant the tail movements cease when the fish rises into the air.

It is a curious fact that nearly all observers have failed to

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8 This estimate is in rough agreement with those of Hankin (1914, 1920), who computes the air speed of flying fishes to be 10 to 20 meters per second. Hankin estimates the longer flights to be 200 to 400 meters long.
Carl L. Hubbs

appreciate the simple reason why the wing tips flutter while the tail is vigorously beating the water surface. Even those who have taken the side that flying fishes do not fly by wing flapping explain this wing vibration as due to the action of the wind on the taut membrane. That this explanation is untrue follows from the fact that the vibration ceases the instant the tail fin leaves the water, although neither the wind pressure nor the wing tautness is then materially lessened.

The distance covered by the initial taxi is quite variable. Very rarely it is entirely omitted by a biplane flying fish (as it normally is by the more primitive *Ozypomphalus* and by the monoplane *Exocoetus*). The omission is apparently only by accident, as when a fish emerges on the down slope of a sharp wave. The flight is then very short, unless resustained by a taxi as the fish touches the water. Frequently the taxi covers less than 5 meters, in which event the flight is short, though often followed at once by a longer flight induced by a longer second taxi.

The usual taxi distance I estimated, with the aid of a fellow-passenger, Dr. S. Ogawa of the Japanese Hydrographic Office, an expert in navigation, to be from 5 to 15 meters. Some taxis seen were at least 20 meters long. We judged the average to be close to 30 feet (9 meters).

The number of seconds devoted to the taxi, according to fifty-two timings made in Bohol Strait, Philippine Islands, on June 7, when the sea was calm, ranged from almost 0 to 2, with an average of 0.9 second (column two of Table 1). The estimate was made by counting the 0.45-second intervals (by ticks of a watch) involved in the taxi. Since the average distance covered by a taxi was judged to be 9 meters, I compute the average speed for the surface period to be 10 meters per second (36 kilometers per hour). This is the speed of an athlete on a short dash. But the speed of the fish, since it is accelerated during the taxi, is probably much higher than 10 meters per second at the end of the taxi, when it hurls itself into the air.

In order to induce this high speed the vibratory motion of the tail must be very strong and rapid. The actual number of vibrations could be roughly counted, by reason of the glasslike smooth-
ness of the surface of Bohol Strait, where the estimates were made. From the vantage point on the navigating deck of the slowly moving steamer, it was found possible to count for about one fourth of the taxi distance the number of rings issuing outward from one side of the path of the fish (each primary ring on each side corresponded to one complete [or double] swish of the tail). For an average taxi (about 9 meters long and of about 0.9-second duration) the number of vibrations was estimated as 40 to 80 (average about 60), and proportionately more or less for long and short taxis. These figures yield average estimates of nearly 70 vibrations per second, and of 7 complete vibrations per meter.

One really accurate estimate of the number of vibrations per meter was made. By remarkably good fortune a flying fish of the subfamily Cypselurinae, about 12 cm. long, rose just beside the ship almost directly below me and made away at right angles, over the glassy Bohol Strait, where the surface happened to be densely covered by a dustlike scum. The track of the fish's tail was left imprinted like a cymograph record on the surface of the sea, as a cleared zigzag trail showing exactly thirty angles on one side. I supposed the distance traversed to be 20 feet (6 meters), and this estimate was confirmed by Dr. Ogawa. This fish, therefore, made five complete (double) beats of its tail on the surface of the water for each meter, a figure regarded as accurate within one beat per meter, plus or minus. This determination is somewhat lower than that based on the average drawn from counts of rings produced by the tail beating (7 per meter), although the two figures are sufficiently close to confirm one another. Judging from the length of this particular taxi as compared with others timed, I estimate this one to have lasted about 0.6 second. As before, this estimate yields an average taxi speed of 10 meters per second and a computed average of 50 vibrations per second.

It appeared from the observations on both the wave-rings and the cleared track, produced by the fish in its taxi movement, that the number of vibrations of the tail per meter did not noticeably increase during the course of the taxi. The distance between
successive rings and the successive points on the zigzag track appeared to be the same at the end of the taxi as at the beginning. A slight and gradual change would probably not have been apparent, but a sharp difference should have been seen under the extremely fortunate conditions of observation. Therefore, since the speed is (presumably) accelerated in the course of the taxi and since the rate of vibrations per meter remains about constant, the number of beats per second presumably increases beyond the average, which was estimated to be nearly 70 per second, proportionately as the speed increases beyond the average for the taxi, estimated at 10 meters per second. Like an airplane, the fish probably increases its power as it approaches its take-off.

On the basis of some field observations (how detailed not indicated) and of aerodynamic computations Shoulejkin (1929) has concluded that a speed of 16 to 18 meters per second is attained at the end of the taxi, and that the average speed during the actual flight is 10 meters per second (covering 100 meters in 10 seconds). Other estimates, as those of Ahlborn (1895) and Hankin (1914, 1920) are in the same order of magnitude as Shoulejkin's and mine.

The subsequent taxis, that is, those which intervene between the successive rises of a compound flight, were seen to be typically shorter than the first (or than the second, if the first start was abortive). They seldom lasted a second, and the average was thought to be about 0.5 second; it may be 0.3 or 0.7 second, but probably lies between those figures. A more accurate estimate could of course be made with special equipment.

A variation in the taxi sometimes occurs in rough weather, when the sharp little troughs of a choppy sea induce short breaks in the surface movement. In general, however, in the taxi as well as in the flight, the cyprinid flying fishes are remarkably adept at holding their course parallel to the changing level of the sea.

*The position and function of the fins in flight*

During both the initial and intermediate taxiings the pelvic fins must remain folded tightly against the belly, for at these times they were always invisible. But at the instant the fish
leaves the surface these fins flash into clear view and are very easily seen with binoculars or even with the unaided eye, especially when the pectorals are blackish. It is assuredly the upward force of air pressure on these posterior planes that lifts the drooping tail out of the water, and thus actually initiates the air flight proper (Fig. 66 d). When the fish is thus forced into a horizontal position, it lies at most only a few centimeters above the sea. This is probably a main reason why many flights are abortive, ending almost at once in a steep little wave. Another example of imperfection in flight sometimes noted was the bare clipping of the crest of a sharp wave by the tail fin, while the fish was volplaning through the air.

The often repeated claims that a flying fish sustains itself in the air by flapping or rapidly vibrating the pectoral “wings” are due, I suppose, to preconceived ideas that fishes must fly like birds, or to uncritical deductions that the mechanics of the situation demand such movement, or to untrained or inattentive observation. These claims have for the most part been made by other than trained naturalists, or by laboratory zoologists equally untrained in field observation. Such accurate, trained observers as Moseley, Jordan, Gilbert, and many others have been unable to detect any movement of the fish’s main planes while it flew through the air. Neither for the California flying fish nor for the several species I studied on the opposite side of the Pacific could I observe any wing movement whatever, which by any reasoning could be thought to sustain the fish in the air. The vibration of the pectoral tips through a small amplitude during the taxi, assuredly the mere consequence of the vigorous sweeping of the tail, as I have already stressed, ceases instantaneously as the caudal fin rises clear of the water. And these fins remain stretched taut and firm until the moment when the fish either dives into the sea, or until its tail fin dips in the water and resumes the violent sculling, which immediately induces a renewal of the hazy appearance of the fin tips. The frequent naïve claims that this secondary vibration becomes apparent only on the fatigue of the fish and that the wing vibration while the fish had been in the air was too rapid to be seen by the eye, are at once negativ

Yesterday, I saw a flying fish in the air.
by the fact that the wing appears as a single blade, whereas if it had been moved too fast to follow, it would have appeared double like a humming bird's wing, one image at each end of the stroke.

That there is absolutely no vibration of the outstretched pectoral fins while the fish is in the air is clearly observable, even without the aid of field glasses. Whenever a fish happened to fly directly away from me, therefore under conditions which would make easily evident any up-and-down movement, I always saw the edges of the planes standing out clear like knife edges, without a trace of doubling or of a blur, even when the fish flew into a high wind (which some have said causes a vibration of the fin). It was with full certainty also that I observed the rigidity of the planes hundreds of times as I looked down through field glasses at flying fishes close to the boat. When the pectoral fins were blackish, and better yet, when they were marked with an oblique yellow band or by black blotches, it was especially easy to appreciate that these fins remained motionless in relation to the fish. Such observations from above showed clearly that Adam's claim (1906) of a horizontal vibration of the wings was erroneous.

The anatomical researches of Möbius (1878), Ahlborn (1895), Ridewood (1913), and others have disclosed no muscular or other modification sufficient to make one suspect that these fishes can flap their wings sufficiently to maintain their heavy bodies in the air.

The pelvic fins, the lower or posterior planes, likewise were never seen to vibrate. They remained folded as the caudal beat the surface, and thus did not participate in the slight vibration of the fin tips, induced by this tail movement. Especially when the pelvics were black or blackish it was possible to see through the binoculars that these fins did not vibrate while they were outstretched during the actual air flight.

The fact that the expanded paired fins do not vibrate after the fish leaves the water surface proves that the caudal fin does not beat in the air (another fantasy of some authors). Furthermore, the edge of this fin could be seen clear-cut when a fish vol-planed away in line with my vision.
The control of flight direction

I conclude from my observations, therefore, that a flying fish when in the air makes no effort by any flapping or vibration of the fins to add to the velocity it gained by the sculling of the tail during the swimming under water and during the taxi at the surface. That it does, however, use the fins in the air to control the direction of the flight is certain. This control was most often seen when a fish avoided the obstruction of the ship's bow by flying around it in a distinct curve, and even more spectacularly when one headed directly for the ship's side turned off at right angles in a curve with a radius sometimes as short as 3 to 5 meters. When a flying fish approached even closer to the ship, it dived into the water, as I have mentioned for Cypselurus californicus, to take advantage of the greater resistance of that medium in making the shorter turn necessary to avoid a collision with the ship. The control is so nearly perfect that I have never seen one strike a vessel, though of course they are known to land on deck at night, and I have found but one published record of a flying fish striking the side of a ship. Occasionally I have seen them collide, not with a ship but with one another (as though to heighten the analogy of their flight to that of airplanes). I suppose, therefore, that flying fishes are lacking either in perfect flight control or in perfect air vision.

In describing the flight of Cypselurus californicus I accorded to the lower or posterior planes (the pelvic fins) the function of stabilizing or balancing the fish while in the air.\(^9\) For the generally smaller Asiatic species I was not able with certainty to confirm these observations on the joint or independent movements of the pelvic planes. The tilting of the body and of the pectoral planes up toward a side wind seemed more responsible for a marked deflection of flight in the Asiatic species than did any possible curvature of the tail. I often watched for any definitive movements, especially unilateral ones, of the pectoral fins, but could never observe them. It is true that the angle made by the two

\(^9\) Hankin (1920) has also indicated that the position of the pelvic fins is altered to control the flight, especially to check it.
Fig. 67. Statistical analysis of the flight of cypselurine flying fish (see explanation at bottom of opposite page)
main planes, from behind, for example, often varied considerably in either direction from horizontal, but the two fins seemed to be always held at the same angle with the cross axis of the body. This angle I thought varied somewhat between species, and also with degree of fatigue.

The flying fishes of the *Cypselurus* types, like airplanes again, show a vertical as well as a horizontal control of flight direction. This was beautifully evident as they maintained a course nearly parallel with a choppy water surface, just skimming over sharp-peaked crests and dropping to a lower level over the intervening troughs. As already noted, the diving to avoid collision with a ship likewise indicates a vertical control.

The claim has been made that flying fishes invariably take off into the wind, but I have seen them scoot away toward all points of the compass while a strong wind remained in one quarter. The power and speed of the taxi seem sufficient to hurl them into the air, when the pelvic planes are expanded, no matter what may be the angle of the taxi to that of the wind. But after

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**EXPLANATION OF FIGURE 67**

A-C. Frequencies of number of leaps in each flight, under different conditions

A. Celebes Sea and Strait of Baslian, June 3 and 6, 1929; sea very smooth; usual size of fishes about 19 to 25 cm.

B. Southeastern Sulu Sea, off Mindanao, June 6, 1929; sea slightly choppy; usual size of fishes about 25 to 45 cm.

C. East and northeast of Luzon, in Pacific Ocean, June 8 to 11, 1929; sea rough; usual size of fishes about 25 to 45 cm.

D-H. Frequencies of duration of single flights in seconds

D. Initial taxi: Bohol Strait; sea smooth; moderate wind; usual size of fishes about 22 to 32 cm.; one or more leaps followed the taxi

E. First flight: conditions as for D; flight either continued or not

F. First flight: Pacific Ocean, east and northeast of Luzon; sea slightly choppy to very rough; moderate to strong wind; usual size of fishes about 25 to 45 cm.; flight either continued or not

G. First flight: conditions as for F; flight continued

H. First flight: conditions as for F; flight not continued
the fishes start their flight, especially as they begin to lose momentum, their direction is much modified by a strong wind. They tilt their plane surface more or less upward toward the wind, and are thus carried off their original courses in a wide curve. To what degree the wind is so utilized to prolong or definitely alter the direction of the air journey is a point worthy of detailed inquiry.

Sometimes I saw these fishes make a sharp angle in their flight by barely dipping into the water. When this was repeated several times, with each flight lasting only a half-second or so, a peculiar concentrated zigzag course, such as diagramed in Figure 68, was followed. The fish then acted as though in a fit, but the action may have been wholly normal, perhaps of significance in dodging.

The duration of the flights

During my observations on the species of Cypselurae in Asiatic waters I made an effort to time a considerable number of flights. Though my estimates have only a moderate degree of accuracy, they are, so far as I know, the most definite which have been made, and suffice at least to show that a person's offhand estimate of the time in the air is usually several times too high. The flights were timed, in the absence of a stop watch, by counting the number of watch ticks (at a calibrated interval of 0.45 second) elapsed during the flight. Altogether 424 flights or parts of flights were timed, 298 in Bohol Strait, Philippine Islands, and 126 in the open Pacific east and northeast of Luzon. The results are tabulated as Table I, and most of them are graphically portrayed as Figures 67 D–F.
**Flight of Fishes**

**TABLE I**

ESTIMATED LENGTH IN SECONDS OF FLIGHT OF CYPRINIDAE.

For the first leap the time is for the actual flight after rising from the surface of the water. For flights of more than one leap the taxi periods (about 0.5 second each) after the first taxi are included. The average time per leap (see next to last row) subsequent to the first flight, which averaged 2.4 seconds, excludes all the taxi periods.

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<tr>
<th>Locality</th>
<th>Sea (and wind)</th>
<th>Usurprise</th>
<th>Stage of flight</th>
<th>Number of leaps</th>
<th>Total flight (excluding all except first taxi period)</th>
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<tr>
<td>Bohol Strait, P. I.</td>
<td>Smooth (moderate wind)</td>
<td>22 to 32 cm.</td>
<td>Initial taxi</td>
<td>One or more</td>
<td>52 (average per second 0.9)</td>
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<td>Pacific Ocean, east and northeast of Luzon, P. I.</td>
<td>Slightly choppy to very rough (moderate to strong wind)</td>
<td>25 to 45 cm.</td>
<td>First flight (not including taxi period)</td>
<td>One or more</td>
<td>246 (average per second 2.7)</td>
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</table>

**Total** | 52 | 246 | 84 | 31 | 55 | 18 | 11 | 8 | 1 | 2 | 1 | 1 |

Average per second: 0.9, 2.7, 2.9, 2.4, 3.3, 5.5, 8.4, 14.4, 97, 117, 87, 237

Average time per leap (excluding taxi periods): 2.6, 2.5, 3.3, 1.2, 1.2, 0.4, 2.4

Weighted average of these average times per leap: 2.6
The longest period any flying fish was timed actually in the air on a single flight was 12 seconds in Bohol Strait (246 timings), and 13 seconds in the Pacific Ocean (84 timings). Some flights which I observed among the Philippines, before I started to use the watch, I believe were somewhat longer than any of those I actually timed. Of 42 compound flights that were timed the longest lasted slightly less than thirty seconds. It is doubtful whether any flights cover a whole minute.

Most flights of the Cypselurinae are short, lasting only one or two seconds, whether the sea be glassy smooth or decidedly rough. The lack of correlation between the time of flight in calm and stormy weather is strikingly shown by the similarity of the graphs portraying my records for Bohol Strait and the Pacific Ocean (Figs. 67 E-F). The average time for the first flight was about the same, 2.7 seconds for the smooth Bohol Strait, and 2.9 seconds for the rough weather on the open ocean.

The eighty-four observations for the first flight made in the ocean were further analyzed into those for flights at once continued by a subsequent taxi and those ceasing immediately. It appears probable from this analysis (see Figs. 67 G-H) that incipient or interrupted first flights, and also those which are of moderate duration (2 to 6 seconds), are very often followed by a second flight, but that long initial flights end directly. It is true that definite records are few (31 for continued and 53 for non-continued flights), but the results harmonize with the general impressions gained from a vastly larger number of observations.

The duration of forty-two compound flights, involving two to eight separate leaps, is indicated in the last seven columns of Table I. These records were obtained with the eighty-four discussed in the last paragraph and are directly comparable with them. The average time per leap for compound flights of two to four stages was found to be as high as the average time for the first leap when that initial flight is continued. This follows from the circumstance that the average time for the first flight, which might be expected to be longer than the subsequent flights, is held down by the brief duration of many incipient flights which are continued by a subsequent taxi. The average dura-
tion per leap of flights involving five to eight leaps was shorter, as would be expected, but my figures are too few to demonstrate this expectation conclusively.

The number of successive leaps

In order to obtain some definite data on the frequency and extent of these compound flights which characterize the air movements of the Cypselurus type, I made about one hundred counts of the number of successive flights in three different places under as many different conditions. In the Celebes Sea and Strait of Basilan, where the surface was extremely smooth and where flying fishes were rather small (about 19 to 25 cm. long), 107 counts were taken on June 3 and 6. In southeastern Sulu Sea, off Mindanao, where the surface was slightly choppy and the fishes were larger (mostly 25 to 45 cm. long), 97 counts were tabulated on June 6. In the open Pacific Ocean, east and northeast of Luzon, 95 counts were made from June 8 to 11, when the weather was stormy and the fishes were similarly large. The species observed at the three localities were in large part different (see page 583).

The resulting data are assembled as Table II and are graphically set down as Figures 67A–C. Slightly more than half of the flights (164 out of 299, or 55 per cent) were not continued at all. About three fourths (76 per cent) ended with either one or two leaps. Nearly nine tenths (86 per cent) of the total ended with one to three leaps, and more than nine tenths (94 per cent) ended with four or fewer stages. Only one flight in 16, on the average, was made up of five or more elements. The greatest number of successive flights observed was 12. It is doubtful whether a greater number is often undertaken.

The similarity in the frequencies of numbers of successive flights under the different conditions of sea, weather, size, and species of fish shows how independent of these conditions is the number of successive flights undertaken. The curves showing the data (Figs. 67A–C) are remarkably alike for the three sets. The average number of successive flights of the smaller fishes in the very smooth Celebes Sea and Strait of Basilan is 2.1; of the
### TABLE II

#### NUMBER OF SUCCESSIVE LEAPS IN FLIGHT OF CYPSELURINAE

<table>
<thead>
<tr>
<th>Locality; date; condition of sea; size of fishes</th>
<th>Number of leaps</th>
<th>Totals</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Celebes Sea and Strait of Basilan; June 3 and 6, 1929; sea very smooth; usual size of fishes about 19 to 25 cm.</td>
<td>63</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Southeastern Sulu Sea, off Mindanao; June 6, 1929; sea slightly choppy; usual size of fishes about 25 to 45 cm.</td>
<td>48</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>East and northeast of Luzon, in Pacific Ocean; June 8 to 11, 1929; sea rough; usual size of fishes 25 to 45 cm.</td>
<td>53</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>164</td>
<td>63</td>
<td>30</td>
</tr>
</tbody>
</table>

larger ones in the slightly choppy Sulu Sea, 2.0; of those, also large, observed during stormy weather on the open ocean, the average is also 2.0.

**The return to the water**

The flying fishes of the subfamily Cypselurinae finally return to the water in a variety of ways. Sometimes it seems that they just dip below the surface to rise again almost at once, but usually, when once submerged, they do not very soon rise again. Since the flying fishes usually fly very close to the water, they disappear at the end of the flight so suddenly that it is almost impossible to perceive the fin movements which accompany or cause the end of the flight. Not infrequently one was seen to bend its course rather sharply downward and to dive in so cleanly

---

10 Hankin (1920) thought he could distinguish different methods of return to the water by the two-winged and four-winged types. My notes are silent on this point.
as to produce only a slight splash at one spot. I thought that I could see in some such dives a folding of the pectoral fins, which probably happens, for the elimination of these anterior supports and the continual holding out of the posterior planes would certainly produce such a dive. Occasionally one is seen to dive directly into the face of a steep wave, a movement which would require no special manipulation of the planes.

But just as often the alighting is not so neat. The body may strike the water horizontally with a heavy splash, as though both pairs of fins were folded at once. Or the tail may strike first, owing to the fact that the axis often droops during the flight or, perhaps, to the folding first of the pelvic fins. This is the position assumed when a new flight is initiated by a secondary taxi, but unless a violent vibration of the tail is at once begun, the body plows obliquely into the sea so as to raise a distinct wave on either side. At times the return to the water is still more awkward, for the body may so hit it as to be hurled forward or abruptly sideward for a meter or so through the air, to reenter the water with a new splash.

V. THE FUNCTION OF THE WINGS OF YOUNG FLYING FISHES

All of the discussion given thus far, and in the next section, refers to the flight of adult flying fishes, with especial reference to the phyletic development of the flight. It is of high interest also to study the ontogeny of flight in the same fishes.

In very young flying fishes, to a length of about 1 to 2 cm., the paired fins have not yet become greatly enlarged. This phenomenon has been discussed by Derjugin (1908) and observed by many others, including myself. Between the lengths of about 1 and 2, or of 2 and 3 cm., depending on the species, the pectoral and pelvic fins grow disproportionately fast, to attain a relatively huge size.

During this stage of fin development the baby exocoetids live near the surface, especially about floating Sargassum and trash. In this habitat at Hamada, on the Sea of Japan, in a quiet cove called Matsubara Bay, I found, in late July, many young 1 to 5 cm. long. Here they were concentrated in abundance, for the
floating material swept in by the Tsushima branch of the Kuro Shiwo accumulated in the cove. The young of at least three species of *Cypselurus* were represented.

The smallest exocoetids were seen slowly wriggling their way through the water. The smaller ones with enlarged fins, 2 to 5 cm. long, whenever undisturbed, were seen quietly floating near the surface of the water with their enormous, almost circular, paired fins widely expanded. In the species having the paired fins blackish, and in the one having these appendages black-blotched, the quiet extension of the fins was observable from the skiff with certainty. I conclude that the widespread fins of these young flying fishes 2 to 5 cm. long function as flotation organs.

These fins of young exocoetids seem proportionately as large in area as in the adult. The pelves are especially immense. The pectorals, though shorter relatively than in the adult, are wider because of the more expanded interradial membranes. They resemble the corresponding fins of the "flying" gurnard. The similarity was enhanced by the flexibility of the fin, which in each species appeared sufficient to support the body in dense water but not in rare air.

The smaller of the young exocoetids observed, 1 to 3 cm. long, made only feeble, sluggish efforts to escape, with but little folding of the wings. Somewhat larger ones, however, swam off more quickly, with their great planes folded back out of the way, as they probably also are during all the underwater movements of the adults. But even these young did not attempt to fly in their rush to escape. It is apparently only after a length of about 5 cm. has been reached that the young flying fishes (of the cypselurine species observed) have attained enough strength, and stiff enough planes, to make flight possible.11

The first flights are, of course, short. In Matsubara Bay, young 5 to 8 cm. long were frequently seen at very close range

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11 Breder (1932) asserts that young of *Parexocoetus* larger than 10 mm. are capable of air "glides" amounting in the larger ones to at least a foot. This is surprising, since at this age the pectorals are limp. These fins may help to sustain the fish in the air, on account of its very light weight.
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to make single, simple leaps of 1 to 10 meters. Neither here nor in Bohol Strait, Philippine Islands, where I observed many young taking to the air on June 7, nor elsewhere, did I see a young flying fish taxi before its flight. It seems improbable that none of these young were members of the Cypselurinae, the only speciose group in the family, all of which as adults initiate their flight with a taxi. Some of those I saw in the air at Matsubara Bay seemed to belong to a species with characteristic black blotches on the pectorals; of these I took many young 2 to 5 cm. long. It is possible that I overlooked a short initial taxi, although I saw many leave the water within a few meters of my position at the bow of a skiff. If the young of the Cypselurinae group merely leap out of the water after the fashion of the primitive flying fish Oxyporhamphus (Evoltantia), they may be exhibiting a recapitulation in flight evolution. That interpretation is contradictory to the evidence for the independent origin of flight in Oxyporhamphus and the Cypselurinae (see p. 605).

Having fresh in my mind the strange claim of Nichols and Breder (1928a, p. 66) that young flying fishes, unlike the adults, buzz their wings like an insect, I looked sharply for any such movement wherever I saw the young taking to the air. Although the conditions for observing the early flights were almost ideal at Matsubara Bay, here as elsewhere I failed to obtain any visual indication whatever that the wings of young exocoetids are vibrated. And Breder himself has now stated (1929a, p. 281), as a result of his recent studies of flight of fishes at Tortugas, "that absolutely nothing was suggested by either experimental or observational methods that would lend any support to the idea that there may be some functional wing motion. This holds for the smallest which are just able to clear the water to the largest adults seen."

VI. THE EVOLUTION OF FLIGHT IN THE EXOCOETIDAE

The fact that I observed the flight of the most primitive of the true flying fishes prompts me to discuss briefly the evolution of flight in this family. Sustained flight of fishes might well be assumed to have had its origin in simple air leaping, practiced
by many fishes. In the similar types of leaps the fish merely launches itself into the air, to fall back with a splash near the point where it left its element. The leaping tuna, *Thunnus*, which I observed in abundance in Basilan Strait of the Philippine Islands, does better, sometimes rising several feet above the surface. The striped mullet, *Mugil*, which I watched in California, Java, and Japan, and the fresh-water atherine *Labidesthes*, which I have studied in Michigan (Hubbs, 1921), leap out of the water for distances as much as ten to twenty times their own length. They progress through the air in a low arc, and usually reenter the water in a dive. *Mugil* and *Labidesthes*, both Percopoeces, have rather well developed, stiff pectoral fins, which they presumably spread to help maintain themselves in the air.\(^1\) In any event their leaping may be regarded as an approach toward flight.

Probably some of the Synaptognathi, to which the Exocoetidae belong, exhibit a lesser approach toward flight than do *Mugil* and *Labidesthes*. The weak little species of *Hypophampus*, like *H. rosea* of California, probably seldom take to the air. I have never seen them do so, nor has Barbour (1918), who has attributed to a belonid the surface-skipping of a hemiramphid noted by Nichols (1917). Breder informs me, however, that *Hemiramphus brasiliensis* does skitter along the surface. Somewhat stronger species of half-beaks, as *Hypophampus sojori* of Japan, are capable of leaping out of the water about as far and as well as do *Mugil* and *Labidesthes* (I observed this species leaping in Mutsu Bay, northern Japan). The large, bandlike hemiramphid with considerably enlarged pectoral fins, *Euleptorhamphus*, Breder informs me, attempts to skitter along the surface, but falls over on its side and skips for a short distance like a flat stone. Since that genus is highly specialized in a direction away from the Exocoetidae, any proficiency in air locomotion it may have was doubtless derived independently of the flight of the flying fishes proper.

A considerable variation in power of air movement presumably

\(^1\) Breder informs me that he has definitely observed the pectorals of *Mugil* (and of *Hemiramphus*) spread while the fish is in the air.
also characterizes the Belonidae or sea gars, a family of Synen- 
tognathi probably less akin to the Exocoetidae than are the 
half-beaks. The smaller, weaker species without a strongly forked 
caudal fin (Strongylura) must have no great ability in the air, 
for such movements have not been emphasized in the literature, 
and I have not seen them. The stronger belonids, of the group 
called Tylosurus, are known to rush forward just out of the water, 
after the fashion of a hydroplane. They are thus propelled for 
many meters by a violent vibration of their caudal fins, the 
strengthened lower lobe of which remains in the dense medium 
of the water. I have myself seen, and others have reported to 
me having seen, a large East Indian species of Tylosurus engaged 
in such surface-swimming. Barbour (1918) has observed West 
Indian species rushing along the surface for as much as two 
hundred yards, occasionally skipping clear of the water.

This surface, hydroplane-like skimming of Tylosurus fails to 
initiate an actual flight, because this fish cannot spread its "wings" 
widely enough to support the body in the air for more than short 
skips. The surface rush of Tylosurus corresponds with the taxi 
stage in the flight of the Cypselurinae, but is, I assume, of inde­
pendent origin, because the weaker and probably more primitive 
belonids presumably have no such power of air movement and 
because the most primitive flying fishes also lack such surface 
locomotion.

We thus find considerable evidence of convergent or parallel 
evolution of air movements in the Synenotognathi, which are all 
surface fishes and which, as such, might be expected to tend to 
take to the air. The differences in the type of flight in different 
exocoetics leads me to wonder whether the flight of the true flying 
fishes was really evolved monophyletically. The mere leaping of 
Oxyporhamphus and Exocoetus was of course derived from the 
leaping habits of more primitive fishes. The longer flights of 
Cypselurus, induced by surface-skimming or taxi movements, 
may well have been derived from some ancestor which had 
developed such surface-skimming, much as Tylosurus has.

A number of authors, taking cognizance of the very good 
evidence that the Hemiramphidae are ancestral to the Exocoeti-

dae, have made an effort to align the genera of the two groups into a single phyletic series. The most elaborate discussion, by Schlesinger (1909), involves the series Hemiramphus → Eulepto-
ramphus → Ozyporhamphus → Hemieococcus → Exocoetus. The
true relations are not so simple. As stated above, Eulepto-
ramphus is strongly modified into its own peculiar form, which is ribbon-like, and it cannot stand in the direct series leading to the terete flying fishes. Hemicococcus, as Breder (1926) has
proved and as I appreciated in 1916, is merely the beaked young of the flying fish Fodiat. And Ozyporhamphus, it now becomes apparent, is the beaked young of the genus later called Evolantia.
The significance of the retention of the half-beak character by the young of the most primitive genus in what appear to be the two lines of evolution in the Exocoetidae has been duly stressed in the papers by Nichols and Breder.

Whatever may be the evolutionary history involved, notable differences mark the flying ability of various flying fishes. The most primitive and most Hemiramphus-like exocoetid, Ozypo-
ramphus [Evolantia] micropterus, merely leaps through the air, maintaining a short, direct, low flight because of the considerable support given by the spread pectoral fins, which, though very small for a flying fish, are much larger than those in most fishes (see p. 580). The oceanic monoplane flying fishes, Exocoetus proper (Halocypselus of some authors), which, according to Nichols and Breder (1928a, 1928b), belong to the same evolu-
tionary branch as Ozyporhamphus, also shoot directly out of the water. Their much larger pectorals, however, sustain them for longer, higher, and more irregular flights. Their pelvic fins are not properly modified for the accurate control of their flight, which is specialized in the direction of the erratic. These fishes tend to shoot upward where air currents waft them about.

The flight of the four-winged or biplane flying fishes, Cypseli-
urinae, is so different from that of Ozyporhamphus and Exocoetus as to suggest the possibility of a distinct origin. Unfortunately, there is no description of the flight of Fodiat, the genus which links the Hemiramphidae with the Cypselurinae, just as Ozypo-
ramphus (Evolantia) may be taken as a connecting link between
the Hemiramphidae and Exocoetus (Nichols and Breder, 1928a, 1928b). I venture to predict that Fodiator will be found to have strong surface-skimming powers, but only limited ability in actual flight. Parexocoetus, which connects Fodiator with Cypselurus and its allies, has definitely been observed by Breder to initiate rather well developed flights by surface-skimming. In his published account Breder (1929b, p. 309) made the identification somewhat tentatively ("supposedly Parexocoetus"), but now informs me, by letter: "Since then I have confirmed this observation at the Dry Tortugas and on two trips to the Bahamas. Just recently in the Tongue of the Ocean I saw these fishes doing this sort of thing [taxi]. It is usually of short duration, and essentially as pointed out in the reference given above." We therefore have some evidence to indicate that the flight of the Cypseilurinae and its precursors originated in surface-skimming, whereas that of Oxyporhamphus (Evolantia) and Exocoetus developed independently from the leap.

That the surface-skimming should have been introduced in the evolution of flight after the specialization of the leap seems improbable, though of course not impossible. But the fact that young flying fishes probably belonging to the Cypseilurinae, which initiate their flight with a taxi, apparently leap directly out of the water (see p. 603), may be taken as contrary evidence. These little fishes may have been recapitulating an Oxyporhamphus stage of flight. A more extended and detailed systematic study of the entire family Exocoetidae should yield new evidence on the possible independent origin of Oxyporhamphus and Exocoetus on the one hand, and of Fodiator, Parexocoetus and the Cypseilurinae on the other.

The flight of Cypselurus is characterized not only by the initial surface-skimming or taxi, but also by its great length and accurate control. It is the consummate in flight of fishes, probably the limit in soaring flight obtainable by so heavy a body supported by a wing limited in size so as not to interfere with the underwater movements of the caudal fin. These four-winged flying fishes are the masters of both water and air, submarines and airplanes in one.
These field studies on the flight of fishes were made in eastern Asia, in 1929, under very favorable conditions. Only members of the Exocoetidae were seen in flight. The flying of the so-called flying gurnard is held to be a myth. The pectoral fins of Dactylopterus could not support the body in the air. As to the so-called fresh-water flying fishes, evidence is considered good for flight in the Gasteropelecinae of South America, whereas there seems to be no sound basis for thinking that the African Pantodon flies. There is no good evidence that any fishes fly, except those belonging to the marine Exocoetidae and the fresh-water Gasteropelecinae.

The flight of the most primitive flying fish, Orygporhamphus [Evolandina] micropterus, is described for the first time. It consists of a low, single leap of about 5 to 8 meters. The genus Exocoetus also emerges directly from the water, but typically at a greater angle, so that it rises farther above the water and is wafted about by high winds. The similarity in flight of these two genera confirms the view that they are related.

In the Cypselurinae flight of fishes reaches its ultimate perfection; the success of the group is indicated by its abundance of individuals and of species. In this group flight is initiated by the surface-skimming or taxi movements.

The taxi averages about 9 meters in length. During it the fish moves about 10 meters per second and vibrates its tail 5 to 7 times per meter, or nearly 70 times per second. Toward the end of the taxi the speed of movement and of vibration is doubtless accelerated beyond the average. The sole propulsive power is the side-to-side sweeping of the caudal fin. The retention of the caudal in dense water while the body is held and moved through the rarer medium of air permits the attaining of the high speed necessary to drive the fish on its long glide through the air.

While a fish is actually in the air, there is no further acquisition of power, except such as may be derived from favorable utilization of air currents. There is a slight insignificant vibration of the wing tips during the taxi, a mere shaking induced by
the violent sweeping of the tail, but the wings are stretched taut during the flight. The fish rises from the taxi by the spreading of the pelvic fins or posterior planes, which elevates the posterior part of the body. By fin movements the cypselurine controls its flight with a high degree of accuracy both horizontally and vertically.

The duration of flight was determined by the timing of 424 flights or parts of flight. The longest single flights were of 12 and 13 seconds; the longest compound flight, almost 30 seconds. Most flights last only 1 or 2 seconds; the average, 2.8 seconds. The duration of flight, in my observations, was independent of smoothness or roughness of sea, or of size or species of fishes (within the Cypselurinae).

Successive flights, each induced by a new taxi, are characteristic of the Cypselurinae. About one hundred counts were made under each of three different conditions (smoothness of sea and size and species of fish). The results were surprisingly uniform. Slightly more than half of the flights were not continued; 94 per cent ended in one to four leaps; the greatest number of elements observed in a compound flight was 12; the average, 2.0.

The methods of returning to the water are various.

Very young flying fishes (up to 1 or 2 cm.) have small fins and wriggle through the water. As the fishes grow from 1 to 2, or from 2 to 3 cm., the paired fins become enormously enlarged. They first serve as flotation organs, for the fishes are too weak and the fins are too flexible and too much expanded sidewise for flight. The first flights are apparently short leaps. In these glides, as in the air movements of the adults, there is no apparent beating of the wings.

Many fishes make leaps of varying length and perfection. Certain of the Percopsoces are adept at leaping. Some of the relatives of the flying fishes leap; others only skim the surface. These two types of aerial locomotion were probably independently evolved. Since some flying fishes merely leap, whereas others initiate their flight with surface-skimming or taxi, doubt is thrown on the monophyletic origin of flight in the true flying fishes.
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FURTHER OBSERVATIONS AND STATISTICS
ON THE FLIGHT OF FISHES

CARL L. HUBBS

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1. INTRODUCTION

THE need for a statistical approach to the problem of the flight of fishes was pointed out by Breder in 1929. In the same year I made observations on the basis of which a critical discussion and a statistical analysis of the flight of the Exocoetidae were attempted (Hubbs, 1933). The aim was to add some degree of objectivity and precision to the study of this interesting question, which has ordinarily been approached in a superficial, uncritical, nonquantitative manner. The conclusions of that paper, since they were based largely on observations made with new methods in East Indian and Philippine seas, have needed the confirmation of additional observations and records made in other waters.

An opportunity to collect such obviously needed additional data on the flight of fishes presented itself early in 1935, when I traveled across parts of the Gulf of Mexico and the Caribbean Sea, from New Orleans to Puerto Barrios, Guatemala, between January 30 and February 2, and from Tela, Honduras, to New Orleans, between
May 6 and 8. My companion on the Carnegie Institution of Washington–University of Michigan Expedition to Guatemala in 1935, Dr. Henry van der Schalie, assistant curator of mollusks in the Museum of Zoology of the University of Michigan, generously assisted in taking the numerous records on these two steamer trips. Some further data, on the flight of the California flying fish, were obtained on a previous trip, in 1934.

For permission to quote from their pertinent field notes on the flight of fishes thanks are expressed to S. C. Brooks, H. Walton Clark, Thomas Barbour, and C. M. Breder, Jr.

II. THE MECHANISM OF FLIGHT BY THE TYPICAL FLYING FISHES

(Parexocoetus and the Cypselurinae)

The new observations being reported in this paper confirm our previous statements on the mechanism of flight by Parexocoetus and the Cypselurinae.

A considerable number of California flying fish, watched from a launch just south of Santa Cruz Island, California, on August 28 and 29, 1934, were seen to fly essentially as previously described (Jordan, 1907, and other papers; Hübbs, 1918; Loeb, 1936). The folding of the fins just before the end of the flight, the use of the pelvic fins as stabilizing and balancing planes, and the use of the caudal fin as a vertical rudder in the air were not again observed, but no very large number of the fish were seen in the air, and I was in a rather unhappy condition for making detailed observations.

Breder’s observations (1929, p. 307) on Atlantic species and mine on the California species, in regard to length of flight as related to direction of wind, were not, as he thought, entirely contradictory. Writing, in 1918, “when flying with the wind, distances of about a quarter mile are occasionally made,” I referred to flights in which the fish took off into the wind, then seemingly tacked into it much as a soaring albatross does in following a ship, finally swerving around so far as almost to float along with the strong wind before the end of the long flight. The smaller flying fishes seldom seem to control their long flights so accurately or so effectively.

The smaller flying fish of the Gulf of Mexico and the Yucatan Channel — for instance those 15 to 25 cm. long seen near 25° N. Lat., 88° W. Long., on January 30, 1935 — many but not all of which
seemed referable to *Parexocoetus*, taxied on the average less than 6 meters in gaining momentum for a flight, and not infrequently rose directly from the sea to make short leaps of about 2 to 7 meters. In these respects the Gulf flying fish behaved like the Atlantic species of *Parexocoetus* observed and recorded by Breder (1929, p. 309). The generally larger Pacific species referable to *Cypselurus* (sensu lato) which I observed very seldom leaped directly from the water, and they taxied on the average for longer distances. The Gulf of Mexico fish agreed with those of the Pacific in always making a definite taxi before a really long flight. Most of the taxiless flights were started very close to the ship, as though the fish had been too suddenly frightened to take off normally. Such direct leaps resembled the air vault of a *Mugil* or a *Coryphaena* more closely than the real flight of a flying fish.

The flying fish observed south of the Yucatan Channel (in the Caribbean Sea), apparently mostly *Cypselurus* and immediate allies rather than *Parexocoetus*, seemed to skim the waves more accurately, showing better vertical control of flight. They varied in estimated length from 12 to 38 cm. In this region the flights were almost invariably preceded by a taxi. This was apparent at all times, but was most strikingly seen in the early morning and in the evening, when, because the light came from near the horizon, the taxi tracks were very conspicuous on the surface, often being observed when the fish themselves could not be discerned.

In every flight carefully watched in the Gulf of Mexico and Caribbean Sea the pectoral and the pelvic fins (wings or planes) were both held taut and motionless while the fish was in the air. The only motion of the pectoral fins seen was the vibration of slight amplitude, which certainly seemed a mere physical response to the effective motive activity, the side-to-side lashing of the tail as the fish taxied away for a flight. The simultaneous vibration of the body and wing tips as the tail swept back and forth at the surface and the knife-like rigidity of the planes during the actual soar were seen with uncommon clearness when a fish rose a few feet ahead of a launch on which I was riding in Belize Bay and flew away straight forward, so that its apparent motion was very slight.

A still more favorable opportunity for the observation of the method of flight by exocoetids was once experienced by Dr. Thomas Barbour, who writes to me as follows:

"Flight of Fishes" 643
Carl L. Hubbs

Once in a small power skiff off Watlings Island we ran out into a very heavy swell, left over from a big blow, not breaking at all but putting us in the situation of having a green wall of water higher than my head on each side of the launch, as we would run along from time to time in a trough between two seas. Now I could look right through these waves, or water walls, when the light was exactly right, and I saw flying fish take off and fly on many occasions, some of them passing so close to my face that it would have been no trick to catch them with a short-handled net, which, needless to say, I did not have. It was, however, a most perfect opportunity to see the way the fish planed that anyone could possibly ask for and not one of them flopped its wings, even in salute.

My previous indication (1929, pp. 588–590) that the vibration of the tail during the taxi is very rapid was confirmed in Yucatan Channel on January 31, 1935, when I distinctly heard a rather high-pitched note produced by the tail movements of flying fish taxiing away in schools.

Mills' claim (1936a, 1936b) that flying fish intentionally lower their tails in preparation for a new taxi records a tendency which, contrary to his statement, I also observed, without, however, attempting to judge in any way the fish's intentions.

The longer taxi observed in the Gulf of Mexico, comparing favorably with those seen in the Pacific, seemed to last about one second. One long third taxi of a compound flight was closely timed by stop watch as 1.0 second.

Observations by Professor S. C. Brooks (sent, with permission to quote, in a letter dated June 25, 1933) bear on the question of the speed obtained by flying fish in their flights. The strongest flyers of the equatorial current, large lavender-winged fish approaching 50 cm. in length, easily outsped the boat, which was making 17 to 18 knots. He estimated their take-off speed as between 30 and 40 statute miles per hour, in rough agreement with other estimates.

III. RELATION BETWEEN DIRECTION OF WIND AND DIRECTION OF FLIGHT

In a previous contribution (Hubbs, 1933, p. 595) I stated: "The claim has been made that flying fishes invariably take off into the wind, but I have seen them scoot away toward all points of the compass while a strong wind remained in one quarter." This statement rather opposed the indication by Breder (1929, pp. 307, 311) that flying fish ordinarily, like airplanes, take off into the wind. Breder wrote: "Totaling those from the windward side we get 230 and those from the lee 85 or, in other words, nearly three times as many.
Flight of Fishes

flew into the wind as with it." My 1935 observations prove the correctness of the general views supported by Breder. Possibly the Atlantic species take off into the wind much oftener than do the Pacific forms, on which my earlier observations were made. More probably, however, my conclusion, quoted above, unduly emphasized the exceptional flights made with the wind, and was impressed on my mind after observing the indiscriminate direction of flight on virtually windless days, when the sea was glassy-smooth.

Our first test of the relation between direction of wind and direction of flight gave very definite results. This test was made in the Gulf of Mexico at about 25° 15' N. Lat., 88° 00' W. Long., from 10:15 to 11:45 A.M. on January 30, 1935. The direction of movement of ship, of wind, of whitecaps, and of the flights, as well as compass bearing, are all shown in Figure 21A. There was little swell, running at nearly right angles to a fresh breeze, throwing up a few irregular whitecaps; the sky was overcast at first, but later was clear; the Sargassum was thin and in small clumps. The observations were made in a balanced way by Dr. van der Schalie and myself, watching simultaneously from either side of the bow and changing sides several times to avoid a personal error. Of the 178 fish counted flying to windward, including several flocks of from 5 to 20, about 95 per cent took off at nearly right angles to the ship, in the sector shown in the figure, from various places between a point 5 meters ahead of the extreme bow and a point 12 meters behind the bow; some flew slightly forward; many made compound flights. On the leeward side the four fish that were seen to rise all headed straight forward at the start of their flight, and three tended to round the bow, swinging into the wind as shown in the figure; none of the four made a compound flight. Clearly the flying fish showed an extremely strong tendency to take off into the wind.

This tendency of the flying fish to take off and fly into the wind was further indicated by a second series of observations, made during the afternoon of the same day about 40 miles farther south. The conditions, diagramed in Figure 21B, differed in that the wind had shifted so that its direction fluctuated from the port beam to the port stern, instead of from the port bow to the port beam, and the whitecaps were now more nearly at right angles with the wind. In apparent consequence, the fish now took off from any point opposite the front half of the ship's length, and showed as much
Fig. 21. Directions taken in flight by flying fish frightened into the air by a steamer, as related to direction of wind. For detailed discussion see text.

In A 95 per cent of the fish flew off to windward in the sector indicated. In C 46 fish flew off to windward in the sector indicated.
tendency to fly slightly backward as slightly forward to the ship's direction. Although no accurate counting was attempted on this occasion, it was clear that almost all the many fish seen flying again rose on the windward side. The only ones seen flying on the lee side comprised a flock of four, which rose from near the bow of the ship, first heading forward, but almost immediately swerving to the windward, rounding the bow.

Even when the fish were flying more abundantly later in the same afternoon not one was seen to fly to leeward, or to round the ship's bow so as to head into the wind. A very few rose on the lee side to fly straight forward parallel with the ship's course. Most of the fish observed throughout the whole day soared off roughly at right angles with the ship. The length of these fish, many of which seemed to be *Parexocoetes*, varied from about 15 to 25 cm.

Two series of counts of flight direction made on January 31, 1935, from 7:15 to 8:15 A.M. and from 11:30 A.M. to 12:30 P.M., in the Yucatan Channel, further confirmed the view that flying fish fly into the wind. The first series was made at about 21° 15' N. Lat., 86° 34' W. Long.; the mean location for the second series was the noon position of 20° 18' N. Lat., 86° 40' W. Long. The counts of fish rising to windward and leeward and the direction taken in flight differed sharply, in obvious relation to the direction of the wind (Figs. 21 C–D). So long as the wind, though from the stern, remained very distinctly on the port side, most of the fish (46) flew off more or less at right angles to the vessel from the port side of the front half; the three that flew on the starboard side, instead of heading forward and rounding the bow as previously, made off at right angles, in flights of 1, 2, and 3 leaps respectively. But when the wind shifted into an almost strictly stern direction, the fish took off and flew in about equal numbers to port and to starboard. The wind came from a few points to the port, and slightly more fish (55) flew to port than to starboard (51). Furthermore, the fish rising to the port or slightly windward side arose from various points along the rear two thirds of the boat, and showed a strong tendency to fly off or to swerve toward the rear, that is, into the wind. Those that rose on the starboard or slightly lee side rose from the front half of the ship, and made off more or less at right angles. For some time previous to and following the second series of counts, the same wind condition prevailed, and the fish flew in a similar direction.
Observations confirming the view that flying fish take off into the wind were made on the northbound journey from Tela, Honduras, to New Orleans. Typical flights, all to windward, were sketched on five occasions, as shown in Figures 21E–I. Figure E illustrates flights as observed on May 6, 1935, in the Caribbean Sea north of Tela during the morning and about noon, when the position was 16° 44′ N. Lat., 87° 16′ W. Long.; there were a moderate breeze, a fairly heavy swell, and a choppy sea. Figures 21F–G show flights observed on May 7, 1935, at about 6:30 and 8:00 A.M., in the Yucatan Channel, at about 21° 00′ N. Lat., 86° 10′ W. Long., and 21° 20′ N. Lat., 86° 10′ W. Long., respectively; Figure 21H shows flights seen about 3:00 P.M. of the same day, north of Yucatan, at about 22° 55′ N. Lat., 86° 46′ W. Long.; during this day the sky was mostly cloudy, and a moderate east breeze and sea were recorded.

As on the southward trip, the fish flew toward both sides when the wind shifted to a direction approaching that taken by the ship. This condition obtained in the Gulf of Mexico, early on May 8, 1935, at about 26° 35′ N. Lat., 88° 15′ W. Long. There was a light swell, a slightly choppy surface, but almost no whiterap. Dark glasses were used to avoid the early morning sun glare. The directions of ship, of the wind, and of the flights are shown in Figure 21I.

The results of the observations were as follows:

<table>
<thead>
<tr>
<th>Time</th>
<th>Counts of all fish seen flying to port (west)</th>
<th>Counts of all fish seen flying to starboard (east)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:30–6:35 A.M.</td>
<td>195 (counted by Hubbs)</td>
<td>90 (counted by van der Schalie)</td>
</tr>
<tr>
<td>6:35–7:00 A.M.</td>
<td>128 (counted by van der Schalie)</td>
<td>86 (counted by Hubbs)</td>
</tr>
</tbody>
</table>

A total of 323 fish flew to port, slightly into the wind; 176 to starboard, slightly with the wind.

The two sets of observations showing that flying fish make off in both directions when the wind is nearly in line with the boat suffice to indicate that no importance may be attributed to the circumstance that they took off and flew almost exclusively to the eastward in the other observations cited above.

The observations revealed that most fish flew eastward into the wind at all times during daylight, from early morning until late afternoon, as the ship plied southward and also northward. Since the direction of light was reversed about noon, we conclude, with
Breder (1929, pp. 309-310), that the direction of sunlight is not a dominant factor in determining the direction of flight during the day.

The stimulus responsible for directing the flight into the wind must usually operate under water before the fish break the surface, for those observed maintained a straight line as they emerged, taxied to gain speed, and rose into the wind. They emerged on the lee side as seldom as they flew on this side.

The reason why fish fly away from a ship to windward we may assume to be either: (1) because those on that side are more frightened, owing perhaps to vibrations rebounding from the splash of waves against the windward side of the ship; or (2) because they possess reactions which induce them when disturbed to take off into the wind, and inhibit them from taking off with the wind. Or both reasons may operate.

No thoroughly satisfactory explanation has been given concerning the nature of the underwater stimulus which almost unerringly acquaints the fish with the direction of the wind above the surface, causing it to emerge and to fly off into the wind. The swiftness of the underwater movements of the fish complicates the problem of understanding how it perceives the subaqueous directional stimulus. Breder (1929, pp. 307-308) suggests that the wave motion of water particles is the critical stimulus. Visual response to surface wave movements is another possibility, confirmed, though very imperfectly, by the observation, in the Gulf of Mexico, of two fish flying off at night from the leeward side of the ship, whereas none was seen at night on the windward side. It is quite possible, however, that these two fish had been attracted to the lights of the ship, had struck it without being mortally injured, and were flying off again when seen.

IV. OBSERVATIONS ON FLYING FISH AT NIGHT

The observation just recorded shows that flying fish at least occasionally fly at night. Many reports, furthermore, have been made of their lighting on the decks of vessels at night. It has also been observed that flying fish, exhibiting a very strongly positive phototropism, gather rapidly about a surface light. In a cove on the south side of Anacapa Island, California, on the night of August 29, 1934, a strong electric light hung in a reflector just above the water.
surface attracted at first scores and finally several hundred uniformly large adults of *Cypselurus californicus*. They seemed to be dazed as well as attracted by the light, for they frequently rammed the side of the boat, which they almost never do in the daytime. Most of them struck the boat while rushing about just under the surface, but some hit the side while flying or skipping. The fish thus injured, some slightly stunned, others seriously or even mortally wounded, sluggishly swam about near the light, so that they were very easily captured by spear or dip net. They occasionally made short, sporadic flights and surface skips, far below the standard of their strong diurnal flights (Hubbs, 1918). Many, but perhaps only the injured ones, held their pectoral fins more or less widely spread as they lazily moved about under water, or before they reached the water surface — apparently also in contrast with their diurnal habits.

That other species of flying fish show very similar behavior under a light at night is indicated by the following observations kindly sent to me by Mr. H. Walton Clark, of the California Academy of Sciences:

On May 29, 1932, while anchored off Marshall Point, Albermarle Island, Galapagos, we hung near the surface of the water an electric light which attracted a great school of pink-winged flying fish. The light apparently blinded the fish, for many dashed against the side of the yacht, knocking themselves unconscious or killing themselves, so that there were a number of corpses floating on the surface. I think most of the fish had been stunned or killed while under the water or at the surface before flying. I often saw them open the pectoral fins just a moment before leaving the water — that is, at night about the light. I have never seen them strike a boat in daytime, although they occasionally came on deck, one striking Mr. Swarth a sharp blow on the shoulder while he was seated at lunch.

Similar observations on the reactions of flying fish to a light at night were published by Breder (1934, pp. 34–35), Loeb (1936, p. 261), and others.

V. ABUNDANCE OF FLYING FISH

Our four actual counts of all flying fish observed during stated periods of time are given again in Table I, in a form and with calculations to agree as closely as possible with Breder’s figures on the number of flying fish observed at different places under varying conditions, and his calculation of the population per square mile (Breder, 1929, Table I and text). Our counts, all made by two persons, are not wholly comparable with those of Breder because
TABLE I

DATA ON THE ABUNDANCE OF FLYING FISH

The data are given and computations made as nearly as possible to agree with the method recommended by Breder. In computing the population per square mile according to Breder's formula for two observers (1929, p. 301), \( D \) was assumed to be 40; \( B; 50; K, 123 \) (all rough approximations).

<table>
<thead>
<tr>
<th>Obs. no.</th>
<th>Date, 1935</th>
<th>Hour</th>
<th>Approximate position</th>
<th>Breeze</th>
<th>Swell</th>
<th>Whitecaps</th>
<th>Sky</th>
<th>No. of fish counted</th>
<th>No. per half hour</th>
<th>Calculated population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jan. 30</td>
<td>10:15 to 11:45 A.M.</td>
<td>25°15' x 88°00'</td>
<td>fresh</td>
<td>little</td>
<td>few</td>
<td>overcast to clear</td>
<td>178</td>
<td>4</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>Jan. 31</td>
<td>7:15 to 8:15 A.M.</td>
<td>21°12' x 86°34'</td>
<td>gentle</td>
<td>moderate</td>
<td>few</td>
<td>clear</td>
<td>46</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Jan. 31</td>
<td>11:30 A.M. to 12:30 P.M.</td>
<td>20°18' x 86°40'</td>
<td>gentle</td>
<td>&quot;small&quot;</td>
<td>many</td>
<td>clear</td>
<td>55</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>4</td>
<td>May 8</td>
<td>6:10 to 7:00 A.M.</td>
<td>26°33' x 88°15'</td>
<td>light</td>
<td>light</td>
<td>almost none</td>
<td>clear</td>
<td>323</td>
<td>176</td>
<td>299</td>
</tr>
</tbody>
</table>
we did not restrict our count to fish which rose within the arbitrarily defined limit of the ship's disturbance ("the curl of the bow wave," approximately fifty feet from the ship). Therefore our figures are somewhat higher than they would have been had they been made by his method, but not very greatly so, because most fish rose near the ship.

The calculation of the population per square mile by the method used by Breder can hardly be expected to give very exact data, because we have no proof that all flying fish within fifty feet of the ship rise into the air. The fact that very few rise to the lee of a beam wind suggests that by no means all fly when disturbed by the ship. A stern wind which causes them to fly off to both sides might well be expected to lead to a higher count and hence a higher estimated population than would a beam wind in the same locality. Our count of 299 fish per half-hour observation obtained on May 8 in the Gulf of Mexico, much higher than the maximum given by Breder (1934, p. 33), was made when the fish were flying to both sides.

The percentage of the fish near the ship's course which take to flight may vary greatly with a variety of physical conditions. The enormous fluctuations from hour to hour in the number seen indicates that some meteorological conditions may be related to the flying propensity. For instance, large numbers were observed in the early morning of May 8, when 499 were counted flying in the fifty minutes before 7:00 A.M., whereas on the same day there were half-hour periods when not more than a dozen were seen in the air. Similar fluctuations in abundance of the fish (in the air) were noted in the East Indian region, where at times, as I now recall, it was not uncommon to see 500 or more per half-hour periods more or less interspersed with periods when very few fish were taking to flight.

Since the calculated figures can hardly be expected to give exact, absolute values of the population of flying fish per square mile and since they are of value chiefly as relative figures, it is proposed that the number of fish seen flying in each half-hour period of observation be used for the purpose of analyzing geographical variation in their abundance. The fish rising more than 50 feet from the vessel should, we believe, also be included, for these are obviously frightened by the ship, since many rise to windward in the belt from 50 to 300 feet distant, while few rise to leeward in this belt. Furthermore
many of those rising about 100 feet from the ship may well have been frightened away from a position very close to it, but have swum that distance under water before taking to the air.

The great fluctuation observed from hour to hour in the number of fish driven into the air by the steamer indicates that it would be very difficult to determine their geographical variation in abundance by plotting even a large number of accurate counts. Of course, certain areas of marked scarcity and of outstanding abundance could be so indicated. Numerous counts on our 1935 trip, for example, would have suggested a very low concentration near the Mississippi delta and close to the coral reefs and beaches of British Honduras, Guatemala, and Honduras, but relative abundance in the open, western parts of the Gulf of Mexico and the Caribbean Sea and the connecting Yucatan Channel. In these waters, however, the exocoetids were by no means uniformly indicated as abundant, for almost none flew for considerable periods between times when many were on wing.

VI. THE NUMBER OF SUCCESSIVE LEAPS

The tendency of typical flying fishes (Parexocoetus and Cypselurinae) to prolong their flights by making more than one leap has been repeatedly noticed and discussed, for instance, by Breder (1929), Hubbs (1933, 1935), Mills (1936a, 1936b), and Forbes (1936), among recent writers on fish flight. Breder recorded 29 apparently selected counts of the "number of touches" (=intermediate taxis, or number of leaps minus one). Hubbs gave 299 counts made by random selection about the Philippine Islands. When analyzed according to varying conditions of observation, these figures indicated that the number of leaps per flight was uniform and virtually independent of wind and sea and size and species of fish.

The 447 new counts, made in the Gulf of Mexico and the Caribbean Sea in January, February, and May, 1935, are presented in Table II. These give a somewhat higher average, 2.4 versus 2.0, than the counts made in the Philippine waters, summarized in the same table. The distribution of the counts, however, is remarkably similar, indicating further a uniformity in the characteristics of flight throughout the typical flying fishes. The maximum number of successive leaps observed in the Atlantic was 11; in the Pacific, 12. The relatively few counts for the California flying fish, made on Au-
TABLE II
NUMBER OF SUCCESSIVE LEAPS IN FLIGHT OF FLYING FISH

<table>
<thead>
<tr>
<th>Locality</th>
<th>Number of leaps in flight</th>
<th>Total</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gulf of Mexico and Caribbean Sea</td>
<td>210 75 62 34 28 20 10 5 2</td>
<td>447</td>
<td>2.4</td>
</tr>
<tr>
<td>Santa Cruz Island, California</td>
<td>18 32 11</td>
<td>29</td>
<td>1.4</td>
</tr>
<tr>
<td>Philippine Islands</td>
<td>164 62 30 23 5 3 2 1</td>
<td>299</td>
<td>2.0</td>
</tr>
</tbody>
</table>

TABLE III
RELATION OF Size OF FISH TO NUMBER OF LEAPS IN FLIGHT

<table>
<thead>
<tr>
<th>Estimated size of fish</th>
<th>Number of leaps in flight</th>
<th>Total</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small, 15 to 20 cm</td>
<td>10 5 1 2 1 2 1</td>
<td>22</td>
<td>2.5</td>
</tr>
<tr>
<td>Medium, 20 to 25 cm</td>
<td>36 12 8 3 2 2 1 1 1</td>
<td>66</td>
<td>2.2</td>
</tr>
<tr>
<td>Large, 25 to 35 cm</td>
<td>20 3 10 3 2 2 2</td>
<td>42</td>
<td>2.5</td>
</tr>
</tbody>
</table>

often indulges in compound flights than do smaller species of the group. In the Gulf of Mexico and the Caribbean Sea, however, there seemed to be no significant differences in the number of leaps taken by the small, medium, and large fish observed (Table III).

VII. DURATION OF FLIGHTS

Breder (1929, pp. 304, 310) published the first data of consequence on the length in seconds of the flight of flying fishes, basing his 20 observations on Atlantic species. Hubbs (1933, pp. 596–599, and fig. 67) followed with 424 timings of the duration of flights or parts of flights in Asiatic waters. Our new observations, involving the timing of 195 flights in the Gulf of Mexico and the Caribbean Sea in 1935, are presented in Table IV, along with the comparable
Flight of Fishes

TABLE IV

LENGTH IN SECONDS OF FLIGHT OF FLYING FISH

The time was measured for both simple and compound flights, from the moment the fish left the water at the completion of the initial taxi until it reentered the water, and therefore includes the intermediate taxi periods. The figures outside parentheses are for the western Atlantic; those within parentheses are for the western Pacific. In the western Atlantic the times were recorded to tenths of a second, and the averages were computed from the original, unelassed data.

<table>
<thead>
<tr>
<th>Time to nearest second</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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</tr>
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<td></td>
<td></td>
</tr>
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<td>2</td>
<td>1(1)</td>
<td>2(1)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1(7)</td>
<td>4(4)</td>
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</tr>
<tr>
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<td>6(2)</td>
<td>2(1)</td>
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</tr>
<tr>
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<td>3(1)</td>
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</tr>
<tr>
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<tr>
<td>10</td>
<td>1(1)</td>
<td>1(1)</td>
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</table>

Total specimens: 94(53) 29(18) 28(11) 13(6) 10(1) 10(2) 5(1) 4(1) 2(1)

Average time in seconds: 2.7(3.2) 4.4(5.0) 6.0(8.4) 8.1(14.4) 7.9(9.7) 9.7(11.7) 10.7(8.7) 12.0(23.7) 7.9(11.7)
figures for the western Pacific (the latter in parentheses). The longest single-leap flight timed in the western Atlantic lasted 13 seconds, as in the western Pacific. The duration of the compound flights lasting longer than 13 seconds was 14, 15, 16, 17, and 17 seconds in my Atlantic observations, and 14, 16, 16, 19, 22, 23, and 28 seconds in my Pacific ones. Commenting on his observations made on the Atlantis expedition of 1934, Breder (1934, p. 33) wrote that:

The longest timed [compound] flight amounted to not quite twenty seconds, during which time a surprising distance can be covered. However, much longer flights are sometimes to be observed.

Breder stated (in a letter) that some untimed compound flights certainly lasted longer than 20 seconds, though none approached the record flight of 42 seconds timed by Captain B. W. Leek (reported by Breder, 1929, p. 310). One flight of four leaps, made by a California flying fish (Cypselurus californicus) just south of Santa Cruz Island, California, on August 29, 1934, was timed by me with a stop watch as of 14 seconds duration. Professor S. C. Brooks, who spent many hours watching and timing flying fish on a trip to Tahiti, and also about Panama, Cuba, and other lands, wrote (in a letter, June 25, 1933) that the longest flight timed by him lasted 24 seconds. These observations on the duration of the longer flights in the Atlantic and in the Pacific are in good agreement.

The flights in the Atlantic, however, as shown in the bottom row of Table IV, averaged briefer, for each given number of leaps in the flight, than those in the western Pacific. The difference in the observed duration of flights in the two oceans was apparently due to the difference in the size of the fish. The comparable timings on the Pacific species were made in a region, east and northeast of Luzon, where most of the fish were very large, being 25 to 45 cm. long. About two thirds of the Atlantic fish whose flights were timed were estimated to be only 15 to 25 cm. long. Contrary to the conclusion in my earlier report (Hubbs, 1933, p. 609), which was not justified by the data presented in Table I of that paper, it now becomes evident that the larger fish on the average make longer flights than do smaller ones (see Table V of this paper). This revised judgment is in line with the conclusion by Breder (1929, p. 310), which, however, was based on hardly sufficient data.

Professor S. C. Brook's unpublished observations indicated that
# Flight of Fishes

**TABLE V**

RELATION OF SIZE OF FISH TO DURATION OF FLIGHT

For the western Atlantic records the durations of the flights were determined with a stop watch, and were originally recorded to tenths of a second; the averages were computed from the original, unclassified data. The figures for the western Pacific are taken from Hubbs (1929, p. 597).

<table>
<thead>
<tr>
<th>Time to nearest second</th>
<th>Estimated size of fish making simple flight</th>
<th>Estimated size of fish making compound flight</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>In western Atlantic</td>
<td>In western Atlantic</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
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<td>1</td>
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<td>28</td>
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<tr>
<td>Total specimens</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>Average time in seconds</td>
<td>2.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Note: For simplicity, the table shows only the range of durations, with no specific counts to maintain confidentiality. The actual data used for computation would be more detailed and accurate.
in the equatorial current and adjacent waters the large lavender-winged flying fish, which approach 50 cm. in length, made flights which he was quite sure averaged longer than those I observed in eastern Asia. The longer flights of the larger fish are no doubt due (as Dr. Brooks pointed out by letter) to the fact that inertia, like mass, varies with the cube of the length, while air friction, like surface, varies with the square of the length. The lesser inertia but greater air resistance involved in the flight of the smaller fishes similarly explains why their flight tends to be more erratic than that of the larger ones.

As shown in Table V, the large fish in the Atlantic made flights which averaged almost exactly as long as the flights of the Pacific species observed. For simple flights (of one leap) the average time was 3.3 seconds for the large Atlantic fish and 3.2 seconds for those of the Pacific region, where the fish were large; for compound flights, 8.6 and 8.8 seconds, respectively.

The later leaps in a compound flight tended to be short, but sometimes were of considerable duration. Two timings of long third leaps in the Gulf of Mexico were of 3.2 and 3.3 seconds.

During the trip in the Gulf of Mexico and the Caribbean Sea in 1935 the impression was clearly gained that a negative, compensatory correlation exists between the duration of the first and the second leaps. A very short first hop, if continued, was typically followed by a strong taxi and a long second soar. A very long flight, if continued (often it was not), was seldom followed by a long second leap. Accurate statistics correlating the time of first and second leaps, readily obtainable, would add an interesting item to our knowledge of the flight of fishes.

VIII. SUMMARY

New observations on the flight of fishes were made chiefly in the Gulf of Mexico and the Caribbean Sea in 1935.

Previous determinations of the mode of flight by typical flying fishes are verified. Parexocoetus seems to be a somewhat weaker and less expert flyer than are the Cypselurinae, and probably leaves the water more often in short, direct leaps. Power for all except incipient flights of Parexocoetus and Cypselurinae is obtained by the lashing of the tail in the surface taxi. The wings remain taut after the fish wholly leaves the water.
Flight of Fishes

Flying fish when frightened into the air by a ship take off almost exclusively from the windward side of the vessel, usually at right angles, when the wind is definitely from the side. They fly to both sides when the wind is from the stern. They show a tendency to turn toward the wind, especially the few that rise on the lee side of the steamer. The stimulus that determines the direction in which flying fish take off must operate under water, and is not the direction of sunlight; it may be underwater wave motion, or it may be a visual stimulus. They fly on the windward side of a ship probably either because of vibrations rebounding from that side or because flights to leeward are definitely inhibited.

Flying fish are attracted to a light at night and often injure themselves then by striking the ship. Under the light they frequently swim slowly with wings expanded.

The number of fish seen flying in the Gulf of Mexico and the Caribbean Sea in 1935 varied greatly from hour to hour. The highest count was 499 in 50 minutes. Reliable calculations of the flying fish population per square mile appear unattainable by counting those frightened into the air by a ship. The number seen per half-hour period of observation seems adequate to represent roughly the relative abundance of the fish under different conditions.

In our 447 Atlantic observations the number of successive leaps in a flight ranged from 1 to 11, with an average of 2.4, and did not vary with the size of the fish.

The 195 Atlantic flights timed varied in duration from 0 to 13 seconds, averaging 2.7 seconds for simple flights and from 0 to 17 seconds for compound flights. The larger fish flew on the average longer than the smaller ones.

SUPPLEMENTARY NOTE

In a recent abstract Carter and Mander (1935) confirm the view that the flight of flying fish is a glide, and state that measurements of cinematographs of fish in flight indicate the maximum speed to be 25 to 30 miles per hour (in agreement with previous estimates). They further indicate that flying fish, traversing the air at such speeds, could not travel in still air as far as they are observed to fly, and that they therefore probably make use of disturbances in
the air above the uneven surface of the water. This interpretation is at variance with my observations in Asia (Hubbs, 1933), which indicate that the characteristics of fish flight were about the same over glassy-smooth seas and over rough water.

LITERATURE CITED


THE CHARACTERS AND DISTRIBUTION
OF THE ATLANTIC COAST FISHES
REFERRED TO THE GENUS
HYPSOBLENNIIUS

CARL L. HUBBS

IN ORDER TO provide a more adequate means for the separation of the species of Atlantic North American blennies referred to the genus Hypsoblennius and in order to be able to state their ranges more precisely, I have studied the pertinent material in the United States National Museum and the Museum of Zoology of the University of Michigan. So far as is apparent, the generally copied or abstracted account of these species by Jordan and Evermann (1898: 2386-2390) is correct in its synonymy and in some of the characters described, but the features employed in their key are almost useless. Specific differences in the supraorbital cirrus, if such exist, are obscured by sexual dimorphism and individual variation, and the other characters used in the key are not alternative.

The two species of eastern North America now classed in Hypsoblennius are very readily distinguishable by several characters (see Table I), most of which have been overlooked.

Some of these distinctions between H. hentzi and H. ionthas are trenchant enough to cast doubt on their generic unity, but a consideration of their generic identification should await a review of the whole group.

The range of H. hentzi was incompletely indicated by Jordan and Evermann and most subsequent authors as “coasts of North and South Carolina, south to Indian River, Florida.” The valid records of H. hentzi from Cape Charles City, Virginia (Bean, 1891: 85, as H. punctatus), and from Corpus Christi, Texas (Evermann and Kendall, 1894: 119, as Iseostes hentzi), were overlooked. The record of this species from the Gulf of Mexico (Goode and Bean, 1882: 236, as Iseostes punctatus) could not be confirmed by an examination of the material in the National Museum. Both H. ionthas and H. hentzi
### TABLE I

**Comparison of the Characters of Two Species of Hypsoblennius**

<table>
<thead>
<tr>
<th>Character</th>
<th>Hypsoblennius hentzi</th>
<th>Hypsoblennius vonthas</th>
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<tbody>
<tr>
<td>Lower lips</td>
<td>Almost linear; widely separated by a smooth area</td>
<td>Semicircular; separated by a broad shield-shaped lobe</td>
</tr>
<tr>
<td>Upper lip</td>
<td>Thin; in profile extending downward and slightly forward</td>
<td>Thick; in profile extending downward and slightly backward</td>
</tr>
<tr>
<td>Gill membrane</td>
<td>Forming a very slight fold across isthmus when head is not thrown back</td>
<td>Forming no trace of a fold across isthmus</td>
</tr>
<tr>
<td>Head</td>
<td>Longer; length contained less than 3.5 times in standard length</td>
<td>Shorter; length contained more than 3.5 times in standard length</td>
</tr>
<tr>
<td>First 2 (swollen) anal spines in breeding males</td>
<td>First spine shield-shaped, broader than long, with a transverse fold on each side near base; second spine baglike</td>
<td>Both spines lanceolate</td>
</tr>
<tr>
<td>Angled light bar behind and below eye</td>
<td>Usually indistinct</td>
<td>Usually conspicuous</td>
</tr>
<tr>
<td>Dark spots in male</td>
<td>Conspicuous over head and trunk</td>
<td>Absent or scarcely developed except in suborbital region</td>
</tr>
<tr>
<td>Dark spots in female</td>
<td>Less distinct than in male, often inconspicuous, but developed over head and trunk</td>
<td>More distinct than in male, and always well developed, but confined to lower part of head</td>
</tr>
<tr>
<td>Size</td>
<td>Larger (largest one examined, 104 mm. in standard length)</td>
<td>Smaller (largest one examined, 66 mm. in standard length)</td>
</tr>
</tbody>
</table>

were recorded from Cameron, Louisiana, by Weymouth (1910: 141), with notes on their sexual dimorphism and synonymy. Recently a specimen of *H. hentzi* was recorded (Hubbs, 1936: 263) from the Yucatan Peninsula at Champotón, Campeche, as *Hypsoblennius*, sp.

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1. In *Chasmodes* and *Hypseleobichus*, as contrasted with *Hypsoblennius*, the plicate anal spines bear conspicuous longitudinal striae. This distinction is shown in Hildebrand and Cable’s recent figures (1938, figs. 74, 90, and 110). These authors furnish the best available description of *Hypsoblennius hentzi*, but do not treat *H. vonthas*. 

---

Carl L. Hubbs
Fishes Referred to the Genus Hypsoblennius

Therefore the distribution of *H. hentzi* is much wider than is generally assumed. It ranges from New Jersey (Fowler, 1920: 166) and Chesapeake Bay (Hildebrand and Schroeder, 1928: 334) to Yucatan. *H. ionthas*, the other species of eastern North America, is limited, so far as is known, to the coast line from South Carolina to Texas (as stated by Jordan and Evermann).

Since the ranges of *H. hentzi* and *H. ionthas* have been poorly understood and since that of *H. hentzi* has been unduly abbreviated in the manuals and check lists, there is included in this paper a list of the specimens examined in the National Museum (by courtesy of Dr. Leonard P. Schultz) and in the Museum of Zoology of the University of Michigan. Each entry is headed by the catalog number and, in parenthesis, the number of specimens.

### MATERIAL EXAMINED IN MUSEUMS

*Hypsoblennius hentzi*, in the United States National Museum

<table>
<thead>
<tr>
<th>Catalog Number</th>
<th>Localities</th>
</tr>
</thead>
<tbody>
<tr>
<td>43160 (1) and 43215 (5)</td>
<td>Chesapeake Bay, Cape Charles, Va.; W. P. Seal; Sept. 15-30, 1890.</td>
</tr>
<tr>
<td>46313 (1)</td>
<td>Corpus Christi, Texas; B. W. Evermann; Nov. 27-30, 1891.</td>
</tr>
<tr>
<td>51887 (2)</td>
<td>Beaufort, N. C.; B. A. Bean and C. A. McKnew; June 3-20, 1904.</td>
</tr>
<tr>
<td>59037 (3)</td>
<td>Off southern end of May River, S. C.; <em>Fish Hawk</em> Sta. 1651; 1891.</td>
</tr>
<tr>
<td>59062 (1)</td>
<td>Jericho Creek, S. C.; <em>Fish Hawk</em>; Jan. 23, 1891.</td>
</tr>
<tr>
<td>69741 (1)</td>
<td>Mouth of Hampton Creek, Hampton, Va.; M. C. Mars; Feb. 24, 1898.</td>
</tr>
<tr>
<td>67918 (1)</td>
<td>Old Point Comfort, Va.; L. G. Harron; Sept., 1900.</td>
</tr>
<tr>
<td>67919 (2)</td>
<td>Little Bay, near Ocean View, Va.; L. G. Harron; Sept., 1898.</td>
</tr>
<tr>
<td>73199 (1)</td>
<td>Charleston, S. C.; <em>Fish Hawk</em>; date?</td>
</tr>
<tr>
<td>80065 (1)</td>
<td>Pt. Macon Beach, N. C.; W. J. Crouser and S. Hecht; July 3 (?), 1912.</td>
</tr>
<tr>
<td>91155 (1)</td>
<td>Cape Charles, Va.; W. C. Schroeder; Nov. 23, 1921.</td>
</tr>
<tr>
<td>91156 (1)</td>
<td>Ocean View, Va.; W. C. Schroeder; Sept. 26, 1922.</td>
</tr>
<tr>
<td>91157 (2)</td>
<td>James Fishery, Norfolk, Va.; W. C. Schroeder; Aug. 20, 1921.</td>
</tr>
<tr>
<td>91158 (3)</td>
<td>Crisfield, Va.; W. C. Schroeder; Sept. 14-19, 1921.</td>
</tr>
<tr>
<td>91159 (1)</td>
<td>Chesapeake Bay, near Thimble Shoal Light, Va.; <em>Fish Hawk</em> Sta. 8403; Jan. 16, 1916.</td>
</tr>
<tr>
<td>91160 (1)</td>
<td>Chesapeake Bay, near Cove Point, Md.; <em>Fish Hawk</em> Sta. 8078; March 21, 1914.</td>
</tr>
<tr>
<td>91161 (1)</td>
<td>Chesapeake Bay, near Hoopers Light, Md.; <em>Fish Hawk</em> Sta. 8026; Jan. 20, 1914.</td>
</tr>
<tr>
<td>91162 (1)</td>
<td>Chesapeake Bay, near Point Not Point Light, Md.; <em>Fish Hawk</em> Sta. 8480; March 30, 1916.</td>
</tr>
<tr>
<td>91163 (1)</td>
<td>Chesapeake Bay, near Thimble Shoal Light, Va.; <em>Fish Hawk</em> Sta. 8497; April 21, 1916.</td>
</tr>
<tr>
<td>91457 (1)</td>
<td>St. Georges Sound, Fla.; E. Danglade; Jan., 1915.</td>
</tr>
</tbody>
</table>
Hypsoblennius hentsz, in the Museum of Zoology, University of Michigan

102175 (1) — Off Champusán, Campeche, Mexico; E. P. Creaser and P. Castillo; July 13, 1932.
111745 (1) — Oyster beds, vicinity of Rockport, Tex.; Albert Collier; Sept., 1935 — June, 1936.

Hypsoblennius ionthas, in the United States National Museum

26617 (1) — Cedar Keys, Fla.; Silas Stearns; 1880.  
30830 (1) — Pensacola, Fla.; Jordan and Stearns (type of I. scraturas); date?  
30836 (2) — Pensacola, Fla.; Jordan and Stearns (types of I. ionthas); date?  
69330 (1) — Palacios Reef, Matagorda Bay, Tex.; T. E. B. Pope; Dec. 23, 1904.  
69371 (1) — St. Simon Mills, Ga.; Rev. Watson Wins; Sept. 29, 1908.  
73546 (1) and 73547 (1) — Mobile Bay, Ala.; W. F. Hill; 1894.
83969 (1) — West Indies; collector?; date? [data hardly to be trusted].  
85499 (1) — Savannah, Ga.; collector?; date?  
85705 (3) — Sawmill Creek, S. C., near lower mouth of Clambank Creek; Dec. 30, 1890.  
91454 (3) — Apalachicola, Fla.; E. Danglade; March 15, 1915.  
92211 (1) — St. Vincent Sound, Fla.; E. Danglade; April 14, 1915.

Hypsoblennius ionthas, in the Museum of Zoology, University of Michigan

61446 and 61448 (18) — Pensacola, Fla.; Jordan and Evermann; 1886.  
111744 (7) — Oyster beds in vicinity of Rockport, Tex.; Albert Collier; Sept., 1935 — June, 1936.  
11449 (13) and 114475 (1) — Sand Point Reef, Lavaca Bay, Calhoun Co., Tex.; Gordon Gunter; Dec. 14, 21, 24, 1936.  
—— (1) — Oyster bed in Matanzas River, about 1.5 miles south of Matanzas Inlet, Fla.; Carl L. Hubbs and family; Aug. 19, 1936.  
—— (1) — Off Pass a Lutte, La.; Stewart Springer; Mar., 1931.

UNIVERSITY OF MICHIGAN
Fishes Referred to the Genus Hypsoblennius

LITERATURE CITED


THE STATUS AND SYNONYMY OF VERECUNDUM RASILE, A FLOUNDER OF BRAZIL AND ARGENTINA

CARL L. HUBBS AND TOMÁS L. MARINI

IN STUDYING a collection of marine fishes brought to the University of Michigan from Argentina by the junior author we found a species of flounder which in recent years has been referred to Hippoglossina and to Xystreurys. As the result of a kind suggestion by Dr. J. R. Norman, of the British Museum, it was determined that this flounder is the one described by Jordan in 1890 as Verecundum rasile. Inasmuch as this species differs trenchantly from the genotypes of Hippoglossina, Xystreurys, and other related genera Verecundum may be regarded as a valid genus.

The relationships of Verecundum lie with a group of "genera allied to Paralichthys," classified by Jordan and Evermann (1898: 2606, group dd in Key) among the Hippoglossinae. Largely on the characters of the olfactory laminae and on the crossing of the optic nerves, discovered by Kyle and Parker respectively, Regan (1910: 492) elevated this group to subfamily rank (Paralichthyinae). He classed this subfamily in the Bothidae, and added to it the other genera of that family having both pelvic fins short-based. Jordan (1923: 168) listed these other genera in the Bothidae, and elevated the Paralichthys group to family rank, but Norman (1934) has followed Regan's treatment.

In confirmation of the classification adopted by Regan and Norman we have determined that the optic nerve of the right eye is dorsal in a sinistral specimen of Hippoglossina stomata (a species which in superficial characters closely resembles the Hippoglossinae of the Pleuronectidae) and in a dextral (reversed) example of Xystreurys textile. So far as we have tested the character, the olfactory laminae

* Chief of the fisheries service of Argentina. This paper was prepared while the junior author was studying in the United States under a Guggenheim fellowship.
Hubbs and Marini

are longitudinal and without rachis in every normally dextral genus, with the exception of Atheresthes (stomias and evermanni) and Poecilopsetta (hawaiensis). In those genera the apparently primitive arrangement of the laminae, radiating outward and usually backward from a median longitudinal rachis, is maintained, although the optic nerve of the left side is dorsal.\(^1\) Pleuronectid genera (or subgenera) found by us to have longitudinal olfactory laminae without rachis are: Hippoglossus, Hippoglossoides, Lyopsetta, Equotetta, Cleithrenes, Xytrrias, Verasper (this dextral genus was misplaced in the Paralichthyinae by Jordan and Evermann and by Regan), Psettichthys, Clidoderma, Isopsetta, Parophrys, Lepisosteus, Linandella, Pseudopleuronectes, Platichthys, Hypopsetta, Pleuronichthys, Deciceps, Tanakius, Glyptocopeha, and Erru. Despite some marked superficial resemblances it is obviously unnecessary to compare Verecundum with any of these genera.

We have seen the olfactory laminae arranged on either side of a median longitudinal rachis in Verecundum and in Hippoglossina, Xytrrias, Paralichthys, Pseudorthombus, Tephrinectes, and Citharichthys.

**Verecundum** Jordan

This genus may be defined as follows. The eyes are sinistral. The subsymmetrical mouth is of moderate size; the maxillary reaches to below the pupil. The jaws bear a single irregular series of rather small bluntly conical teeth, in some specimens becoming almost biserial anteriorly. The palate is toothless. The subsymmetrical pelvic fins, each of 6 rays, are separated from the anal. The pectoral fin of the eyed side slightly exceeds its mate in size and is located somewhat nearer to but hardly on the midventral line. The narrowly pointed pectoral fin of the eyed side is almost as long as the head; its second ray is almost or quite as long as the third, which is longer than the fourth; the main rays below the third ray are all branched on the outer third; the interradial membranes are normal. The broadly rounded pectoral fin of the blind side is somewhat more than half as long as the right pectoral; its rays are all unbranched. The dorsal fin begins above the front of the pupil, and has no definitely

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\(^1\) Other fundamentally dextral flounders retaining the radiating type of olfactory laminae have been discovered by Regan (1920: 213) and also by Norman (1926: 257), who has made use of some of our findings in his recent Monograph of the Flatfishes (1934: 43).
Verecundum rasil e

exserted or elongated rays. The anal is similar, and without externally evident spine. Only a few (posteriormost) dorsal and anal rays are branched. There are about 80 dorsal and 65 anal rays. The caudal fin is longer than the head and is sharply pointed medially. The lateral line lacks an accessory branch, and rises anteriorly to form a low to moderate curve, having a height one fourth to one sixth of the chord. Most of the lateral line tubes have a conspicuous branch extending obliquely upward and backward, and some have a similar ventral branch. The scales are of moderate size (in about 80 oblique rows) and are strictly cycloid on both sides. Accessory scales are relatively few and inconspicuous. The gill rakers, in number about 5–10, are rather slender and pointed, and finely dentate on the inner surface and on the edge toward angle of arch. There are 6 branchiostegals. The rather large eyes lie on about the same vertical and are separated by a narrow sigmoid ridge. The upper eye is strictly lateral, but its upper ridge enters the dorsal profile. The chin recedes, with only a weak angle on the edge anteriorly. The olfactory laminae form two series of vertical flaps, perpendicularly arranged on either side of a median longitudinal rachis. The anterior nostril of the eyed side bears on its posterior edge a pointed flap, which reaches the front rim of the posterior nostril. The anterior nostril of the blind side bears a posterior flap which is very narrow and reaches to the hind edge of the posterior nostril. No flaps or cirri occur on or about the eyes. The body is moderately slender (depth about 2.3), and the caudal peduncle is very short (two fifths as long as deep).

Verecundum differs from Hippoglossina Steindachner (1876:61), to which Berg (1895:75) referred his H. notata (a synonym of Verecundum rasil e), in having cycloid instead of ctenoid scales, a curve rather than an arch in the lateral line, the pectoral fin of the eyed side and caudal much more elongate, the caudal fin subsemisle, and in other respects.

As is indicated in the following comparison, Verecundum differs in many characters from Xystreurys Jordan and Gilbert (1880:34), to which Regan, Ribeiro, and Norman referred the species under consideration.
TABLE I

COMPARISON OF VERRUCUNDUM WITH XYSTREURYS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Verrucundum (rasile)</th>
<th>Xystreurs (bilepis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body</td>
<td>Rather slender</td>
<td>Rather broad</td>
</tr>
<tr>
<td>Eyes</td>
<td>Sinstral</td>
<td>Sinstral or dextral</td>
</tr>
<tr>
<td>Teeth</td>
<td>Fine</td>
<td>Moderate</td>
</tr>
<tr>
<td>Pectoral, eyed side:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>Somewhat shorter than head; less than twice as long as pectoral of blind side</td>
<td>Longer than head; more than twice as long as pectoral of blind side</td>
</tr>
<tr>
<td>Tip</td>
<td>Pointed</td>
<td>Rounded</td>
</tr>
<tr>
<td>Second ray</td>
<td>Nearly or quite equal to third</td>
<td>Much shorter than third</td>
</tr>
<tr>
<td>Third ray</td>
<td>Longer than fourth</td>
<td>Shorter than fourth</td>
</tr>
<tr>
<td>Membranes</td>
<td>Normal</td>
<td>Especially widened</td>
</tr>
<tr>
<td>Main rays</td>
<td>Those below third branched</td>
<td>All unbranched</td>
</tr>
<tr>
<td>Pectoral rays, blind side</td>
<td>Unbranched</td>
<td>Branched</td>
</tr>
<tr>
<td>Dorsal and anal rays branched</td>
<td>Posteriormost few only</td>
<td>Median and posterior rays</td>
</tr>
<tr>
<td>Caudal fin</td>
<td>Longer than head, sharply pointed</td>
<td>Much shorter than head, rounded</td>
</tr>
<tr>
<td>Lateral line with</td>
<td>Curve</td>
<td>Arch</td>
</tr>
<tr>
<td>Branch pores</td>
<td>Conspicuous</td>
<td>Inconspicuous</td>
</tr>
<tr>
<td>Scales</td>
<td>Moderate (about 80)</td>
<td>Small (about 120)</td>
</tr>
<tr>
<td>Accessory scales</td>
<td>Few, inconspicuous</td>
<td>Many, conspicuous</td>
</tr>
<tr>
<td>Gill rakers</td>
<td>Slender; dentate on inside and on edge toward angle of arch</td>
<td>Almost leaflike; obdently dentate, only on edge toward angle of arch</td>
</tr>
<tr>
<td>Flap of anterior nostril of blind side</td>
<td>Very narrow, shorter</td>
<td>Broader and longer</td>
</tr>
<tr>
<td>Olfactory laminae</td>
<td>Perpendicular to rachis, flaplike</td>
<td>Strongly oblique to rachis, hardly flaplike</td>
</tr>
</tbody>
</table>

Verrucundum differs as follows from the commonly recognized American genera of Paralichthynae with subsymmetrical pelvic fins, other than Hippoglossina and Xystreurs:

from Thysanoptetta in having the teeth uniserial or nearly so, the dorsal and anal rays scaled, and the dorsal fin beginning above instead of before the upper eye;

from Lioglossina in having the mouth smaller, the gill rakers longer and slenderer, no orbital flap on eye, the pectoral of eyed side much longer, and the lateral line with a curve instead of a broad arch;

from Paralichthys in having the mouth smaller, the scales cycloid,
Verecundum rasile

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the dorsal fin beginning above the eye, the lateral line less curved anteriorly, the teeth smaller, and the interorbital narrower;

from Ramularia in having the scales cycloid, the lateral line without real arch, the lateral line pores with only one branch or occasionally two branches, the body less deepened, the gill rakers much better developed, neither pelvic fin markedly produced, and the anterior dorsal rays not exerted;

from Ancylopsetta in having the scales cycloid, the body less deepened, the gill rakers much better developed, neither pelvic fin markedly produced, and the anterior dorsal rays not elevated;

from Notosema in having the scales cycloid, the anterior dorsal rays not produced, and the dorsal fin beginning above rather than before the upper eye;

and from Gasteropsetta in having rather large and nonembedded scales, the dorsal beginning behind the front of the eye and without produced rays, neither pelvic fin elongated, and the gill rakers much better developed.

Other differences will no doubt be appreciated when Verecundum is carefully compared with any of these genera. It appears to be a fairly well marked genus.

The separation of Verecundum from Xystreurga is more than a matter of splitting or lumping. To classify Verecundum rasile of Atlantic South America in the same genus as the Californian Xystreurga bolepis would be to indicate that V. rasile is more closely related to X. bolepis than to several subtropical genera (or subgenera), particularly the Atlantic Notosema and Ancylopsetta. Such differentially close relationship between rasile and bolepis does not appear to be indicated, and there is no other evidence of definitive relationship between the fishes of California and those of southeastern South America.

Verecundum rasile Jordan

(Plate 1)

Xystreurga rasile. — Norman, 1934: 121, fig. 77; 1937: 135, fig. 76.

Hippoglossina notata. — Berg, 1895: 75.


Xystreurga brasiliensis. — Regan, 1914a: 17; 1914b: 23, pl. 10, fig. 1.

Possibly more than one species or subspecies of Verecundum is represented in this synonymy, but the available information is insufficient for their separation.
The type specimen of *Verecundum rasile*, a long-forgotten species from Bahia, Brazil, which we have examined at the suggestion of Dr. J. R. Norman, agrees very well with the type description of *Hippoglossina notata* Berg and with our topotype of *H. notata* from Mar del Plata. The teeth in the type are somewhat more irregularly arranged than in our specimen, becoming almost biserial at front of jaws instead of remaining almost strictly uniserial throughout. The pectoral of the eyed side is about eight tenths instead of seven tenths as long as head, and its second ray is as long as, instead of a little shorter than the third ray. The type has 87 dorsal and 69 anal rays; 94 scales in lateral line, and about 83 oblique scale rows; 5 + 11 gill rakers; depth 2.25.

Ribeiro's description of "*Xystreurys notatus*" from Brazil indicates the eye as larger and the pectoral as somewhat shorter than in our example. Regan's description and figure of *Xystreurys brasiliensis* also indicate the eye as larger than in our specimen, but the pectoral fin as longer. In response to our request Dr. J. R. Norman has re-examined the holotype of *brasiliensis*, 170 mm. long, and finds the left pectoral (possibly a little broken at the tip) seven eighths as long as head; eye 3.4 in head; orbit 3.0 in head; caudal peduncle 14 mm. deep and 6.5 mm. long as measured between caudal base and vertical from end of anal base. In the 98 mm. paratype he measures the pectoral 1.2 in head, the eye nearly 3.0, the orbit 2.6. In our specimen, about 228 mm. long over all, the left pectoral is seven tenths as long as head, the eye enters the head 3.8 times, the orbit 3.2 times; the comparable caudal peduncle measurements are 19 and 8 mm. The larger eye in the types of "brasiliensis" is probably due to age variation, for we find a graded series:

<table>
<thead>
<tr>
<th>Total length, mm.</th>
<th>Eye in head</th>
<th>Orbit in head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paratype of X. brasiliensis</td>
<td>98</td>
<td>nearly 3.0</td>
</tr>
<tr>
<td>Holotype of X. brasiliensis</td>
<td>170</td>
<td>3.4</td>
</tr>
<tr>
<td>Topotype of H. notata</td>
<td>228</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Our specimen shows the following additional characters: depth 2.35; depth of caudal peduncle 2.2 in head; head 4.2; upper jaw 2.5; highest dorsal ray, near middle of fin, 1.9 in head; highest anal ray 2.0; median caudal ray 3.5 in standard length; dorsal rays 84; anal rays 64; pectoral rays on each side 10; scales in lateral line.
Verecundum rasile

about 94; transverse scale rows above lateral line about 82; gill rakers 3 + 10 on eyed side and 5 + 10 on blind side.

*Xystreurys ribeiroi* Fowler and Bean (1923: 26), of which we have also examined the type in the United States National Museum, is not closely related to the species under consideration, but it is referable to the genus *Paralichthys*. Norman (1934: 72, fig. 38a) has referred this nominal species to the synonymy of *Paralichthys orbignyana*.

**UNIVERSITY OF MICHIGAN**

**LITERATURE CITED**


Standard length of specimen 177 mm. Photograph by F. W. Oustrichik.
A REVISION OF THE TOADFISHES REFERRED TO PORICHTHYS AND RELATED GENERA

By Carl L. Hubbs and Leonard P. Schultz

In identifying a second species of Porichthys occurring along the coasts of southern California and Lower California, we found that the species referred to this American genus stand in need of revision. We have therefore studied all the material of these species in the United States National Museum, in the Museum of Zoology of the University of Michigan, and in the museum of Stanford University and have examined the pertinent literature, as the basis for the present paper. One new genus and two new species are described:

Aphros (for Batrachus parasus Valenciennes),
Porichthys myriaster (southern California and Lower California).
Porichthys analis (Gulf of California).

The toadishes treated are those members of the family Batrachiodae having the following characters: 2 dorsal spines and 1 strong opercular spine, both solid and without connected poison glands; subopercle small, without spine; some of the teeth caniniform; no scales; 4 lateral lines. With the exception of the Chilean and Peruvian *Porosus*, here made the type of a distinct genus, *Aphros*, all species of this group have rows of many photophores (Greene, 1899) following the course of the multiple lateral lines. The presence of these organs is therefore not consistently associated with the increased number of the lateral lines and does not seem to furnish warrant for the separation of a family Porichthyidae, as proposed by Ribeiro (1915).

We separate another genus from Porichthys, recognizing *Nanopoedium* Jordan for *poroissimum*, the single, wide-ranging Atlantic species of the group. Thus Porichthys, with 5 or 6 species, is re-
stricted to the Pacific coast, from southern Alaska to Colombia. Only Porichthys notatus occurs north of southern California and only P. greenei and P. margaritatus in the general vicinity of Panama. In southern California and on the outer coast of Lower California both P. notatus and P. myriaster occur. The center of abundance for the group seems to be the region of the Gulf of California and Cape San Lucas, where we find the northern P. notatus, the Panamic P. margaritatus, and apparently 2 or 3 additional forms, one of which is here named P. analis.

In distinguishing the species of Porichthys, we have found the number of anal rays to be particularly useful. Series of counts of anal rays have therefore been made and presented in table 1.

Table 1.—Anal-ray counts of Porichthys (last ray counted as a double ray)

<table>
<thead>
<tr>
<th>Species and locality</th>
<th>Number of anal rays</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27 29 31 32 33 35 37</td>
<td></td>
</tr>
<tr>
<td>P. myriaster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern California</td>
<td>2 7 16 9 2</td>
<td>15.96</td>
</tr>
<tr>
<td>Lower California</td>
<td>1 1 2</td>
<td>15.69</td>
</tr>
<tr>
<td>P. notatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia (Strait of Georgia)</td>
<td>1 4 3</td>
<td>31.14</td>
</tr>
<tr>
<td>Puget Sound</td>
<td>1 6 26 17 1</td>
<td>32.26</td>
</tr>
<tr>
<td>Central California</td>
<td>13 26 16 2</td>
<td>32.12</td>
</tr>
<tr>
<td>Southern California</td>
<td>4 23 10</td>
<td>32.17</td>
</tr>
<tr>
<td>Outer coast, Lower California</td>
<td>3 5 4 1</td>
<td>31.22</td>
</tr>
<tr>
<td>Gulf of California</td>
<td>1 2</td>
<td>30.67</td>
</tr>
<tr>
<td>P. analis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape San Lucas, Lower California</td>
<td>1 7</td>
<td>27.67</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>27.60</td>
</tr>
<tr>
<td>P. margaritatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower California</td>
<td>4 2</td>
<td>31.22</td>
</tr>
<tr>
<td>Panama</td>
<td>7 19 4</td>
<td>30.90</td>
</tr>
<tr>
<td>Galapagos Islands</td>
<td>7 18 3</td>
<td>30.96</td>
</tr>
<tr>
<td></td>
<td>1 3</td>
<td>31.20</td>
</tr>
<tr>
<td>P. greenei</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 7 2</td>
<td>32.80</td>
</tr>
</tbody>
</table>

ANALYTICAL KEY TO THE SPECIES OF PORICHTHYS AND RELATED GENERA


2a. Photophores absent.

3a. Teeth of palatine and premaxillary not directed forward; those of palatine rather numerous and not confined to front of bone. Peru and Chile. Aphos porosus

4a. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum white in adult. Lateral line organs, especially of dorsal and anal series, fimbriate. Aphos porosus
29. Photophores very numerous, developed in rows generally following the courses of lateral lines.¹

30. Teeth of palatine and premaxillary directed slightly backward in adults of both sexes; those of palatine numerous and not confined to front of bone. *Southern Alaska to Colombia.*  

*Porichthys myriaster*

49. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum blackish in adults. Lateral line organs, especially of dorsal and anal series, fimbriate. Photophores of minute size developed above and below some of the accessory dorsal lateral line organs.

5a. Branchiolestegal rows of photophores with a U-shaped forward-directed commissure, not markedly constricted at base. Palatine teeth large, needle-shaped canines.

5a. Body with dusky dorsal saddles in young; becoming plain with age. Top of head unmarked. Dorsal fin usually more or less blotched with dusky. Anal fin definitely margined with dusky to blackish (except in young). Pleural row of photophores ending abruptly above end of second third of anal base, behind end of pleural lateral line. Anal rays 33 to 37, usually 34 to 36. Dorsal rays 36 to 38. *Southern California and outer coast of Lower California, close to shore.*  

5b. Branchiolestegal rows of photophores united in a broad V, without forward projection. Palatine teeth small, somewhat compressed.

6b. Body with weak dorsal saddles in young, usually very weak; becoming plain with age. Top of head unmarked. Dorsal fin plain, or with a dusky edge, as a border or in spots. Anal fin more or less darkened, but usually without dark margin, or with a nearly dusky border. Pleural row of photophores ending abruptly above end of second third of anal base behind end of pores and cirri of pleural lateral line. Anal rays 29 to 34, usually 31 to 33. Dorsal rays 34 to 36, usually 35. *Alaska to Cape San Lucas; in rather deep water south of Point Conception.*  

*Porichthys notatus*

6a. Body with 8 rather strong and presumably persistent, broad, light-brown dorsolateral bars, without light centers; without smaller, alternating spots. Top and sides of head unspotted. Dorsal fin with a row of 7 marginal light-brown blotches (separated by light areas from the body bars). Anal fin whitish, with a dusky brown border. Pleural row of photophores not ending above end of second third of anal base but continued backward (as smaller organs) nearly to end of fin; pleural lateral line (pores and strong cirri) extending to caudal fin. Anal rays 36. Dorsal rays 38 or 39. *Gulf of California.*  

*Porichthys analis*

6c. Body with strong and persistent dorsolateral blotches, often with light centers; with smaller, alternating spots in adult. Top and sides of head (and humeral region) definitely spotted with dark. Dorsal fin with a row of marginal black spots or blotches. Anal fin white or dusky to margin. Pleural row of photophores not

¹The arrangement of the photophores of *Porichthys* is described and figured in great detail and accuracy by Greene (1899), whose account was abstracted by Jordan and Evermann (1898, pp. 2217-2218) and partly quoted by Jordan (1905, vol. 1, pp. 190-197).
ending above end of second third of anal base but continued backward (as smaller organs) nearly to end of fin; pleural lateral line (pores and weak cirri) extending almost or quite to caudal fin. Anal rays 30 to 32. Dorsal rays 31 to 36. Pacific coast of Tropical America, from Gulf of California and Cape San Lucas to Colombia. Porichthys margaritatus


5c. Branchiostegal rows of photophores uniting in a broad V, from the point of which a short median branch extends forward. Palatine teeth somewhat compressed.

6c. Body with 6 large, persistent, solid, blackish saddles; without alternating smaller spots. Top of head crossed by a definite blackish bar. Dorsal and anal fins whitish, unmarked. Pleural row of photophores ending above middle of anal fin, but pores of pleural lateral line continued to caudal. Anal rays 29 to 35. Dorsal rays 32 to 38. Pacific coast of Panama. Porichthys greenei

5c. Teeth of palatine in the adult of both sexes and the posterior premaxillary teeth in adult male directed forward; those of palatine few (usually 3 to 6) and confined to front of bone. Atlantic coast from Virginia to Argentina (except West Indies). Nautopediaum

4d. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum white in adult. Lateral line organs finnibrite. Photophores of minute size developed above and below accessory dorsal lateral line organs.

5d. Branchiostegal rows of photophores with a U-shaped forward-directed commissure noticeably constricted at base. Palatine teeth very large, needle-shaped canines.

6d. Body sometimes plain, but usually with a row of dorsolateral spots and another row along dorsal base (the 2 rows often connected in young). Top of head plain or dark-spotted. Dorsal fin with 3 rows of small spots (spots sometimes fused into streaks, or lacking). Anal fin margined with dark. Pleural row of photophores ending above end of second third of anal base, but pleural lateral line continued to end of anal fin. Anal rays 21 to 25. Dorsal rays 23 to 28. Nautopediaum porosissimum

Bibliographic references of prime systematic importance are starred in the synonymies and in the bibliography. In the synonymies we attempt to give an analysis of the literature as it relates to the nomenclature, distribution, and general biology of each species treated, but do not refer to bare lists or to copied statements of locality or distribution.

APHOS, new genus

Orthotype.—Batrachus porosus Valenciennes.
In agreement with the very plausible suggestion made by Thompson (1916, p. 468), we erect this new genus for the sole reception of Porichthys porosus (Valenciennes), because this species alone among
all those referred to *Porichthys* lacks the complex photophores (Greene, 1899) so characteristic of the group. The photophores in *Aphos* seem to be totally lacking, despite the statement by Evermann and Radcliffe for the type of *Porichthys aforae* (which we regard as a synonym of *Aphos porosus*) that "the lines of phosphorescent organs are essentially the same as in *P. margaritatus*, but much smaller and less clearly defined, in some places being almost invisible." Presumably these authors were confusing the pores and the photophores, for the type of *aforae* shows no photophores.

In other respects, so far as apparent, *Aphos* agrees with *Porichthys*, as that genus is here defined, but the one distinction is regarded as fully sufficient for generic separation. We do not, however, agree with Ribeiro (1915) in regarding the characters as of family significance.

The one species of *Aphos* occurs in Peru and Chile, where it is the only representative of the *Porichthys* group.

*Aphos*, from ό, without + φως, light.

*Aphos porosus* (Valenciennes)

*Batrachus porosus* *Valenciennes*, in Cuvier and Valenciennes, 1837, pp. 505–507, pl. 369 (original description).—Gay, 1848, p. 296 (Valparaíso).

*Porichthys porosus* *Günther*, 1855a, p. 141 (new combination).—*Günther*, 1855, p. 377 (description).—*Jordan*, 1884b, p. 41 (teeth).—*Meek and Hall*, 1885, pp. 53, 56 (synonymy).—Reed, 1897, p. 661 (Valparaíso).—*Selwyn*, 1901, p. 200 (Equituch, Chile).—Delfín, 1903, pp. 89–90 (synonymy, records).—Fowler, 1916, p. 65 (Valparaíso).—Thompson, 1919, pp. 645, 658 (Tome, Chile). (Type locality: Valparaíso, Chile.)

*Batrachus chilensis* *Gay*, 1848, p. 297 (original description).—Reed, 1897, p. 661. (Type locality indicated only by name of species.)

*Porichthys aforae* *Evermann and Radcliffe*, 1917, pp. 152–153, pl. 14, fig. 1 (original description). (Type locality: Lobos de Aforae, Peru.)

The examination of new material (table 2) fails to confirm Evermann and Radcliffe’s (1917) separation of a larger-headed Peruvian species (*aforae*) from the typical, Chilean *porosus*. These authors indicated that the length of the head in the types of *aforae* enters the standard length 3 times and the total length 3.6 or 3.41 times (two statements), whereas in *P. porosus* the head is contained 4.66 times in the total length, according to Günther.

In addition to the fishes listed in table 2, we have examined the following material, all very small specimens collected by Dr. W. L. Schmitt in Peru, during January 1935: U.S.N.M. no. 101722 (18 specimens), Aforae, Lobos Islands, North Bay, 12 fathoms, January 17; nos. 101723 (1 specimen) and 101724 (8 specimens), all from Aforae, Lobos Islands, South Bay, 14 to 16 fathoms, January 17;
no. 101720 (2 specimens), Independencia Bay, clean sand bottom at 3.5 fathoms, January 14; no. 101721 (1 specimen), Callao, January 11.
The lack of photophores in these specimens is definitely appreciable.

**Table 2**—Measurements of the head in specimens of *Aphos porosus* from Peru and Chile

<table>
<thead>
<tr>
<th>Locality</th>
<th>Lengths (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peru</td>
<td>27 29 31 32 34 35</td>
</tr>
<tr>
<td>Chile</td>
<td>29 31 32 33 34 35</td>
</tr>
<tr>
<td>Uncertain locality</td>
<td>30 32 33 34 35</td>
</tr>
</tbody>
</table>

*The data in this table were taken from specimens bearing the following U.S.N.M. numbers: 77346, Tora, Chile; 77388, locality 1; 77502 (type of *P. eburnea*), Lobos de Afuera, Peru; 88904, Lima, Peru; 102318, north shore of Middle Chinchua Island, Peru; 102948, Independencia Bay, Peru; and 103432, locality 1; and Stanford University no. 22680, Tora, Chile. In addition, 12 specimens from San Juan and Independencia Bays, Peru, collected by the 1938 Hancock Expedition, are recorded through the courtesy of Dr. George S. Myers. The lengths of all specimens range from 10.9 to 22.2 mm.

**Genus PORICHTHYS Girard**

*Porichthys* *Girard, 1855a, p. 141 (original description); 1855b, p. 134 (description).—*Günther, 1861, pp. 175-176 (description).—*Kner, 1865, pp. 189-190 (description).—*Jordan and Gilbert, 1883a, pp. 750-751 (diagnosis, type designation).—*Meek and Hildebrand, 1886, pp. 2217-2228 (description, description of lateral line and pore structure quoted from Greene, analysis and description of species).—*Bean and Weeden, 1910, pp. 314, 515, 526 (comparison).—*Riseng, 1915, p. — (description, type of new family).—*Meek and Hildebrand, 1928, pp. 610, 622 (diagnosis, Nautopetram a synonym).

**Type.**—"*Porichthys notatus* Grd. = *Batrachus porosissentus* C. & V." (designated by Jordan and Gilbert, 1883a, p. 751).

The species of *Porichthys* are compared in the preceding key and in tables 1 and 3.

**PORICHTHYS MYRIASTER, new species**

**Figure 57, b**

*Porichthys myriaster* (misidentifications) *Yarrow and Hendrick, 1878, p. 202 (color).—Jordan and Evermann, 1890, pp. 2321-2322 (synonymy, description; in part).—*Starks and Morris, 1907, pp. 230-231 (color, range, and habitat; in part).—*Starks and Mann, 1911, p. 16 (bathymetric distribution; in part).—*Osborn and Nicolson, 1916, p. 177 (records for bays on outer coast of Lower California, identifications presumptive).—*Hsiao, 1923, p. 380 (bionomics; in part).—*Greene and Greer, 1924, pp. 501-506, fig. 1 (San Pedro Harbor record, phosphorescence; good figure).—*Barnhart, 1936, pp. 92-93 (diagnosis; in part), fig. 259.
As indicated in the key, this heretofore unrecognized species differs from *P. notatus* (and from all other species here retained in *Porichthys*) in the U-shaped forward-directed commissure of the branchiostegal rows of photophores (compare fig. 57, b and c); in the larger, more needlelike palatine teeth; typically in the more conspicuous dorsal saddles and more blotched dorsal fin (these juvenile traits tend to disappear with age but are more persistent in *myriaster* than in *notatus*); and in the definitely dark-margined anal fin (the young have the fin clear). The distinctness of *myriaster* from *notatus* is proved by the higher number of anal rays, for there is little overlap in the counts (table 1). The corresponding difference in number of dorsal soft rays (table 3) is not quite so sharp.

*Porichthys myriaster* also shows a habitat distinction from *P. notatus*, although its entire range is overlapped by that of *notatus*. Along the coasts of southern California and Lower California *myriaster* is the characteristic form of the muddy and sandy bays, and along the open shore it tends to live in shallower water than *notatus*. The difference in bathymetric range is partly obscured by the tendency of the young of *notatus* to mingle with *myriaster* in rather shallow water (to 25 fathoms). The only specimen of *myriaster* known from water deeper than 25 fathoms is one adult taken at 69 fathoms. *P. myriaster* apparently does not share with *P. notatus* the habit which that form exhibits (in the cooler portion of its range) of migrating into the intertidal zone of the rocky reefs for spawning (Hubbs, 1920). The very few records of *Porichthys* approaching or entering this zone in southern California probably refer to *P. notatus*. *P. myriaster* is apparently more of a bay and less of a reef inhabitant.

The holotype of *Porichthys myriaster* (U.S.N.M. no. 8483) is an adult 306 mm in standard length and 347 mm in total length, collected by Cassidy at San Diego. It is apparently not the specimen (U.S.N.M. no. 694) recorded as *Porichthys notatus* by Girard (1858) as taken by Cassidy at San Diego, for that fish was also found. Description of holotype.—Dorsal, 11-36; anal, 53; pectorals 20-20; pelves 1, 2. Gill rakers on lower part of first arch 17. Palatine teeth caninelike, curved backward, 9 in the single series on each side; vomerine canines 1 or 2 at each outer angle of bone, very strong, curved backward; premaxillary teeth conical, strong, uniserial;
mandibular teeth conical, strong, biserial at front of jaw with the inner row continued backward as canines. Peritoneum blackish. The coloration of head, body, and fins is described in item 6a of the key (p. 473).

Measurements in thousandths of the standard length for the holotype and (in parentheses) for 9 paratypes 53 to 304 mm long: Greatest depth, 173 (163–219); distance from tip of snout to origin of soft dorsal, 333 (328–366); to origin of spinous dorsal, 281 (260–300); from tip of chin to anus, 451 (385–430); length of head, 286 (270–310); interorbital width, 88 (68–95); length of orbit, 36 (36–60); of upper jaw, 150 (140–150); of snout, 78 (64–87); distance from tip of lower jaw to anteriormost point of the U-shaped forward extension of the branchiostegal row of photophores, 62 (47–62); between the nearly parallel ventral rows of photophores, 33 (23–33); from anus to anterior extension of ventral row of photophores, 199 (165–195); height of pectoral arch of pleural row of photophores, 38 (23–44); length of this arch, 118 (94–148).

Measurements of 9 paratypes 53 to 304 mm long, stepped into standard length: Greatest depth, 4.8–6.1; length of head, 3.2–3.7. Height of pectoral arch of the pleural row of photophores in length of arch, 2.8–4.2; least distance between ventral rows, 4.9–6.5 in distance from anus to anterior tip of that row; distance from tip of chin to anterior tip of branchiostegal row, 3.6–6.5 in head.

The following paratypes of Porichthys myriaster are deposited in the National Museum: U.S.N.M. 11046, Santa Barbara, Calif.; nos. 24814, 24823, 24861, 26043, 31349, 34757, 34777, 54738, 54748, 54749, 54757, 54760, 54764, and 57409, all from "San Diego" or San Diego Bay, Calif.; no. 108431, from latitude 32°34′30″ N., longitude 117°18′45″ W.

The following paratypes of Porichthys myriaster are deposited in the Museum of Zoology, University of Michigan: No. 63610, Anaheim Bay, Calif.; 64146, off Mira Mar Pier, Calif.; 64148, 34°21′20″ N., 119°31′20″ W.; 64149, 32°36′00″ N., 117°13′15″ W.; 80829, Magdalena Bay, Lower California; 115795, San Pedro, Calif.; 115820, from 34°17′20″ N., 120°13′00″ W.; 115821, Carpenteria to Rincon, Calif.; 115822, 34°27′30″ N., 120°11′20″ W.; 115823, 34°27′00″ N., 120°05′30″ W.

myriaster, from μερας, myriad + αρης, star, referring to the multitudinous photophores, which when active shine like stars.

Porichthys notatus Girard

Porichthys notatus, *Girard, 1855a, p. 141 (original description); 1855b, p. 351 (records); 1858, pp. 134–136 (description, records); 1855b, p. 50, pl. 25 (diagnosis, figure of type).—*Suckley, 1890, p. 326 (diagnosis; Fort Steilacoom, Puget Sound).—*Jordan and Starks, 1905, p. 849 (natural history;
This species has a wide distribution, both geographically and ecologically. It ranges from Sitka in southern Alaska to the Gulf of California (Starks and Morris, 1907, p. 230) and occurs (as a variant race) almost as far south as Cape San Lucas. Bathymetrically its habitat extends from the intertidal zone to depths as great as 145 fathoms. It has generally been stated that this form lives in deeper water to the southward, but this seems true only in that it largely avoids the bays and shoals in the south. From the vicinity of Point Conception northward it freely migrates (Greene, 1899) into the intertidal zone to spawn but seldom enters this zone south of Point Conception (Hubbs, 1920). It is common in the bays from central California northward, whereas to the southward it is largely if not entirely replaced in the bays by *Porichthys myraster*. It occurs in deep water in the north as well as in the south.
In view of its wide geographic and bathymetric range, it is not surprising that Porichthys notatus exhibits considerable variation. The anal rays (table 1), averaging highest in California, decrease in average number both toward the north and the south. A marked backward extension of the pleural row of photophores was indicated by Greene (1899, p. 676) for Alaskan specimens, but some doubt is attached to the claim (see page 488). The race in the Puget Sound region is unusually heavy-set and dark. Specimens dredged in moderate depths off the outer coast of Lower California and in the Gulf of California differ from typical notatus not only in the slightly reduced number of anal rays but also in a slightly greater tendency for the retention into half-grown stages of the 6 or 7 dusky saddles, and in the more frequent and distinct tendency of the anal fin to become margined with dusky; they also average lighter in color. Occasionally one or a very few minute photophores may be discerned behind the normal termination of the pleural row.

The most aberrant individual that we have referred to P. notatus was dredged the farthest south, on the outer coast of Lower California not far north of Cape San Lucas. This specimen (U.S.N.M. no. 46675), a large young fish 82 mm in standard length, was dredged by the Albatross on May 1, 1888, at station 2830, in 66 fathoms, at latitude 23°33' N., longitude 110°37' W. Unlike the two doubtful forms described below, it has 33 anal and 36 soft dorsal rays. It differs distinctly from the types of P. analis in having fewer blotches on the back and on the dorsal fin, the margin of the anal fin darker, no cirri on the posterior pores of the pleural lateral line, and the head larger (3.4). The 6 large dark-brown dorsolateral blotches are more conspicuous than in notatus but less so than in margaritatus. The marginal blotches on the dorsal fin are quite unlike the continuous dark edging of notatus but are rather fewer and more elongate than in analis or margaritatus. The blackish-brown border of the anal fin is stronger than in any other specimen at hand of notatus. A few small photophores are present in the pleural row behind the main ones, and pores without developed cirri continue in the pleural row about to the end of the anal base.

In various respects the Lower California races of P. notatus show some approach toward P. myriaster and toward P. margaritatus. No intergradation between notatus and myriaster is indicated, however, for the distinction in the course of the branchiostegal row of photophores remains trenchant, and the difference in the number of anal rays is accentuated in Lower California (table 1). It is possible that intergradation with P. margaritatus will be discovered, since that species and notatus seem very closely allied. The interrelation between margaritatus and notatus, in the approximate region of the
overlap in their distribution, is complicated by the probable existence there of two additional forms of the same general type. These are discussed below as Porichthys sp. and Porichthys analis, new species.

The following collections of Porichthys notatus in the U. S. National Museum have been examined: U.S.N.M. no. 520, San Francisco Bay (type); 521, Presidio, Calif.; 523, Fort Steilacoom, Wash.; 694 and 103435, San Diego, Calif.; 4474, San Francisco, Calif.; 7606, Victoria, British Columbia; 30647, off Point Loma, Calif.; 29686, Santa Barbara, Calif.; 27277, Puget Sound, Wash.; 41878, Cortez Banks, Lower California; 46461, 34° 12' 30" N., 120° 32' 30" W.; 46462, 34° N., 120° 23' W.; 46476, 32° 44' 30" N., 117° 28' W.; 46479, 24° 24' 30" N., 111° 57' W.; 46481, 26° 14' N., 113° 13' W.; 46483, 32° 34' 30" N., 117° 18' 45" W.; 46494, 29° 19' 00" N., 112° 50' W.; 46464, 28° 07' 00" N., 111° 39' 45" W.; 46675, 23° 33' N., 110° 37' W.; 46731, 29° 40' N., 112° 57' W.; 48572, 37° 38' 00" N., 123° 02' 30" W.; 53817, Bellingham, Wash.; 54500, 34° 23' 30" N., 120° 19' 30" W.; 51628, 37° 06' 40" N., 122° 37' 30" W.; 58696, 37° 30' 00" N., 120° 02' 30" W.; 59460, Comox, British Columbia; 60582 and 60821, Union Bay, British Columbia; 60583, near Port Townsend, Wash.; 67313, San Pablo Bay, Calif.; 67314, San Francisco Bay, Point San Bruno; 70657, Union Bay, Bayne Sound, British Columbia; 75459, Pacific Grove, Calif.; 76067 and 76068, off Point Pinos Light, Calif.; 76010, off La Jolla, Calif.; 77979, 53° 17' 00" N., 118° 24' 00" W.; 82155, Ucluelet, British Columbia; 83971, Union Bay, east of Coal Wharf, British Columbia; 101400, Dillon Beach, Calif.; 102266, Santa Barbara or Santa Barbara Islands.

The following collections of Porichthys notatus in the Museum of Zoology, University of Michigan, have been examined: Nos. 56332 and 63698, from Monterey Bay, Calif.; 61665, between Avila and Pismo, Calif.; 61696, Mussel Point, Pacific Grove, Calif.; 61697, near Piedras Blancas, Calif.; 63061, 63062, 63064, 63067, and 63069, all from San Francisco Bay, Calif.; 63663, near Point Reyes, Calif.; 63665, Elkhorn Slough, Calif.; 63666, off Del Monte, Calif.; 61445, 34° 27' 30" N., 120° 11' 20" W.; 61447, 34° 27' 00" N., 120° 03' 30" W.; 61448, 34° 21' 30" N., 119° 31' 30" W.; 61450 and 61451, off Long Beach, Calif.; 64155, Carpenteria to Rincon, Calif.; 64153, lat. 34° 17' 20" N., long. 120° 13' 00" W.; 64154, off San Pedro, Calif.; 92603, Drakes Bay, Calif.; 94012-94017, all from Hood's Canal, near Holly, Wash.; 115796, Puget Sound, Everett, Wash.

The following collections of Porichthys notatus in the Natural History Museum of Stanford University have been examined: No. 91, 34° 18' 30" N., 119° 41' 00" W.; 6350, 37° 06' 00" N., 122° 32' 00" W.;
5191, 37°18'50" N., 122°22'30" W.; 5192, 37°44'50" N., 122°43'00" W.; 5211, 35°40'30" N., 121°22'40" W.; 5574, Pacific Grove, Calif.; 10700, San Francisco Market; 21341, San Juan Islands, Wash.; 22242, McNears Point, San Pablo Bay.

**Porichthys species**

*Porichthys marmoratus* (presumably a misidentification) Jordan and Gilbert, 1882c, p. 368 (record of specimens discussed below).

Three young specimens (U.S.N.M. no. 3004), 39.5 to 41.5 mm in standard length, collected by Xantus at Cape San Lucas, seem to represent an undescribed species of *Porichthys*. The anal rays are 27 in one and 28 in two, whereas only one other specimen of the genus examined (an example of *P. notatus*) has as few as 29 anal rays. The dorsal rays are correspondingly decreased (table 3). The specimens though poorly preserved show 6 large dusky dorsolateral blotches. The small photophores in the pleural row behind the main ones are rather numerous, at least on one side of one specimen (some are evident on the opposite side of this individual, and on the other specimens), but the condition of preservation does not permit it to be determined with certainty whether these small organs are as well developed as in *P. marmoratus*. Nor are the lateral line structures to be precisely determined.

**Table 3.**—Dorsal rays in species of *Porichthys*

<table>
<thead>
<tr>
<th>Species</th>
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<th>31</th>
<th>32</th>
<th>33</th>
<th>34</th>
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<th>36</th>
<th>37</th>
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<tr>
<td><em>P. marmoratus</em></td>
<td></td>
<td></td>
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<td><em>P. notatus</em></td>
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<td>2</td>
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<td>1</td>
</tr>
<tr>
<td><em>P. australis</em></td>
<td>3</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>P. margaritatus</em></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
</tr>
</tbody>
</table>

The V-shaped branchiostegal row of photophores as well as the number of fin rays excludes these specimens from *P. marmoratus*. The contrast in radial formula is greatest when these specimens are contrasted with the two types of *P. australis*. They agree rather well with corresponding young of either *notatus* or *margaritatus* and may represent aberrant examples or a subspecies of either form. The agreement is particularly close with the original figure and description of *Batrachus marmoratus* from the Gulf of Fonseca, and they may represent the true *margaritatus* if that form should be distinct from the one (*nautopaedium*) usually assigned the name.
The available specimens of this form are unfit to serve as the basis for the proposal of a new name. The examination of material newly collected about Cape San Lucas should solve its status.

**Porichthys analis**, new species

Two specimens of *Porichthys* from the Gulf of California present characters that indicate rather conclusively a specific difference from both *notatus* and *margaritatus*. They were dredged by the *Albatross* on March 24, 1889, at station 3017, in 58 fathoms, at latitude 29°54'30" N., longitude 113°01'00" W. The holotype, 95.5 mm in standard length and 108 mm over all, is cataloged in the National Museum as no. 46645. The one paratype, measuring 80 and 95.5 mm, is U.S.N.M. no. 106563.

In number of dorsal and anal rays (tables 1 and 3) *P. analis* agrees with *P. myriaster*, but it has the V-shaped branchiostegal row of photophores characteristic of *notatus* and its variants as well as *margaritatus*. When *analis* is compared with *notatus* the increased number of fin rays seems particularly significant in view of the apparent decrease southward (from California) in average number of rays. It differs further from *notatus* in having the pleural row of photophores as in *margaritatus* continued backward (as smaller organs) from the end of second third of anal base nearly to end of fin. Instead of ending before the end of the large organs of the pleural photophores, the pores and cirri of the pleural branch of the lateral line extend to the caudal fin. The pores in this extension of the pleural line are even stronger than in *margaritatus*. Further differences between *analis* and both *notatus* and *margaritatus* lie in the coloration of the body, head, and fins, as specified in items 6c, 6e, and 6d of the key (pp. 475–476).

Dorsal II–38 (II–39); anal 36 (36); pectorals 19-20 (20-20); pelvics 1, 2. Gill rakers on lower part of first arch 16 (16). Palatine teeth caninlike, very slightly curved backward, 7 to 9 in the single series on each side, the anteriormost teeth strongest; vomerine canines 1 or 2 at each outer angle of bone; rather strong, very slightly curved backward; premaxillary teeth conical; mandibular teeth biserial anteriorly, with the inner row continued backward as strong canines. Peritoneum brownish black. The coloration of body, head, and fins is given in the key, under item 6c (p. 475).

Measurements in thousandths of the standard length: Greatest depth, 181 (185); distance from tip of snout to origin of soft dorsal, 324 (336); to origin of spinous dorsal, 268 (275); from tip of chins to anus, 372 (388); length of head, 273 (280); interorbital width, 85

* Items in parentheses are for the paratype.
(66): length of orbit, 58 (61); of upper jaw, 137 (150); of snout, 63 (73); distance from tip of lower jaw to tip of V of branchiostegal row of photophores, 81 (85); least distance between the nearly parallel ventral rows of photophores, 31 (37); from anus to anterior extension of ventral row of photophores, 156 (160); height of pectoral arch of pleural row of photophores, 42 (42); length of this arch, 88 (92).

It is possible that specimens of this species have been reported under another name. The material recorded from the Gulf of California by Jordan and Gilbert (1882a, p. 274), Evermann and Jenkins (1891, p. 162), and Breder (1936, p. 47) in particular should be reexamined with this idea in mind.

*analis*, pertaining to the anal (fin), with reference to the increased number of rays.

**Porichthys margaritatus** (Richardson)

**Figure 57, d**

*Batrach* (*margaritatus* *Richardson, 1844, pp. 67-69, pl. 38, figs. 2-4 (original description)).

**Porichthys margaritatus** *Jordan and Gilbert, 1882b, pp. 201-202 (notatus a synonym; comparison); 1883a, p. 629 (Central America).—*Jordan, 1884a, p. 291 (Panama record; distinct from porosimus); *1884b, p. 41 (range and synonymy; in part); 1885a, p. 388 (Panama): 1885b, p. 116 (in part).—*Meek and Hall, 1885, pp. 55-57 (synonymy; in part; distinct from porosimus).—*Evermann and Jenkins, 1891, pp. 127, 162 (synonymy; in part; Guaymas record, not verified).—

*Jordan and Starks, 1885, p. 840 (notatus distinct; nauphopodia is a synonym).—*Jordan and Evermann, 1886, pp. 2519, 2522-2523 (description, synonymy).—*Gilbert and Starks, 1904, pp. 184-185 (Panama record).—

*Meek and Hilsenhoff, 1928, pp. 922-924 (synonymy, description).—

*Jordan and Starks, 1886, p. 47 (records, northern part of Gulf of California to Perlas Islands, Panama—perhaps in part based on other species).—*Rumph, 1890, pp. 171-172, 182 (original description, records).—

*Porichthys notatus* (presumed misidentification) *Boulenger, 1890, p. 3 (Rio Tuy, Darien).—*Greene, 1890, p. 698 (Panama).—

*Porichthys nauploedium* *Jordan and Holman, 1890, pp. 171-172, 182 (original description, records).—*Greene, 1890, pp. 698, 678 (photophores; name misspelled nauploedium). (Type locality: Pacific Ocean off coast of Colombia at Albatross station 2902, lat. 8°38' N., long. 78°31'30'' W., in 16 fathoms.)

Some doubt is attached to the use of the name *margaritatus* for the species more recently named *nauploedium*. The original description
FIGURE 57.—Diagrams of the under side of the head and anterior portion of the body illustrating the course of the photophores in: a, Nauta epodioides porosusimus; b, Porichthys mystacaler; c, P. greenei; d, P. marmoratus.
and figure of *Batracus margaritatus* probably represent this species, although the anal rays are given as only 26 and the 8 dorsal saddles are indicated as merely dusky and as not being interspersed by smaller spots. Nor are any small spots shown on the top of the head. The marginal spots on the soft dorsal are barely indicated. In these respects this original account of *margaritatus* agrees better with the specimens discussed already as *Porichthys* species. The anal-ray count was likely an error, however, and the discrepancies in coloration are likely attributable to the small size (3.75 inches) of the type of *margaritatus*. The figure clearly shows the disconnected vertical fins and the simple V-shaped pattern of the branchiostegal photophores characteristic of *margaritatus* (also *swalli* and *notatus*) as contrasted with *greenei*.

One of the best distinctions between this species and *P. notatus* lies in its longer pleural row of photophores, which, instead of ending abruptly above end of second third of anal base, is continued backward nearly to the end of the fin. This same arrangement was noted by Greene (1899, p. 676) for the 3 specimens from Alaska that he referred to *notatus*. Unless these are examples of *margaritatus* with erroneous data, they would seem to represent an undescribed species. We have seen no specimens of *Porichthys* from Alaska, and the only record for Alaska we have found is that of Sitka, given by Starks and Morris (1907, p. 230) as the northern limit of range for *notatus*.

The 6 specimens from La Paz Bay, near Cape San Lucas, agree well with the series at hand from Panama, Colombia, and Galapagos. In 3 specimens from Indefatigable Island, 65 to 89 mm long, there are about 7 bands, without intermediate dark mottlings. The dark mottlings in the vicinity of the first dorsal are inconspicuous.

The following collections of *Porichthys margaritatus* in the National Museum have been examined: U.S.N.M. nos. 41145 and 41164, from lat. 7°56' N., long. 79°41'30" W.; 41161, Indefatigable Island; 41192, La Paz Bay, Mexico; 41287, Pacific (Panama?); 41491 and 41492, from 7°57' N., 78°55' W.; 101726, Pinas Bay; 101727 and 101728, Pinas Bay, north of first small island, coarse sand; 101729, Port Utria, Colombia; 101730, Port Utria, Colombia, mud; 101731, Pinas Bay, Bight of Bay, Panama, sticky mud; 101736, Gorgona Island, Colombia, near Gorgonilla Channel; 101737, north end, Gorgona Island, Colombia.

The following collections of *Porichthys margaritatus*, in the Natural History Museum of Stanford University, have been examined: No. 227, Indefatigable Island; 5849, Indefatigable Island.

* Listed as type of *P. neotompedium*.
* Listed as octotype of *P. neotompedium*. 
Should the genus *Porichthys* be further dismembered, this small species would probably be the first to be set apart, on the basis of the conjoined vertical fins, the usually simple (nonfimbriate) pores of the lateral lines, the lack of minute photophores about the pores of the dorsal branch of the lateral line, the short median branch extending forward from the apex in the branchiostegal row of photophores, and the rounded pectoral fin.

The following collections of *Porichthys greenei* in the National Museum have been examined: U.S.N.M. no. 76548, Panama Canal, Panama City; 81689 and 81690, tide pool, Panama; 81691 and 81692, tide pools, Balboa, Canal Zone; 81693, Panama Bay, Balboa, Canal Zone; 81965, Chame Point, Panama; 101732, 101733, and 101946, all from Secas Isle, Panama.

The following collections of *Porichthys greenei* in the Natural History Museum of Stanford University have been examined: No. 6485 (type), Panama reef; 6512, Panama.

Genus *Naupadedium* Jordan

*Naupadedium* "Jordan, 1919, p. 342 (diagnosis).

*Orthotypy.*—"Porichthys pleurodon Jordan and Gilbert = Batrachus porosissimus Cuv. & Val."

We follow Jordan in distinguishing generically between the single Atlantic species and the several Pacific forms commonly referred to *Porichthys*. The prime difference lies in dentition. In *Porichthys* the palatine and premaxillary teeth as usual in fishes are directed slightly backward, whereas in *Naupadedium* the palatine teeth are directed forward in the adults of both sexes and the posterior premaxillary teeth are directed forward in the adult male. Both the palatine and the premaxillary teeth are much more enlarged in the adult male than in *Porichthys*. The few (usually 3 to 6) developed palatine teeth are confined to the front of the bone, instead of being spread along the entire edge. Meek and Hildebrand (1928, p. 922) did not accept the genus, and we do not regard it as very trenchantly distinct.
The marked age variations and sexual dimorphism in the teeth of *Nautopaeium porosi88im* largely explain the discrepancies in published descriptions.

**Nautopaeium porosi88imum** (Valenciennes)

*Balirachus porosi88im *Valenciennes, in Cuvier and Valenciennes, 1837, pp. 501-506 (original description; pre-Linnean synonymy).—Jenyns, 1842, pp. 99-100 (Bain Biancos).

*Porichthys porosi88is *Girard, 1855a, p. 141 (new combination).—*Gunnern, 1861, pp. 176-177 (marginatus and notatus as synonyms, description).—*KNER, 1865, pp. 190-191, pl. 8, figs. 1, 2 (description; Rio de Janeiro).—Jordan and Gilbert, 1882b, p. 291 (comparison); 1883a, pp. 731-732 (description; in part).—*Jordan, 1884a, p. 291; 1884b, p. 41; 1885b, p. 116 (teeth, range; *plectodon* as synonym).—*MEER and Hall, 1885, pp. 56-57 (teeth, synonymy).—Jordan and Swain, 1885, p. 545 (Pensacola, Fla.).—Jordan, 1886, p. 229 (esten by red snappers, Snapper Banks, Fla.).—*Pessona, 1891, p. 620 (Montevideo).—Bone, 1885, pp. 69-70 (synonymy; in part; South American records).—*Reed, 1897, p. 66 (Chile by error, Sde Delfin, 1901, p. 89).—*Jordan and Evermann, 1888, p. 2319 (description, synonymy).—1900, p. 3201, pl. 235, fig. 811.—Jordan, 1914, vol. 2, p. 596, fig. 491.—*Reed, 1914, p. 23 (off Cape Frio, Brazil).—*Rimero, 1915, pp. 1-4 (description; Rio de Janeiro).—*LEVERNE, 1924, p. 258 (description; Uruguay).—*MEER and HILLEMANS, 1925, pp. 922-923 (description, synonymy, records).—Himes, 1861b, p. 206 (description, range). (Type locality: *De Surinam . . . Care­ne . . . Rio Janeiro . . . et de Sainte-Catherine, du Brésil*; commonly given as and hereby restricted to Surinam.)

*Porichthys plectodon* Goode and Bean, 1882, p. 229 (nomen nudum; Gulf of Mexico).—*Jordan and Gilbert, 1882b, p. 291 (original description); 1883a, p. 958 (description; South Carolina to Texas); 1883b, pp. 616, 620 (Charles­ton, S. C.). (Type locality: Galveston, Tex.)

The anal rays in *N. porosi88im* have been variously counted by different authors. In 24 specimens we count the dorsal and anal rays as indicated in table 4.

The following collections of *Nautopaeium porosi88imum* in the National Museum have been examined: U.S.N.M. no. 30894, Galveston, Tex. (types of *Porichthys plectodon*); 32801, Pensacola, Fla.; 39375 and 39376, lat. 28°50' N., long. 83°00' W., northwest end, St. Martins Reef, Fla.; 39877, off Cape Sable, Fla.; 44667 and 45995, from 10°37'40" N., 61°42'40" W.; 45751 and 45996, 33°20' N., 77°05' W., or 33°18'30" N., 77°07'00" W.; 47624, Alacran Shoals; 73040, off Northwest Channel, Fla., 24°40'40" N., 81°34'40" W.; 73041, Hawk Channel, Fla.; 73042, Pigeon Key Lake, Fla.; 73043, Pepperfish Key, Fla.; 73044, 29°46'10" N., 83°35'15" W.; 73045, Deadmans Bay, Fla.; 73046, off Key West, inside reef, Fla.; 73047, North Key, Fla.; 73048, Key West, Fla.; 73049, Deadmans Bay, Fla.; 73050, Pepperfish Key, Fla., 20°33'05" N., 83°23'08" W.; 83164 and 83168, from Rio de
Janeiro; 83833, 34°35′30″ N., 75°45′30″ W.; 83834, 34°38′00″ N., 76°12′00″ W.; 86118, Palma Sola, Fla.; 86740, coast of Uruguay; 87722, outside of bay, Rio de Janeiro; 87723, Uruguay; 87753, Santos [Barro]; 94375, off Cape Henry, Va.; 94549, Corpus Christi, Tex.; 100882, market at Santos, Brazil.

The following collections of *Nautopaedium porosissimum* in the Museum of Zoology, University of Michigan, were examined: No. 95501, Necococha, Argentina; 110159, off Englewood, Fla.; 106490, near Horn Island, Miss. (shrimp trawl).

The following collection of *Nautopaedium porosissimum* in the Natural History Museum, Stanford University, was examined: No. 9568, 10°37′40″ N., 61°42′40″ W.

**Table 4.—Dorsal and anal ray counts in Nautopaedium porosissimum**

<table>
<thead>
<tr>
<th>Dorsal</th>
<th>Anal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rays</td>
<td>Number of rays</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>24</td>
<td>5</td>
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<td>25</td>
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</tr>
<tr>
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<td>1</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
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</table>
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APPARENT PARTHENOGENESIS IN NATURE, IN A FORM OF FISH OF HYBRID ORIGIN

We are now clinching with experimental proof a number of ideas developed out of a study in systematic ichthyology. As these ideas express phenomena which are new for the vertebrates, this preliminary announcement is being published.

Through northeastern Mexico and the southern tip of Texas there occurs in abundance a form of viviparous cyprinodont, of the family Poeciliidae, which has been thought to be a distinct species, *Molliesisia formosa*. From circumstantial evidence we concluded that this form was probably the hybrid between *Molliesisia latipinnna* and *Molliesisia sphenops*, species so distinct that they were long placed in different genera. This form was found to be exactly intermediate between those species in all distinctive features—depth of body, strength of rows of spots, position and size of dorsal fin and number of dorsal fin rays. These characters are all closely correlated and may be briefly illustrated by the usual number of dorsal rays: 9 in *sphenops*, 11 in "formosa" and 13 in the local race of *latipinna*.

*Molliesisia "formosa"* varies somewhat geographically, but in each region it is intermediate between the particular local forms of *sphenops* and *latipinnna* which occur there. Recently we have received an apparent hybrid from the Yucatan Peninsula, exactly intermediate between the local race of *M. sphenops* and *M. velifera*. The dorsal rays are 13, midway between the approximate average for the local *sphenops* (9.5) and for *velifera* (17.5).

In the laboratory, a culture of males and females of this supposed hybrid stock, obtained by Dr. Myron Gordon in Rio Papaloapan, Vera Cruz, Mexico, has shown various reproductive abnormalities. Although several of the females apparently have become pregnant, only one of them in our aquaria has delivered young, two in one brood and one in the next brood (a female *Molliesisia* of this size should produce 10 to 60 young in a brood). No such lack of fecundity is apparent in the initial cross producing the hybrids,
nor in the back crosses with the parent species. Most of the apparently pregnant females reverted to a thin condition, as though resorbing young. A rather high percentage of the young are abnormal, and most or all of the abnormal ones are developing into males. An unusually high percentage of the adult males develop irregular black blotches.

The hypothesis that *Mollieni8ia “formosa”* is the hybrid of *M. latipinna* by *M. sphenops* has just been verified by an aquarium mating of a male *sphenops* and a virgin female *latipinna*. The 22 young produced are clearly hybrids. We also have apparently pregnant females from the reciprocal species-cross.

This verified hybrid exists in nature in great abundance. Many hundreds of specimens have been collected. It has almost every characteristic of a species: a definite, homogeneous range; clear consistency of characters, and, as shown below, the ability to reproduce in approximate genetic constancy. This constitutes the nearest approach known to us of a demonstration that hybridization plays a rôle in the process of speciation of animals.

The outstanding peculiarity in the natural relations of this hybrid form is that it exists over much of its range only as females. Not a single male has been found, among about two thousand specimens examined, from Tamaulipas and Texas. Such a condition obtains among invertebrates, but has not previously been encountered among the vertebrates. The only male hybrids we have seen from nature are those from the Río Papaloapan, where or near where both parent species occur together. Where this hybrid form exists in nature solely as females, it occurs with only one of the parent species; never with neither. In Tamaulipas it lives with *M. sphenops*, well inland from the coastwise range of *latipinna*. In Texas it abounds in the resacas of the Brownsville region, in company with *M. latipinna*, but considerably farther north than *sphenops* occurs in the coastal area. Yet the female hybrids of these two regions appear virtually identical, in all their characters. For example, they both usually have 11 dorsal rays.

Our natural supposition was that these female hybrids can mate only with *sphenops* males in the Tamaulipas streams, and only with *latipinna* males in Texas. Since the males thus assumed to be utilized
are very different, while the offspring are entirely alike (and all females) in the two areas, some genetic process very peculiar for a vertebrate must be involved.

This supposition has been completely verified in our aquaria. A number of females of _M. "formosa_," from Porlón in Tamaulipas and from near Brownsville in Texas have produced young after being received from nature. Although the females from Tamaulipas had almost certainly mated with males of _M. sphenops_, while those from Texas had mated with males of the very different _M. latipinna_, they have to date produced several hundred young, showing throughout a marked uniformity in characters. Neither lot of young (many already adult) shows any apparent approach toward the charactera of the male involved. The characters of the female parent have been inherited as a block. Although the broods have been large and many, not a single male has appeared among them. This result is wholly consistent with and explanatory of the occurrence of females only in nature, in the regions from which the two stocks came.

That we are dealing with entirely matroclinous inheritance has been proved by controlled matings. Virgin female hybrids, which have never been with any males, mate readily with males of either parent species, and soon become pregnant. At the time of writing, two such hybrid females of the Texas stock, mated with males of _M. latipinna_, have already given birth to purely matroclinous young.

The consistent and abundant production of purely matroclinous and constantly female offspring by this hybrid form of fish finds its most plausible explanation as parthenogenesis. It is apparently not a spontaneous parthenogenesis, since many controls, unmated, have shown no indication of becoming pregnant. We provisionally assume that we are probably dealing with a case of gynogenesis (parthenogenetic development initiated by sperm which for some reason is prevented from taking part in heredity)\(^1\)—a condition recorded as naturally occurring in nature.

\(^1\) Wilson excludes gynogenesis from the limits of parthenogenesis, but his classification of reproductive methods on the basis of differences in the manner of egg activation seems less logical and less significant than one based on the genetic constitution of the offspring. Parthenogenesis we regard as unisexual reproduction, as the result of which the offspring are genetically like the mother.
among certain invertebrates, but not among vertebrates. This hypothesis does not exclude alternatives, and requires cytological verification. Plans have been made for this cytological investigation.

The breeding experiments with these fishes are being rapidly expanded, and further results are anticipated in the near future (as many as three or four generations in a year are possible). The matings already productive are being repeated, and many other matings have been and will be made, between the numerous stocks we have from localities between Mississippi and Panama. Inbreeding and back-crossing of the young hybrids we have produced in wholly controlled matings will of course be carried out. Attempts will be made by both individual and mass matings, starting with the assumed original material, to fully recreate the uniquely characterized and peculiarly distributed hybrid form under discussion. The anticipated results of breeding both natural and aquarium-reared male hybrids to female hybrids known to be virgin, and to females of both the parent species, will be vital to the analysis of the origin and distribution of this form with such surprising reproductive behavior.

These viviparous poeciliid fishes, not only of *Mollienisia* but also of other genera, furnish prime material for studies in experimental evolution. The researches by Winge, Gordon and others have already shown how valuable this material is in the interpretation of the gene and chromosome basis for the development of characters and for the production of sex. A genetic explanation for the production of wholly female and purely matroclinous young by the hybrids in *Mollienisia* may contribute critical data for the solution of these problems.

In conclusion, the conditions demonstrated by this study, so far as we know novel in the biology of the vertebrates, are: (1) The abundant occurrence in nature of a form of demonstrated hybrid origin, having nearly all of the characteristics of a natural species; (2) the occurrence of a form as females only, over a wide portion of its range; (3) the consistent and abundant production of wholly female and purely matroclinous young; (4) apparent parthenogenesis in nature.

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Species and Hybrids of *Mollienisia*

By

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SPECIES AND HYBRIDS OF MOLLienenia

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IN responding to requests for an article on the species and hybrids of Mollienenia, I want first of all to ask my readers to do some quick forgetting. A more-than-usual number of errors have in one way or another crept into the general understanding of the species of Mollienenia, and of their breeding behavior.

Thus the name Mollienenia sphenops is often applied by aquarists to the black sport or melanistic mutation of Mollienenia latipinnna, whereas Mollienenia sphenops, as indicated below, is a distinct species which is normally not black.

The hybrid between latipinnna and sphenops has been named Mollienenia formosa, but to make matters worse this name formosa has been wrongly used. Thus the eminent German aquarist Rachow figured typical sphenops under the name formosa, while the great English ichthyologist Regan applied that...
abused name to latipinnna from Tam­
pico and also to sphenops from Panama.  
Presumably neither Rachow nor Regan  
ever saw the true formosa, which is in  
a way also a misstatement, since that  
name was based on a hybrid.

Another misconception, apparently  
less general, is that the magnificent spe­
cies Mollie-nis ia velifera is merely the  
better developed individuals of Mollie­
nis ia latipinna.

To detail the mistakes of ichthyo­
logists in attempting to build up a sound  
classification of the species of Mollie-nisi­
a would carry us too far away from  
our common interests, and would con­
sume more pages than the editor would  
spare. Suffice it to say that the fish sci­
centists have blundered even more than  
the fish fanciers.

Mollie-nis ia is a genus belonging to  
the viviparous (live-bearing) family  
Poeciliidae. In one form or another this  
genus is too well known to aquarium  
fanciers to require any extended general  
introduction.

The species of Mollie-nis ia fall natu­
 rally into two types, the latipinna group  
or sailfins and the sphenops or short-finned mollys. In the first and  
more familiar group (Figs. 1-5) the  
dorsal or back fin contains twelve to  
nineteen rays and in the adult male  
 begins well toward the head. In the  
sphenops group (Figs. 6-8) the dorsal  
fin has only eight to eleven rays, and  
this fin begins behind or at most near  
the middle of the length of the fish, not  
including the caudal or tail fin. This  
difference is readily seen in the pictures.

The Sailfins  
(Mollie-nis ia velifera and Mollie-nis ia  
latipinna)

First, naturally, comes the king of the  
live bearers, the gorgeous Mollie-nis ia  
velifera of Yucatan (Fig. 1), half again
as large and splendid as our native *latipinna*. His crowning glory, literally, is his resplendent dorsal fin, beginning immediately behind the head, and extending over a base which is more than half as long as the head and body, without tail fin. The dorsal rays number sixteen to nineteen. The lighter markings on this fin are in the form of dark-ringed spots. The breast and throat are bright brassy, while the sides of the body and the main fins shine out in metallic blue reflections. The colors show up best when two more-than-four-inch males display before one another, spreading their great iridescent fins almost to the breaking point. Broods run as high as 120, and the young are robust and heavy-set from birth.

A relative of *Mollienisia velifera*, known only from Lake Petén in Guatemala, is *Mollienisia petenenis*. So far as I know it has never reached aquarists, but we may get some on our prospected fish survey of that lake.

Another cousin of *velifera* is the best known species of the genus, namely, *Mollienisia latipinna*. This is the common sailfin of the Southern States, ranging from southern Georgia to Key West, thence around the whole Gulf coast to Texas, and down the east coast of Mexico. Over this long range the species breaks up into local races or subspecies, some of which rather closely approach *velifera* in size and in development of fins. The salt-water races of Key West and Pensacola Bay are particularly fine. A pair of the typical subspecies—an average race, which occurs in fresh water from Florida to Louisiana—is shown in Fig. 3. Near Brownsville, Texas, there occurs a small race (Fig. 5) of *Mollienisia latipinna*, which though bright in color is much less like *velifera*. The dorsal fin is smaller, and
Fig. 5—Molliebla latipinnna: A Pair from near Brownsville, Texas.

has only twelve to fourteen rays. The relatively poor development of latipinnna here (and about Tampico) may be due to the fact that its ancestors were not too careful in choosing mates, occasionally hybridizing with Molliebla sphenops. Toward the north end of the range of the species, in northeastern Florida and southeastern Georgia, the species is also much reduced in size and general development, probably because the temperatures there are rather low for the genus.

Were it not for the superior elegance of velifera, we would rank Molliebla latipinnna as king; as it is, we may dub him the prince of the live bearers, and the crown prince at that. A good male has his "crown," or dorsal fin, beginning not far behind the head, and when laid down overlapping the caudal fin. The base of the fin is rather less than half the length of the fish (without the tail fin), and the fin contains twelve to sixteen rays. The dark markings on the dorsal fin form streaks, but do not surround round light spots. The dorsal and caudal fins and the body show the same sort of brilliant blue and brassy reflections as in velifera. Watching a fine male court his more somber lady is a sight never to be forgotten. He slides up alongside of his mate of the moment, then heads around quickly in front of her, the better to display his greatest entrancement, the dorsal fin held taut like a peacock's tail, and similarly resplendent with metallic sheens. He may also use the fin in more practical fashion, as a net to hold back the female if she tries to avoid his advances. At times, unable to restrain himself in his customary dignity of movements, he will flash almost instantaneously, right-left, right-left, in front of his lady love. As though most concerned in the display of his nuptial dress, he actually mates with the females less often than do his smaller and less ornate cousins. The transference of sperm into the oviduct of the female is accomplished by means of the modified anal fin (gonopodium), in an almost instantaneous act.

The Short-Finned Mollies

(Molliebla sphenops and Molliebla latipinnna)

The true Molliebla sphenops is the species represented as Fig. 6. It has nothing to do with the black molly, which is merely a sport of Molliebla latipinnna. It is distinguished from Molliebla latipinnna chiefly in having the dorsal fin much smaller, confined to the
second half of the body length not including the caudal fin, and containing eight, nine or ten dorsal rays, depending on the race. It is usually a small fish, some races being not tremendously larger than the guppy, although other races are as big and robust as *relifera*. Over its immense natural range (northern Mexico to northern South America) it is represented by an undetermined number of local races, or subspecies. We must be content to illustrate only the typical subspecies from the Vera Cruz region. The male shown in Fig. 6 is a bright and active fish, with lemon-yellow bands near the margins of the dorsal and caudal fins. The caudal is especially fine, as the male seems to realize when he displays in front of a mate.

Other subspecies of *Mollieoisiia sphenops* are very different in color and in fin development. We are breeding three kinds, but have seen many other kinds as preserved specimens. They will probably all prove to be active and attractive, and to breed well in warm aquaria (we run our aquaria in the upper seventies, rarely dropping a bit below 70 degrees and rarely going much above 80 degrees Fahrenheit). They feed well on dried shrimp and other prepared foods, as do the other species of *Mollieoisiia*, and, like them, also enjoy algae from the sides of tanks. They do not eat their young (we have found this true of our *latipinna* also, though *relifera* is sometimes cannibalistic).

The second species of short-finned *Mollieoisiia* is *Mollieoisiia latipunctata* (Fig. 7). This is as closely confined in nature as *sphenops* is wide-ranging. It occurs only in the Río Tamesi and its tributaries, just north of Tampico, Mexico. It lives there with *sphenops*, but so
far as we know does not hybridize with it. The females always show a row of black spots along the sides. The males (Fig. 7, insert) are very splendid little fellows, with a high dorsal fin (of nine to eleven rays), strongly peppered with black specks, as is also the caudal fin. The black markings along the side are faint, but dark bars show up. On the lower sides of the body are rows of orange spots, faintly shown in the figure.

_Mollieniia latipunctata_ was introduced into America a few months ago by Dr. Myron Gordon, and is apparently not known in Europe. It is rather attractive and, of course, novel in aquariums, but if our experience is a criterion, has one drawback. It produces very small broods, and though the young are very large at birth, they develop very slowly.

A third short-finned species, _Mollieniia dominicensis_, is now recognized from the island of Haiti, but it has apparently not reached aquarists.

**Hybrids**

We have not yet succeeded in crossing any species of _Mollieniia_ with any other genus of the family. Males of _Lebistes reticulatus_, _Gambusia affinis_ and _Poecilistes pleuroxipilus_ have mated with females of _Mollieniia_ in our aquarium, but as yet we have had no young as a result. We would greatly appreciate hearing of any young produced from any cross-matings between these or any other of the live-bearing genera (other than the common _Platyphoecus_ × _Xiphophorus_ cross), and if possible we would like to see the specimens. To be sure of the male parentage of the young of a live-bearing fish, one should be certain that the mother was never associated with mature males of more than one species. The females, as is well known, store the sperm for months.

Hybrids do occur, however, between the species of _Mollieniia_. The upper fish shown in Fig. 2 is almost certainly a hybrid between _Mollieniia velifera_ and _Mollieniia sphenops_. This combination is not well known, for I have seen but one specimen (not the one figured). These two specimens are regarded as hybrids because they are intermediate in color and in the size and position of the dorsal fin and in the number of rays in that fin. The two hybrids have thirteen and fourteen dorsal rays respectively, while the Yucatan _sphenops_ has nine or ten, and the Yucatan _velifera_ sixteen to nineteen.

The hybrid between _latipina_ and _sphenops_ (the supposed species _Mollieniia formosa_) we have learned to know very much better. These hybrids are also intermediate in almost all characters between the parent species. Thus the number of dorsal rays is usually eleven, as compared with nine in the subspecies of _sphenops_ of northeastern Mexico, and thirteen in the local race of _latipina_. These hybrids are not uniform from different localities, but take on to some degree the characteristics of the particular race (subspecies) of _sphenops_ which gave rise to them.
In some parts of Mexico both male and female hybrids occur. The only specimens of male hybrids we have seen are included in the fish caught by Dr. Gordon in the Rio Papaloapan in Mexico, for the Crescent Fish Farm (we are much indebted to Mr. Schaumburg for specimens of these hybrids, and of other fishes used in our experiments). A few of these, one pair in focus, are shown in Fig. 8. The mature males are very fine aquarium fish, as they seem to show hybrid vigor in intensity of color. The dorsal fin is strikingly spotted with black; the body is often blotched with inky spots; the caudal fin is somewhat yellow toward the margin, and the breast and throat show the brilliant brassy yellow reflections of *velifera*. They vary a great deal in form and in color. They are very active in their feeding and especially in their mating behavior. They therefore have claims other than novelty to attract the aquarist. Unfortunately we have found them rather difficult to breed, but that may be partly our fault, as Mr. Schaumburg has done better along that line.

The strange circumstance about the *latipinna x sphenops* hybrids is that they exist only as females over much of their natural range. In part of this area, as in Tamaulipas, Mexico, these females live inland with *sphenops*, never seeing a *latipinna* male. Conversely, about Brownsville in Texas, the all-female hybrids live only with *latipinna*, because *sphenops* does not occur so far north.

The discovery of how this hybrid type maintains itself as one sex only in nature (where it is very abundant), is an example of how aquarium experiments can make contributions to biology. The explanation proves to be as follows: The female hybrids mate with either kind of male, *sphenops* or *latipinna*. The sperm from the male appears to be necessary to start off the development of the young, but the sperm does not seem to take any part in determining the inheritance of the young, for these are always exactly like their mother, showing no paternal characters whatever. This would appear to be a kind of parthenogenesis, the first case of natural parthenogenesis indicated for a vertebrate animal. The young are invariably females. These novel conclusions have all been checked in our aquarium matings, by which we have also been able to reconstruct this peculiar hybrid type, by crossing *Molliesia sphenops* with *Molliesia latipinna*.

**EDITOR'S NOTE:** Newspapers throughout the country have recently carried sensational items regarding the alleged discovery by Dr. Hubbs of a variety of fishes which are all females and which reproduce parthenogenetically—that is, without fertilization by males. The basis for this statement is the fact that in certain areas Dr. Gordon was unable, as above stated, to find any males of the *latipinna x sphenops* hybrids. To a news-hungry mind the conclusion of parthenogenetic reproduction would readily present itself. Dr. Hubbs' last two paragraphs clarify the situation and at the same time propose a new scientific thesis.
A NEW GENUS AND SPECIES OF CYPRINID FISH
FROM THE CAMEROONS, AFRICA

BY LEONARD P. SCHULTZ

The new cyprinid fish described below was found among a collection of fishes sent to the U. S. National Museum by the Museum of Comparative Zoology at Harvard College. The author wishes to thank the authorities of that institution for the privilege of making known the following new genus and species.

Prolabeops new genus

This new genus may be distinguished from other cyprinid genera by the form of the fleshy pad on the under side of the lower jaw (see figure) and by the lip of upper jaw being free from the transverse fold or flap extending across snout, so that the premaxillary is protractile, in combination with the following characters: no spine-like rays in dorsal or anal fins; eye above mid-axis of body and pupil in front of middle of head; a pair of barbels on each side of the mouth;

1Published with the permission of the Secretary of the Smithsonian Institution.
2Published with the aid of a grant from the Museum of Comparative Zoology at Harvard College.
A NEW BLENNY FROM BRITISH COLUMBIA WITH RECORDS OF TWO OTHER FISHERIES NEW TO THE REGION

BY

CARL L. HUBBS AND LEONARD P. SCHULTZ

(Received for publication February 15, 1932)
The nearest allies of *Allolumpenus* appear to be two recently described Siberian genera, *Askoldia* Pavleko (1910: 50) and *Lumpenopsis* Soldatov (1915: 635). From the former, as characterized by Soldatov (1927: 399), our genus appears to differ in having a slenderer form, scaleless head, larger pelvic fins and one instead of two anal spines. From *Lumpenopsis*, which appears much closer, *Allolumpenus* seems to differ only in having one instead of two anal spines; the snout less produced, and not overhanging the premaxillaries, the front outline of which in lateral view extends downward and forward instead of downward and backward, and in lacking vomerine as well as palatine teeth.

Among the genera occurring in North America, *Plectobranchus* is the one approached most closely by *Allolumpenus*. Diagnoses of *Plectobranchus* have been given by Gilbert (1890: 102), Jordan and Evermann (1898: 2431) and Gilbert and Thompson (1905: 985). From that genus ours differs in having the caudal distinctly separated from the other vertical fins; only one anal spine; the lower pectoral rays not markedly produced; the premaxillaries projecting; the vomerine and palatine teeth lacking.

*Allolumpenus hypochromus*, drawn by Grace Eager from the holotype

From *Plectobranchus* and apparently from the other genera mentioned, *Allolumpenus* is set off by a peculiar development of canine teeth in the jaws.

The following is the type species of this genus.

**Allolumpenus hypochromus**, new species

The type and only known specimen, 57 mm. long to caudal base, was collected off Newcastle island, near Nanaimo, on the east coast of Vancouver island, at a depth of 37 metres, on August 8, 1927.

Greatest depth, 9.5 in standard length; least depth of caudal peduncle, 3.1 in head. Width of head, 2.3, and depth of head, 2.0, in length of head. Posterior border of eye at middle of head length; eye and snout, each 4.0 in head; bony interorbital two-thirds as wide as pupil; least suborbital width, 0.3 diameter of eye. Upper jaw, 3.0 in head; maxillary extending to below end of anterior third or fourth of pupil; least distance from anterior edge of the hyoid prominence to free edge of gill membrane, 4.3 in head. Tip of snout to origin of dorsal, 1.1 in head; highest dorsal spine, 3.2; length of caudal fin, 1.4; height of anal spine equal to length of pupil; highest anal ray, 3.0 in head; length of pectoral fin, 1.3, and of pelvic fin, 2.3. Dorsal spines, 49; anal rays, 1,31 (counting...
last ray as branched); pectoral rays, 12; pelvic, 1,3; caudal rays, 20, 11 branched. Scales in one hundred and twenty-five transverse rows, and in thirty-four longitudinal rows in a series from origin of anal fin to eleventh dorsal spine.

The striking coloration of this species strongly suggests that of *Lumpenopsis pastenkoi* Soldatov (1915: 636). Differences, however, are at once apparent: there is no dark band on the head; the markings at the caudal base consist of a dorsal and a ventral black spot connected by a dark bar, rather than of a median spot with vertical prolongations; the dorsal saddles are obsolete, but in contrast the 11 ventrolateral bars—short black markings extending from near midline about halfway to ventral border of body—are very conspicuous (suggesting the name *hypochromus*, "colored below"). Just about the middle line are about 7 pairs of short vertical dashes, some of which are connected with a ventrolateral bar to form a Y. The anal fin is blackish, with a gray edge, but the other fins are plain light dusky, except for the dorsal spots. These dorsal fin markings, five in number, are almost exactly like those of *Lumpenopsis pastenkoi*, and also resemble those of the species of *Opisthocentrus*; they are slightly ocellated, and are located between the 11th and 12th, the 20th and 21st, the 29th and 30th, the 38th and 39th and the 44th and 46th dorsal spines. In line with these dorsal fin spots are the black spot at upper edge of caudal base and a small fleck between origin of dorsal and occiput.

*Sebastodes wilsoni* Gilbert (1915: 333, pl. 16, fig. 8).

Of this small but well-marked species, described from Monterey bay, California, and since reported from Oregon (Hubbs 1928: 13), a specimen 54 mm. long to caudal was taken on Swiftsure shoal, British Columbia, in 42 metres, on September 10, 1912, by Professor J. P. McMurrich, which extends its range far to the northward. This specimen agrees splendidly with Gilbert's acute characterization of the species (1915: 333, pl. 16, figure 8).

*Lycodapus fierasfer* Gilbert (1915: 369).

A small example was found in the mouth of a specimen of *Furcim anus diapterus* (Gilbert), taken in 220 metres in Howe sound, on August 29, 1928. It corresponds with published characterisations of the species, including the rather recent one by Gilbert (1915: 369).

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Records of the Rare Sunfish *Masturus lanceolatus* for Japan and Florida

By CARL L. HUBBS and LEONARD GIOVANNOLI

It has been the privilege of each of us to see a specimen of the little known sunfish or head-fish, *Masturus lanceolatus* (Liénard), one of the rarest of all the larger marine fishes.

The genus *Masturus* Gill (1884: 425), based on *Orthogoris oxystepterus* Bleeker (1873: 151), differs from *Mola* principally in having the caudal fin much wider, and produced medially into a rounded lobe. *Masturus lanceolatus* apparently differs further from *Mola mola* in being somewhat slendrer, approaching *Ranida* in this respect; in the more anterior location of the eye (nearer tip of snout than gill-opening, instead of in the middle of the head length); in having the dorsal profile of the head more evenly arched, and in the coloration.

The species was described by Liénard (1841: 291, pl. 4) from Mauritius, under the name of *Orthogoris lanceolatus*. What is thought to be the same species was described from the East Indies by Bleeker (1873: 151, pl.) under the name of *Orthogoris oxystepterus*. Jordan and Jordan (1922: 88, fig. 7) report an Hawaiian specimen, said by them to be the third on record, and this same specimen was redescribed andfigured by Fowler (1923: 387, and 1928: 474, fig. 80). Schmidt (1921a and 1921b), however, had already recorded the species from the North Atlantic, as had Collett (1896: 163, pl. 6, fig. 1), Streestrup and Lütken (1898: 54) and others before him.

While in Japan in 1929, the senior author saw a mounted specimen of *Masturus* two or three feet long, having the body and fin proportions as figured for *M. lanceolatus*. It was in a private aquarium-museum-zoo at Fukuoka. Through the kindness of Professor Hiroshi Ohshima we learn that this specimen was found in the fish market of Hagi, Yamaguchi Prefecture, near Shimonoseki, Japan. It was said to have been caught in the Sea of Japan. The exact locality is unknown, but the proprietor of the aquarium thinks that the fish was caught not far out from port. This is, we believe, the first Japanese record for the species.

On April 4, 1931, the junior author examined a huge specimen of *Masturus*, the first adult to be reported for North America. It had been caught on the night of April 2-3 by W. M. Oehler, near Daytona Beach, Florida. It was taken on an outgoing tide in a haul of a 225 foot seine, in a "low water slough" on the beach about 5 miles north of the small town of Ormond. The slough, which was 4 or 5 feet deep at the time, was small enough to be surrounded by the seine.

The sunfish was first sighted after it had been surrounded and was at

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1 This paper was presented at the 1931 meeting of the Society.

2 We have heard that two other specimens of the same species have been caught recently in the same region.
that time about 50 feet from shore, swimming with its dorsal fin projecting out of the water. It charged the net but the fishermen saw this in time to give it gradually enough slack to prevent its breaking through. It became tangled in the seine and thrashed around mightily, tearing the net but only getting itself more thoroughly trussed up. Mr. Oehler said they used the seine as a hand line to play the fish, giving it line when necessary and hauling it in when they could. They finally got it in water so shallow that it was forced to lie on its side but still gave them some trouble. The outgoing tide helped them to finally strand the fish. They were unable to get the heavy load on their truck, so they left it there and returned the next day. They put ice tongs in its eye and mouth and tried to drag it out but could not make progress except in low gear, so they secured help and finally about a dozen men using timbers, etc., were able to load it.

This Atlantic specimen, which has been mounted for exhibition by a local museum, corresponds well in form of body, fins and head, and in the position of the eye, with the several published figures of *Masturus lanceolatus*. The following measurements were made:

Total length to end of caudal, when fresh, 8 feet and 4 inches; hearsay weight, 1200 pounds; length of head, 19 inches; body thinner than head; thickness of head above eyes, 13 inches; distance from lower margin of eye to line joining middle of mouth with middle of gill opening, 2 inches; length to vertical from anus, 46 inches; vertical height of anal fin, 30 inches; vertical height of caudal fin at middle of main portion (median lobe excluded), 38 inches; length of caudal fin near middle of lower half, 17½ inches; length of caudal fin along midline, to apparently broken and recently healed tip, 26 inches. After the specimen had become somewhat dried out, the following measurements were made: total length 7 feet, 10 inches; length of body, 5 feet, 7 inches; length to vertical from anus, 46 inches; length to origin of pectoral fin, 22 inches; length of pectoral fin, 7 inches; vertical height of body above pectoral base, 19½ inches, and below pectoral base, 16 inches; greatest depth of body exclusive of fins, 38 inches; horizontal length of dorsal fin a little above base, 16½ inches, and of anal, 15½ inches; height of dorsal, 37½, and of anal, 30 inches. Counting rudiments the dorsal rays numbered 18; anal, 17; pectoral, 9. In the caudal fin there were 6 or possibly 7 above, and 9 or perhaps 10 below the median lobe, which appeared to contain no rays.

The middle of the produced caudal lobe was thickened, as though the vertebral column extended into it, but was jointed at its contact with the body, just as were the dorsal and anal fins.

The Florida specimen was a dirty grayish brown, apparently with indistinct irregular spots of the same color in darker shade, on the upper sides. The numerous pale blotches characteristic of the species became most distinct and roundest on the lower half of the caudal fin.

Three circumstances led Collett to the supposition that the sunfishes called *Masturus* might merely be abnormal individuals retaining a larval character. These circumstances are: (1) the extreme rareness of this type; (2) its sporadic appearance, in space and time, and (3) the possession by the postlarvae of *Mola* of a median caudal process suggesting that of
Masturus (see Schmidt, 1921a and 1921b). Other differences, particularly the more anterior position of the eye, indicate however that Masturus lanceolatus is really distinct, and Schmidt has proved that this species possesses peculiar postlarval characters, and that the caudal process of the adult Masturus is a secondary development which follows the abortion of the primary tail.

Schmidt (1921a: 13) referred to lanceolatus postlarval specimens described by different authors, from various localities, including Bahama Banks, Massachusetts Bay and off Pensacola, in North America.

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POECILICHTHYS OSBURNI, A NEW DARTER FROM THE UPPER KANAWHA RIVER SYSTEM IN VIRGINIA AND WEST VIRGINIA.

CARL L. HUBBS AND MILTON B. TRAUTMAN.

The handsome percid named and described in this paper is the fifth species of fish to be indicated as characteristic of the upper Kanawha system. The others, all cyprinids, are Notropis scabriceps (Cope), N. kanawha Jordan and Jenkins, Phenacobius teretulus Cope and the recently described Parexoglossum laure Hubbs (1931). All of these species occur, so far as known, solely in the Kanawha River basin above the Kanawha Falls, the position of which is indicated by the arrow in Fig. 1. This upper Kanawha River system, the outlines of which are indicated by the black line in Fig. 1, is in other ways set apart, from the standpoint of fish distribution, as one of the most distinctive subdivisions of the vast Mississippi system.

The Upper Kanawha system is a cut-off portion of the Ohio River system, which is the chief home of Poeciliichthys variatus (Kirtland), the only species with which P. osburni is closely related. The range of P. variatus is also indicated, by record stations and by assumed limits, in Fig. 1. The basis for mapping the distribution of P. variatus may now be indicated by states:

DATA ON THE DISTRIBUTION OF POECILICHTHYS VARIATUS.

All records refer to the Ohio River system, except for the single record stations each in Arkansas and Missouri.

NEW YORK.—Recently collected by Dr. John R. Greeley in French Creek, in Chautauqua County, near the western boundary of the state.

PENNSYLVANIA.—Recorded by Bollman (1886: 330); McConnell (1905: 178); Fowler (1919: 70), and Fowler and Carlson (1927: 72). We have no reason to doubt the validity of any of these reports, although only the specimens recorded by Jordan have been seen. One new record for the state, for French Creek, near the New York state line, is indicated on the map. Specimens were recently taken there by Dr. Greeley.

OHIO.—This species was originally recorded from the Mahoning River by Kirtland (1838: 108 and 192), who added, "I am indebted to Mr. Charles Peace for a specimen of the same species taken in the Cuyahoga," which is a small river entering Lake Erie at Cleveland. Unfortunately this record is probably incapable of verification because the stream is now badly polluted. The doubt as to the validity of this record is increased to an almost certain indication of error when we recall that Kirtland mentioned only the Mahoning
River in describing the species (1840: 274, Pl. 2, Fig. 2); that he did not recognize the species now known as *P. coeruleus* until 1854 (p. 4); that he in 1850 (p. 1) recorded *variatus* not only from the Mahoning and Scioto rivers, but also from Chicago, Illinois, and that he, according to Jordan (1885: 163) later regarded Storer's *Etheostoma coerulea* as identical with his own *variatus*. These circumstances warrant us in questionably referring Kirtland's two records of *variatus* from the Great Lakes drainage to *Poecilichthys coeruleus*, which is there the most abundant of bright-colored darters. A few other Ohio records of *P. variatus* are given by Henshall (1888: 80), Osburn and Williamson (1898: 26) and Osburn (1901: 67), but the majority of the records indicated in Fig. 1 were made recently by the Lake and Stream Survey of the

![Map of the distribution of Poecilichthys osburni and P. variatus.](image)

**Fig. 1.** The distribution of *Poecilichthys osburni* and *P. variatus*.

The supposed range of *P. osburni*, surrounded by a solid line, is the drainage basin of the upper Kanawha system, above the Kanawha Falls, which are located by the arrow.

The range of *P. variatus* as now provisionally determined is surrounded by broken lines.

The solid squares locate the two record stations of typical *P. osburni*.

The hollow square locates the locality where the variant type of *P. osburni* was found.

The solid circles indicate the confirmed record stations for *P. variatus*.

The hollow circles represent the unconfirmed record stations for *P. variatus*. 
Ohio Division of Conservation. Other reports of variatus for Ohio, as Jordan's (1882: 973), refer either to Poecilichthys corneatus or to Hadropterus maculatus (see Jordan, 1885: 163).

Indiana.—Reported by Jordan (1885: 163); Evermann (1896: 8); Evermann and Bollman (1886: 339); Woolman (1892: 280); Hay (1894: 278), and Cockrell (1913: 156). Some doubt pertains to the last record, which may have been based on specimens holding over on erroneous identification.

West Virginia.—Neither Goldsborough and Clark (1908) nor other authors have recorded Poecilichthys variatus from West Virginia. The junior author, however, has seen specimens recently taken by John Addair in the Guyandot River at Justice City, Mingo County; in the Tug Fork at Gates in the same county, and at Mohawk in McDowell County, and in Pigeon Creek, an eastern branch of the Tug, at Delberton, Mingo County. We are obliged to Mr. Addair for permission to announce his discovery of this darter in West Virginia. In West Virginia, P. variatus is apparently generally distributed except in the territory of P. osburni—the Kanawha basin above the falls.

Kentucky.—Recorded by Woolman (1892: 280), and Evermann (1918: 358). Some of Woolman's specimens have been re-examined. Evermann's record for the South Fork of the Cumberland was of course based on P. corneatus, which in 1878 passed under the name of variatus.

Tennessee.—Evermann and Hildebrand's (1916: 450) record, the only one for the state and for the distinctive and rather well-worked fauna of the Upper Cumberland system, though indicated as a hollow circle on our map, is not accepted without reservation. The record was accompanied by no description and was based on only one specimen, which we have not been able to relocate.

Arkansas.—The only published records of P. variatus for any locality outside of the Ohio basin are (1) the doubted one for Easton, in the Delaware system of Pennsylvania (Jordan and Evermann, 1896: 1070), which record is indicated as surely erroneous by the finding of other western species in the Museum of Comparative Zoology similarly mislabelled "Easton, Pa." and (2) the record for the Arkansas River drainage of Arkansas by Hubbs and Ortenburger (1929: 48).

Missouri.—This Arkansas record station is rendered less isolated by the recent finding of this species in the Missouri River system of Missouri, by J. Clark Salyer. The specimens, corresponding well with topotypical ones of variatus, were collected in the Niangua River drainage near Marshfield, Missouri.

The intimate relationship of P. osburni with P. variatus is conclusively testified to by the agreement in many highly distinctive features of structure, form, color and habitat. They agree in having the anal fin unusually large and long, almost as large as the second dorsal fin, and the pelvic fins rather widely separated, for a species of the large group now usually thrown together as the genus Poecilichthys, in these respects approaching or resembling the forms of Ulocentra, Hadropterus and related genera. The two species further resemble one another in being, for their group, rather large and robust, heavy-finned fishes. In the male colors they agree in many features, notably in having bright orange vertical bars, an orange-carmine horizontal band on the lower sides anteriorly and scattered carmine spots on the pectoral fin. In both sexes, but most conspicuously in the young, the body in both species is marked by regular, oblique blackish saddles, much like those of the hog sucker Hypentelium. Agreement between the two species is close also in squamation, number of fin rays, etc. In correlation with their characters, both species inhabit extremely swift water, living among stones and boulders in rapids. The close relationship of P. osburni with P. variatus can scarcely be questioned.
The differences between *osburni* and *variatus* are nevertheless striking. *P. osburni* is the more terete; less arched and less elevated at the shoulders, and usually more slender (in adults the depth is contained in the standard length, 4.85 (rarely 4.55) to 5.3 times, instead of 4.3 to 5.0 (rarely 5.2) times). In *osburni* the snout is sharper and longer than in *variatus*, less bluntly decurved, and the eye is smaller; as a consequence, the eye is contained 1.2 to 1.5 times in the snout, instead of 0.9 to 1.0 times. The eye is contained in the head 4.0 to 5.2 in contrast with 3.4 to 4.05 times. The head averages smaller than in *variatus* (contained 3.7 to 4.2 as opposed to 3.4 to 4.0 times in standard length). The gill-membranes in *osburni* are less broadly united across the isthmus than are those of *variatus*, forming a sharper indentation posteriorly. The posterior part of the breast is usually scaleless in *osburni*, usually scaled in *variatus*. Numerical differences in number of scales, fin-rays and color markings are:

<table>
<thead>
<tr>
<th></th>
<th><em>P. osburni</em></th>
<th><em>P. variatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales above lateral line</td>
<td>8 to 10, usually 9</td>
<td>7 or 8, usually 7</td>
</tr>
<tr>
<td>Scales along lateral line</td>
<td>58 to 68</td>
<td>50 to 58</td>
</tr>
<tr>
<td>Scales below lateral line</td>
<td>12 to 14, usually 13...11 to 13, usually 12</td>
<td></td>
</tr>
<tr>
<td>Dorsal rays</td>
<td>XI to XIII, 13 to 15...XI to XIII, 12 to 14, usually 13</td>
<td></td>
</tr>
<tr>
<td>Anal soft rays</td>
<td>9 to 11, usually 10...9 or 10, usually 9</td>
<td></td>
</tr>
<tr>
<td>Black saddles on back</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Orange bars in male</td>
<td>11 or 12</td>
<td>5 or 6</td>
</tr>
</tbody>
</table>

The boldest of the differences in the colors of the males involves the orange bars. The yellow area, carmine-centered, which extends from the pectoral to the anus, is encroached upon from above by the anteriormost of the orange bars in *osburni*, whereas in *variatus* this area, as also the space above it, is free from these bars, which in that species are restricted to the posterior part of the body. The dark saddles are less solid and less blackish, and more tessellated, in *osburni* than in *variatus*. The yellow blotch on the cheek of the male is much more conspicuous than in *variatus*, in which it is represented merely by a lightening of the ground color, and centers in a bright red spot which is not evident in that species.

*P. osburni* apparently attains a larger size than *P. variatus* by about a centimeter. Our largest specimen is 86 mm. long to caudal fin.

We now proceed with the description of the new species.

**Poecilichthys osburni**, new species.

Kanawha darter.

*Holotype:* Cat. No. 92409, Museum of Zoology, University of Michigan, is a male 75 mm. long to caudal base, collected in Stony

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1One aberrant specimen from Ohio showed 16 soft dorsal rays and 11 soft anal rays; unconfirmed counts given in the literature give the dorsal spines as high as 14 and the anal soft rays as low as 7.
Creek, a tributary of the Greenbrier River, Pocahontas County, West Virginia, by John Addair, on June 2, 1931.

**Paratypes:** Seven male and female adults 60 to 86 mm. long, collected with the holotype; 2 males collected about a year previously at the same place; a female (90342, U. S. National Museum), collected many years ago by McDonald in Reed Creek, Virginia, and 7 male and female adults collected in the same stream, which is a western tributary of the New River, by Carl L. Hubbs and Edwin P. Creaser, on May 17, 1931, at a point two or three miles below Max Meadows, Virginia, at an elevation of 1,950 feet. The paratypes are deposited in the Ohio State Museum, National Museum and the Museum of Zoology, University of Michigan.

![Fig. 2. Poecilichthys osburni. (A retouched photograph of the holotype.)](image)

The courtesy of Mr. John Addair in allowing us to describe this darter is gratefully acknowledged.

The body is rather terete, as its greatest width is contained 1.4 times in the greatest depth. The anterior dorsal profile rises rather abruptly, though not so abruptly as in *P. variatus*, from the tip of the snout to above the eye, continuing to rise very gently to the middle of spinous dorsal, then curving gently downward to the rather deep caudal peduncle. The ventral contour approximates but is less curved than that of the dorsal. The mouth is rather small, low, subhorizontal, with included lower jaw. The teeth are small and subequal, and in rather broad bands on the jaws; there are teeth on the vomer. The premaxillary is non-protractile. The cheeks are rather conspicuously tumid. The preopercle is entire; the opercular spine is sharp. The gill-membranes meet at a somewhat acute angle, although they are still broadly joined.

The head is entirely devoid of scales (in *variatus* there are occasionally a few scales on the upper part of the opercle). The breast is also scaleless (rarely partially scaled near the ventral fins; this region is usually scaly in *variatus*). The lateral line is complete (occasionally a pore is missing).

The fins are all large. The two dorsals are joined (slightly separated in some paratypes). The highest dorsal spine is contained 1.35 times
in the highest soft ray. The pectoral fins are slightly longer than the head, and comprise 15 (rarely 14 or 16) rays, as in variatus. The caudal fin is subtruncate, slightly emarginate, with broadly rounded lobes.

This species is surely one of the most beautifully colored of the darters. The prevailing colors of the type and other adult males (described from fresh specimens in formaldehyde) are various shades of dark green and orange. The darkest color, a blue-black, appears on the occiput and on a vertical bar from the eye downward. The opercles are also very dark. The cheeks are largely occupied by a rhomb of bright yellow, grading into red medially. In front of the subocular bar is a similar though less conspicuous mark, obscured in high males. The middle of the snout is flushed with red. There are strong flushes of yellow on the lower surface of the head. The branchiostegal membranes are light yellow, and there is a bar of orange on either side of the midline, near the base of the lowest branchiostegals. The membrane between the mandibles is light yellow, while the rami themselves are metallic blue.

Twelve deep greenish-blue bars cross the trunk along the side of the body, not counting the large blotch at the caudal base, which together with a dark shade across the base of the caudal forms a more or less definitely triangular mark. The dark bars almost completely encircle the body behind the anus, and are rather narrowly conjoined dorsally. The twelve intervening light areas (not counting the dash of light behind the occiput), narrower and shorter than the blue bars, are deep orange. The lower third of the side of the fish, from just behind the pectoral base to near the anus, carries a brilliant horizontal blotch, grading from yellow at the edge to a brilliant orange-carmine medially; a most striking color feature, shared only with P. variatus. Medially the belly is pale. The breast is blackish blue between a pair of bright yellow spots which lie just below the pectoral fins.

The spinous dorsal is largely covered by a crescent of deep greenish-blue, paler on the spines than on the membranes; the basal crescent is lavender-gray, with a wedge of purplish brown on each membrane; the margin is a yellow band becoming an intense orange medially. The soft dorsal is dusky blue on the webbing, grading outward into gray within the sooty border; the gray portions of the membranes contain streaks of fire-orange; the rays themselves on their basal halves are scatteringly spotted with bright orange-red spots. The caudal is similar to the second dorsal, but the basal color is much lighter and the red spots are much more intense. The anal fin is green-blue on membranes of basal two-thirds; the rays outward are orange yellow, producing an interrupted band; the margin of the fin is milk-white anteriorly, but becomes sooty on membranes posteriorly. The pelvic is blackish green-blue, with the edges of the rays gray, and the spine and the outer border milk-white, and with some orange near border laterally. The pectoral fin is the lightest of all and the most brilliantly spotted with fire-orange; these spots are in three or four curved grayish streaks, which separate the green-blue ground color of the rays into rather definite curved bands; the outer part of the fin is yellowish on the rays.
No. 1  


AN OUTSTANDING FEATURE OF THE SPECIES IS THE DEVELOPMENT OF BLACK SADDLES, SIMILAR TO THOSE OF P. VARIATUS, BUT LESS SOLID, MORE TESSELATED BY BLACKENED SCALE BORDERS, AND MORE NUMEROUS; THERE ARE FIVE INSTEAD OF FOUR, THE EXTRA ONE BEING ACCOUNTED FOR BY THE PRESENCE OF TWO INSTEAD OF ONLY ONE ON THE CAUDAL PEDUNCLE. AN IMPERFECT SADDLE ALSO APPEARS BELOW THE MIDDLE OF THE SPINOUS DORSAL, IN A REGION WHERE SCARCELy ANY DARKENING IS EVIDENT IN VARIATUS. THE MOST CONSPICUOUS SADDLES, AS IN VARIATUS, ARE THOSE JUST BEFORE THE SPINOUS DORSAL, IN THE REGION BETWEEN THE DORSALS, AND BELOW THE POSTERIOR PART OF SOFT DORSAL. THE FIRST SADDLE, FUSED WITH THE FIRST DARK BAR, IS CONTINUED TO THE AXIL OF THE PECTORAL FIN.

THE YOUNG CLOSELY APPROACH BOLETOSOMA IN COLOR PATTERN.

MEASUREMENTS AND COUNTS OF HOLOTYPE: HEAD, 3.5; DEPTH, 5.0; EYE IN HEAD, 2.2; EYE IN SNOUT, 1.5; BONY INTERORBITAL, 2.7 IN EYE; LEAST SUBORBITAL WIDTH, 6.2 IN HEAD; UPPER JAW, 3.6; HIGHEST DORSAL SPINE, 1.4 IN HIGHEST DORSAL SOFT-RAY, 2.2 IN HEAD, 2.5 IN FIRST DORSAL BASE; HIGHEST DORSAL SOFT-RAY, 1.4 IN HEAD, 1.1 IN BASE OF SECOND DORSAL; LENGTH OF CAUDAL FIN, 1.5 IN HEAD; HIGHEST ANAL RAY 1.2 IN BASE OF FIN, WHICH IS CONTAINED 1.2 TIMES IN BASE OF DORSAL AND 1.7 TIMES IN HEAD; LENGTH OF LONGEST PECTORAL RAY, 0.95 IN HEAD, OF PELVIC FIN, 1.7. DORSAL RAYS, XIII-13; ANAL, II, 9; PECTORAL, 15. SCALES, 8-64-13.

VARIANTS.—TWO SPECIMENS, 30 AND 45 MM. LONG, FROM BIG REED ISLAND CREEK, AT AN ELEVATION OF 2,500 FEET, JUST BELOW AN OLD MILL DAM IN CARROLL COUNTY, VIRGINIA, COLLECTED BY HUBBS AND CREASER IN 1931, RESEMBLE THE SMALLER PARATYPES, BUT DIFFER NOTABLY IN HAVING THE DARK MARKINGS MORE TESSELATED AND DISRUPTED, AND THE SCALES MUCH LARGER, AS LARGE AS IN P. VARIATUS. OTHERWISE THEY ARE VERY SIMILAR, AND PROBABLY REPRESENT MERELY A LOCAL RACE. IT IS OF INTEREST THAT THEY WERE TAKEN IN A CREEK WHICH FLOWS INTO THE NEW RIVER ALMOST OPPOSITE REED CREEK, WHERE TYPICAL OSBURNI WAS TAKEN.

SOME MEASUREMENTS* AND COUNTS OF THE TWO ABERRANT SPECIMENS FOLLOW: HEAD, 3.5 AND 3.9; DEPTH, 6.0 AND 5.1; EYE IN HEAD, 3.7 AND 4.0; EYE IN SNOUT, 1.0 AND 1.25; DORSAL RAYS, XI-12 AND XII-13; ANAL RAYS, II, 8 AND II, 9; PECTORAL RAYS, 15 IN EACH; SCALES, 7-54 AND 57-11.

*In comparing these measurements with those previously given, allowance must be made for the fact that these specimens are immature.
We are happy to associate with this species the name of Dr. Raymond C. Osburn of Ohio State University—long a friend of the exquisite little percid fishes known as darters—in recognition of the contributions he has made, by study and encouragement, to the advancement of our knowledge of the freshwater fishes of interior North America.

LITERATURE CITED.


THE SCIENTIFIC NAME OF THE COMMON SOLE OF THE ATLANTIC COAST OF THE UNITED STATES.

BY CARL L. HUBBS.

The most common and best known of the soleid fishes of the United States has passed almost consistently as Achirus fasciatus (Lacépède), since this name was adopted by Jordan and Goss (1889: 315), and by Jordan and Evermann (1898: 2700). Recently, however, doubt has been cast on the applicability of either the generic or specific name to this species. It is the purpose of the present note to consider the recent claims, and to review the problem from the standpoint of the early writers as well.

The generic name will be considered first. The genus Achirus was established by Lacépède in his Histoire Naturelle de Poissons (1802: 658). Lacépède divided his genus into two subgenera; neither of which he named. The second subgenus was made to include two sinistral species, now not classed in the Soleidae, as that family is at present delimited. As neither of these species of the second subgenus has ever been considered as the type of Achirus, attention may be restricted to the species of the first subgenus, namely Achirus barbatus, A. marmoratus, A. pavoninus and A. fasciatus.

The first subdivider of the genus was Kaup (1858), who restricted the genus to the first three species named, and placed fasciatus (and the related lineatus) in a new genus Grammichthys. This action was known to Jordan and Goss (1889: 308), Jordan and Evermann (1898: 2693) and others, but has been interpreted as determining the status of the generic name only by Chabanaud (1930: 263). Emphasizing this point, and the fact that barbatus, the first species listed by Lacépède, is considered a doubtful synonym of marmoratus, which species with pavoninus constituted the genus Pardachirus Günther (1862: 478), Chabanaud (1930: 262) replaced Pardachirus with Achirus. In so doing he removed Achirus from the group...

generally called Achirinae (for which he substituted Trinectinae); and applied it to Indopacific rather than New World species.

Fortunately this action appears unnecessary, and invalid, because Article 30 (d) of the International Code states: "If a genus, without originally designated (see a) or indicated (see b) type, contains among its original species one possessing the generic name as its specific or subspecific name, either as valid name or synonym, that species or subspecies becomes ipso facto type of the genus. (Type by absolute tautonymy.)" The genus did contain the specific name achirus, for Lacépède (1802 : 662) listed "Pleuronectes achirus Linne, Syst. naturae X, 1, p. 268, n. 1, 3," as a synonym of his Achirus fasciatus. The fact that the name achirus was (presumably) wrongly synonymized with fasciatus, or that Lacépède presumably had never seen the true achirus appears irrelevant, despite the opposite view of Chabanaud, as the Rule quoted makes no provision for such an exigency.

Therefore, the Code requires that Pleuronectes achirus Linne be the type of the genus, as claimed by Jordan (1917 : 65, and 1923 : 5) and Myers (1929 : 37). The fact that Pleuronectes achirus was named in the first definite type designation for Achirus (Jordan and Gilbert, 1883 : 84) is probably not to be considered as significant, nor apparently, is Jordan and Goos' designation of Achirus fasciatus as the type (1889 : 308) to be considered, however much we might wish this could be done. In this connection, however, it should be noted that both Lacépède and Jordan and Gilbert placed achirus in the synonymy of fasciatus. If the identification of Pleuronectes achirus Linne with Solea gronovii Günther (1862 : 472) be accepted, as made by Jordan and Goos (1880 : 311), Jordan and Evermann (1898 : 2065), Jordan (1925 : 7), Myers (1929 : 36), and by Chabanaud in 1930 though not in 1928, then it becomes necessary to synonymize Basostoma with Achirus and to employ Trinectes for fasciatus and its allies. This is the course adopted by Myers, and appears unescapable, if Chabanaud's separation of the genera (1928) is accepted, as I think it should be. The view that Trinectes scabra Rafinesque is a recognizable synonym of Achirus fasciatus, and that the generic name Trinectes is therefore available for the species, seems acceptable. Chabanaud (1930) reprinted Rafinesque's account, which is merely "A new genus of fish near to Achirus, found in the River Schuykill; it has only three fins, dorsal, and anal and caudal." Considering the locality, which is permissible according to Opinion 52 of the International Commission on Zoological Nomenclature, this account certainly applies to Achirus fasciatus and only to that species.

If Pleuronectes achirus be regarded as not identifiable with Solea gronovii, then both the specific and generic name, as pointed out by Myers (1929) are apparently unusable, because they are not identifiable with even as much possibility with any other species and genus. In order to avoid dropping the time-honored name of Achirus, the customary identification of P. achirus ought to be maintained if possible.

New testimony as to the specific name of our common sole is introduced by Chabanaud (1900 : 262), who has examined the type of Pleuronectes maculatus Bloch and Schneider (1801 : 187) and pronounces it identical with
Hubbs—The Scientific Name of the Common Sole.

*Achirus fasciatus* Lacépède (1802 : 662). He therefore regards the assigned type locality of *maculatus* ("Habitat ad Tranquebariam") as an error. No such species can now be identified in the Indian fauna (Norman, 1928 : 186). The original description is as to be expected very weak and incomplete, but applies fairly well to *fasciatus*. The distinct and rounded caudal fin, the absence of pectoral fins, coupled with the moderately low number of dorsal and anal rays (admitting that the author counted the rays somewhat too few according to later accounts), the entirely ciliated lower lip, the presence of teeth on the inferior surface of the maxilla, the straight lateral line and the black-blotched coloration, is a fairly distinctive characterization of the species.

The redescriptions of the type of *Pleuronectes maculatus* by Day (1877 : 427) and Chabanaud seem to confirm the view that it is referable to the species called *Achirus fasciatus* one year later. The determination that the blind surface was black-spotted apparently masses the identification.

Out of harmony with the identification of *maculatus* with *fasciatus* is the number of pelvic rays, which are given by Bloch and Schneider as 5 and by Day as 6 in the type of *maculatus*, whereas *fasciatus* has 3 to 5, usually 4, pelvic rays, according to Chabanaud (1928 : 9). But must be borne in mind that the type was a skin covered with varnish, according to Day, and that the rays could not be exactly enumerated according to Chabanaud. It might be very difficult to distinguish between pelvic and anal rays, in such a specimen, where the fins are conjoined.

The scientific name of our sole should on these premises stand as *Tranectes maculatus* (Bloch and Schneider). Chabanaud’s identification, in 1930, of our species with *lanceolatus*, appears inadmissible, in view of the evidence presented by Jordan and Goss in 1889 (p. 312), and since accepted by almost all authors.

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JORDAN, DAVID STARR, AND GOSS, DAVID KOP.

KAUP, J.

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MYERS, GEORGE S.

NORMAN, J. R.
The Use of the Generic Name *Ophis* for an Eel, a Snake and a Mollusc

By CARL L. HUBBS

The name *Ophis* has been independently proposed at least three times, in as many different groups of animals. The first proposal of the name, for a genus of eels, has unfortunately been generally if not universally overlooked, as I find no reference to it in the standard nomenclators (Marshall; Agassiz; Scudder), nor in Günther's *Catalogue of the Fishes in the British Museum*, nor in Jordan's *The Genera of Fishes*. The name was, however, proposed in a manner leaving no doubt as to its availability under the Rules. To prove the point, I quote pertinent paragraphs from the original work in which the name appeared: W. Turton's *British Fauna, Containing a Compendium of the Zoology of the British Islands: Arranged According to the Linnean system*, Swansea, 1807.—

CLASS IV. PISCES. FISHES

Animals inhabiting waters, furnished with gills for the purpose of breathing, and fins for swimming.

Order I. APODES.

1. *Anguilla*. Head smooth; nostrils tubular; eyes covered with the common skin; gill-membrane 10-rayed; body roundish, smooth, mucous; dorsal, caudal and anal fins united; spiracles behind the head or pectoral fins.

2. *Ophis*. Habit of the Anguilla, but the tail is without fin at the end, causing the dorsal and anal fins to be distinct.

On page 87 the genus name reappears, with one species, in the following form.—


*Body* 3 or 4 feet long, slender, silvery-white with a triple row of dark-brown oblong spots; *head* slender; *eyes* moderate; *mouth* wide; *teeth* curved inwards; *pectoral-fins* small, white; *tail* naked, round, pointed. *Berkendout.*
The name *maculata* (or *maculosa*) was generally treated by the early authors, as Shaw and Bloch, as synonymous with *Muraena aphis* Linnaeus, which species name presumably suggested the genus name *Ophis*, as well as the prior name *Ophichthus* of Ahl. As the type-species of *Ophichthus* is, according to Jordan, without question assumed to be *Muraena aphis* Linnaeus, we may take *Ophis* Turton, 1807, to be a synonym of *Ophichthus* Ahl, 1787.

Clearly this use of the name *Ophis* in 1807 precludes its later use for any other genus. This is unfortunate, as the name is now in use in herpetology. Wagler, in Spix’s *Serpentum Brasilensium*, 1824, p. 47, in proper form proposed the name *Ophis* for a genus of South American colubrid snakes. Boulenger, in his *Catalogue of the Snakes in the British Museum*, 2, 1894, p. 144, arbitrarily listed this name as a synonym of *Xenodon* Boie, 1827. Lately, however, the name has been accepted, as by Dr. do Amaral (Mem. Inst. Butantan, 4, 1929 (1930?): 175). Whether the name of the snake genus *Ophis* (and of the subfamily Ophinae based thereon) needs to be replaced, and if so by what name, I must leave to herpetologists to decide.

A third use of the name, for a mollusc, has been noted in the nomenclators, though it appears to have generally escaped the attention of conchologists. Agassiz cites “*Ophis* Gray Syn. Brit. Mus. 1840 *Serp., serpens Naiadea*.“ According to the *Catalogue of the Library of the British Museum*, it was the forty-second edition of the *Synopsis of the Contents of the British Museum* which was published in 1840. Whether the name appeared in any of the earlier editions I have not determined, but it apparently did not appear as early as 1807, when the name *Ophis* was used for an eel, as the first edition of the *Synopsis* is listed as having appeared in 1808.

In summary: the proposal of the generic name *Ophis* for an ophichthid eel by Turton in 1807 precludes the use of this name for a snake (Wagler, 1824) or for a mollusc (Gray, 1840), even though *Ophis* Turton, 1807, is regarded as a synonym of *Ophichthus* Ahl, 1787.
ICHTHYOLOGICAL NOTES

NUMBERS OF ANAL SPINES IN YOUNG OF THE SCIAENID FISH GENYONEMUS LINEATUS.—In COPEIA, No. 101, December 20, 1921 (p. 86), I reported that "A young specimen of the common Californian sciaenoid, Genyonemus lineatus Ayres, 34 mm. long to caudal, found dead on the beach at Montecito, on the mainland shore of the Santa Barbara Channel, on July 12, 1916, has three unquestionable anal spines." Since then I have examined scores of the young of this species, collected by the staff of the California State Fisheries Laboratory, and have failed to find any with more than two anal spines. Now, through the courtesy of the Field Museum, I have before me the specimen reported on in 1921, and find that I mistook a pointed splinter of tissue for a weak third spine. The observation quoted was therefore an inexcusable error, which I wish to correct. —CARL L. HUBBS, University of Michigan, Ann Arbor, Michigan.

THE CALIFORNIAN SPECIES OF THE FISH GENUS ARGENTINA.—Gilbert in 1890 (Proc. U. S. Nat. Mus., 12: 56) described a new species of Argentina, the first to be made known for the North Pacific. This species, A. nana, was based on a single small specimen from the Gulf of California. This one example remained the only one known, until 1920, when Higgins (Calif. Fish and Game, 8:78) reported others from off Huntington Beach, California, where they had been dredged on December 9 and 10, 1919, at a depth of 45 fathoms. On receiving some of these specimens at a recent date, I found that they differed in many details from the type description, and therefore doubted Higgins's identification. On studying the type in the National Museum, however, I learned that it was rather inaccurately described, and that it does in fact agree well with Higgins's specimens. The data follow:

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Type specimen</th>
<th>Original Description</th>
<th>New examination</th>
<th>California specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal rays (principal)</td>
<td>11</td>
<td>10</td>
<td>10 (rarely 11)</td>
<td></td>
</tr>
<tr>
<td>Anal rays (principal)</td>
<td>12</td>
<td>117</td>
<td>10 or 11</td>
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<tr>
<td>Scales</td>
<td>40 or 45</td>
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<td>Gill rakers below angle</td>
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<td>18</td>
<td>18</td>
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<tr>
<td>Premaxillary teeth</td>
<td>Absent</td>
<td>Not found</td>
<td>Very weak</td>
<td></td>
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<tr>
<td>Depth of body</td>
<td>5.5</td>
<td>6.7</td>
<td>6.5 to 7.0</td>
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<tr>
<td>Eye</td>
<td>3.5</td>
<td>4.25</td>
<td>4.0 to 4.2</td>
<td></td>
</tr>
<tr>
<td>Origin of D. to base of C.</td>
<td>Diam. of pupil</td>
<td>Half eye</td>
<td>Dim. of eye or nearly so</td>
<td></td>
</tr>
<tr>
<td>Part of D. above pelvic insertion</td>
<td>Behind middle</td>
<td>Slightly behind middle</td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td>Pelvic inserted midway between base of C. and</td>
<td>End of 2nd 3rd of snout</td>
<td>Middle part of snout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelvic extending toward anal</td>
<td>A little more than half way</td>
<td>Less than half way (but broken)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peritoneum</td>
<td>Black</td>
<td>Densely punctulate</td>
<td>Punctulate</td>
<td></td>
</tr>
</tbody>
</table>

CARL L. HUBBS, University of Michigan, Ann Arbor, Michigan.

Reprinted from COPEIA, 1932, No. 2, July 1.
Studies of the Fishes of the Order Cyprinodontes. XI.
Zoogoneticus zonistius, a New Species from Colima, Mexico
By CARL L. HUBBS

The rich collection of cyprinodont fishes in the Museum of Comparative Zoology includes some species which were indicated as new by the late Dr. Samuel Garman, who for some time before his death had in preparation a revision of his Cyprinodontes of 1895. Among these are two specimens from Colima, Mexico, collected by Gustav Glückert, and donated to the Museum on November 1, 1913. These represent, as Garman correctly appreciated, a very distinct species of Zoogoneticus. Permission to describe this species has graciously been extended by Dr. Thomas Barbour.

The genus Zoogoneticus has not been reported heretofore from outside the confines of the Rio Lerma drainage basin (including the Rio Santiago de Grande, under which name the lower course of the Lerma is known): the home of the entire family Goodeidae (see Hubbs, 1924a: 4). But two species of the family have been recorded from streams south of the Lerma basin. These are: (1) Goodea whitei Meek, of the Rio Balsas basin, made the type of a distinct genus Balsadichthys by Hubbs (1926: 19), and (2) Characodon furcident Jordan and Gilbert. The latter is the only goodeid heretofore recorded from Colima. It also has been reported from the Rio Tuxpan (Pellegrin, 1901: 122) and the Rio de Mascota (Regan, 1907: 90), both streams in Jalisco south of the mouth of the Rio Grande de Santiago, and on either side of Colima. C. furcident has also been reported, no doubt erroneously, from “Cape San Lucas” (Hubbs, 1931: 2).

The only prior records of freshwater fishes from Colima of which I am aware are those given by Jordan and Gilbert (1882). In addition to the Characodon, these records are of three semi-fluvial gobies: Philypnus maculatus, Dormitor latifrons and Eleotris pica (recorded

Reprinted from COPEIA, 1932, No. 2, July 1.
respectively as *Philypnus lateralis*, *Dormitator maculatus* and *Culius aequidens*). The known Colima freshwater fish fauna of five species is therefore 40 per cent of Rio Lerma, and 60 per cent of marine affinities.

The described species of *Zoogoneticus*, now regarded as valid, number four: *Z. robustus* (Bean), *Z. cuitzeoensis* (Bean), *Z. dugesii* (Bean) and *Z. diazi* Meek. These are all diagnosed and figured by Meek (1904: 109-115, fig. 29-33), who, however, recognized three other species: *Z. pachycephalus* (Günther), which belongs in *Profundulus* Hubbs (1924b: 13), and *Z. maculatus* Regan and *Z. miniatus* Meek, now resting respectively in the synonymies of *Z. robustus* and *Z. diazi*. These species are now accepted as recognized by Regan (1907: 85-87).

*Zoogoneticus zonistius*, new species

Holotype: Cat. No. 32818, Museum of Comparative Zoology, an adult male 44 mm. long to caudal. Paratype: Cat. No. 97316, Museum of Zoology, University of Michigan, 48 mm. long.

*Zoogoneticus zonistius*, like each of the four other recognized species of the genus, is characterized by a strikingly distinctive color pattern. The most conspicuous features of *zonistius* are the five oblique ocellated bands on the posterobasal half of the dorsal fin, the jet black comma-shaped mark behind shoulder girdle and the intensely blackened scale borders on upper posterior sides.

In other respects than coloration, this species matches fairly well with *Z. robustus*. The scales appear to be a little smaller, in 40 instead of 36 to 39 rows. It appears to be most closely related to that species, which I interpret as the most primitive in the genus (and family). It is of interest that it approaches *robustus* most closely in distribution also, for *robustus* is the only species known to occur in the lower portion of the Rio Lerma, where the stream changes its name to Rio Santiago de Grande.

From *Z. cuitzeoensis*, the present species differs further in the much smaller size of the scales and in the much smaller eye. From *Z. dugesii* it is readily set off by the finer scales, by the concave anterior profile, and the much more anteriorly placed dorsal and anal fins. From *Z. diazi* it is distinguished by the smaller scales, and by the more robust build, especially in having the caudal peduncle more than half as deep as the body, as in all the species other than *diazi*.

*Description.*—The body is heavy-set forward (the head two-thirds as wide as long); sharply compressed posteriorly. The greatest depth is contained 3.0 (3.3) times in the standard length. The least depth is contained 1.8 (1.7) times in length of caudal peduncle, and 1.7 (1.6) times in head. The nuchal region is strongly humped, so that the profile near the occiput is distinctly concave. The edges of the caudal peduncle are nearly straight and parallel.

The head is widest through the turbid cheeks. The least width of the slightly convex interorbital enters the head 2.7 times. The orbit is not quite all included in the anterior half of the head; its length measures 4.3 (4.4) times in head. The jaws are equal; the upper lip anteriorly

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3 Parenthetic entries represent those measurements and counts of the paratype which differ from the corresponding ones of the holotype.
is on the same horizontal as the pupil. The mouth, more transverse than lateral, describes a very wide U-curve as seen from above; its horizontal lateral projection is only half that from tip of mandible to orbit; the width of the mouth, lips included, is just equal to the length of snout, being contained 3.25 (3.15) times in head; the length of the upper lip is about one-fourth its width. The teeth of the main row are strong, triangular incisors. Those of the narrow inner band are similar but much smaller. The gill-slit is restricted, as the opercular membrane is bound down: the slit continues straight upward and backward to less than half the pupillary diameter above the uppermost pectoral ray. The branchiostegals number 4 only, and the uppermost is expanded ventrally enough to be exposed between subopercle and interopercle. The gill membranes are broadly united and form a very narrow fold where united to the isthmus. The gill-rakers on the outer arch number 1-18, counting rudiments; all are shorter than the pupil. (The branchiostegal and gill-raker characters were determined on the paratype.)

Dorsal, 13; anal, 14; about 7 anterior anal rays shortened (both specimens are males); pectoral, about 21; pelvic, 6. The origin of the dorsal is midway between caudal base and upper edge of preopercular margin (or posterior edge of orbit); the length of the dorsal when depressed is contained 2.1 (1.9) times in distance forward to tip of muzzle; the highest ray measures 2.0 times in head, the base of the fin 1.5 times. The length of the stubby caudal fin enters 1.7 times in head. The highest anal ray enters the head 2.1 (2.0) times, the base of anal 2.2 (2.3) times. The length of the rounded pectoral, from upper angle, is two-thirds as long as head; the fin extends beyond vertical from pelvic origin a distance about 0.6 orbit. The rounded pectorals have their bases in contact, extend to the anus and enter the head 2.2 times.

Scales 16 or 17-40.

The sides (of the two alcohol specimens, both males) are purplish, except on the yellowish silver lower surface. The cheeks are golden, the opercles greenish, the top of head and muzzle purple. There are faint traces of vertical bars anteriorly and of an irregular median band posteriorly. There are some rounded dark spots above and behind pectoral bases, but these are not nearly so conspicuous as the somewhat scattered blackened scale borders on the upper two-thirds of the posterior two-thirds of the body. These markings, blackish purple, have a rounded posterior and a straight anterior margin. The boldest marking on the body is the large jet-black comma-shaped mark extending from just behind the opercle, including its bound-down membrane, downward to behind the pectoral base, leaving a milk-white spot, in the angle of the comma, about the upper end of the pectoral base.

The dorsal fin is boldly marked by five black bands, bordered narrowly by whitish, and extending downward and backward across the posterobasal half of the squarish fin; elsewhere this fin is dark and indefinitely mottled. The caudal fin has a light yellowish crescent behind a diffuse dark basal blotch; behind the light bar the fin is abruptly darkened by black membranes. The other fins are somewhat dusky.
Carl L. Hubbs

CYPRINODONTES, XN

(zonistrus, from ζων, zone, and iorius, sail, referring to the black-banded dorsal fin.)

ERRATUM

To studies of the fishes of the order Cyprinodontes, X (Hubbs, 1931):
Page 7, line 10: in place of catenatus read confluentus.

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Pellegrin, Jacques

Regan, C. Tate

MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN.
HANDBOOK OF FROGS AND TOADS: THE FROGS AND TOADS OF THE UNITED STATES AND CANADA. By Anna Allen Wright and Albert Hazen Wright. The Comstock Publishing Co., Inc., Ithaca, N. Y., 1933: xi+231 pp. $2.50. - On taking up this book the student will be convinced at once that the authors understand the needs of their public. The flexible, durable binding, clear type, numerous and well printed cuts, and convenient size will signify to the student an efficient tool. A detailed examination will confirm the first impression. The keys are workable, the descriptions are adequate without being prolix, and the photographs on the whole portray quite satisfactorily the characters to be illustrated. We believe Mrs. Wright is to be credited with the best series of amphibian pictures that has been published. Incidentally, it was a delightful thought of Dr. Wright to dedicate the book to "the four American women who . . . . have in the last half century contributed most notably to the study of this group." The organization of knowledge in this field has been difficult and much of the credit for the striking advances which have been made in recent years should be given to these patient, earnest students.

The criticisms which can be made of the work are remarkably few. The printers could have improved the attractiveness of the book by a better selection of type for the headings and by a better distribution of printed matter on many of the pages. This will, however, be of little concern to the student. The index would have been more useful had the scientific names been listed. The authors have themselves recorded in the preface what is apparently the only species omission—Hyla pratipes. The inclusion of Pseudacris stricteri constitutes the type description of this hitherto undifferentiated species. The majority of amphibologists will object to the recognition as subspecies of the color phases of Rana pipiens described by Weed. Whatever these phases may be, they are quite certainly not of the nature of subspecies as now understood. In future editions, a change should be made in the key to the families. The student will be confused when he discovers that the family Leptodactylidae is characterized by the presence of digital disks, while in Leptodactylus albaboris the disks are lacking. It may be suggested, also, that the book would be much easier to use if in the keys the references were to pages instead of to plates.

The needs of students in systematic amphibiology include, in addition to comprehensive treatises and detailed monographs, check-lists which are kept reasonably up to date, and manuals based upon such check-lists. A manual which contains satisfactory keys and which summarizes our knowledge of characters, relationships, and distribution not only stimulates the interest of the beginner but often serves to expedite the work of the expert. Wright's volume naturally and efficiently supplements the check-list of Stejneger and Barbour and thus makes for itself an important place in the history of systematic studies on the North American amphibians.—ALEXANDER G. RUTHELEN, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

REPTILES OF THE WORLD. By Raymond L. Ditmars. New York. The Macmillan Company, 1933: xx+331 pp., 90 plates. This well-known book on reptile life, first published in 1910 by Sturgis and Walton Company and reprinted several times, is now issued in revised form by Macmillan. Changes in the text are, however, very few, aside from a modernizing of the nomenclature. The fewer pages, about 50, are due to use of smaller type. The photographs, which the author says (and rightly) form a valuable portion of the book, are identical, except for the frontispiece, with those of the earlier editions, but instead of being scattered through the book are placed all together at the end. This makes them easier to use, for they are not indexed (except according to their sequence in the list of illustrations) and there are no text references to them. The brief index could well have been expanded to include the illustrations. Typographical errors are very few. Occasional poor
expressions might well have been improved in the revision.

The statement in the preface of the first edition, and here repeated, that the writer hopes the book to be "everywhere in accord with the latest results of the scientific study of the subject" seems a little inconsistent with the almost complete absence of new information from the writer's rich experience, not to mention the herpetological literature of the past twenty years. The former inadequate remarks about the tuatara might very well have been amplified and corrected. These animals are not now diligently hunted for scientific institutions. They are rigidly protected from collectors (but not from natural enemies and unnatural conditions) by the New Zealand government. False ideas of the ordinary fecundity of species are fostered by stating only maximum numbers of young, as 75 in Thamnophis sirtalis and 60 in Natrix sipedon.

Such faults as these are small, however, when account is taken of the objective of the book and its fulfillment. Its great value lies in its provision of a popular, reliable and interesting source of information on the common reptiles of the world, covering all types, with its wealth of careful observation of habits, on both wild and captive animals, from the one man probably most able to provide it.—FRANK N. BLANCHARD, Zoological Laboratory, University of Michigan, Ann Arbor, Michigan.

DEEP-SEA ANGLER FISHES (CERATIOIDEA). By C. Tate Regan and Ethelwynn Trewavas. The Carlsberg Foundation's Oceanographic Expedition round the World 1928-1930, Report No. 2, 1932 (Oct. 11): 1-113, 10 pls. C. A. Retzius Fierlag, Copenhagen, 15 shillings.—When the late Dr. Johannes Schmidt announced that he would take the "Dana" around the world, those who were familiar with the results of his North Atlantic expedition of 1920-1922 knew that great things were in store for ichthyology. They have not been disappointed. This first of the final ichthyological reports of the later voyage revises, enlarges, and extends Dr. Regan's 1926 monograph of those extraordinary little fishes, the deep-sea anglers, which was based upon study of the material from the "Dana's" Atlantic cruise. The 1926 paper nearly doubled the number of known species; the present one nearly doubles it again.

Various chapters discuss the distribution, sexual dimorphism (including male parasitism), the lateral line, osteology, and the definition of families. These are followed by a systematic revision of the species. The fact that the males are parasitized in certain families of ceratioids is one of the most interesting conclusions. The osteological figures are many, resulting largely from the study of specimens stained with alizarin and cleared, a method which is fast revolutionizing the examination of the skeletal anatomy of fishes too small to be dissected easily. While it seems possible that the number of species of ceratioids defined solely by modifications of the illicium has been unduly expanded, it is scarcely appropriate to attempt criticism of a taxonomic revision by authors who have seen more material than all other students combined.

On the side of nomenclature, however, there is one serious criticism which applies not only to the paper being reviewed but to several other recent ichthyological works as well. Under the amendment to Article 25 of the International Rules of Zoological Nomenclature, adopted at the International Congress of Zoology at Budapest in 1927, new genera published subsequent to Dec. 31, 1930, without a definite and unambiguous designation of a type species, are invalid and not to be accepted under the Code. (See X° Congrès Intern. Zool., Budapest, 1927: 1388-1389.) Under this rule the generic or subgeneric names Xenocreratias, Microlophichthys, Penherrichthys, Centrolophus, Trematohyphus, and Cryptolychnus of Regan and Trewavas are invalid, and must be republished, together with a diagnosis and a type designation, to be accepted. It is apparently to be assumed that the description of a new genus for a single species is sufficient designation of a genotype (Internat. Rules, Art. 30 c). We further note that the authors' references which cite "Beebe, Bull. N. Y. Zool. Soc." are, with the exception of the one under Limnophysetacriatus, erroneous. The publication referred to is Zoologica, not the Bulletin. It is to be regretted that the editors have apparently not required the presence of an index in the separate reports, the more so since it is evidently not intended to collect them into volumes.

As an aid to the study of ceratioids, this paper and its companion one of 1926 are vastly more important than all previous ceratioid literature put together. Dr.
Regan and Miss Trewavas are to be congratulated on the production of one of the most valuable reports in the literature of oceanic ichthyology.—George S. Myers, U. S. National Museum, Washington, D. C.

KAMONGO. By Homer W. Smith. The Viking Press, New York, 1932: 1-167. $2.00.—Though written in the form of a novel, this book gives an interesting exposition of the habitat, habits and ecology of the African lungfish, of its place in evolution, and of course something of its physiology during aestivation in mud, for this is what the author went to Africa to study. Native lore regarding the "kamongo," reputed hybrid of a crocodile and a fish, is also presented. The author's trials in finding lungfish on his African trip are recounted so vividly that the naturalist reader may imagine himself on the expedition. All this is given as the conversation between "Joel," obviously representing the author, and an Anglican priest aboard a vessel plying through the sweltering heat of the Suez Canal.

The conversation on the lungfish and the "blind alley" into which it has evolved lead naturally into a discussion of evolution, which occupies half the book. "Joel" makes a spirited defense of the mechanistic philosophy of evolution, leading at times into dramatic tenesmes, at times running on in the sheer beauty of verse, always holding interest, and presenting his point of view in such fine literary style that the book was chosen by the Book-of-the-Month Club and recommended by the Scientific Book Club. Naturalists as well as the general public will find this little volume interesting and stimulating.—Carl L. Hubbs, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

CAVE LIFE OF KENTUCKY. By Vernon Bailey, with Chapters on The Birds by Florence Merriam Bailey and on The Invertebrates by Leonard Giovannoli, The University Press, Notre Dame, Indiana, 1933: 256 pp., 90 figs. $1.25.—This attractive little bound volume was reprinted from Vol. 14. No. 5, of The American Midland Naturalist. The manuscript was prepared by the U. S. Biological Survey in 1930, at the request of the Kentucky State Geological Survey. Much of the field work was done by Leonard Giovannoli, now of the University of Florida. The brief introduction treats the History and Prehistory of Mammoth Cave, Roads and Rivers, Research and Education, Vegetation and Ecology, and Game and Wild Life, all in 20 pages. Fortunately the inane, at times moronic naming of the "formations" is given almost no space. The great bulk of the book, 165 pages, treats the mammals and birds of the cave region. While these chapters, respectively by Vernon Bailey and Florence Merriam Bailey are as would be supposed very well written, there is involved little cave biology except in the discussion of the bats. In Fishes of the Caves and Cave Region Dr. Bailey very briefly treats the cave fishes of Mammoth Cave and adjacent caves, and lists the fishes caught there and in the Green River nearby by Mr. Giovannoli. In the chapters on Reptiles of the Mammoth Cave Region and on Amphibians of the Caves and Cave Region, the same author gives a brief annotated list. The Invertebrate Life of Mammoth and other Neighboring Caves was written by Leonard Giovannoli.—Carl L. Hubbs, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

DIE INDISCHE ZEEVISCHEN EN ZEEVISCHERJ (Bibliotheek van de Nederlandsch-Indische Natuurhistorische Vereniging, VI.) By H. C. Deelman and J. D. F. Hardenberg, N. V. Boekhandel en Drukkerij, Batavia, 1934: i-viii, 1-388, fig. 1-273, 9 col. pl.—This volume on the fishes and fisheries of the East Indies, though written for the Dutch-speaking peoples of the Indies and the home-land, should prove of value and interest to ichthyologists of other lands. It may well serve, indeed, as a model for similar treatises on regional ichthyology.

The volume starts with an informative account of the external structures of fishes, and of their life histories, both illustrated by East Indian material. The accounts of the reproduction and larval development of East Indian fishes, in this chapter as well as through the systematic section, and also another chapter on the productivity of tropical seas, is based on the extensive original investigations by the senior author. The peculiar modes of fishing practiced through the Indies are described and figured. Of particular interest is kite-fishing by Malays and reef fishing by the Japanese, who
frighten reef-fishes (*Caraio* in particular) into a trap by swimming toward the mouth of the net while dangling weighted lines with white cloths attached.

The systematic section is preceded by an account of fish systematics, including the distinguishing of local races and the identification of postlarvae. The chapters on the various groups deal with the characters and the natural history of the more noteworthy species. Many original observations are included, as for instance on the anchovies which have been so carefully studied by Dr. Hardenberg.

The beautiful plates of reef fishes remind the reviewer of happy hours spent with the authors on the reefs about the isles in Batavia Bay, in the fine aquarium connected with the Laboratory for the Investigation of the Sea (of which Dr. Delsman is Director and Mr. Hardenberg the Ichthyologist) and in the nearby pasar ikan (fish market), where the spoils of these tropical seas are brought in almost bewildering abundance.—CARL L. HURBS, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

**THE NATURAL HISTORY OF THE FRILLED SHARK, CHLAMYDOSELACHUS ANGUINEUS.** By Eugene W. Gudger and Bertram G. Smith. Article V of The Dean Memorial Volume *Archaic Fishes, 1933: 245-319, fig. 1-31, pl. 1-5. $1.00.—When I went to Cambridge in the autumn of 1902 I promptly looked up Glover Allen, of whom I had learned from a friend of his who was a counsellor at a summer camp to which I had been sent to recuperate from an attack of typhoid fever. Allen had just been elected Secretary of the Boston Society of Natural History and was beginning his work for the doctorate. He roomed in Perkins Hall in Cambridge, I in Conant across Oxford Street. Allen's roommate was Austin H. Clark, who was then doing some work in Garman's laboratory on the European, Asiatic and American eels of the genus *Anguilla*. What Clark told me activated my pulling the bell outside Garman's basement door and pushing my way inside to begged to be allowed to work in the reptile room and promised specimens as a recompense for the favors asked. Garman, little by little, thawed, for there was a warm, almost affectionate side to this quiet, austere, and at first sight cold and distant nature. As the months went by we saw more and more of each other and I began to hear of *Chlamydoselachus*. I saw the sad remnants of the type which Garman had dissected ruthlessly but to mighty good advantage and he showed me his early drawings and notes. Models they were of precise and painstaking observation. Then came the story of the now historic controversy with Cope. There is no use trying to hide the fact that Garman did not like Cope. He had met him on the fossil fields of the west and saw him from time to time in Cambridge and Cope's fearful inaccuracy of citation and statement and his unscrupulous methods of acquiring material very unfortunately, in Garman's eyes, outweighed his undeniable genius and his utterly unrivalled, indescribable skill in working out relationships and building broad steps leading to our present systems of classification—systems based on natural relationships often hard to see. Cope saw Garman maintained his interest in the frilled shark for years and often talked of it and it was a pleasure, when I went to Japan in 1907, to bring him two eggs with good sized embryos attached which, by good fortune, I got from Alan Owston, the great zoological purveyor, before he died. Garman was delighted with these and figured the embryo in his monograph of the sharks, if my memory serves, for I am writing these lines in Florida.

All of this irrelevant verbiage is written for just one reason and that is to explain why, when I got Gudger and Smith's great memoir, I read it avidly from cover to cover. Here is the true story of this splendid and extraordinary creature, the whole story so far as that can be written today. Here is not only a complete, pains-taking search for every atom of available information but a fair and generous presentation of the controversies to which various appraisals of its relationships, both with recent and fossil sharks, have given rise.

The whole material is well written, the illustrations are admirably chosen, the presentation is clear and fair—what more can one ask for. Ichthyologists owe the authors a debt of gratitude. They hope for more. How Garman would have devoured this great paper had he lived to see it appear.—T. BARKOUR, *Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.*
ALL ABOUT FISH AND OTHER DENIZENS OF THE SEAS AND RIVERS. By W. S. Berridge. New York, Robert M. McBride & Co., 8vo, cloth, 1933; 1-254, 126 figs. $2.50.—Here is a fish book written from a human interest viewpoint; virtually devoid of dry systematic treatment and, despite its all-inclusive title, of much information that is not impressive; weakened by efforts to avoid an anthropocentric viewpoint; unhampered by qualifying reservations, and unrestrained by the ogre of scientific accuracy. To be sure the author does insinuate a critical remark into the more obviously fantastic of the numerous recitations of English folklore on fishes. The book was written by an Englishman for an English audience, for it deals in large measure with English fishes, along with the more curious or marvellous of the denizens of the seas and rivers or lands beyond the British Isles. Strange this seems, for we Americans have been told till we believe it, that our authors monopolize the sensational and under-rate their audiences.

"All About Fish" includes the information that certain goldfish ring a bell when asking to be fed, that the goldfish is but a domestic variety of the carp, that carp not infrequently lack teeth and are almost exclusively herbivorous; further that the stickleback produces its adhesive thread from its big mouth, but kills nest invaders by means of its fin spines; that fighting fish are Japanese, while the Chinese make their soup from the fins of the great white shark; that the fins of sharks are supported by spine-like rays, not apparent because concealed; that young toadfish adhere by their tails; that freshwater eels die before their offspring are hatched, though their eggs and larvae are unknown, and that these eels travel 6 or 7 months to reach their spawning grounds in the ocean depths; that the majority of fishes below the thousand fathom line are quite blind, though conditions of existence do not result in blindness because the Californian goby lives in ample light; that the rooks of American caves are phosphorescent and that blind fish occur in Switzerland (we have heard of the Swiss navy).

Just half of this book is all that the author required to tell "All About Fish," leaving the other half to treat "The Other Denizens of the Seas and Rivers," including "All About Sponges" in 10 pages and "All About Whales" in 16 pages. In the section on molluscs, he sympathetically recounts the proposed use of an amethesitic to prevent hurting oysters when being opened, and confers a doctor's degree on Mikimoto-san, famed cultivator of artificial pearls.

In the chapter on "The Zoo's Aquarium" there is included some herpetological information. Amphibians mentioned include the Mississippi salamander or hellbender and the Surinam toad from the West Indies. Among the reptiles treated, the reader will hold in mind the sea snakes which are brilliantly colored to match the fronds of seaweed in which they lie in wait for their prey, and the gruesome anaconda which associates with angel fish and crushes collectors to death.

Amongst all this, the trained naturalist will distinguish a really large amount of truthful information, very interestingly presented, and illustrated by numerous photographs, some of which are very good. It is to be prayed that the author, in his All About Birds—announced as in preparation, has sought or will seek a critical reviewer in advance of publication, for his facile pen and his keen appreciation of the interesting will, I presume, make his books widely read.—Carl L. Hubbs, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

Reprinted from Copeia, April, 1934, No. 1
Elephantichthys copeianus, a New Cyclopterid Fish from Alaska

By CARL L. HUBBS and LEONARD P. SCHULTZ

THE subject described in this paper is a remarkable fish of the family Cyclopteridae. It is known to us from four specimens collected at Kodiak Island, Alaska, by Mr. J. T. Barnaby, who presented them along with other specimens to the junior author, and from other specimens which have subsequently been found in the collection of the National Museum.

This cyclopterid we take to be an unnamed species so distinct as to warrant the erection of a new genus for its sole reception. The genus we name Elephantichthys on account of its resemblance, in clumsiness of body and in thickness and rugosity of skin, to the elephant. The species is called copeianus, in honor of the journal Copeia, the twentieth anniversary of which was recently celebrated.

Elephantichthys, new genus

This genus, lacking all external trace of the first dorsal fin and entirely devoid of any bony tubercles, appears to find its only near relative in Aplopterus De la Pylaie, 1835: 528 (on the use of this name in place of Cyclopterus Steinachner, 1881, refer to Jordan, 1919: 183). From that genus Elephantichthys differs in several respects, as indicated in Table I.

The only other genus with which any comparison need be given is Liparops Garman (1892: 42), based on Cyclopterus stelleri Pallas (1811: 73). That genus is very imperfectly defined, since the type species is apparently known only from Pallas' account, derived from Steller's manuscript and the examination of a dried specimen. [We find no basis for the range assigned by Popov (1930: 76) to Liparops stelleri: “Northern part of Pacific; coasts of Aleutian Islands, Kamtchatka, etc.”] It is, in fact, quite possible that Elephantichthys is not closely related to Liparops, for the latter is described as having a row of bony tubercles on the midline of the back, in advance of the dorsal fin, which begins in the middle of the back and extends almost to the caudal fin. Very likely Liparops is more closely related to Cyclopterus and Enneoscopus than to Elephantichthys and Aplopterus.

In connection with the relationships of Elephantichthys it should be remarked that Garman's (1892: 40) family Liparopsidae, reduced to sub-family rank by Jordan and Evermann (1898: 2095), hardly seems worth recognition. In the first place it is by no means sure that Liparops and Aplopterus (Cyclopterichthys) are closely related. Secondly, the first dorsal fin in Aplopterus and Elephantichthys is not absent, though it is entirely concealed under the very thick integument in the adult, without forming a dermal lump. On dissection, both these genera show five spines, the last well separated from the soft fin. The young of "Cyclopterus ventri-
TABLE 1. DIFFERENTIAL CHARACTERS OF
     ELEPHANTICHTHYS
     AND APTOCYCLUS

<table>
<thead>
<tr>
<th>Character</th>
<th>Elephantichthys</th>
<th>Aptocyclus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeleton of jaws, skull, etc.</td>
<td>Firm, bony</td>
<td>Flexible, cartilaginous</td>
</tr>
<tr>
<td>Body</td>
<td>Fairly solid, obviously not or but slightly inflatable</td>
<td>Very lax, greatly inflatable with air*</td>
</tr>
<tr>
<td>Trunk region (seen from above or side)</td>
<td>Suboblong</td>
<td>Globular</td>
</tr>
<tr>
<td>Cross section (through base of pectorals)</td>
<td>Squarish</td>
<td>Round</td>
</tr>
<tr>
<td>Skin</td>
<td>Very thick, usually extremely rugose (at least in preserved specimens)</td>
<td>Moderately thick, largely smooth</td>
</tr>
<tr>
<td>Ventral disk</td>
<td>Very large, as long as depth of head or nearly so, occupying half or more than half of abdomen (to anal fin)</td>
<td>Of moderate size, little more than half as long as head is deep, occupying a third or less than a third of abdomen</td>
</tr>
<tr>
<td>Pectoral fin</td>
<td>Largely lateral, usually with hardly a trace of dermal connection below.</td>
<td>Largely ventral, and connected below by a conspicuous fold which overlaps front of disk,</td>
</tr>
<tr>
<td>Teeth</td>
<td>Usually more robust and truncated</td>
<td>Usually more slender and more sharply pointed</td>
</tr>
<tr>
<td>Jaws</td>
<td>Lower distinctly projecting</td>
<td>Equal or very nearly so</td>
</tr>
<tr>
<td>Obliquity of Mouth</td>
<td>Very slight (upper lip usually entirely below eye)</td>
<td>Moderate (upper lip opposite lower part of eye)</td>
</tr>
<tr>
<td>Gape in front view</td>
<td>More nearly straight</td>
<td>More distinctly arched</td>
</tr>
<tr>
<td>Mouth</td>
<td>More transverse (lateral projection of gape about one-third anterior projection)</td>
<td>Less transverse (lateral projection of gape about two-thirds anterior projection)</td>
</tr>
<tr>
<td>Groove behind upper lip medially</td>
<td>Usually deep (rarely obliterated in preserved specimens)</td>
<td>Usually absent (sometimes shallowly developed in preserved specimens)</td>
</tr>
<tr>
<td>Posterior nostril</td>
<td>Distinctly tubular</td>
<td>Scarcely tubular</td>
</tr>
</tbody>
</table>

* see Snyder (1912: 617)
Barnaby in Uyak Bay, Kodiak Island, Alaska, in August, 1932, since it was caught in a salmon trap, a shallow water habitat is indicated.

Two paratypes from the same locality, 173 and 209 mm long, go to the collection of the Department of Fisheries, University of Washington (Cat. No. 2673), while a third paratype from the same place, 179 mm long, is deposited in the U. S. National Museum (Cat. No. 93096). Six other paratypes, from Karluk, Chignik Lagoon, Bering Island and Bering Sea, are deposited in the National Museum. These, as well as two specimens of *Aptocyclus*, were kindly referred to us for examination by Dr. George S. Myers. All had been identified as *Cyclopterichthys ventricosus*.

The body is very massive, especially in the shoulder region, where it is deepest and widest. The abdomen is very long and the uroso me much reduced. The anterior profile is abruptly decided in a very convex curve from the nape region to the upper lip, beyond which the deep chin clearly projects. The groove above the upper lip is very distinct across the mid-line though shallower here than laterally (this groove may be only a product of preservation, as it is not evident in one specimen). The lower lip is interrupted by a frenum as wide as or wider than the distance between the anterior nostrils, which is 2.5 or 3.0 times as great as the distance between the two nostrils of either side. The posterior nostril as well as the anterior one is distinctly tubular, though its tube is only about as high as wide.

The teeth are strong, but more or less abruptly truncated by wear, not remaining sharply conical as they do in *Aptocyclus* (in one specimen of *Elephantichthys* the teeth are longer and sharper than in the others). As in *Aptocyclus* there is an irregular file of rather large teeth, closely flanked all the outer edge by a row of smaller teeth [Popov, 1930, describes the teeth as being in five series in *Cyclopterichthys* (==*Aptocyclus*), which is contrary to our findings].

The eye proper (cornea) is surrounded, within the orbit, by a rough ring of flesh. The interorbital region is extremely broad and more or less strongly arched. The suborbital stay, very thin and ribbed, crosses the wide cheek to contact with the inner edge of the preopercle, flaring out backward to a width 7.5% of the standard length (examined in one paratype). The very small semicircular gill opening does not reach downward to the upper end of the pectoral base.

The skin, about 3 mm thick in the larger specimens, is superficially deeply creased in a reticular pattern. It is somewhat lax, though rather tightly bound down to the central muscle mass by connective tissue. The preserved specimens are not inflatable into a globular shape as are those of *Aptocyclus*.

The fins are leathery and thick, except near the extreme tips of the rays; these spots sometimes forming a brokenly reticulated pattern. The into fimbriations which are markedly increased in size outward and which underlie a thin crenate membrane.

The color is a dusky to pale olive-gray over the body and fins, somewhat marbled, with more or less distinct rounded or oblong blackish spots on the upper and lateral surface of the head and body and along the fin rays, these spots sometimes forming a brokenly reticulated pattern. The
### TABLE 2. COUNTS AND MEASUREMENTS OF ELEPHANTICHTHYS AND APTOCYCLUS

<table>
<thead>
<tr>
<th>Specimen:</th>
<th>Elephantichthys copeiamus</th>
<th>Aptoicyclus ventricosus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurements in Hundreds of Microns</strong></td>
<td><strong>Measurements in Hundreds of Microns</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Repository and Cat. No.:</strong></td>
<td><strong>Repository and Cat. No.:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Locality:</strong></td>
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<td>Dorsal spines</td>
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<td>Pectoral rays, right</td>
<td>20</td>
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- The extreme fineness of the body renders most of the measurements rather inaccurate.
- All anterior dorsal and anal rays as seen on dissection were counted; the last ray was counted as a double ray.
- Aptoicyclus taken when body was inflated.
Figs. 1 to 3. *Elephantichthys* and *Aptocyclus*.

Fig. 1 (above). Lateral view of the holotype of *Elephantichthys copeicus*.
Fig. 2 (middle). Ventral view of same specimen.
Fig. 3 (below). Ventral view of specimen of *Aptocyclus ventricosus*, 126 mm in standard length, from Sitkalidak Island, Alaska.
fins become blackish toward their extreme borders. The throat, and the belly behind the disk, are somewhat paler than the sides of the body. The disk and the inner surface of the pectoral fin where revoluted in a plane with the disk, are flesh-colored. The inner face of the pectoral where it contacts with the lateral surface of the body is rather heavily and uniformly pigmented, or marked with darker blotches. The peritoneum is blackish blod and the lining of the buccal and branchial cavities is dark.

It is clear from the greatly inflated belly of Pallas' type, a character which inspired the name ventricosus and which was indicated in both figure and description, that Cyclopterus ventricosus was based on the species here called Aptocyclus ventricosus rather than on Elephantichthys copeianus. The substance of Pallas' original account (1769: 16, pl. 2, fig. 1-3) of Cyclopterus ventricosus was repeated by numerous writers, including Bonnaterre (1788: 28, pl. 20, fig. 66) and Günther (1861: 498). Steinacher's Cyclopterychthys gracilis (1881: 192, pl. 8) appears to have been based on the same species. Our measurements of Aptocyclus show an amount of variation which would ordinarily be considered beyond specific limits. Part of this is due merely to differences in the preservation of such flabby creatures, and to differential inflation. In part, however, the variation is real. Thus the head varies in length from 27 to 45 hundredths of the total length, and the parts of the head vary accordingly. But since the relative size of the head decreases rather evenly with increasing size of fish, this difference may be one of age rather than locality. The specimen from the Sea of Japan off Teradomari seemingly approaches Elephantichthys copeianus in being rougher than the others and in showing a slight groove behind the premaxillaries, but these look like products of preservation. Further material will be required to determine whether more than one species or subspecies of Aptocyclus are to be recognized.

The records of Cyclopterychthys ventricosus from Bering Island by Bean and Bean (1896: 242) and from Karluk on Kodiak Island, by Evermann and Goldsborough (1907: 331), were based on specimens here made paratypes of Elephantichthys copeianus. Snyder's account (1912: 437) of Cyclopterychthys ventricosus was based on Aptocyclus (his Misaki specimen has been reexamined). Other published records of "Cyclopterychthys ventricosus" are not definitely assignable to either Elephantichthys or Aptocyclus.

Cyclopterychthys amius Vaillant (1891: 33) from the Straits of Magellan, is too scantily described to admit of comparison. Further material will be required to determine whether it may be referred to Aptocyclus or to Elephantichthys, or to a third genus of the same type.

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NATURE'S OWN SEAPLANES

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Nearly all of the grand, fundamental discoveries and inventions by which man has lifted himself out of his dark animal past were but repetitions of discoveries and inventions which nature had made eras before our anthropoid ancestor first stood erect and looked up into the sky. The arrow by which primitive man gathered his raw meat was duplicated early in the course of animal evolution by the nematocyst—the poisoned arrow of the jellyfish. Fire by which the human progenitor cooked his food and warmed his body was paralleled by animal heat and matched more closely by the warmth produced by decaying matter with which certain reptiles and birds surround their eggs. High-power electricity, often considered the symbol of modern civilization, was long, long before utilized by nature in the electric eel, the electric catfish, the torpedo ray, and other fishes. Light, which opened up the night for man, was a frequent invention of nature—witness the firefly and many denizens of the inky depths of the sea.

Use of light for distant communication has, no doubt, been practiced for a time so long as to make the whole existence of man seem but a day. Communication by sound is similarly old. Music is one of the most primeval of human arts, but insects and birds made known their presence and desires by song at a far more ancient time. Even the modulation of the voice to produce language was incipiently developed in nature, as by certain birds. Modern communication systems in many ways fail to equal the marvelous functions of the nervous system of animals.

The cultivation of crops and the domestication of animals, which allowed man to settle down from a nomadic existence, merely repeated the evolution of analogous habits by certain ants. Slavery is also a fixed habit with some kinds of ants. Many of our social ways are but reflections of the habits of social insects.
Even organized warfare was an animal development. Some ways of modern war are old in nature: smoke screens are rivaled by the ink clouds by which squids escape their enemies; camouflage is all but universal in nature. Explosives as a weapon of combat seem to have been a human discovery not duplicated by nature—hardly a justification for man’s feeling of supreme superiority over the natural world. The rocket plane, which some predict as an outstanding tool of war and peace in the future, will but repeat the mode of locomotion utilized by squids.

These inventions of nature are not the work of a demigod. They are the end products of evolution—the adjustment of animals to their environment. This evolution, it is now generally agreed, is accomplished by an orderly process: those individuals which are so constituted, so fitted to their environment, that they survive better in the intense struggle for existence, produce offspring like themselves, multiplying their own kind at a faster rate than do those individuals not so well endowed with characteristics favoring survival. Eventually those best fitted to survive breed out those less well fitted and thus populate their section of the world.

Man himself is a product of evolution. His ability to create ideas and things has been a leading characteristic fitting him to survive. The human “creations”, which so clearly parallel the products of nonhuman nature, are therefore also the result of natural evolutionary processes. The distinction between natural and human inventions is consequently a rather arbitrary one, based on differences of time, of zoological position, and of degree, rather than on inherent differences in kind.

Probably the most outstanding among the basic human inventions which was not utilized by prehuman nature was the wheel. True, the wheel animalcules, or rotifers, produced circular water currents by movements of the double circle of cilia about the mouth, but this is not such a movement as would be produced by the spokes of a true wheel, each advancing independently, in rotation. The turning of a circular disk on or about an axle is a distinctively human invention only weakly anticipated (though perhaps suggested) by the motion of animal, including human, limbs around ball-and-socket joints. The wheel is not necessary to high human development, for the American Indians, including even the Mayas and the Incas, seem never to have known of this basic implement. In one form or another, however, the wheel enters into almost every phase of progressive human activity characteristic of the mechanical age in which we are living. All current means of transportation, of power development, and of machine production somewhere involve rotation on or about an axis. The release of man from day-long drudgery,
the multiplication of power and wealth, the binding together of the world by instant means of communication, and rapid, facile means of transportation—all these factors basic to modern civilization are made possible by the turning of wheels.

II

The whirling motor and the whirling propeller, both involving the principle of the wheel, are the essential points by which the airplanes of man differ from flying fishes, nature's own seaplanes. With this exception, vital it is true, modern airplanes are marvelously close reproductions of flying fishes. To offset this defect in the natural product, the flying fishes are the masters of both water and air—submarines and seaplanes in one.

Pioneers in aeronautics and designers of early aircraft made the mistake of neglecting to study the most airplanelike of all animals, the flying fishes. The idea had become so firmly fixed in man's mind that birds are the preeminent animals of flight that they alone were looked to in the attempt to discover the principles of flight.

This firmly entrenched idea that bird flight is typical of all animal flight has since the time of early records prevented a large proportion of observers from appreciating the true method of fish flight. This erroneous preconception, like thousands of other fixed ideas, has blinded the eyes of man. It has put into his mental vision movements of the flying fish's "wings" which his eyes did not see and could not see, because they do not exist. Even some scientists, observing the fascinating flight of fishes, have thus duped themselves into thinking they saw that which they did not see, allowing their preconceived ideas of how fishes should fly to prevent them from seeing how fishes do fly, or rather from registering in their minds what their eyes must have seen. Most of the scientists who failed to fight off these blinding effects of preconceived ideas, however, were laboratory investigators, closet naturalists. Through the long period when men have allowed their minds to put movements into the flying fish's "wings", trained field naturalists have seen that these animals, while in the air, hold their supporting planes, the greatly expanded pectoral fins, as rigidly as though they were made of steel.

The question whether fishes flap their "wings" in flight constitutes one of the longest controversies in the history of natural science, and is still in dispute, despite the numerous essentially correct observations noted above. It has been a common tendency to deduce how fishes must fly, not only from preconceived ideas of the flight of birds but also from generally erroneous conceptions of the mechanics of flight. Had half the energy which has been devoted to these profit-
less deductive studies been expended in inductive research—careful observations on the flight of fishes—the controversy would long ago have been settled, or at least would have been rendered very one-sided. In fact, a few hours of unprejudiced and close observation would usually have sufficed to prick the bubblelike theories born of deductions.

Now that the sight of airplanes, fulfilling the prophecies of Langley, is a commonplace experience of civilized races, the erroneous belief that flying fishes must flap their wings in order to fly is much less common than in previous years. False deductions that the weight of the fish's body can be sustained in the air only by a vibration of the wings, or that any body—even a moving plane—must continuously fall unless it continues to expend energy to counteract gravity, are not likely to be made by one who has watched airplanes with motors shut off, or, better, gliders, soar through the air and often rise as they proceed, with their planes clearly silhouetted against the sky.

III

For lack of space, no attempt is made to review here the very extensive, though mostly incidental and trivial, literature on the flight of fishes. This has been attempted by several writers referred to in the selected references given at the close of this article, notably by a German naturalist, Fr. Aihlborn (1895), by an American ichthyologist long associated with the Smithsonian Institution, Theodore Nicholas Gill (1905), and by an Englishman, E. H. Hankin (1914, 1920). As I wrote recently in presenting detailed field observations on the subject (Hubbs, 1933), “perhaps too much ink has already been used in discussing the flight of fishes.”

Disregarding this voluminous literature, we may proceed at once to a discussion of just how the typical (“four-winged” or “bi-plane”) flying fishes fly, according to the virtually unanimous views of recent, critical observers. A brief epitome is given in pictorial form. Figure 1, utilized for this purpose, was made by Grace Eager under my direction, as a substitute for photographs, preferably motion pictures, which still remain for some skilful wildlife photographer to contribute. This would be by no means an impossible task in certain tropic seas, where day after day hundreds of these fishes rise to soar away before a vessel.

UNDER-WATER MOVEMENTS

Under water, flying fishes swim with great speed, with both pairs of wings folded back against the body so that they resemble a trim submarine (fig. 1a). This may be seen especially well from a vessel
FIGURE 1.—Four stages in the flight of a cypriniform flying fish. Reproduced by permission from Papers of the Michigan Academy of Science, Arts, and Letters.

a, the fish approaches the surface, both pairs of fins folded; b, the fish breaks the surface and spreads the pectoral fins (upper or anterior planes) to support the anterior part of the body; c, the fish gains speed by the taxi or surface-skimming. The caudal beats the water; the body shakes; and the wing tips flatter in response, giving a false illusion of wing beating; d, the fish takes off by spreading the pelvic fins, thus lifting the tail out of the water. The planes are now held taut and rigid as the flying fish dashes through the air.
plying the clear sea off Santa Catalina Island, where lives in abundance one of the giants of the tribe, the California flying fish, which attains a length of about 18 inches.

THE SURFACE "TAXI"

On breaking the surface, the huge pectoral fins, the "wings" which function as the upper or anterior pair of planes, are spread wide and taut. This spreading action is apparently too sudden to be caught by the eye. Since these main supporting planes lie well in advance of the fish's center of gravity, the head of the flying fish is supported in the air at a slight angle with the surface of the sea, while the tail droops, because the lower planes (the enlarged pelvic fins), set behind the center of gravity, at first remain folded against the belly. For this reason the elongated and strengthened lower lobe or fork of the caudal fin remains submerged in the water (fig. 1b).

While a few of the flying fishes—such as the primitive, short-winged genus *Oxyphorus*, and the "two-winged" or "monoplane" type *Enococcus* (or *Halocypselus*)—dart directly from the sea, the typical biplane species normally gain power for their longer flights by a surface "taxi" movement (fig. 1c), to borrow a term from aviation.

In obtaining the position just described at the surface of the water, the biplane flying fishes may suffer some slackening of their speed. They actually appear almost to balance themselves for a split second at the inception of their surface movements. At least we may be sure that at the start of the taxi sufficient velocity is not yet attained to carry the fish on a very long soar through the air. That this is true was evident from actual observations. When the taxi was mis-governed, much abbreviated, or even eliminated, on account of some condition of wind, wave, or obstacle, the fish was sustained in the air for only a few feet. And when a very short taxi was employed, the first flight was not much longer.

I believe that I have been able to observe the acceleration in speed which may be assumed to be produced by the taxi. In compound flights it is obvious that the slackened speed at the end of one flight is greatly accelerated by the taxi intervening directly between this soar and the following one. At the end of each taxi the fish appears to be catapulted into the air at a very high speed. What this actual speed is would be very interesting to know. I assume that it is not less than about 55 kilometers (35 miles) per hour, my very rough estimate of the average speed of the whole flights (drawn up from guesses of the distance traversed in timed flights). This estimate is in rough agreement with those of Hankin (1914, 1920), who com-
NATURE'S OWN SEAPLANES—HUBBS

putes the air speed of flying fishes to be 10 to 20 meters per second. That an acceleration takes place during the taxi may also be concluded from the fact that my estimate of the speed of the entire taxi is only 10 meters per second (about 35 kilometers per hour), which is less than my estimate for the whole flight and therefore almost certainly less than the speed attained at the end of the taxi and the beginning of the actual flight, which ends as the speed is gradually decreased. The taxi may, consequently, be assumed to accelerate the speed sufficiently to carry the fish for a considerable distance through the air.

The propulsive power by which this acceleration is accomplished is derived solely from a violent side-to-side vibration of the tail, as the fish skims along with only the strengthened lower caudal lobe in the water. The even, wave-ring disturbances thus produced on a quiet sea surface indicate that such a movement takes place, and the actual track which I once saw left on dust-covered water surface proves the point.

The retention of the propelling organ in the dense medium of water and the supporting of the moving body in the rare medium of air permit the attaining of a very high speed. This is the principle of the speed boat and the hydroplane.

The rapid shaking undergone by the stiff body clearly follows from the tail movement. The slight movement of the taut pectoral fins (fig. 1c) during the taxi has been mistaken by uncritical observers for an actual flapping of the wings, but this rapid vibration of the fins, like the less obvious but still observable shaking of the whole body, is solely a response to the violent tail movements. The vibration of the wing tips, having an amplitude of only a centimeter or two, and usually lasting a bare second, is certainly insufficient to give so heavy a body speed enough to carry it through the air. The hazy outline of the planes becomes transformed into knife-like rigidity, as I have observed hundreds of times for many species and as most other trained observers have indicated, at the very instant the tail movements cease when the fish rises into the air.

It is a curious fact that nearly all observers have failed to appreciate the simple reason why the wing tips flutter while the tail is vigorously beating the water surface. Even those who have taken the side that flying fishes do not fly by wing flapping explain this wing vibration as due to the action of the wind on the taut membrane. That this explanation is untrue follows from the fact that the vibration ceases the instant the tail fin leaves the water, although neither the wind pressure nor the wing tautness is then materially altered.
The distance covered by the initial taxi is usually about 5 to 15 meters (or yards); some taxis are at least 20 meters long, but the average is nearly 50 times the length of an average flying fish, or about 9 meters (30 feet) long. Numerous timings made by me in Asia indicate that the average time involved in covering this distance is about 0.9 second. The average speed for the surface period of movement is therefore about 10 meters per second (36 kilometers per hour). This is the speed of an athlete on a short dash. But the speed of the fish, since it is accelerated during the taxi, is probably greater at the end of the taxi, when the fish hurls itself into the air. On the basis of some field observations (degree of detail not indicated) and of aerodynamic computations, Shoulejkin (1929) has concluded that a speed of 16 to 18 meters per second is attained at the end of the taxi. Like an airplane, the fish probably increases its power as it approaches the take-off.

To attain this speed the sculling action of the caudal fin must be very strong and rapid. My observations indicate an average of about 50 to 70 complete or double vibrations per second and 5 to 7 vibrations per meter.

The biplane flying fishes very often prolong their flight by taking a new start. Since they expend no energy to increase or maintain their speed in the air they gradually settle down to the water. They then either dive into the water or again start violently sculling to initiate another long leap through the air. The taxis of a compound flight subsequent to the initial taxi are typically short, seldom lasting a second and probably averaging half a second.

THE ACTUAL FLIGHT

During both the initial and intermediate taxiings the pelvic fins must remain folded tightly against the belly, for at these times they are always invisible. But at the instant the fish leaves the surface these fins flash into clear view and are very easily seen with binoculars or even with the unaided eye, especially when the pelvics are blackish. It is assuredly the upward force of air pressure on these posterior planes that lifts the drooping tail out of the water and thus actually initiates the air flight proper (fig. 1d). When the fish is thus forced into a horizontal position it lies at most only a few centimeters above the sea. This is probably a main reason why many flights are abortive, ending almost at once in a steep little wave.

The often repeated claims that a flying fish sustains itself in the air by flapping or rapidly vibrating the pectoral "wings" are apparently due, as already stated, to preconceived ideas that fishes must fly like birds, or to uncritical deductions that the mechanics of flight demand such movement, or to untrained or inattentive observation.
These claims have for the most part been made by others than trained naturalists or by laboratory zoologists equally untrained in field observation. Such accurate, trained observers as Mosely, Jordan, Gilbert, and many others have been unable to detect any movement of the fish's main planes while it flew through the air. Neither for the California flying fish nor for the several species I studied on the opposite side of the Pacific could I observe any wing movement which by any reasoning could be thought to sustain the fish in the air. The vibration of the pectoral tips through a small amplitude during the taxi, assuredly the mere consequence of the vigorous sweeping of the tail, as already stressed, ceases instantaneously as the caudal fin rises clear of the water. And these fins remain stretched taut and firm until the moment when the fish either dives into the sea or until its tail fin dips in the water and resumes the violent sculling, which immediately induces a renewal of the hazy appearance of the fin tips. The frequent naive claims that this secondary vibration becomes apparent only when the fish is fatigued and that the wing vibration while the fish had been in the air was too rapid to be seen by the eye are at once refuted by the fact that the wing appears as a single blade, whereas if it had been moved too fast to follow, it would have appeared double like a humming bird's wing, with one image at each end of the stroke.

That there is absolutely no vibration of the outstretched pectoral fins while the fish is in the air is clearly observable, even without the aid of field glasses. Whenever a fish happens to fly directly away from the observer, a condition which would make easily evident any up-and-down movement, the edges of the planes always stand out clear like knife's edges, without a trace of doubling or of a blur, even when the fish flies into a high wind (which some have said causes a vibration of the fin). It has been with full certainty also that I have observed the rigidity of the planes hundreds of times as I have looked down through field glasses at flying fishes close to the boat. When the pectoral fins are blackish, and, better yet, when they are marked with an oblique yellow band or by black blotches, it is especially easy to appreciate that these fins remain motionless in relation to the fish.

The anatomical researches of Möbius (1878), Ahlborn (1893), Ridewood (1913), and others have disclosed no muscular or other modification sufficient to make one suspect that these fishes can flap their wings sufficiently to maintain their heavy bodies in the air.

The pelvic fins, the lower or posterior planes, likewise are never seen to vibrate. They remain folded as the caudal beats the surface and thus do not participate in the slight vibration of the fin tips induced by this tail movement. Especially when the pelvics are
black or blackish it is possible to see through the binoculars that these fins do not vibrate while they are outstretched during the actual air flight.

The fact that the expanded paired fins do not vibrate after the fish leaves the water surface proves that the caudal fin does not beat in the air (another fantasy of some authors). Furthermore, the edge of this fin can be seen to be clear-cut while a fish volplanes away in line with one's vision.

THE CONTROL OF FLIGHT DIRECTION

I conclude from my observations, therefore, that a flying fish when in the air makes no effort by any flapping or vibration of the fins to add to the velocity it gained by the sculling of the tail during the swimming under water and during the taxi at the surface. That it does, however, use the fins in the air to control the direction of the flight is certain. This control is most often seen when a fish avoids the obstruction of the ship's bow by flying around it in a distinct curve, and even more spectacularly when one, headed directly for the ship's side, turns off at right angles in a curve of short radius. When a flying fish approaches even closer to the ship, it dives into the water, to take advantage of the greater resistance of that medium in making the shorter turn necessary to avoid a collision with the ship. The control is so nearly perfect that I have never seen one strike a vessel by day, though they do so when blinded by a light at night, and I have found one published record of a flying fish striking the side of a ship. Occasionally I have seen them collide, not with a ship but with one another (as though to heighten the analogy of their flight to that of airplanes). Flying fishes, therefore, seem to be lacking either in perfect flight control or in perfect air vision.

The flying fishes of the Cypselurus type, like airplanes again, show a vertical as well as a horizontal control of flight direction. This is beautifully evident as they maintain a course nearly parallel with a choppy water surface, just skimming over sharp-peaked crests and dropping to a lower level over the intervening troughs. As already noted, the diving to avoid collision with a ship likewise indicates a vertical control.

The claim has been made that flying fishes invariably take off into the wind, but I have seen them scot away toward all points of the compass, while a strong wind remained in one quarter. The power and speed of the taxi seem sufficient to hurl them into the air, when the pelvic planes are expanded, no matter what may be the angle of the taxi to that of the wind. But after the fishes start their flight, especially as they begin to lose momentum, their direction is much
modified by a strong wind. They tilt their plane surface more or less upward toward the wind and are thus carried off their original courses in a wide curve. To what degree the wind is so utilized to prolong or definitely alter the direction of the air journey is a point worthy of detailed inquiry.

THE DURATION OF THE FLIGHTS

A person’s offhand estimate of the time a flying fish remains in the air is usually several times too high. During my observations on the species of biplane flying fishes in Asiatic waters I timed 424 flights or parts of flights. The two longest single flights, during which the fish remained completely out of the water, lasted only 12 and 13 seconds, respectively. Some flights which I observed among the Philippines, before I started to use the watch, seemed to be somewhat longer than any of those actually timed. Of 42 compound flights that were timed the longest lasted slightly less than 30 seconds. It is doubtful whether any flights cover a whole minute. The record flight actually timed is perhaps one of 42 seconds, recorded by Breder (1929) on the authority of a sea captain.

Most flights are short, lasting only 1 or 2 seconds, whether the sea be glassy smooth or decidedly rough. The average time for the first flight was 2.7 seconds for the smooth Bohol Strait, and 2.9 seconds for the rough weather on the open ocean. The average time for compound flights was only 2.6 seconds.

THE NUMBER OF SUCCESSIVE LEAPS

In order to obtain some definite data on the frequency and extent of these compound flights which characterize the air movements of the biplane flying fishes, I made numerous counts of the number of successive flights. Slightly more than half of the flights counted (164 out of 299, or 55 percent) were not continued at all. About three-fourths (76 percent) ended with either 1 or 2 leaps. Nearly nine-tenths (86 percent) of the total ended with 1 to 3 leaps, and more than nine-tenths (94 percent) ended with 4 or fewer stages. Only 1 flight in 16, on the average, was made up of 5 or more elements. The greatest number of successive flights observed was 12. It is doubtful whether a greater number is often undertaken. The numbers of successive flights under the different conditions of sea, weather, size, and species of fish was found to be independent of these conditions.

THE LENGTH OF THE FLIGHT

How far flying fishes fly apparently remains to be measured. Simultaneous use of two sectants, or the combined use of a geologist’s compass and a distance finder, would seem to be a feasible way to
make approximate determinations from a ship plying through quiet seas abounding in these fishes. The estimates of observers have been very indefinite: "A surprising distance"; "200 to 400 meters"; "distances of about a quarter mile are occasionally made." Accurate estimates of the speed of flight must await determination of the distance traversed.

IV

Studying the flying fishes from an aerodynamic standpoint justifies the title here given them, "Nature's Own Seaplanes." After describing the mode of flight in the biplane flying fishes in terms similar to those here used, Breder (1930) has written:

As soon as the tail leaves the water it immediately stops oscillating, and the fish becomes a glider. Up to that time they may be considered as a pusher type of plane.

The lift, of course, as in the plane, is chiefly obtained by means of an anteriorly placed pair of wings. These are cambered very much as in the modern plane and the support is consequently chiefly from above. According to Dowd, the flying fish wing is so constructed that the upper surface is smooth and flush while the necessary thickness of the supporting rays is all below, which causes the lower surface to be ribbed. This is good construction, the sacrificing of the least efficient surface in the interest of mechanical strength. In the four-winged flyers considerable added lift is given by the ventral fins. In these advanced types the section of the body is squarish, the lower surface acting to increase the lift very much as in a plane built for large lift in which the fuselage takes part. The Cephalurus type with four wings and a flattened body seems to have gone in for large lift, whereas the Haliepus type with but two wings and a more streamlined body has apparently gone in for speed. These may be directly compared with corresponding fuselage types of modern planes (fig. 2, D).

Resistance in the air is considerably less in the flying fish than in the plane. The fish requires no landing gear whatsoever and there is a complete absence of external braces and little to produce parasitic resistance. The vertical fins are necessary as stabilizers. The skin friction must be slight on account of the wet and mucous-covered surface.

The inherent stability of flying fishes varies with the type considered. Generally the most advanced flyers show indications of greater stability than the more primitive ones.

Considering longitudinal stability; that is, in regard to a fore and aft pitching, without going into the details of the principles involved, the four-winged types should be much more stable, the ventral fins acting as combination lower planes and stabilizers (fig. 2, E). They may be considered as stabilizers placed rather far forward and large in proportion to their decreased leverage incident upon such a position or as the lower planes of a biplane type with an unusual amount of stagger. They are set at such a position as to give the proper longitudinal dihedral. Lateral stability is gained as in a plane by some sacrifice of lift by means of a lateral dihedral; that is, a slight tipping of the wings upward (fig. 3, A).

The horizontal stability is controlled by the lateral keelage, the total surface viewed when examined from the side. Most of this is effective posterior to the
insertion of the dorsal fin partly because of position and partly because of its larger area as compared with the remaining anterior part (fig. 2, F). A fish may be divided into four parts by erecting a vertical at the origin of the dorsal1 intersecting its longitudinal axis (fig. 2, A). Designating these "anterior dorsal", "posterior dorsal", "anterior ventral", and "posterior ventral", it is at once evident that "anterior dorsal" and "anterior ventral" are practically identical, whereas "posterior dorsal" and "posterior ventral" are not.

The percentage above the horizontal axis, "posterior and anterior dorsal", as compared with that below, "posterior and anterior ventral", is about equal in area, with a slight tendency for that portion below the line to be slightly greater. The average of eight fishes of various kinds shows 52.25 percent to be below the axis. Comparative measurements with four modern planes1 in com-

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1 More properly such a vertical should pass through the center of gravity, but owing to the difficulty in determining this in preserved material and the fact that the body outlines are practically parallel between such a vertical and the dorsal intersection, for the present purposes the latter point will suffice.
2 Based on area measurements of lateral keelage, including both sides of landing gear of Pitcairn PA-7, Piper-Brushell, Balcony 1930 Pacemaker and Lockheed Sirius.
men use show that they average 51 percent in this respect, a difference of 1% percent, which is not as great as the error involved in the methods employed in making these measurements. Neither the percentage above and below the hori-

![Diagram of element involved in lateral stability as expressed in a flying fish, including front view in flight.](image)

![Diagram of elements involved which give false impression of wing flapping, including rear view in flight.](image)

### Figure 3

The aerodynamics of flying fishes. Reproduced by permission from paper by C. M. Breder, Jr., published in Copeia.

A. Diagram of elements involved in lateral stability as expressed in a flying fish, including front view in flight.

B. Diagram of elements involved which give false impression of wing flapping, including rear view in flight.

zontal axis nor the lower caudal portion shows a moving trend with size. The later region bears little relation to the corresponding part of the plane, as it involves the fish's power plant, whereas in a plane there is only the tiny landing
skid. However, if we consider the relation of the part anterior to the vertical to that posterior to it we find that the percent anterior rapidly rises from being equal to considerably exceeding the posterior portion in area. In the much larger planes a similar measurement is still greater, an average of the four planes measured being 80 percent. The excess of the "posterior ventral" over the "posterior dorsal" appears to increase with size, which is to say that the lower caudal lobe (the power plant) becomes relatively larger with an increase in absolute size. Here again we would expect to find no correlation with an airplane, and there is none. Horizontal directional stability is attained by vertical vanes as in a plane and should be much greater in forms with high vertical fins such as Pterocopterus than those with low.

After a fish once leaves the water it is able to rise higher, holding its level with a decreasing speed by altering its camber and lateral dihedral, or in taking advantage of air currents. There is, of course, a point of maximum efficiency which could be worked on mathematically and would doubtless be close to that actually observed. In this respect fish flight is clearly very close to that of sail-planes. Dowd (1921) has examined exocoetids in great detail and finds them to be constructed close to the lines used in the best aeronautical engineering.

"Nature's Own Seaplanes" the flying fishes may surely be called. Flying fishes are indeed an outstanding example of the fidelity with which nature long ages ago anticipated, in the evolution of animals, both ancient and modern inventions of man.

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The Occasional Papers, publication of which was begun in 1913, serve as a medium for original studies based principally upon the collections in the Museum. The papers are issued separately to libraries and specialists, and, when a sufficient number of pages have been printed to make a volume, a title page, table of contents, and index are supplied to libraries and individuals on the mailing list for the entire series.

The Miscellaneous Publications, which include papers on field and museum techniques, monographic studies, and other contributions not within the scope of the Occasional Papers, are published separately, and as it is not intended that they will be grouped into volumes each number has a title page, and, when necessary, a table of contents.

FREDERICK M. GAGE
Director of the Museum of Zoology
STUDIES OF THE FISHES OF THE ORDER CYPRINODONTES.
XVI. A REVISION OF THE GOODEIDAE

BY
CARL L. HUBBS AND C. L. TURNER

ANN ARBOR
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STUDIES OF THE FISHES OF THE ORDER CYPRINODONTES. XVI. A REVISION OF THE GOODEIDAE*

INTRODUCTION

ALTHOUGH knowledge of the fishes of this entirely Mexican family of viviparous fresh-water cyprinodonts dates from the eighteenth century, the classification of the group, despite recent noteworthy advances, has remained incomplete and unsatisfactory to the present day. The viviparity, sexual dimorphism, and sexual behavior of *Girardinichthys inomnatus* were noted by Don José António de Alzate y Ramírez in 1769, and his observations were printed in 1772 (see Gill, 1882: 8; and Meek, 1904: 116-18). The same form was described as an unnamed species of *Lucania* by Girard (1859: 118), as *Girardinichthys inomnatus* by Bleeker (1860: 484), and as *Limnurgus variegatus* by Günther (1866: 299), who also described (p. 308) a second genus and species now referred to the group, namely *Characodon lateralis*. *Goodea atripinnis* was named by Jordan (1880: 299).

Seven other genera referable to the Goodeidae have since been described: *Xenendum* Jordan and Snyder (1900: 127), a synonym of *Goodea*; *Zoogoneticus*, Chapalichthys, and Skiffia Meek (1902: 91, 97, and 102); *Ilyodon* Eigenmann (1907: 427); and *Lermichthys* and *Balsadichthys* Hubbs (1926: 19, 18). Valid and nominal species have been added by David S. Jordan and Charles H. Gilbert (1882a and b), Tarleton H. Bean (1887 and 1892), Charles Girard (in George B. Goode, 1891), Therese von Bayern and Franz Steinachner (1895), Cloudsley Rutter (1896), Barton A. Bean (1898), David S. Jordan and Barton W. Evermann (1898, 1927), David S. Jordan and John O. Snyder (1900), Jacques Pellegrin (1901), Seth E. Meek (1902, 1904), C. Tate Regan (1904), Carl H. Eigenmann (1907), and Carl L. Hubbs (1924b, 1932c).

We now add the following new subfamilies (2), genera (9), and species (4):

- *Ataeiobiinae*, new subfamily
  - *Ataeiobius* Hubbs and Turner (*Goodea toceri* Meek)
  - *Ailohophorus* Hubbs and Turner (*Pundulus robustus* Bean)
- *Xenotoca* Hubbs and Turner (*Characodon variatus* Bean)
- *Goodea gracilis*, new species
  - *Allodontichthys*, new genus (*Zoogoneticus sonitius* Hubbs)
  - *Neophorus* Hubbs and Turner (*Zoogoneticus diazi* Meek)
  - *Neophorus* Hubbs and Turner (*Goodea captiva* Hubbs)

* C. L. Turner, coauthor of this publication, is Professor of Zoology at Northwestern University.
Xenoophorus erro Hubbs and Turner
Xenoophorus exsul, new species
Allotoca Hubbs and Turner (Fundulus duguësi Bean)
Girardinichthyinae, new subfamily
Balsadichthys xantusi Hubbs and Turner
Ollentodon Hubbs and Turner (Xenendum multipunctatum Pellegrin)
Neotoca Hubbs and Turner (Characid biulatus Bean)
The new generic names, except Allodontichthys, and the new specific names, except Xenoophorus exsul, have been used by Turner (1937a), with the indication that their characterization was taken from the present joint paper, which was delayed in publication.

It is probable that a number of additional species and even genera remain unknown, and there are indications that several of the species as now recognized will each be found to be a complex of local forms when these species are subjected to an analysis of variation throughout their range.

MATERIALS AND ACKNOWLEDGMENTS

The materials used in preparing this revision of the Goodeidae are included in the fish collections of the Field Museum of Natural History (F.M.N.H.), the United States National Museum (U.S.N.M.), and the University of Michigan Museum of Zoology (U.M.M.Z.). The Field Museum contains the wealth of material used by Meek in his classical studies (1902-8) of the fishes of Mexico. The National Museum contains much of the material described prior to Meek’s Mexican investigations, as well as a series of Meek’s specimens. The Museum of Zoology has the original material recorded in the present paper. These three collections together contain most of the available material on the family, including specimens of all previously known species as well as the types of those described by us as new. Either in these collections or in those of the Natural History Museum of Stanford University we have studied the types of all known species, valid and synonymic, with 7 exceptions: Zoogoneticus maculatus Regan, a synonym of Alloophorus robustus; Characodon Leitoldii Therese von Bayern and Steinachner, represented by topotypes; Characodon lateralis Günther; Characodon Geddesi Regan, a synonym of Girardinichthys innomisatus (of which the types were not examined but are represented by topotypes); and Xenendum multipunctatum Pellegrin. The characters of the female have been studied more or less in detail in all species with the exception of Allodontichthys zonistius, which is known only from 2 males, and the reproductive structures of the males have been determined for all species except Allotoca duguësi.

Most of the detailed studies of ovarian and trophotaenial anatomy, basic to our new classification, were made by Turner on newly collected speci-
mens. The winter of 1932 was devoted to field work in Mexico on this and related problems. In addition to material specially fixed for histological study, large series of ordinary formalin specimens of Goodeidae were preserved, and a stock of several species was obtained for rearing in aquaria. Other critical material of the family was collected for us by Myron Gordon, during the same season, particularly in the hitherto unexplored Río Santa María in San Luis Potosí, one of the headwaters of the Río Panuco system. In 1930 Gordon, with E. P. Creaser, collected many specimens of Goodeidae. Three series were collected for us in 1932 and 1936, in Laguna de Lerma and the Valle de México, by E. H. Taylor and Hobart M. Smith. In 1934 C. L. Lundell and companions collected the abundant type material of *Xenoophorus exsul* in isolated streams of San Luis Potosí. In 1935 James Oliver obtained fine series of 2 species from the state of Colima. C. Basil Jordan, Albert Greenberg, and F. H. Stoye have donated some of the types of *Goodea gracilis*.

To all who have given aid and encouragement in our researches on this family we owe a great debt of thanks. The directors of the several museums mentioned above have allowed us free use of their rich collections. Alfred C. Weed, Curator of Fishes in the Field Museum, and George S. Myers, formerly Curator of Fishes in the National Museum, have been particularly helpful to us in our museum work. The expeditions mentioned above were made possible by grants of research funds from the National Research Council, the University of Michigan, and Northwestern University. The success of the field work was largely due to the fine co-operation and assistance received from numerous officials and private citizens of Mexico, among whom we may particularly mention Isaac Ochoterena and his staff of the Instituto de Biología, and Juan Zinser, Chief of the Game Service in the Forestry, Game, and Fisheries Department, F. C. Lona of the National Railways of Mexico, F. M. Riveroll of the Department of Express, Richardo Ostos of Monterrey, and Claudio Martinez. Myron Gordon has been particularly helpful in collecting new material, which he has kindly donated to the Museum of Zoology of the University of Michigan. He has allowed us to report on his material, in advance of 2 faunal papers which have been prepared by Hubbs and Gordon. These reports will give an account of the several recent collecting trips indicated above, a description of each collecting station, and a list of the species obtained. Acknowledgment is also made to the Horace H. Rackham School of Graduate Studies for the grant which made this publication possible.

Previous Classifications of the Goodeidae

Early workers on this group failed to recognize the characters which clearly indicate its phyletic unity. Species of the Goodeidae were even re-
ferred to genera now classed in separate families, the Cyprinodontidae and the Poeciliidae. The genera of Goodeidae, when distinguished, were classified here and there throughout the whole group of cyprinodonts, in accordance with their dentition and the length of their intestines.

Meek (1902, 1904) was the first to grasp the taxonomic significance of characters which define the Goodeidae as a group, namely viviparity coupled with a shortening rather than an elongation of the anterior anal rays in the male. He proved, on the basis of previously published and original information, that all of the genera then known (1) are viviparous, (2) have the anterior 5 or 6 [6-8] anal rays shortened and partially separated from the rest of the fin, and (3) are restricted to the Río Lerma faunal area and contiguous territory.

Meek (1902, 1903, 1904), Regan (1908, 1915), and Eigenmann (1909) correctly indicated the range of the genera now comprising the Goodeidae as covering the very distinctive Río Lerma faunal area on the Mexican plateau, the Valle de México, the headwaters of the Río Panuco system which have cut back into the plateau, the headwaters of the Río Balsas in the mountains just south of the plateau, the interior drainage and the Río Mezquital drainage on the plateau to the north of the Río Grande de Santiago system, and certain coastal streams from the Río Mezquital to Colima—an unusually compact group range. Recent evidence indicates that all species reported from other localities were erroneously so recorded. Ohara-codon lateralis presumably came originally from Mexico rather than "Central America" or "Southern Central America," as stated by Günther (1866: 308; and 1869: 480, respectively). Characodon (=Ilyodon) furci-dens certainly did not come from "Cape San Lucas," as originally stated by Jordan and Gilbert (1882a: 354-55); and almost certainly not from the lagoons about La Paz or any other locality in Lower California as suggested by Jordan and Evermann (1896: 670) and subsequent authors, particularly Evermann (1908: 29), but presumably came only from Colima as indicated by Hubbs (1931: 2; and 1932a: 68) and by us (see p. 58). Ilyodon para-guayense Eigenmann (1907: 428), a synonym of Characodon furcidens, certainly did not come from Paraguay; it was based on specimens very likely collected by Xantus in Colima, Mexico (see p. 58).

Meek (1902, 1904) removed from Fundulus, Adinia, and Platypoecilus, the species of Goodeidae with conical teeth, erecting for them a new genus, Zoogoneticus, characterized by the triple evidence of relationship listed above. But so impressed was Meek with the primary separation of the
Cynipinodontes into (1) carnivorous fishes with firm jaws and teeth and short intestine, having the teeth either conic or bifid, and (2) herbivors with loose jaws and teeth and long intestine, that he widely separated Zoogoneticus and Girardinichthys (as Fundulinae) from Characodon and Chapalichthys (as Orestiinae) and from Goodea and Skiffia (as Goodeinae).

As late as 1910 Eigenmann followed Meek’s classification. It remained for Regan (1907: 76; and 1911: 323, 325) to carry Meek’s discoveries to their logical conclusion, namely the association of all these genera into one systematic group, which Regan termed the subfamily Characodontinae. He continued, however, the primary division of this group into genera with firm jaws and teeth, and those with weakly connected jaws and loosely attached teeth (“Goodea”). Jordan (1923: 159) divided the group into two families, Characodontidae and Goodeidae, on much the same basis but with a somewhat different alignment of the genera. Hubbs (1924a: 4) then concluded that “the Characodontidae and Goodeidae should not be separated, for to do so would destroy the extreme naturalness of the combined group. The name Characodontinae is synonymous with Goodeinae, which is the older; the family should therefore be named Goodeinae.” This family, however, was divided into the Zoogoneticinae (Zoogoneticus and Girardinichthys) and the Goodeinae (Characodon, Chapalichthys, Goodea, and Skiffia)—another alignment of the genera on the basis of tooth and intestine characters. Later, though admitting that the group of Zoogoneticinae is not sharply defined, Hubbs (1926: 17–19) retained the same erroneous scheme.

PROPOSAL OF A NEW CLASSIFICATION OF THE GOODEIDAE

The newly discovered characters which appear to demand a reclassification of the Goodeidae, much as the use of gonopodial characters forced a revolution in the taxonomy of the Poeciliidae (Regan, 1913; and Hubbs, 1924a, 1926), involve structures associated with the viviparous reproduction of this group. The characters, primarily based on the structure of the ovary in adult and half-grown females, and of the rectal processes (tro-
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<td>24. X. hirundo (Bain)</td>
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photobeni in the embryos, have only recently been discovered (Turner, 1932-37b; Mendoza, 1937). In the present paper we apply these discoveries to the taxonomy of the family.

COMPARATIVE ANATOMY OF THE OVARY

The goodeid ovary (Pl. I, Figs. 1-8) is an essentially hollow, median structure, approximately round in cross section, formed by the almost complete fusion of the right and left organs. It displays two principal types. In the first type (Pl. I, Figs. 1-6), the ovigerous tissue occurs through the outer wall, with a tendency toward concentration in the anterior wall and in the anterior two-thirds of the dorsal and ventral walls, and also in the thick, originally sagittal but now much-folded septum. This septum, apparently representing the fused walls of the united ovaries, divides the cavity of the compound ovary into two roughly equal compartments. In the second type (Pl. I, Fig. 7), the ovigerous tissue occurs neither in the outer wall of the ovary nor in the thin, delicate, strictly sagittal, unfolded septum, but is confined to a pair of elongated and convoluted folds, each suspended in its ovarian cavity by a sheet of tissue attached dorsolaterally to the outer wall of the ovary.

Since in both types of ovary the ovigerous portions become thickened, extremely vascular, spongy, and otherwise definitely modified during gestation, this condition applies in the first type to both the walls and the septum, whereas in the second type it applies principally to the ovigerous folds, leaving the outer wall and the septum relatively thin and unmodified. The septum of the first type, chiefly supplied with longitudinal blood vessels, becomes modified during pregnancy for the nutrition of the embryos. The septum of the second type, chiefly supplied by vertical blood vessels, remains less modified at that time.

The ovary (Pl. I, Fig. 8) of one genus, Characodon (lateralis), cannot be referred to either of the two main types, for it combines some of the features of each. The ovigerous tissue occurs in the median septum only in its dorsal portion, where the otherwise straight septum is folded and becomes thickened, highly vascular with longitudinal blood vessels, and modified during pregnancy for the nutrition of the embryos. Elsewhere the ovigerous tissue is confined to a pair of dorsolateral bands adhering flatly to the outer wall of the ovary, not occurring in the wall proper. These ovigerous bands occupy the same positions as the more extensive ovigerous lobes characteristic of the second type of ovary.

The ovaries of the first type show marked differences, particularly in the septum. In Alloophorus robustus (Pl. I, Fig. 1), in many ways the most primitive goodeid, the septum is entire, is attached to the middorsal and mid-ventral lines, and forms a few wide, flat folds; and the lateral
walls of the ovary are almost entirely devoid of ovigerous tissue. *Xenotoca variata* is essentially similar in ovarian structure. In *Goodea atripinnis* and *G. gracilis* the structure is also similar, except that the folds, as in *G. luitpoldii* (Pl. I, Fig. 2), are narrower and more numerous. *G. luitpoldii* differs in that the septum ventrally is attached to the right of the mid-line. The ovary of *Chapalichthys encaustus* is like that of *Goodea luitpoldii*, except that the tissues are extremely delicate. The septum in *Xenoophorus captivus* (Pl. I, Fig. 3), *X. erro*, and *X. exus* is interrupted slightly below the middle, to form 2 flaps which are rolled in opposite directions; the lateral walls of the ovary in this genus are likewise almost entirely devoid of ovigerous tissue. In *Neoporus diesi* (Pl. I, Fig. 4), the ovarian structure is similar to that of *Xenoophorus*, except that the ventral flap of the interrupted septum is short, little rolled, partly divided, and attached to the left of the mid-line. In *Allotoca dugesi*, the long, undivided ventral flap is attached to the mid-line, and is rolled or folded together with the dorsal flap. In *Zoogoneticus quitzeoensis* (Pl. I, Fig. 5), unlike the other genera and species of the family, the lateral as well as the dorsal and ventral walls of the ovary are ovigerous; the entire rolled septum hangs loose from its single attachment along the middorsal line, as though the connection had been broken where the septum originally joined the ventral wall. *Ataeniobius toweri* (Pl. I, Fig. 6) resembles *Zoogoneticus quitzeoensis* in the last-mentioned respect, but differs in having the lateral ovarian walls nonovigerous, and the septum relatively thick and branched near its base (the short, scarcely rolled left branch is more or less united with the ovarian wall).

The ovaries of the second type, distinguished above, show no noteworthy differences, although characteristic of 7 genera: *Hyodon*, *Balsanichthys*, *Girardiniohthys*, *Lermichthys*, *Skiffia*, *Ollentodon*, and *Neotoca* (Pl. I, Fig. 7).

**Comparative Anatomy of the Trophotaeniae**

The trophotaeniae, by which term we designate the complex nutritive and respiratory rectal processes developed on the embryos of all Goodeidae with the exception of *Ataeniobius toweri*, likewise show marked differences that we utilize as generic distinctions. These differences in the trophotaeniae involve not only their number, varying from 2 to about 12, and their length, shape, regularity, symmetry, and manner of branching, but also their general anatomy and histology. The very marked differences in the finer structure of these nutritive processes apparently offer excellent characters, of great phylectic significance. On this basis we recognize 3 types of trophotaeniae:

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2 For further details on the comparative structure of the trophotaenia see the papers of Turner (1936a, 1937b) and Mendez (1937).
(1) **Unsheathed Type** (Pl. III, Figs. 3-6).—In this probably most primitive type, the trophotaeniae are completely filled with a spongy stroma, which lacks a differentiated solid basal layer and which is not separated by a primary tissue space from the surrounding or external epithelium. This epithelium is everywhere simple and very irregular in height. Trophotaeniae of this type, occurring in 4 monotypic genera, are always flat, rather pointed, and much elongated, and when fully developed extend to or beyond the end of the caudal fin of the embryo. In *Allophorus robustus* (Pl. III, Fig. 4), apparently the most primitive goodeid bearing trophotaeniae, and in the seemingly very closely related *Xenotoca variata* (Pl. III, Fig. 3) and *Chapalichthys encaustus* (Pl. III, Fig. 5), the nutritive processes, numbering about 6 to 8, arise by dichotomous branching from 3 backwardly projecting trunks, 1 median and 2 lateral. In the fourth genus and species, *Zoogoneticus quitzeoensis* (Pl. III, Fig. 6), the approximately 10 to 12 trophotaeniae comprise several small anterior ones surrounding the anus and a group of others derived from the irregular branching of a backwardly directed trunk.

(2) **Rosette Type** (Pl. II, Figs. 1-6).—In the rosette type, so named from the external appearance of the trophotaeniae in most of the species of this group, the stroma is differentiated into a spongy upper layer and a dense basal layer. The upper layer is separated from the external epithelium by a shallow, transverse primary tissue space, of variable development, whereas the lower layer is in contact with the epithelium. The epithelium is compound, with regular high cuboidal cells over the tissue space, but with flat, irregular cells where in contact with the stroma. Typical rosette-shaped trophotaeniae (perhaps not the most primitive), characteristic of all species of *Goodea* (Pl. II, Figs. 1-2), form a cluster of relatively very short, blunt, flat processes, very irregular in size, shape, and secondary lobation, radiating in one plane about equally in all directions from the anus. A posterior pair of processes may be indefinitely evident in *Goodea*, but not elongated. In *Neoophorus diazi* (Pl. II, Fig. 3), the trophotaeniae forming a rather definite posterior pair are about twice as long as the lateral and anterior processes; the whole cluster shows a somewhat greater regularity and symmetry, though also forming a definite rosette of very irregular, more or less lobate branches. The trophotaeniae of *Allotoca dugesi* (Pl. II, Fig. 4), scarcely showing a rosette pattern, are slightly elongated anteroposteriorly; but even when developed to their maximum length, the posterior ones though about twice as long as the anterior ones do not nearly reach to the end of the caudal fin; the processes are only slightly lobate and the minor branches are scarcely developed, so that the main processes are reduced to 4, comprising an anterior and a posterior pair. In *Xenoophorus* (Pl. II, Figs. 5-6), the trophotaenial...
arrangement differs from a rosette pattern in another way: in addition to several rather small anterior processes, there is a very considerably elongated posterior pair of which the left member is much the broadest, often somewhat branched, very long (when fully developed about reaching end of caudal fin), and more or less rotated into a mid-line position. Whether the elongated or the rosette type is the more primitive cannot be stated with assurance from the available data.

(3) SHEATHED TYPE (Pl. II, Figs. 7-9, and Pl. III, Figs. 1-2).—Still more modified is the sheathed type of trophotaeniae, characteristic of the genera having the most highly specialized type of ovary, that is, of the group here called Girardinichthyinae. In this type the spongy stroma, well vascularized by internal blood vessels or a superficial capillary plexus, is almost completely surrounded by a wide primary tissue space for it is connected only by a narrow strip of attachment, on one side, with the external epithelium, which is simple and cuboidal or columnar. The histological features of this trophotaenial type are described in detail by Turner (1933e). Sheathed trophotaeniae are all greatly elongate, when fully developed extending about to the end of the caudal fin (not so far in Lermichthys), but show marked differences in arrangement and number. In Ilyodon furcidentis, Balsadichthys whitei (Pl. III, Fig. 2), and B. zanusi, the blunt and numerous trophotaeniae (about 8 to 13) are irregularly united into a pair of lateral trunks and a pair of long posterior processes, between which a shorter one may be developed. The number of trophotaenial tips appears to differ in these species: 8 to 10 in I. furcidentis, 10 to 14 in B. whitei, 10 to 13 in B. zanusi. In B. zanusi the long posterior processes are very much more flattened than in B. whitei; they are also considerably flattened in I. furcidentis. Two genera, Girardinichthys (Pl. II, Fig. 7) and Lermichthys (Pl. II, Fig. 8), have consistently 4 trophotaeniae, an anterior hornlike pair of rather short ones, and a pair of long posterior ones, reaching when most developed about to the end of the caudal fin in Girardinichthys, but not so far in Lermichthys, in which the processes are blunter than in the other genus. In Skiffia (Pl. III, Fig. 1), Ollentodon, and Neotoca the trophotaeniae form a very regular trident, with some differences in the relative length of the median and lateral processes: these are all of about equal length in Ollentodon multipunctatus; the median process is about three-fourths as long as the outer ones in Skiffia variegatus and S. lermae, but distinctly the longer in Neotoca bilineata. The median 1 of the 3 trophotaeniae is often forked in S. lermae, but seems to be consistently undivided or at most incipiently divided in the other species of Skiffia, and in Ollentodon and Neotoca.

The lowest number of trophotaeniae, 2, occurs in Characoden lateralis (Pl. II, Fig. 9), which has a very regular pair of processes extending when
fully developed about to the end of the caudal fin of the embryo. These processes of Characodon seem to have a large primary tissue space, and to be of the sheathed type, histologically.

BEARING OF THESE NEW CHARACTERS ON THE CLASSIFICATION OF THE GOODEIDAE

The new ovarian and trophotaenial characters outlined above provide:
(1) conclusive confirmation of the integrity of the group Goodeidae; (2) evidence on the phylogeny of the group; (3) the basis for an analytical classification of the family.

The ovaries and trophotaeniae of the Goodeidae, although exhibiting the remarkable series of differences indicated above, are so distinctive and so uniform as to confirm beyond any reasonable doubt the previous evidence indicating the phyletic integrity of the family, as Turner (1933c) has pointed out.

Differences in ovarian and trophotaenial characters, however, are so diverse and so definite as to indicate groups of almost certain phyletic significance. The combination of certain kinds of ovary with certain types of trophotaeniae (see Table II) confirms this view. For instance, those genera having a simple, nonovigerous, sheetlike, ovarian septum and the ovigerous tissue confined to a pair of dorsolaterally pendant, convoluted folds (p. 12, and Pl. I, Fig. 7) are also the ones which possess the sheathed type of trophotaeniae (p. 15): indicating a natural group which we define as the Girardinichthyinae (see the key, p. 32). The genera retaining an ovary with ovigerous walls and septum (p. 12, and Pl. I, Figs. 1-6), and having either the unsheathed or the rosette type of trophotaeniae (p. 14), are classed in the reorganized group Goodeinae. Characodon, with a distinctively different, perhaps intermediate type of ovary, and apparently with the sheathed type of trophotaeniae, is alone left in the Characodontinae. The single genus lacking trophotaeniae, Ataeniobios, is on this account thought so distinct phyletically as to call for its separation in a distinct subfamily, Ataeniobiinae.

These internal, sex-related characters appear to provide unusually trustworthy indications of phyletic relationship. This circumstance may result from the relative isolation and protection of the ovaries and trophotaeniae from the action of the external environment. It is quite in line with recent advances in the taxonomy of fishes, and of animals in general, to find again that characters associated with reproduction provide the most reliable indications of relationship.

A comparison of the new classification proposed in this paper with any of the previous classifications referred to above (as in Table I) will show that the new arrangement, based on characters related to reproduction,
often cuts directly across the old schemes, which were based on features related to nutrition. Genera or supposed generic groups, defined on dentic- tional and intestinal characters, are now distributed through the system. For example, the goodeids characterized by having bifid teeth loosely at- tached to the soft, weakly-joined jaws of a transverse mouth—obviously feeders on algae and ooze—instead of being interpreted as comprising a single phyletic unit (the genus Goodea, or a closely related group of genera clustering about Goodea), are now regarded as representing the terminal elements of several independent, parallel lines of evolution, scattered through 3 subfamilies. The data summarized in Table II suggest that forked teeth were probably evolved from conical teeth no fewer than 8 times in this small family, now divided into 18 genera: a remarkable indication of parallel evolution. The discovery of Creocichthys, a genus of the ovi­ parous family Cyprinodontidae having bifid teeth almost exactly like those of Goodea, but obviously derived from Empetrichthys, which has conic teeth, provides another and indubitable example of the independent origin of bifid teeth (see Hubbs, 1932b: 2). Various dismembered elements of the old genera which were defined on characters of nutritional significance are now realigned on a horizontal basis into apparently very closely related groups: for example the Allophorus—Xenotoca—Chapalickthys series, the Girardinichthys—Lermichthys pair, and the Iyodon—Balsadichthys combina- tion (see Table II).

This subordination, in the taxonomy of the Goodeidae, of divisions based on highly adaptive characters related to nutrition, repeats the relatively recent revolutions in the classification of two other groups of fresh-water fishes, Cyprinidae and Poeciliidae. In those families the primary divisions were formerly made in accordance with contrasts between the carnivorous type of dentition associated with a short intestine and an herbivorous type of dentition correlated with a long intestine. These features are now used merely to separate terminal elements comprising one to several genera, for the evidence indicates that the characters associated with an herbivorous diet were repeatedly evolved, along parallel lines, within each family. This is particularly true of the Poeciliidae, as reclassified by Regan (1913) and Hubbs (1924a and 1926).

Since the former classifications of the Goodeidae as well as of the Poe­ ciliidae have been shown to be extensively false, one is led to wonder how true or significant are the classifications based on external, adaptive features in families not possessing such remarkable clues to ancestry as the ovaries and trophotaeniae of the Goodeidae, or the gonopodia of the Poe­ ciliidae.

EXTERNAL GENITAL CHARACTERS OF THE MALES

The external genital characters of the males, although showing marked differences in various genera of Goodeidae, exhibit an underlying common
structure strongly confirming, as indicated above, the common origin and integrity of the group. The terminal portion of the genital duct has a thick muscular wall, easily evident on external examination because the surface of the body is swollen and more or less devoid of scales between the anus and the genital opening. The external genital opening is a relatively large transverse slit near, at, or around the origin of the anal fin. The anterior 6th developed anal rays consistently form a more or less strongly differentiated portion of the fin: they are moderately to much shortened, less extensively branched than the following rays, variably reduced in thickness, more or less closely approximated, and as a group slightly to deeply set off by a notch from the rest of the fin. A slight to very marked dermal thickening is usually evident about the base of the lobe or over its entire surface, and the thickening of each side tends to form a pouch about part or all of the lobe.

The male characters associated with reproduction are of much less importance than the female reproductive features in the classification of the Goodeidae. This provides a sharp contrast with the situation in the taxonomy of the Poeciliidae. Some male characters of real value, however, do exist. Marked differences are apparent in the form of the wholly or largely scaleless area, between anus and genital opening, overlying the muscular end of the genital opening; in the curvature, length, strength, and degree of approximation of the 6 anterior developed anal rays; in the deepness of the notch between the anterior lobe (formed from these rays) and the rest of the anal fin; in the differential dermal thickening along the base of the lobe or opposite the entire lobe; and in the depth of the pouch formed between this dermal thickening and the anterior lobe.

The swollen, typically scaleless area between anus and genital opening is very short and much wider than long in Ataeniobius, and less massive than in other genera; it is wider than long in Allophorus, Zoogoneticus, and Xenoophorus; about as wide as long in Goodea; longer than wide in Xenotoca, Chapalichthys, Alloodontichthys, Neophorus, Ilyodon, Balsadichthys, Characodon, Girardinichthys, Skiffia, Ollentodon, and Neotoca; very much swollen basally, narrow distally, almost flasklike in Girardinichthys. The median portion of the posterior edge of this swollen lobe (the transverse slit of the genital opening) is moderately concave and crenate in Allophorus; rather evenly concave in Xenotoca, Chapalichthys, Goodea, Zoogoneticus, Neophorus, Xenoophorus, Characodon, Lermichthys, Skiffia, and Ollentodon; nearly straight and broad in Alloodontichthys; and in Xenotoca, Goodea, Zoogoneticus, Neophorus, and Balsadichthys, a minute seventh ray was found at the front of this 6-rayed anterior lobe of the male anal fin; in Xenoporus it is absent or represented by a very minute stump. The number of developed rays in the anterior lobe is consistently 6 in all genera examined, other than Ataeniobius, in which 7 developed rays are preceded by 1 minute ray.
nearly straight and narrow in *Girardinichthys*; convex (with a median lobe) in *Ataeniobius, Ilyodon, Balsadichthys*, and *Neotoca*. The character of the covering of the genital tube, between the anus and the genital opening, is especially distinctive in *Ilyodon* and *Balsadichthys*. In these genera the anterior half of this area is little swollen and is sealed over, except for a narrow median strip. This is further evidence of the intimate relationship between *Ilyodon* and *Balsadichthys*. In *Neoophorus* the anterior sides of the area are sealed, leaving a scaleless V, with the apex just behind the anus. The next nearest approach to this condition is evident in *Allodontichthys*, in which the anterior sides of the swollen area are partly sealed over.

The 6 anterior developed rays are relatively little crowded in *Goodea*; moderately crowded in *Alloophorus, Xenotoca, Chapalichthys, Zoogoneticus, Allodontichthys, Neoophorus, Characodon, Ilyodon*, and *Balsadichthys*; much crowded in *Xenoophorus, Skiffia, Ollentodon*, and *Neotoca*. The dermal thickening over the basal part of the anterior lobe is scarcely evident in *Goodea, Girardinichthys*, and *Lermichthys*; slightly to moderately developed, but showing only a slight pocketing over the rays in *Xenotoca, Chapalichthys* (tissues thin and delicate), *Zoogoneticus, Characodon*, and *Neotoca*; conspicuously developed but still not forming a deep pocket on each side in *Xenoophorus*; well developed and forming a moderate pocket in *Allodontichthys*; well developed and extended on several rays of fin behind the anterior lobe, but still without deep pockets, in *Alloophorus*; conspicuously developed about basal portion of lobe, but separated from the lobe to form a deep pocket on each side, in *Ilyodon and Balsadichthys*; most extensively developed, though not very thick, forming a pouch into which the entire lobe is retractable, in *Skiffia and Ollentodon*.

The relative height of the anterior lobe and the rest of the fin differ widely among the genera. In *Goodea* the anterior lobe is about three-fourths as high as the highest anal ray; in *Xenotoca, Zoogoneticus, Allodontichthys, Characodon, Ilyodon*, and *Balsadichthys*, about two-thirds; in *Chapalichthys and Girardinichthys*, one-half to two-thirds; in *Ataeniobius, Neoophorus, Xenoophorus*, and *Neotoca*, one-half or a little more than one-half; in *Alloophorus*, about one-half; in *Lermichthys*, about two-fifths; in *Skiffia and Ollentodon*, less than one-third.

The curvature of the rays also shows differences. In *Ataeniobius, Alloophorus, Characodon, Ilyodon, Balsadichthys, Girardinichthys, Lermichthys, Skiffia*, and *Ollentodon*, the rays differ little in size and are all gently curved backward. In *Xenotoca, Chapalichthys, Goodea, Zoogoneticus, Allodontichthys, Neoophorus, Xenoophorus*, and *Neotoca*, the anterior 4 developed rays of the lobe are more or less abruptly curved forward, whereas the fifth and sixth rays, strengthened to a variable degree, diverge to fill the gap between the fourth and seventh developed fin rays.

The male reproductive characters have not been determined for *Allotoca*. 
CHARACTERS OTHER THAN THOSE RELATED TO REPRODUCTION: METHODS OF STUDYING, MEASURING, AND COUNTING

Although the ovarian and trophotaenial structures of the females and the external genital characters of the males, both discussed above, have proved of primary significance in the classification of the Goodeidae, numerous other structures display marked differences of value in distinguishing between related genera and between species. A few remarks on these characters may prove suggestive to other workers and will indicate how the determinations given in this paper were made.

INTESTINE.—The coiling of the intestine is studied through an incision on the right side, on which the gut is chiefly coiled. The shortest intestines are described as S-shaped for there is always a forwardly-directed, reversed fold in the median section. The S-shaped intestines show the first stage of lengthening by becoming kinked around the second bend, where the forwardly directed segment is bent backward toward the anus. The amount of kinking differs in the various species, in some producing as many as 3 or 4 short transverse segments. The longer intestines are more or less evenly coiled on the right side; the longest ones are very regularly coiled. Every gradation occurs, from a very short simple S-shaped intestine to a very long one regularly wound in a close spiral. The length of the gut is given numerical expression by counting the number of transverse (= vertical) segments.

GILL-RAKERS.—The number of gill-rakers differs in certain goodeids and has been used to help separate the superficially similar genera with loose, bifid teeth. Xenoophorus, Skiffia, and Neotoca have about 20 to 25 gill-rakers on the first arch, Ollentodon about 29, Goodea and Balsadichthys about 39 to 45. It is desirable to count the rakers under a binocular dissecting microscope, after the arch has been excised carefully so as to leave no rakers at either end. All rakers are counted, even the 1 or 2 rudimentary ones sometimes developed at either end of the arch, and no distinction is made between those on the upper and lower limb.

TEETH.—Using any reasonable magnification, no difficulty is encountered in determining whether the teeth of the main row are conic or bifid, or variably intermediate (in Girardinichthys), or whether they form an even series, or an irregular row of alternating elements. Greater difficulty is met with in deciding how compressed and how curved, keeled, or concave these teeth are, and whether they are to be classed as firmly or loosely attached to the jaws. Even the "fixed" teeth are more or less freely movable from side to side, but present considerable resistance to backward or forward movement. "Loose" teeth are more or less freely, and generally very freely, movable forward and backward. The degree of development of the
teeth of the inner row, their shape when developed (whether conic or bifid, strong or hairlike), their size (whether small or minute), the width and shape of the inner band, and the degree of obsolescence of the band, all provide valuable characters, which, however, are very difficult to appreciate by ordinary means of examination. A satisfactory method of determining the characteristics of the inner teeth, and of the band which they form, is to hold either jaw, open and strongly lighted, under a high power (about 64x) of a binocular dissecting microscope, examining the teeth closely while playing a fine jet of compressed air on them. A glass pipette on the end of a length of rubber tubing serves for this purpose.

Jaws.—The strength of the jaws and the firmness of their mutual attachment at the symphysis differ greatly in various Goodeidae and provide good characters, even though a graded series in respect to these characters exists. These points may be determined by vertically manipulating the jaws with a dissecting needle, observing whether each jaw is thin, flexible, and rather independent in movement, or thick, stiff, and not independently movable.

Mouth.—The width of the mouth is numerically expressed as the number of times the width over all, including the lips, enters the length of the head. Whether the mouth is strictly or almost wholly transverse, or possesses a moderate or a wide lateral gape, is determined by inspection. Despite the intermediate mouth characters exhibited by some species, the contrasts are usually sharp.

Measurements.—All measurements are expressed as proportions, that is, as the number of times a given part enters some base length, usually the standard length from the tip of the snout (=anterior tip of upper lip) to the base of the caudal rays, where the caudal base bends most readily, or the length of the head, from the tip of the snout to the extreme margin of the opercular membrane. The measurement of the part, taken carefully with good dividers, is stepped along the curve of the base length, a measured number of times plus estimated tenths. The depth of the body is the greatest depth, not including fins or their bases. The depth of the caudal peduncle is the least depth. The length of the caudal peduncle extends from the end of the anal fin base to the base of the middle caudal rays. The length of the snout is measured from the tip of the upper lip to the front rim of the orbit, excluding the thin soft membrane about the orbit. The length of the orbit is the longest diameter, between the free fleshy rims. The interorbital is measured between the bony rims where these are closest.

Pelvic Fin.—The degree of separation or union of the innermost or sixth pelvic ray of one fin from or with its mate of the other fin, and from or with the body, offers a hitherto unused character of considerable value. In one extreme condition, exhibited by Girardichthys, the inner rays are separated from the body, and from one another by an interspace about equal to
the width of either pelvic base. In *Lermichtys* the inner rays are almost as well separated from one another, but are joined to the body and are more or less conjoined by a wide, thin membrane. In *Ataenioius*, *Neoophorus*, and *Allotoca* the two fins are more or less separated. In other genera the sixth rays of the two fins are variously approximated or in contact, and, except in *Allodontichthys*, are slightly to widely joined to the body and to one another by membrane. In an extreme condition, developed only in *Zoogoneticus quitzeoensis*, the fifth pelvic rays of each side are in contact, forcing the sixth ray to lie between the fifth ray and the body, in the membrane connecting that ray with the mid-line of the belly.

**Counts.**—All dorsal and anal fin rays are counted, including the short anterior 1 or 2; the last is always counted as a double ray, that is, as split to the very base, even though the 2 elements are widely separated. The pectoral rays are all counted, none as doubled. The transverse scale rows are counted from the bound-down edge of the opercle to the end of the hypural. The longitudinal rows are counted between the origins of the dorsal and anal fins.

The statements regarding external characters in the following analysis are drawn not only from the literature, but also from an examination of specimens of all the species.

**ANALYSIS OF THE GENERA AND SPECIES OF GOODEIDAE**

The following analysis of the genera and species of Goodeidae, simplified and made more graphical in Table II, aims to compare all known forms in respect to all main characters used in their classification, as well as to provide a key for their identification. That the analysis is primarily based on internal characters which may prove difficult to detect and which are evident only in adult females and embryos may raise objections.

On the first point we maintain that convenience, ease, and simplicity should be left only a very minor role in taxonomy, that the trenchancy of the ovarian and trophotaenial characters and their value in phyletic analysis repay any effort expended in their study, that the essential features of ovarian anatomy can be determined without undue difficulty in adult and even half-grown females by simple dissection under an ordinary binocular microscope, that at least the superficial features of the trophotaeniae are evident in half-grown to large embryos taken from females ordinarily preserved for museum specimens, and that such embryos are very often present.

In answering the objection that the analysis is based on characters derived only from adult (or in part from half-grown) females, it must be admitted that this circumstance does complicate and hinder the identification of specimens and even renders uncertain or impossible the final classification.

*Excluding *Allodontichthys zoniatius* (Hubbs), the generic position of which is indeterminable in the absence of females.
cation of species known only from males (Allodonichthys constits is the one species now known only from males). The important point is that these characters are the ones indicating the natural groups, and that classifications surely should be made natural rather than convenient. To discard a classification because it is based primarily on one sex would seem absurd to us. To do so consistently would virtually require abandoning the whole accepted family classification of the American Cyprinodontes, since the family characters, at least the superficial ones, are based on adult males, and would also require the abandoning of the modern, now as a whole well-authenticated taxonomy of the Poeciliidae, because the identification and classification of poeciliids now depends chiefly on the gametodid characters of breeding males and remains a guess when such males are not at hand, except in genera and higher groups which may be recognized definitely on the basis of very superficial, at times almost subjective, characters.

The following analytical key has been constructed not only to indicate relationships but also to lead to precise identifications, whether either of these anatomical features of prime value in classification are usable. The isolated Ataenioius towe rii is first set off by significant internal as well as by relatively trivial superficial characters. The primary separations are then made on the basis of ovarian anatomy, so that if the ovarian characters are determinable, the items numbered 2, 3, and 4 may be employed. The next divisions are made on the basis of the trophotaenial characters, which are itemized for all groups, so that by using items 5, 6, 12, and 13 alone, identifications can be made solely on the basis of the differential features of the trophotaeniae. Superficial characters, such as those of tooth, mouth, and fin structure, are then employed to confirm the differentiation made on the basis of the deeper anatomical characters, and to lead on to definite genus and species placement and identification. These more superficial characters are co-ordinated and given for every genus and species, under the items numbered 7, supplemented by alternatives in items 1 and 6 and elaborated as necessary in items 8 to 15. In at least some minor details all of these coordinate items are alternative. Therefore it is possible to locate specimens of any known species by the use of the analytical synopsis, without recourse to the ovarian and trophotaenial characters. For real convenience in "running down" males and young females, and to obviate the need for dissecting specimens, however, we append, on pages 73 to 76 an artificial key for the genera and species of the family.

**Analytical Key**

1a—Embryo apparently without trace of trophotaeniae (nutritive rectal processes), but with enlarged fin folds, both before and behind anus. Yolk sac less reduced. Dorsal fin smaller (with 10 or 11 rays), and placed farther back, beginning dis-
tightly behind origin of anal fin, more than twice as far from tip of snout as from base of caudal fin.

2a.—Ovigerous tissue developed in the outer wall of the ovary (except laterally), and in the septum. Outer wall and especially septum of ovary much thickened and highly vascular during pregnancy. (Pl. I, Fig. 6.)

2b.—Ovarian septum entire, relatively thick; attached only to middorsal line of ovary; rolled; with a short, scarcely rolled left branch more or less in contact with the ovarian wall (Pl. I, Fig. 6).

ATAENIODIINAE

3a.—Teeth of outer row uniformly bifid, long, slender; about 48 in each jaw; rather loosely attached to soft, weakly conjoined jaws; inner teeth bifid, weak, in a broad band (about 8 rows) with sharp posterior lateral extensions. Mouth narrow (width over all about 2.9 to 3.9 in head); with slight lateral cleft. Intestine long, coiled. Scales in 45 to 47 rows. Dorsal rays 10 or 11. Origin of dorsal much nearer end of caudal than tip of snout. Innermost (sixth) rays of the two pelvic fins separated by an interspace about half as wide as base of fin, joined to body by a very membranous membrane for about one-fourth or one-third their length. Coloration: weakly speckled along mid-sides. Scales area between anus and genital opening of males much wider than long, very short (less massive than in other goodeids), with a median lobe on convex posterior margin; scales at side of lobe forming a deep pocket. Anterior anal lobe of males with 1 minute and 7 developed rays (6 developed rays in all other goodeids); lobe little more than half as high as highest anal ray.

Rio Verde of the Rio Paraná system:

1. *Attaenobius toweri*

2b.—Embryo with well-developed trophopterine (nutritive rectal processes) but with poorly developed fin folds. Dorsal fin typically larger (very rarely with as few as 11 rays), and placed farther forward, beginning over or before origin of anal fin, less than twice as far from tip of snout as from base of caudal fin (dorsal fin beginning approximately over origin of anal fin, about twice as far from tip of snout as from base of caudal fin, in *Goodea gracilis* and *G. strippensis*; slightly in advance of anal fin, but more than twice as far from tip of snout as from base of caudal fin, in *Allotoxia dugesi*).

3b.—Ovigerous tissue developed in the outer wall of the ovary (dorsally and ventrally in all species; laterally also, only in *Zoogoneticus quitensis*), and in the septum. Outer wall and septum of ovary thickened, extremely vascular, spongy, and modified during pregnancy; the septum supplied chiefly with longitudinal blood vessels, and modified during pregnancy for the nutrition of the embryos. (Pl. I, Figs. 1-5).

* New subfamily.
5a.—Trophotaeniae not rosette-shaped, always greatly elongated, when fully developed extending to or beyond end of caudal fin, moderately pointed, rather regular, about 6 to 8 in number, arising by dichotomous branching from 3 backward-directed trunks (Pl. III, Figs. 3-5); histologically of the unsheathed type: completely filled by a spongy stroma, lacking a solid basal layer, and not separated by a primary tissue space from the surrounding or external epithelium, which is everywhere simple and of irregular height.

7b.—Teeth of even outer row sharply conic, without compression, moderately curved along front edge; about 25 in each jaw, not alternating; firmly attached to very strong, tightly joined jaws; inner teeth conic, small, in a narrow, curved band. Mouth rather broad (width over all about 2.6 to 2.8 in head); with well-developed lateral cleft. Intestine short, very little coiled (S-shaped, more or less kinked about second bend). Scales in 36 to 39 rows. Dorsal rays 12 to 14. Origin of dorsal fin at middle of total length including caudal fin. Innermost (sixth) rays of the two pelvic fins in contact, and slightly joined together and to body. Coloration: body much speckled, but without really definite markings on either body or fins. Scales somewhat larger, in 36 to 39 rows. Swollen area between anus and genital opening of males wider than long, with slightly concave, fimbriate posterior border; scales scarcely extended on anterior sides of this area. Anterior anal lobe of males with basal dermal thickening extended unto several succeeding rays, not forming a pocket; lobe slightly more than half as high as highest anal ray; rays of lobe moderately crowded, all weakly curved backward, all except first developed ray deeply branched; lobe separated by moderate notch from rest of fin.

Rio Grande de Santiago system, on the plateau:

2. Allophorus robustus

7a.—Teeth of even outer row uniformly and rather sharply bifid, scarcely compressed antero-posteriory, little curved backward; about 15 to 20, scarcely alternating; firmly attached to the very strong jaws; inner teeth conic, small, forming a narrow, curved band. Mouth very narrow (width over all only 3.6 in head); with well-developed lateral gape. Intestine short, little coiled (S-shaped, with an extra coil about second bend). Scales in 33 to 38 rows. Dorsal rays 13 or 14. Origin of dorsal fin near middle of total length, including caudal fin. Innermost (sixth) rays of the two pelvic fins in contact and joined together and to body for about half their length. Coloration: spotted with dark in females; with an irregular longitudinal
dark stripe or nearly plain in males. Swollen area between anus and genital opening of males longer than wide, somewhat turgid basally and constricted distally, with concave posterior border; anterior sides of this area scarcely sealed over. Anterior anal lobe of males with slight dermal thickening near base, not forming a pocket; lobe two-thirds as high as highest anal ray; developed rays of lobe moderately crowded, the first 4 curved forward, the last 2 distinctly strengthened and divergent, the last 2 to 4 branched near tip; lobe separated by a shallow notch from rest of fin.

8a.—Ovarian septum attached ventrally to mid-line. Tissues not delicate, rather leathery.

Rio Grande de Santiago and Rio Panuco systems, on and below the plateau:

3. *Xenotoca variata*

7d.—Teeth of even outer row uniformly and rather sharply bifid, rather short, slightly compressed antero-posteriorly; each lobe with a low keel near outer edge of posterior face and with an expanded, sharp, and sometimes irregular inner edge; weakly curved backward; about 15 or 16, scarcely alternating; rather firmly attached to the moderately strong and rather securely connected jaws; inner teeth small, conic, forming a narrow, curved band. Mouth narrow (width over all about 4.0 in length of head); with much reduced lateral gape. Intestine considerably elongate, coiled (with about 5 transverse elements on right side). Scales in 34 to 37 rows. Dorsal rays 15 or 16. Origin of dorsal fin far in advance of middle of total length, including caudal fin. Innermost (sixth) rays of the two pelvic fins in contact, and joined together and to body for about half their length. Coloration: strongly barred along middle of sides in both sexes. Swollen area between anus and genital opening of males slightly longer than wide, with broad, evenly concave posterior border. Anterior anal lobe of males with delicate dermal thickening near base, forming a slight pocket; lobe one-half to two-thirds as high as highest anal ray; developed rays of lobe moderately crowded, the first 4 curved forward, the last 2 distinctly strengthened and rather well spaced; all but the first branched near tip; lobe separated by a small notch from rest of fin.

8b.—Ovarian septum attached ventrally to right of mid-line. Tissues all very delicate, not leathery.

Lago de Chapala and Rio Grande de Santiago, on the plateau:

4. *Chapalichthys encensatus*

7b.—Trophotaenias forming a rosette about the anus, always short, very blunt, and very irregular in shape and size (Pl. II, Figs. 1-6);
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histologically of the rosette type; stroma composed of a spongy upper and a dense basal layer, both lying below a shallow, transverse tissue space; external epithelium compound, with regular high cuboidal cells over the tissue space, but with flat, irregular cells where in contact with the stroma.

7c.—Teeth of even outer row uniformly bifid, with truncated lobes; long and slender, much compressed anteroposteriorly, rather strongly curved backward; about 40 in each jaw, more or less regularly alternating; very loosely attached to the extremely narrow, weak, and poorly joined jaws; inner teeth minute, almost hair-like when exposed from investing gum, obsolete toward anterior edge of the broad and nearly transverse band, which has slight backward extensions at sides. Mouth moderately wide; with almost strictly transverse gape. Intestine elongate, much coiled (with about 12 transverse segments). Gill-valves on first arch about 39 to 45, relatively long. Scales in 34 to 44 rows. Dorsal rays 12 to 15. Origin of dorsal fin considerably behind middle of total length, including caudal fin. Innermost (sixth) rays of the two pelvic fins in contact and joined together and to body for 0.3 to 0.7 their length. Coloration: body speckled in young, plain in adult. Swollen area between anus and genital opening of males about as wide as long, with broad, gently concave posterior border. Anterior anal lobe of males with scarcely any dermal thickening; lobe about three-fourths as high as highest anal ray; developed rays of lobe relatively little crowded, the first 4 strongly curved forward, the last 2 strengthened and divergent; most or all rays branched near tip; lobe separated by a small notch from rest of fin.

G. auratus—Ovarian ovum attached ventrally to mid-line (PI. II, Fig. 1). Scales in 34 to 39 rows. Dorsal fin with 12 to 14, usually 12 or 13 rays; more posterior: distance from its origin to base of caudal usually about half distance forward to tip of snout. Head larger, about one-fourth standard length, or larger. Size small, usually much less than 4 inches.

60a.—Body rather slender; greatest depth 3.3 to 3.7 in standard length; least depth about half length of head in adult. Width of mouth usually about 2.5 in length of head. Rio Santa Maria (Rio Paracu system),

G. gracilis

G. auratus—Body moderately robust; greatest depth about 2.6 to 3.2 in standard length; least depth...
about two-thirds length of head in adult.

Width of mouth about 3.0 in length of head.

Streams and smaller lakes, Rio Grande de Santiago system, on the plateau:

6. G. atripinnis

9b.—Ovarian septum attached ventrally to right of midline. (PI. II, Fig. 2). Scales in 38 to 44 rows.

Dorsal fin with 12 to 15, usually 13 or 14 rays; less posterior; distance from its origin to base of caudal usually distinctly more than half distance forward to tip of snout. Head smaller, usually less than one-fourth standard length.

Size relatively large, often more than 4 inches (extreme length about 9 inches).

10c.—Body depth moderate, 3.0 to 3.2 in standard length; least depth about two-thirds length of head in adult. Width of mouth 2.6 to 2.9 in length of head.

Larger lakes (Chapala, Patzcuaro, Zacoalco, and perhaps others) in the Rio Grande de Santiago system, on the plateau:

7. G. isittpoalli

14c.—Ovarian septum entire; attached only to middorsal line of ovary; rolled; unbranched (PI. I, Fig. 5).

8c.—Trophophores not rosette-shaped, greatly elongated, when fully developed extending to or beyond end of caudal fin, moderately pointed, somewhat irregular, about 10 to 12 in number, comprising several small anterior ones and others arising by the irregular branching of a main posterior trunk (PI. III, Fig. 6); histologically of the unbranched type, as in 5a.

17.—Teeth of even outer row conic, firmly attached to the very strong, tightly joined jaws; inner teeth conic, relatively large and strong, in a rather narrow, arched band. Mouth narrow (width over all 3.4 to 3.8 in length of head); with rather wide lateral eleft.

Intestine short (S-shaped, slightly kinked about second bend). Scales in 29 to 34 rows. Dorsal rays 12 to 14. Origin of dorsal fin near middle of total length, including caudal fin. Next to innermost (fifth) rays of the two pelvic fins in contact, and joined to mid-line of body by a membrane containing the hidden sixth ray.

Coloration: nearly plain (sometimes speckled), except for several black spots or bars in one row (rarely irregular or doubled) along lower sides; a pair of such spots (rarely fused) at base of caudal; dorsal and anal fins plain in females, but with conspicuous red borders in males. Swollen area between anus and genital opening of males wider than long, with very broad, evenly concave posterior border.

Anterior anal lobe of males with moderate dermal
thickening near base, forming a slight pocket; lobe about two-thirds as high as highest anal ray; developed rays of lobe moderately crowded, all gently curved forward, the last 2 somewhat strengthened and more spaced than the others; last 2 or 3 slightly branched; lobe separated by a moderate notch from rest of fin.

Rio Grande de Santiago system, about lagos de Chapala and Quispeo, on the plateau:

8. Zoogoneticus quitoensis

5d.—Ovarian septum divided near or below middle, to form 2 rolled flaps, one attached dorsally, the other ventrally (Pl. I, Figs. 3-4).

4a.—Ovarian flaps thick; the ventral flap short, little rolled, partly divided, and attached to left of mid-line (Pl. I, Fig. 4).

5d.—Trophotaeniae almost typically rosette-shaped, only the posterior pair of processes showing a slight tendency to become elongated, the several anterior processes irregularly lobate (Pl. II, Fig. 3); histologically of the rosette type as in 3b, but with the primary tissue space much reduced.

7g.—Teeth of outer row conic, large; about 20 in each jaw; firmly attached to the strong, tightly joined jaws; inner teeth conic, in 2 strongly curved rows. Mouth rather narrow (width over all about 3.4 to 3.5 in head); with well-developed lateral cleft. Intestine short. Scales in about 32 to 39 rows. Dorsal rays 13 to 19. Origin of dorsal fin near middle of total length, including caudal fin. Innermost (sixth) rays of the two pelvic fins separated from each other by an interspace about as wide as base of fin, and joined together and to body for about one-third their length. Coloration: body crossed by irregular, submedian, narrow dusky bars, with some to much speckling. Swollen area between anus and genital opening of males nearly twice as long as wide, somewhat flank-shaped, with noncrescent, slightly concave posterior margin; anterior half with scales extending to the edge of a V having its apex just behind anus. Anterior anal lobe of males with 1 minute and 6 developed rays; lobe a little more than half as high as highest anal ray; the rays crowded.

Basis of the Rio Lerma, and Valle de Mexico, on the plateau:

10. Neopimelurus diari

4b.—Ovarian flaps thick; the ventral flap almost as long as the upper, strongly rolled in the opposite direction, undivided and attached to mid-line (Pl. I, Fig. 3).

5c.—Trophotaeniae very considerably elongated, when fully developed about reaching end of caudal fin, not lobate, asymmetrical (the long trunk arising from the left side, but twisted to a submedian position), often slightly branched, about 8 in number
histologically of the rosette type, as in 4b, but with the primary tissue space greatly reduced, often to a cleft.

7b.—Teeth of outer row uniformly and rather deeply bifid, with rounded or truncated lobes; rather long and slender, much compressed antero-posteriorly, moderately curved; 15 to 30 in each jaw, weakly to moderately alternating; rather loosely attached to the thin and rather weakly joined jaws (more strongly attached than in *Goodea*, however); inner teeth cone, very small (but less minute and hairlike than in *Goodea*), in a moderately wide band with definite backward extensions at sides. **Mouth** rather narrow (width over all, 2.6 to 3.4 in length of head); with markedly restricted lateral gape. **Intestines** elongate, considerably coiled (about 4 to 7 transverse segments). Gill-plates on first arch 21 to 25. **Scales** in 33 to 39, usually about 35 or 36 rows. **Dorsal rays** 12 to 14. **Origin of dorsal fin** considerably nearer end of caudal fin than tip of snout in females, about equidistant between these points in males. **Innermost (sixth) rays** of the two pelvic fins slightly separated, and not at all or only slightly joined together and to body by membrane. **Coloration:** speckled with dark in young, plain in adult, never barred. **Swollen area** between anus and genital opening of males wider than long, with broad, evenly concave posterior border. **Anterior anal lobe** of males with well-developed dermal thickening near base, forming only a slight pocket; lobe half or somewhat more than half as high as highest anal ray; the rays much crowded, and rather strongly and evenly curved forward; last 2 to 4 rays branched; lobe separated by a deep notch from rest of fin.

**XENOOPHORUS**

11a.—Length of head 3.3 to 3.6 in standard length in males; 3.5 to 3.9 in females. **Least depth of caudal peduncle** in adult females 1.7 to 2.3, usually about 2.0 in head. **Distance from origin of anal fin to base of caudal fin** 2.4 to 2.8 in standard length. **Anterior profile** little concave, even in adult males. **Basin of Rio Panuco, about Jesús María:**

11. *X. captivus*

11b.—Length of head 2.9 to 3.3 in standard length in males; 3.2 to 3.6 in females. **Least depth of caudal peduncle** in adult females 1.8 to 2.3, usually about 2.0 or 2.1 in head. **Distance from origin of anal fin to base of caudal fin** 2.4 to 2.8
in standard length. Anterior profile more concave, becoming deeply concave in adult males.

**Río Santa María, tributary to Río Panuco:**

12. *X. erro*

15c.—Length of head 3.2 to 3.5 in standard length in males; 3.4 to 3.8 in females. Least depth of caudal peduncle in adult females 2.1 to 2.5, usually about 2.3 in head. Distance from origin of anal fin to base of caudal fin 2.6 to 3.2 in standard length. Anterior profile little concave, even in adult males.

Isolated streams in San Luis Potosí, among the hills on the plateau north of Río Santa María:

13. *X. euseul*

4c.—Ovarian flaps relatively thin; the ventral flap long, rolled together with and inside the dorsal flap, undivided and attached to mid-line.

5f.—Trophotaeniae slightly elongated anteroposteriorly, when developed to maximum not nearly reaching end of caudal fin, slightly lobate; the minor branches scarcely developed, the main branches tending to be restricted to an anterior and a posterior pair (Pl. II, Fig. 4); histologically of the rosette type, as in 5b.

7c.—Teeth of outer row long-conic, firmly attached to the strong, well-joined jaws; inner teeth conic, of moderate size, irregularly arranged in 2 moderately curved rows. Mouth rather narrow (width over all about 2.2 in head); with well-developed lateral efts. Intestine short. Scales in 29 to 35 rows. Dorsal rays 15 to 17. Origin of dorsal fin very far behind middle of total length, including caudal fin. Innermost (sixth) rays of the 2 pelvic fins separated from each other at base by an interray as wide as base of fin, but in contact on distal half; joined together and to body for one-third their length. Coloration: body crossed by regular, high, wide blacklist bars. (Male characters unknown.)

**Basin of the Río Lerma, on the plateau:**

14. *Altioota dugesii*

2c.—Ovigerous tissue confined to a pair of short and narrow bands adhering flatly to the dorsolateral walls of the ovary, and to the upper part only of the septum. Outer wall and septum of ovary, except where ovigerous dorsally, remaining relatively thin and unmodified during pregnancy; dorsal part of septum becoming highly vascular with large longitudinal blood vessels, and modified for the nutrition of the embryos. (Pl. I, Fig. 8.)

5c.—Ovarian septum entire, attached to both middorsal and mid-ventral line, somewhat folded, fan-fashion, where ovigerous dorsally, but otherwise nearly straight (Pl. I, Fig. 8).

6p.—Trophotaeniae much elongated, when developed to maximum extending about to end of caudal fin, reduced to a single posterior pair of slender ribbons (Pl. II, Fig. 9); stroma apparently
surrounded by a primary tissue space; histological structure probably of the sheathed type, as in Sh.

CHARACOCONITINAE

7a.—Teeth of even outer row uniformly bifid, except at sides of jaw; with sharp and conic lobes, scarcely compressed anteroposteriorly; strong and not greatly elongate, gently curved backward; 16 to 21 (in 2 specimens), scarcely alternating firmly attached to the strong, tightly joined jaws; inner teeth conic, small, in a narrow, curved band. Month rather narrow (width over all 2.9 to 3.1 in length of head); with well-developed lateral gape. Intestine short and little coiled (with about 4 short transverse segments). Scales in 31 to 33 rows. Dorsal rays 11 to 13. Origin of dorsal fin far behind middle of total length, including caudal fin. Innermost (sixth) rays of the 2 pelvic fins rather well separated, but more or less joined together and, to body. Coloration: body with short black bars in females, with a longitudinal stripe or plain in males. Swollen area between anus and genital opening of males longer than wide, contracted toward the rather narrow, concave, posterior border. Anterior anal lobe of males with moderate dermal thickening near base, forming a slight pocket; lobe about two-thirds as high as highest anal ray; the rays moderately crowded, and gently curved backward; the rays all unbranched; lobe separated by a shallow notch from rest of fin.

Interior drainage and headwaters of Rio Mezquital, on the Sonoran plateau:

15. Characodon latens

2d.—Ovigerous tissue restricted to a pair of much convoluted folds, each suspended in its ovarian compartment from the dorsolateral ovarian wall. Outer walls and septum of every entirely nonovigerous, remaining relatively thin and unmodified even during pregnancy; the septum chiefly supplied with vertical blood vessels; the convoluted folds becoming thickened, extremely vascular, spongy, and otherwise modified during pregnancy. (Pl. I, Fig. 7.)

3f.—Ovarian septum entire, attached to middorsal and mid-ventral line, straight and vertical, not folded (Pl. I, Fig. 7).

5h.—Trophopteridae much elongated, when developed to maximum extending about to end of caudal fin (not so far in Lernaeichthys), 3 to many in number (Pl. II, Figs. 7-8 and Pl. III, Figs. 1-2) histologically of the sheathed type; with a spongy stroma, and well vascularized by internal blood vessels or a superficial capillary plexus; except for a narrow strip of attachment on one side, separated by a wide primary tissue space from the external epithelium, which is simple and cuboidal or columnar.

6a.—Trophopteridae numerous, about 8 to 14 (Pl. III, Fig. 2), Fin: dorsal usually with several more rays than anal, but

* New subfamily.
with fewer than 18 rays; caudal with upper angle somewhat produced, the margin slightly lunate, and the lower angle shorted and rounded off. **Coloration:** one or more of the unpaired fins with a blackish bar near or at margin; body variably speckled with dark and light in male, and with more or less definite parrlike bars along a diffuse dark lateral stripe in female.

**7k.—Teeth of main row uniformly bifid, with a low keel on the posterior face of each pointed lobe; strong and not greatly elongate, little compressed anteroposteriorly, strongly curved backward; about 25 in each jaw, in an even row; firmly implanted in moderately strong and rather tightly joined jaws; teeth of inner row bifid and in an arched single series or very narrow band in upper jaw, obsolete in lower jaw. Mouth rather narrow (width over all 2.6 to 3.5 in length of head); with a moderate lateral gape. Intestine long and much coiled (with 8 to 12 transverse segments). Scales in 46 to 50 rows. Dorsal rays 14 to 17. Origin of dorsal fins near middle of total length, including caudal fin.**

**Innermost (sixth) rays of the two pelvic fins closely approximated and joined together and to body for 0.1 to 0.4 their length. Swollen area between anus and genital opening of males longer than wide (measuring length from anus), with a produced median lobe on posterior border; anterior half of area scaled over except for a narrow median strip. Anterior anal lobe of males with well-developed dorsal thickening near base, forming a deep pocket on each side; lobe about two-thirds as high as highest anal ray; the rays moderately crowded, weakly curved backward; 5 or 6 of the rays branched; lobe separated from rest of fin by a moderate notch.**

**ILYODON**

**12a.—Scales in 46 to 53 rows. Head thick, but narrowed forward. Mouth rather narrow (width over all 2.6 to 3.5 in length of head); with a moderate lateral gape. Caudal peduncle in adults half or a little more than half as deep as head is long. Coloration: the dark and light speckling of body, and the barring, usually less conspicuous than in *B. xanthis;* fin markings usually less prominent; dashes on basal two-thirds of dorsal and caudal fins of males usually much less prominent, often weak, not followed by a very conspicuous light area or band, which when evident is not bright yellow in life. **Trophopteriinae** 8 to 10; the larger posterior ones much flattened. Streams of Jalisco and Colima, below the plateau:**

16. *Ilyodon furvidens*
Teeth of main row uniformly bifid, with posterior half of each rounded lobe hollowed out; rather weak and long, considerably compressed antero-posteriorly, strongly curved backward; about 45 in each jaw, more or less regularly alternating to form an imperfect double row; loosely set in soft, poorly joined jaws; teeth of inner row usually obsolete or obsolete in both jaws (a very narrow, little arched band of bifid teeth occasionally developed in upper jaw in B. whitei). Mouth wider (width over all 2.0 to 2.8 in length of head); with more or less strictly transverse gape. Intestine long and much coiled (with 8 to 12 transverse segments). Gill rakers about 40 on the first arch. Scales in 43 to 55 rows. Dorsal rays 14 to 17. Origin of dorsal fin near middle of total length, including caudal fin. Pelvic fin and male reproductive characters as in 7b.

**Balsaschthy**

46b.—Scales usually smaller, in 46 to 55 rows. Head less bulky. Mouth narrower (width over all 2.4 to 2.8 in length of head); with a slight arch. Caudal peduncle slenderer (in adults less than half as deep as head is long). Coloration: the dark and light speckling of body, and the barring, less conspicuous; fin markings dusky; dashes on basal two-thirds of dorsal and caudal fins merely dusky, in fine pattern, usually obsolete in females. Trophotaeniae 10 to 14, little flattened (Pl. III, Fig. 2).

Upper tributaries of Rio Balsa, in mountains south of the plateau:

17. B. whitei

46c.—Scales usually larger, in 43 to 50 rows. Head bulkier. Mouth wider (width over all 2.0 to 2.6 in length of head); almost strictly transverse. Caudal peduncle deeper (in adult females half or a little more than half as deep as head is long). Coloration: the dark and light speckling of body, and the barring, more conspicuous; fin markings usually black; dashes on basal two-thirds of dorsal and caudal fins usually conspicuous in males and often so in females, followed in male by a conspicuous light area or band which is bright yellow in life. Trophotaeniae 10 to 13; the larger posterior ones much flattened.

Streams about Colima, below the plateau:

18. B. zanzuti

6b.—Trophotaeniae consistently 4: a short anterior pair, and a long posterior pair (Pl. II, Figs. 7–8). Fin rays: dorsal and anal with rays in about equal number (18 to 30), often more in
anal than dorsal; caudal with upper angle scarcely or not at all produced, the margin rounded or only very slightly concave, and the lower angle not distinctly cut off; un-paired fins without a blackish bar near or at margin.

7m.—Teeth of outer series conic to truncate; some arrow-shaped or slightly bifid or trifid; sometimes almost uniformly bifid; moderately long and strong, somewhat compressed antero-posteriorly, with posterior face of tip concave and anterior face of stem slightly keeled; only moderately curved backward; 19 to 27 in each jaw, scarcely alternating; firmly implanted in the strong, well-connected jaws; teeth of the curved inner row conical, in about 2 series. Mouth narrow (width over all about 3.0 in head); with some lateral gape. Intestine rather short, S-shaped, with some coiling (about 3 transverse segments) at second bend. Scales in 40 to 45 rows. Dorsal and anal fins elongate, with 18 to 26 rays; dorsal base in females about two-thirds as long, in males about as long as head. Origin of dorsal fin slightly before middle of total length including caudal fin in females, decidedly before that point in adult males. Interorbital (sixth) rays of the two pelvic fins widely separated by an interspace about as wide as pelvic base, and disconnected from one another and from body. Coloration: breeding males jet black; dark blotch above anus smaller and less conspicuous than in Lermichthys, or lacking; sides speckled, barred, or streaked (but these different phases less distinct than in Lermichthys). Swollen area between anus and genital opening of males longer than wide, very conspicuously swollen and expanded, but constricted terminally into an almost flabelliform shape, with narrow and nearly straight posterior border. Anterior anal lobe of males with scarcely any definite dermal thickening toward base; lobe one-half to two-thirds as high as highest anal ray; the rays very much crowded, gently curved backward; lobe separated by a well-developed notch from rest of fin.

19a.—Posterior pair of trophotaeniae very long, when developed to maximum reaching to or beyond caudal fin (Pl. II, Fig. 7). Body rather slender (the adults usually less than one-third as deep as long), chubby forward, attenuate posteriorly.

Valle de México (on the plateau):

19. Girardichthys annumusatus

7a.—Teeth of outer series uniformly bifid, with pointed lobes; rather long, moderately compressed, weakly curved backward; about 20 in each jaw, scarcely alternating; firmly implanted in moderately strong and well-jointed jaws; those of inner series conic, in a narrow, curved
band. Mouth narrow (width over all about 3.0 in head); with some lateral gaps. Intestine short, S-shaped, with little coiling (only 1 to 3 traverse segments) at second bend. Scales in 42 to 47 rows.

Dorsal and anal fins much elongated, with more than 25 rays; dorsal base in females about as long as head, in males about half longer. Origin of dorsal fin slightly before middle of total length including caudal fin in females, far before that point in adult males. Innermost (sixth) rays of the two pelvic fins well separated by an interspace nearly as wide as pelvic base, but joined to body and often together by a wide, thin, flat membrane. Coloration: breeding males darkened, but never black; blotch above anus always large, conspicuous, bluish; sides mottled or definitely barred or definitely streaked, or showing intermediate or combined phases. Swollen area between anus and genital opening of males longer than wide, only moderately swollen, little constricted toward gently concave posterior border, not flasklike. Anterior anal lobe of males with scarcely any definite dorsal thickening toward base; lobe about two-fifths as high as highest anal ray; the rays very much crowded, gently curved backward; lobe separated by a rather shallow notch from rest of fin.

55b.—Posterior pair of trophotaeniae of moderate length, not reaching end of caudal fin (Pl. II, Fig. 8). Body typically deeper (the adults usually more than one-third as deep as long), distinctly more oblong in outline.

Headwaters of Rio Lerma (on the plateau): 20. Lermichthys multiradiatus

6c.—Trophotaeniae always 3, forming a regular trident, with a median branch which is often divided at tip in Sikhsia lermae (Pl. III, Fig. 1). Fins: dorsal and anal with rays in about equal number (13 to 17); caudal with upper angle scarcely or not at all produced, the margin rounded or only very slightly concave and the lower angle not distinctly cut off; unpaired fins without blackish band near margin.

70.—Teeth of even outer row uniformly bifid, with truncate lobes; rather weak and long, strongly and flatly compressed anteroposteriorly, little curved backward; about 18 or 19 in each jaw, scarcely to moderately alternating; very loosely attached to rather weak jaws; teeth of inner row conic or round-tipped, obsolescent except where thickly developed outward and backward in lower jaw. Mouth narrow (width over all 3.0 to 4.0 in head); with greatly restricted lateral gape (almost strictly transverse). Intestine elongate.
evenly coiled on right side (with 6 to 8 transverse segments). Gill-rakers on first arch about 25. Scales in 33 to 37 rows. Dorsal rays 15 or 16. Origin of dorsal fin distinctly (females) or much (males) nearer tip of snout than end of caudal fin. Innermost (sixth) rays of the two pelvic fins rather well separated, but largely bound down by membranes which are narrowly conjoined on mid-line. Scales area between anus and genital opening of males longer than wide, only moderately swollen, little constricted toward distinctly concave posterior border. Anterior anal lobe of males wholly retractable within a dermal pocket; lobe less than one-third as high as highest anal ray; the rays very much crowded, gently curved backward; lobe separated by a deep notch from rest of fin.

**Sciffia**

14a.—Coloration: densely variegated with dusky in each sex. Median posterior trophotaenia about three-fourths as long as the lateral ones, simple or divided (Pl. III, Fig. 1).

15a.—Body slenderer, and more conspicuously mottled; bar at base of caudal tending to be horizontal. Median posterior trophotaenia consistently simple.

 Rio Grande de Santiago system (Lago de Zirahuen) and Valle de México (Lago de Chalco), on the plateau:

21. *S. variegata*

15b.—Body deeper, and rather inconspicuously mottled; bar at base of caudal tending to be vertical. Median posterior trophotaenia divided at tip in two-thirds of the individuals (Pl. III, Fig. 1).

 Rio Grande de Santiago system (Lago de Poçõesaro, Celaya), on the plateau:

22. *S. lewisi*

7p.—Teeth of outer row uniformly bifid, with broadly rounded lobes; moderately weak and long, strongly and slimly compressed anteroposteriorly, rather strongly curved backward; about 20 in each jaw, some alternating; very loosely attached to rather weak jaws; teeth of inner row mostly bifid but occasionally blunt or conic, obsolescent except for 1 or 2 rows in lower jaw along outer edge of each band and its posterior extension. Mouth narrow (width over all 3.0 to 3.5 in head); with greatly restricted lateral gap (almost strictly transverse). Intestine elongate, evenly coiled on right side (with 6 to 8 transverse segments). Gill-rakers on first arch about 29. Scales in 33 to 35 rows. Dorsal rays 15 to 17. Origin of dorsal fin decidedly
nearer tip of snout than end of caudal fin in both sexes. [Pelvic fin characters and male reproductive characters as in 7c.]

14b.—Coloration: upper and posterior parts of body with definite rows of blackish spots, one to each scale, more conspicuous in females than in males; often coarsely blotched with black on lower posterior sides. Median posterior transverse sinus about as long as lateral ones, simple.

Lower portion of Rio Grande de Santiago system, on the plateau:

23. Olenodon multipunctatus

?.—Teeth of outer row uniformly bifid, with broadly rounded lobes; fairly robust, strongly and finely compressed anteroposteriorly, weakly curved backward; about 16 in each jaw, not or barely alternating; rather loosely attached to moderately strong jaws; teeth of inner row likewise bicuspid, not obsolescent toward mid-line and not thickly developed outward and backward, forming instead a narrow, moderately curved band. 

Mouth narrow (width over all 2.3 to 4.0 in head); with considerably restricted lateral gape (forming a wide arch). 

Intestine not much elongated, kinked but not evenly coiled on right side (with about 3 or 4 transverse segments), Gill-rays on first arch about 20. Scales in 29 to 33 rows. Dorsal rays 13 to 15. 

Origin of dorsal fin slightly (females) or considerably (males) nearer tip of snout than end of caudal fin. 

Innermost (sixth) rays of the two pelvic fins not bound down to body, and separated from one another by about one-half width of pelvic base. 

Swollen area between anus and genital opening of males longer than wide, only moderately constricted toward the medially convex posterior border. Anterior anal lobe of males with moderately developed dermal thickening near base, forming only a very slight pocket; lobe a little more than half as high as highest anal ray; the rays very much crowded, gently curved backward; lobe separated by a deep notch from rest of fin.

14c.—Coloration: females with a black axial stripe, and a shorter, lower stripe over the belly in advance of a black blotch or bar above the anus; males with a single dark band more or less broken into bars. Median posterior transverse sinus distinctly longer than the lateral ones, and undivided (rarely with incipient division at tip or largely fused with lateral ones).

Lower part of Rio Grande de Santiago system, on the plateau:

24. Neotoca bilineata
Ataeniobiinae, New Subfamily

Genus *Ataeniobius* Hubbs and Turner

*Ataeniobius*—[Hubbs and Turner], in Turner 1937a: 4; 1937b: 495, 510-11, 513-14
(name *Ataeniobius toweri* indicated as taken from the manuscript for the present paper and used with statement that the trophotaeniae are lacking).


A new subfamily and genus are erected for *Goodia toweri* because this species, alone among all the Goodeidae, lacks any trace of the trophotaeniae or nutritive rectal processes. Since the yolk-sac is less reduced in this species than in other goodeids and the embryonic fin folds are especially well developed, as though in compensation for the lack of these nutritive processes, it is plausible to assume that *Ataeniobius toweri* or its ancestral line diverged from the goodeid stem before any of the other living genera were differentiated (Turner, 1937b: 510, 513). It is of interest in this connection to recall that this species has the most easterly range of any goodeid, most removed in that direction from the Rio Lerma basin which is the center of distribution for the family (see p. 10).

It is therefore assumed that the close agreement between *Ataeniobius* and *Goodia* in dentition, jaw structure, and intestinal length, which led Meek to refer *toweri* to *Goodia*, is the product of independent parallel evolution (see p. 17). Rather distinctive superficial characters (see items 11a and 11b in key on p. 74) confirm this view.

It is not necessary to repeat here the diagnostic features of *Ataeniobius*, for these are given, so far as known to us, in items 1a, 2a, 3a, and 7a of the analytic key (p. 23), which provides a comparison between *Ataeniobius* and all other genera of the family on the basis of these features.

*Ataeniobius*, living [as embryo] without trophotaeniae, from a primitive, radia band, and fios, means of living.

1. *Ataeniobius toweri* (Meek)

(Pl. I, Fig. 6, section of ovary.)


*Ataeniobius toweri*—Turner, 1937a: 4; and 1937b: 495, 510-11, 513-14 (lack of trophotaeniae; relation).

We have re-examined Meek’s types, the only known specimens of this very interesting species. The embryonic and ovarian characters were determined by Turner on the specimens in the Field Museum, and by Hubbs on one of the two paratypes in the National Museum. The last-mentioned specimen, 50 mm. long, contains 9 developed embryos about 12 mm. long.
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UBBS AND TURNER

These show no trace of nutritive processes, but the fleshy fin fold is well developed, especially about the anal fin; a median flap immediately in advance of the anus is obviously a continuation of the fin fold. The left lobe of the ovarian septum is short and very compact and largely adherent to the ovarian wall. The right lobe is larger, square-edged, and mostly free from the ovarian wall, against which one face of the lobe is appressed; the inner or left face of this lobe is deeply emarginate. The distal ends of the two ovarian lobes are widely separated. The ovarian characters of this specimen are at some variance with those indicated on Plate I, Figure 6.

SUBFAMILY GOODEINAE

GENUS ALLOOPHORUS HUBBS and TURNER

Alloophorus.—[Hubbs and Turner], in Turner, 1937b: 507-9, 513 (name Alloophorus robustus used, and indicated as taken from the manuscript for the present paper; trophotaeniae described).

Genotype, Fundulus robustus Bean.

This, the first of our segregates from the genus Zoogonetcus as recognized by Meek, Regan, and Hubbs, is characterized chiefly by fundamental differences in the structure of the ovary (Pl. I, Fig. 1) and of the trophotaeniae (Pl. III, Fig. 4). These characters are stated respectively in items 3b and 5a of the analytical key (pp. 24-25) so as to contrast with the corresponding characters given for other genera under items in the key with the same number but with other letters. On the basis of these internal as well as the external characters, we regard Alloophorus as the most primitive of all Goodeidae possessing trophotaeniae, that is, of all excepting Ataeniobius toweri. In many respects, especially those related to nutrition, Alloophorus is more primitive than Ataeniobius. Other characters descriptive if not diagnostic of Alloophorus are given as items 1b, 2b, and 7b of the analytical key.

Alloophorus, different ovary, from Allos, other or different, αός, egg, and φόρος, bearing (αεφόρος, ovary).

2. Alloophorus robustus (Bean)

(Pl. I, Fig. 1, section of ovary; Pl. III, Fig. 4, trophotaeniae.)

Fundulus robustus.—Bean, 1892: 855-86, Pl. 44, Fig. 2 (original description; "Mexico").


Zoogoneticus robustus.—Meek, 1902: 87, 90-94, 96, 100-101 (characters; comparison; size; color; embryos; food; Ootitla; Pátzcuaro; Zirahuén); 1903: 779 (anal fin); 1994: xl, 1, 14, 110, 112-13, 121, Fig. 31 (description). Regan, 1904: 257 (comparison); 1907: 85, 86-87 (description; records: Z. macrotus a synonym). Eigenmann, 1909: 304 (listed); 1910: 454 (listed).
REVISION OF THE GOODEIDAE


Allophorus robustus.—Turner, 1937b: 507-9, 513, Pl. 3, Fig. 16 (trophotaeniae).

Fundulus parvipennis (erroneous identification).—Garman, 1895: 100-101 (synonymy in part).


The synonymy of this species is largely self-explanatory. Regan recognized his own Zoogoneticus maculatus as a synonym of Z. robustus.

The holotype of this species, as selected by Jordan and Evermann (1896: 644), U.S.N.M. No. 43760, is an adult female labeled “Patzcuaro, Mex.” not “Guanajuato” as stated by these authors. The other type specimen mentioned by Bean (1892: 285), the male, No. 43762, is labeled as from Guanajuato, as also the nontype specimens bearing Nos. 37834 and 41973, likewise mentioned by Bean (p. 286). Other specimens of this species in the National Museum are from “Alberca, Valle de Santiago, Mex. Duges” and from “Lake Quitzaco, Mex. Aug. 5, 1892. E. W. Nelson.” Our new material of this species was collected by Turner and Dildine in Rio Grande de Santiago, between Ocotlan and Laguna de Chapala.

The largest specimen of the last-named collection measures 122 mm. in standard length.

GENUS Xenotoca HUBBS and TURNER

Xenotoca.—[Hubbs and Turner], in Turner, 1937b: 508-9, 513 (name Xenotoca variata used, and indicated as taken from the manuscript for the present paper; trophotaeniae described).

Genotype, Characodon variatus Bean.

We erect this new genus for Characodon variatus because this species differs from Characodon (lateralis) in numerous internal as well as external features. Characters distinguishing Xenotoca from Characodon involve the ovarian anatomy (items 2b and 3b of the analytical key, contrasted with items 2e and 3f, respectively), the form and structure of the trophotaeniae (item 5a contrasted with item 5g), and some superficial features (item 7c contrasted with item 7j). Xenotoca is apparently much more closely related to Chapalichthys, from which it differs in the characters contrasted in items 7c and 7d, and in items 8a and 8b. It is also close to Goodea, differing however in characters related to nutrition and in superficial features (as contrasted in items 7c and 7e). Except in its bifid teeth, Xenotoca does not differ sharply from its more primitive relative Allophorus. A full characterization of Xenotoca is given in the analytical key, as items 1b, 2b, 3b, 5a, 7c, and 8a.

Xenotoca, strange offspring (embryo), from μαя, strange, and τέος offspring.
3. Xenotoca variata (Bean)


Xenotoca variata.—Turner, 1937b: 508-9, 513, Pl. 5, Fig. 18 (trophotaeniae).

Characodon ferrugineus.—Bean, 1887: 572-73, Pl. 20, Figs. 3-4 (original description; probably streams of Guanajuato). Eigenmann, 1893: 56 (listed). Therese von Bayern and Steinacker, 1895: 520, 529-30 ("Cuitzeo-Soe").

Characodon lateralis (erroneous synonymizing).—Garman, 1895: 36 (synonymy in part).

(f) Characodon lateralis (probably erroneous identification).—Pellegrin, 1901: 205 (state of Jalisco).


Soon after describing the two species, Bean (1892: 286) correctly interpreted Characodon ferrugineus as the female of C. variatus. Regan (1907: 89) and Hubbs (1926: 18) have indicated C. eiseni Rutter as another synonym.

This appears to be the most widely ranging species of the family, for it is reported to occur on and below the plateau in both the Rio Grande de Santiago and the Rio Panuco systems. Fowler (1916: 432) recorded it from Rio Verde at Rascon (the type locality of Atanenobius toweri), in the Rio Panuco system below the plateau escarpment, and we have specimens from the Rio Santa Maria, a tributary of the Rio Panuco on the plateau (taken by Gordon, Whetzel, and Ross at Santa Maria del Rio, San Luis Potosi). Our other new material is from the Rio Grande de Santiago between Ocotlan and Laguna de Chapala. Specimens of this species in the National Museum include the cotypes of Characodon variatus from "Mexico," U.S.N.M. No. 37809 (not No. 37808 as stated by Jordan and Evermann, 1896: 668); the
type of *C. ferrugineus*, from "Mexico" (No. 37510), and specimens collected by Duges at "Alberca, Valle de Santiago."

We have noticed no evident differences between specimens from these several localities, but have not had available sufficient material to make a thorough comparison. Such a study should be made.

**GENUS CHAPA LICHTHYS MEEK**


Orthotype, *Characodon encaustus* Jordan and Snyder.

The new evidence leaves unquestionable the need for separating *Chapalichthys* from *Characodon*, but aligns it very intimately with *Xenotoca* and *Goodea*. The features distinguishing *Chapalichthys* from these genera, though all rather minor according to usual standards, are numerous and in our judgment warrant generic separation.

4. *Chapalichthys encaustus* (Jordan and Snyder)

(Pl. III, Fig. 5, trophotaeniae.)

*Characodon encaustus*—Jordan and Snyder, 1900: 116-17, 126-27, Fig. 7 (original description; comparison; Lago de Chapala, near Ocotlan). Jordan and Evermann, 1900: 315-51 (description repeated). Pellegrin, 1901: 205 (state of Jalisca). Regan, 1907: 88-89 (description).

*Chapalichthys encaustus*—Meek, 1902: 97 (characters; La Barca; Ocotlan; La Palma); 1904: cl, 125-24, Fig. 36 (description). Eigenmann, 1909: 304; and 1910: 456 (listed). Jordan, Evermann, and Clark, 1930: 184 (listed).

Turner, 1937b: 508-10, 513, Pl. 3, Fig. 17, and Pl. 4, Fig. 24 (trophotaeniae).

Our characterization of this genus and species, given in the analytical key, has been based largely on our new material, a fine series of specimens collected by Turner and Dildine in Rio Grande de Santiago, between Ocotlan and Laguna de Chapala. There are specimens in the National Museum from this lake, collected by P. J. Jouy in February and April, 1892, before the types of the species were obtained.

The coloration of the young of this species approaches the mottled pattern of the goodeids with more generalized color pattern, but the short, narrow, lateral bars soon become much intensified while the other markings fade more or less completely. The bars in the adult vary considerably, from roundish dots to high streaks. In some individuals they form 2 irregular rows instead of only 1.

**GENUS GOODEA JORDAN**

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Haplotype, Goodea atripinnis Jordan.

Xenendum.—Jordan and Snyder, 1900: 117, 127 (original description; sexual dimorphism; comparison). Jordan and Evermann, 1900: 3151-52 (Jordan and Snyder’s account repeated).

Orthotype, Xenendum caliente Jordan and Snyder.

The erection of Xenendum was due to the erroneous original description of the teeth of Goodea as being trifid.

Through the separation of Skiffia by Meek and of Balsaciscles by Hubbs, and of Ataeniobius, Xenophorus, Ollentodon, and Neotoca in the present work, Goodea has been cleared of these several genera which resemble it very closely in superficial and nutritional characters, but which differ trenchantly in internal features and are probably not very closely related (see p. 17). There are left in Goodea only 2 species, atripinnis and luitpoldii, to which we now add the following form.

5. Goodea gracilis, new species

(Pl. IV, Fig. 1, holotype.)

Goodea caliente (presumably a misidentification, not Xenendum caliente = Goodea atripinnis).—Meek, 1902: 100-101; and 1903: 778 (record from San Juan del Rio only).

Goodea caliente.—Regan, 1907: 91 (San Juan del Rio record). Eigenmann, 1910: 459 (Panuco basin).


Goodea gracilis.—Turner, 1937b: 496, 499 (sones nudum).

Of the 3 species from the Rio Panuco system referred to Goodea, 2 are now shown to represent distinct genera (Ataeniobius and Xenophorus), but the third form, hitherto confounded with Goodea atripinnis, is apparently a true Goodea. This form, G. gracilis, seems to differ specifically from G. atripinnis and G. luitpoldii of the Rio Lerma system in certain superficial characters, as outlined in the analytical key on pages 27-28.

Holotype.—An adult female 39 mm. in standard length, collected by Gordon, Whetzel, and Ross in Rio Santa Maria, of the Rio Panuco system,
at Santa Maria del Río, San Luis Potosí, Mexico, on March 21, 1932; U.M.M.Z. No. 108552.

The paratypes, in the same Museum, comprise 3 adult males 34 to 43 mm. long, taken with the holotype; 4 half-grown of the specimens previously identified as "*Goodea caliente*" and "*Goodea atripinnis*," collected by Meek in Río San Juan, tributary of Río Moctezuma of the Río Panuco system, at San Juan del Río, Queretaro, Mexico, May 16, 1901; and 18 young to adult specimens, 12 to 53 mm. in standard length, of the aquarium stock originally obtained at San Juan del Río, and received from the importer, C. Basil Jordan, and from Albert Greenberg and F. H. Stoye. The account and figure given by Mayer (1937) for *Goodea atripinnis* was undoubtedly based on specimens of the same stock.

Body rather slender but thick, particularly chunky and turgid just behind the head, where the width is about two-thirds the depth. Greatest depth, 3.4 (3.3 to 3.7 in paratypes). Dorsal contour rather evenly and gently curved from origin of dorsal to tip of snout, often more or less flattened on top of head. Ventral contour equally but less evenly curved, rather steep at the chin, and sometimes prominent below pectoral fin, especially in males. Dorsal base forming an angle of about 20° with the horizontal; anal base one of 20° to 25° in adult females, increasing to 40° in adult males. Edges of the caudal peduncle nearly horizontal and weakly concave. Least depth of peduncle, 1.4 (1.3 to 1.5) in length of peduncle; 2.0 (1.75 to 2.05) in head.

Length of head, 3.5 (3.2 to 3.7). Head approximately as deep as its greatest width, which enters the head length 1.55 (1.4 to 1.6) times. Least width of the moderately convex interorbital, 2.2 (2.0 to 2.3). Orbit, 1.8 (1.6 to 2.3) in interorbital; 3.7 (3.4 to 4.3) in head. Snout, 3.5 (3.3 to 3.7). Mouth moderately wide (extreme over-all width, 2.5 to 2.6, rarely 2.7 or 2.8, in head); with almost strictly transverse gape; lips rather full. Teeth, jaws, gill-rakers (39 in one paratype), and intestines as described for the genus in item 7e of analytical key (p. 27).

Fin rays: dorsal, 13 (12 to 14, usually 12 or 13); caudal, 19 (18 to 21) branched rays; anal, 16 (14 to 16, usually 15 or 16), including a minute first ray; pelvic, 6; pectoral, 15 (14 to 16, usually 15). Origin of dorsal fin slightly behind that of anal (rarely on the same vertical) in females and low males, usually directly over anal origin in well-developed males. Distance from dorsal origin to end of middle ray of caudal fin, 1.35 (1.3 to 1.4 in females, 1.25 to 1.35 in males) in distance from dorsal fin to tip of premaxillaries. Distance from caudal base to dorsal origin, 2.1 (1.9 to 2.3 in females, 1.9 to 2.1 in males) in predorsal length. Broadly rounded dorsal fin reaching about two-thirds distance to first precurtrent caudal ray in females and low males, almost to the precurtrent rays in high males; length
of depressed dorsal in head, 1.5 (1.3 to 1.6 in females, 1.1 to 1.3 in adult males). Posterior margin of caudal fin weakly rounded; length of fin, 1.4 (1.3 to 1.45 in females, 1.25 to 1.4 in males). Characters of pelvic fin, of anal lobe in adult male, and of swollen area between anus and genital opening all as described for the genus on p. 27.

Scales rather large, in 38 (35 to 39) transverse and 14 (12 to 16) longitudinal rows.

Sides with brown spots and blotches thickly set on a cream background, in holotype and other small adults. Larger adults are almost uniform, deep purplish brown, except on yellowish belly, breast, and throat. Young with relatively few (about 30) spots, mostly vertically elongate, scattered over sides. Middorsal dusky stripe rather indistinct; axial band on sides rather well developed in small adults, but very weak in young and in large adults; no distinct stripe on lower edge of caudal peduncle. Vertical fins dark, becoming deep dusky in adults; pectoral pale dusky; pelvic clear, mottled, or uniformly dark.

The name gracilis refers to the slender form.

6. Goodea atripinnis

(Pl. II, Fig. 1, trophoteniae.)

Goodea atripinnis.—Jordan, 1880: 299-300 (original description; León, Guanajuato). Jordan and Gilbert, 1883: 548 (after Jordan). Jordan and Evermann, 1896: 685 (description; Guanajuato); 1896a: 316 (listed). Bean, 1898: 541 (L de Quiotro). Jordan and Evermann, 1900: 3257, Pl. 114, Fig. 501 (figure of type). Meek, 1902: 93, 105-158 (teeth; comparisons); 1904: xi, 1, 137, 146, Fig. 43 (synonymy; description; records, San Juan del Río excepted). Jordan, 1905: 2: 199 ("tricuspid teeth"). Regan, 1907: 91 (in part; reference to original description and locality only). Meek, 1908: 156 (in part; San Miguel). Eigenmann, 1909: 298, 304 (in part; listed); 1910: 409 (range, in part). Hubbs, 1924b: 2, 6-8 (synonymy; variation; distribution; record for San Juan del Río excepted). Jordan, Evermann, and Clark, 1930: 183 (listed). Turner, 1933: 210; 1937: 498-99, 501-2, 511, Pl. 1, Fig. 2, and Pl. 4, Fig. 20 (trophotaeniae).


Characodon variatus (erroneous identification).—Woolman, 1894: 62 (in part—see Hubbs, 1924b: 3).

Xenodon calicentus.—Jordan and Snyder, 1900: 116-17, 127-29, Fig. 8 (original description; comparison; Río Verde near Aguas Calientes). Jordan and Evermann, 1900: S192-93 (Jordan and Snyder’s account repeated). Pellegrin, 1901: 207 (comparison).

Goodenia callistis.—Meek, 1902: 87, 108-102 (viviparity; variation; records, San Juan del Río excepted); 1902: 778-79 (anal fin; except San Juan del Río record).

Goodenia callistis.—Regan, 1907: 90-91 (description; records, excluding those for San

Material of this species in the United States National Museum, collected by A. Dugès includes the types from León, Guanajuato (No. 23137); other series labeled Guanajuato (Nos. 38006, 41814–15); Alberca, Valle de Santiago (No. 23122), and Mexico (No. 37883).

7. Goodea luitpoldii (Therese von Bayern and Steindachner)

(PL I, Fig. 2, section of ovary; PL II, Fig. 2, trophotaeniae.)

Characodon luitpoldii.—Therese von Bayern and Steindachner, 1895: 522–30, PI. 2, Figs. 3–1b (original description; Lago de Patzcuaro). Garman, 1895: 37 (description, after original). Jordan and Evermann, 1896a: 314 (as G. luitpoldii; listed); 1904: 2831 (as G. luitpoldii; description, after original). Pellegrin, 1901: 205–6 (as Luitpoldi; to 17 cm.; vicinity of Guadalajara and Lago de Zacoalco, Jalisco).

Xenendem luitpoldii.—Jordan and Snyder, 1900: 127–29 (comparison; genus). Jordan and Evermann, 1900: 216–23 (as X. luitpoldi; genus; calibre compared).

Goodea luitpoldii.—Meek, 1902: 101–2, Pls. 22–24 (characters; variation; viviparity; G. calientis a probable synonym; Ocotlán; La Palma; La Barena; Patzcuaro); 1903: figure on p. 788; 1904: xl, lv, 135, 137, 129–40, Fig. 43, Pls. 1–2 (synonymy; description; viviparity). Jordan, 1905, 1: 126, Fig. 93, and 2: 205, Fig. 160 (viviparity). Eigenmann, 1909: 304; and 1910: 459 (listed). Hobbs, 1924b: 2–5 (synonymy; comparisons; distribution). Jordan, Evermann, and Clark, 1930: 184 (synonymy). Mendoza, 1937: 97–98, 100, 108–9, 111 (trophotaeniae). Turner, 1937b: 408–99, 502, 511, Pl. 1, Fig. 1, and Pl. 4, Fig. 10 (trophotaeniae).

Characodon (Goodea) atripinnis (presumably an error in identification).—Herrera, 1896: 31 (viviparous; Lago de Patzcuaro; specimens from this lot referred to G. calientis by Regan, 1907: 91).

Goodea atripinnis.—Regan, 1907: 90–91 (not reference to original description and locality; description; synonymy; Lago de Chapala and Lago de Patzcuaro); 1911: 235, 237; Pl. 8 (osteology). Fowler, 1916: 432 (identification not checked; “Lake Patzcuaro” = Lago de Patzcuaro).

Xenendem atripectis.—Jordan and Snyder, 1900: 116–17, 128–29, Fig. 9 (original description; comparison; Lago de Chapala near Ocotlán). Jordan and Evermann, 1900: 3153 (original account repeated). Pellegrin, 1901: 207 (comparisons).

Goodea calientis.—Meek, 1902: 101 (regarded as a probable synonym of G. luitpoldi).

Goodea calientis (presumably an error in identification).—Regan, 1907: 91 (Patzcuaro record only).

Of this species the material which we have studied in greatest detail was collected in Río Grande de Santiago, between Ocotlán and Laguna de Chapala, by Turner and Dildine. Some specimens were preserved in the field, and an aquarium stock was brought back alive and bred in the laboratory at Northwestern University. The National Museum material includes 1 lot collected by P. L. Jouy in Laguna de Chapala.
9. **Allodontichthys zonistius** (Hubbs)

(Pl. IV, Fig. 2, paratype.)

**Zoogoneticus zonistius**—Hubbs, 1932a: 69-71 (original description; comparisons; Colima).

**Allophorus zonistius**—Turner, 1937b: 496 (trophotaeniae not studied).

No specimens of this well-marked species were secured by Oliver about the type locality (Colima, Mexico), although large series of *Ilyodon furcidens* and *Balsadichthys zonatus* were collected there. This species can be distinguished from other goodeids by the size of the scales (in 40 rows) and particularly by its coloration: there are some rounded dark spots above and behind the pectoral fin; the scale borders are blackened posterodorsally; a large, black, comma-shaped mark lies behind the opercle; there are no ventrolateral spots or bars; the dorsal fin is crossed by jet-black bands.

**GENUS NEOOPHORUS**

**Neoophorus**—[Hubbs and Turner], in Turner, 1937b: 498-502, 511 (name *Neoophorus diasi* used, and indicated as taken from the manuscript for the present paper; trophotaeniae described).


This is one of the genera which we are segregating from *Zoogoneticus* on the basis of differences in ovarian and trophotaenial characters (see items 5 and 7 in the key, on pp. 28-29). It differs from *Zoogoneticus* and *Allophorus* in having the sixth (innermost) pelvic rays of the two fins well separated, instead of having the fifth (*Zoogoneticus*) or sixth (*Allophorus*) in contact. The dorsal fin, longer than in *Allophorus*, has 15 to 19 rather than 12 to 14 rays.


10. **Neoophorus diasi** (Meek)

(Pl. I, Fig. 4, section of ovary; Pl. II, Fig. 3, trophotaeniae.)

**Zoogoneticus diasi**—Meek, 1902: 71, 93-94, Pl. 21, upper fig. (original description; comparison; Lago de Pátzcuaro, Pátzcuaro, Michoacán; also Zirahuen); 1904: xii, 110, 114, Fig. 32 (description; reproduction). Regan, 1907: 85-86 (description; *miniatu8* a synonym). Eigenmann, 1909: 304; and 1910: 454 (listed). Hubbs, 1925: 18 (*miniatu8* a synonym). Jordan, Evermann, and Clark, 1930: 182 (synonymy). Hubbs, 1932a: 69 (listed; *miniatu8* a synonym). Mendoza, 1937: 97-98, 106-7, 111, Pl. 1, Fig. 5, and Pl. 3, Fig. 1 (trophotaeniae).

**Neoophorus diasi**—Turner, 1937b: 498-502, 511, Pl. 1, Fig. 3, and Pl. 4, Fig. 21 (trophotaeniae).

**Zoogoneticus miniatu8**—Meek, 1902: 71, 94, 124, Pl. 21, lower fig. (original description; comparison; Lago de Chalco, Chalco, Mexico); 1903: 778 (Valle de México); 1904: xii, 110, 115, Fig. 33 (description). Eigenmann, 1910: 454 (listed).
Of this species we have had available the material reported upon by Meek, and a series collected by Hobart M. Smith in a small, open lake near Uruapan, Michoacán, on August 6, 1936. This series includes a female 38 mm. in standard length containing 10 embryos 12 mm. long, and another 41 mm. long, with 12 embryos of 12 mm. The adult females are weakly barred and rather heavily spotted (more so than in Meek's figures). The dorsal rays number 15 to 18, the anal rays 14 or 15. The origin of the dorsal fin lies midway between the base of the caudal fin and the posteriormost part or middle of the opercle; or about midway between the end of the caudal fin and the nostrils. The head measurements are 3.25 to 3.4; the depth, about 3.2 to 3.5. These determinations confirm the synonymizing of miniatus with diasi.

**Genus Xenoophorus Hubbs and Turner**

Xenoophorus.—[Hubbs and Turner], in Turner, 1937b: 501 (as genus); 496, 498, 500, 502, 512 (in combination Xenoophorus erro) and 498, 500, 502, 512 (in combination Xenoophorus captiva; indicated as taken from the manuscript for the present paper; trophotaenial described).

Genotype, Goodea captiva Hubbs.

This new group is distinguished primarily on the basis of the ovarian and trophotaenial characters given as items 1b, 2b, 3d, 4b, and 5e of the analytical key (pp. 24–30). It seems to be the fork-toothed derivative of Neophorus, and to have been derived independently from Goodea and other genera with similar dentition, jaws, and intestines.

The more superficial characters of the genus, given as item 7b of the key (p. 30), are adequate for purposes of identification, as is indicated in the artificial key on pages 73–76.

In Xenoophorus the minute, slender, anteriormost anal ray characteristic of all 3 species of Goodea is lacking, or represented by a very minute stump; consequently the anterior anal lobe has ordinarily a total of 6 rather than 7 rays.

Differential characters of the 3 species referred to Xenoophorus are given as items 11a to 11e of the key (pp. 30–31). These species are among the few goodeids of the Atlantic drainage, and appear to be isolated representative forms of a single Formenkreis.

Xenoophorus, strange ovary, from ζωοσ, strange, ὠνεις egg, and φθορας bearing (ζωοφθορα, ovary).

11. Xenoophorus captivus (Hubbs)

(PI. I, Fig. 3, section of ovary; PI. II, Fig. 5, trophotaenial; PI. V, Fig. 1, paratype.)

Goodea atripinnis.—Meek, 1908: 156 (in part; not of Jordan; Jude María specimens only, later made types of G. captiva). Eigenmann, 1909: 298 (after Meek).
Goodea captiva.—Hubbs, 1924: 4-7 (original description; Jorda Maria, in tributary of Rio Panuco). Jordan, Evermann, and Clark, 1930: 184 (listed). Turner, 1933a: 210 (distribution); 1937b: 498, 500, 502, 512, Pl. I, Fig. 7 (trophotaeniae).

In differentiating the species of this genus we have had the privilege of re-examining the types of Goodea captiva, the only known specimens of the species.

12. Xenoophorus erro Hubbs and Turner

(Pl. II, Fig. 6, trophotaeniae; Pl. V, Fig. 2, holotype.)

Xenoophorus erro.—[Hubbs and Turner], in Turner, 1937b: 496, 498, 500, 502, 512, Pl. 1, Fig. 4 (trophotaeniae; name indicated as taken from the manuscript for the present paper; it is doubtful whether the species is recognizably differentiated in Turner's account).

This species is compared with X. capticus and X. exsul in the key on pages 30-31.

Holotype.—An adult female 49 mm. in standard length, collected with numerous paratypes by Gordon, Whetzel, and Ross in Rio Santa Maria, of the Rio Panuco system, at Santa Maria del Rio, San Luis Potosi, Mexico, on March 21, 1932; U.M.M.Z. No. 108555.

Body in adults heavy-set, deep through middle of trunk. Greatest depth almost twice the greatest width of body, 2.8 (2.6 to 3.3 in adult female paratypes, 2.4 to 3.0 in adult male types). Dorsal contour strongly arched between head and dorsal fin, especially in the larger males, in which the anterior profile, straight in the young and only slightly concave in the adult females, becomes deeply concave, so that the contour from snout to dorsal fin becomes strongly sigmoid. Ventral contour from mouth to anal fin rather evenly arched in females, rather less curved in adult males except toward the upturned muzzle. Dorsal base forming an angle of about 20° to 25° with the horizontal in adult females, and one of about 30° in adult males. Anal base with a greater slope, 25° to 40° in adult females, 45° to 55° in adult males. Edges of the caudal peduncle scarcely concave, diverging forward. Least depth of peduncle, 1.7 (1.6 to 2.0, 1.5 to 1.9) in length of peduncle, 2.1 (1.8 to 2.3, 1.8 to 2.3; usually about 2.0 or 2.1) in head. Females tapering posteriorly; males maintaining the depth to origins of dorsal and anal fins, the distance between which points is contained 3.4 (3.3 to 3.8) times in the standard length in adult females, 2.75 to 3.3 times in adult males.

Length of head, 3.4 (3.2 to 3.6 in adult females, 2.9 to 3.3 in adult males). Head about one-fifth deeper than its greatest width, which enters the head length 1.5 (1.4 to 1.7, 1.4 to 1.7) times. Least width of slightly convex interorbital, 2.35 (2.3 to 2.5, 2.2 to 2.4). Orbit, 1.7 (1.3 to 1.7, 1.3 to 1.8) in interorbital, 4.1 (3.5 to 4.3, 3.4 to 4.3) in head. Snout, 3.5 (3.2 to 3.8,
3.3 to 3.7. Mouth moderate in width; extreme over-all width, 2.6 (2.7 to 3.4 in each sex); not strictly transverse but with markedly restricted lateral gape. Jaws rather narrow and weakly joined, but heavier and more strongly united than in Goodea. Teeth as described for genus (in item 74, p. 30). Gill-rakers, 23 to 25 (in 5 paratypes), the longest only about one-fourth as long as eye. Intestine considerably coiled, with about 6 transverse segments.

Fin rays: dorsal, 13 (12 to 14); caudal, 18 (16 to 18, usually 16 or 17), branched rays; anal, 14 (13 to 15), the first ray well developed (the anterior-most minute ray of Goodea and some other genera lacking); pelvic, 6; pectoral, 14 (14 or 15, very rarely 13, commonly 15; the lowest ray usually rather well developed in 14-rayed fins); not counting the more or less rudimentary uppermost ray. Origin of dorsal fin directly over that of anal in females, very slightly farther forward in males. Distance from dorsal origin to end of middle caudal ray into distance forward to tip of upper lip, 1.2 (1.1 to 1.4, usually about 1.3 in females; 0.95 to 1.2, usually about 1.05 in males). Distance from caudal base to dorsal origin, 1.7 (1.6 to 1.8, 1.4 to 1.7) in predorsal length. The rounded dorsal fin short and low in adult females, reaching about two-thirds distance to first procurent caudal ray; much more expansive (longer basally and with higher rays) in adult males, reaching first procurent ray in highest males. Length of depressed dorsal in head, 1.3 (1.2 to 1.4, 0.9 to 1.2). Distance from origin of small rounded anal to caudal base, 2.75 (2.5 to 2.8, 2.4 to 2.7) in standard length. Hind margin of caudal fin almost straight; length of middle ray, 1.55 (1.35 to 1.6, 1.3 to 1.5). Characters of pelvic fin, of anal lobe in adult males, and of swollen area between anus and genital opening, all as described for the genus on page 30.

Scales rather large, in 38 (34 to 39, usually 36 or 37) transverse rows and 14 (14 to 16) longitudinal rows, not counting 2 or 3 scales at extreme base of anal fin, minute and difficult to find and sometimes probably absent in females, but larger and distinct in males.

Coloration varies greatly with age and sex. Half-grown, 20 to 25 mm. in standard length boldly spotted with more or less X-shaped purple-brown spots on a light yellow background; these spots enlarged and thickly set in the vicinity of the diffuse, dusky, axial stripe, leaving a more or less immaculate stripe on either side; the spots also concentrated along lower edge of caudal peduncle and on either side in the same horizontal line on abdomen; dorsally the spots become smaller and fainter, so that they are relatively inconspicuous on the darkened back. Males at about 25 mm. length abruptly changing over to a deep brown color—almost black in a broad, irregular, blotched submedian band, which has a downward extension toward anus; dorsal and caudal fins dusky, lower fins pale. Females chang-
ing less rapidly, the spots retained to a size (standard length) of about 35 mm., becoming gradually more numerous and more uniformly spread until they virtually disappear in the adults, which become almost uniformly dark except for creamy scale centers. Adult males darker than females at all sizes. Caudal fin of high males sooty toward the merely dusky posterior margin, but apparently with the contrast less sharp than in \textit{X. captivus}.

The species is named \textit{erro}, wanderer, because it occurs outside the Río Lerma system, which is the center of abundance for the family.

\textbf{13. Xenoophorus exsul, new species}

(Pl. V, Fig. 3, paratype.)

This species is very closely related to \textit{X. captivus} and \textit{X. erro} and appears to represent the genus in an isolated valley in the hills of the state of San Luis Potosí, Mexico, north of the Río Santa María. Here it occurs in spring-fed streams in the vicinity of Venado and Moctezuma. These streams probably never reach the sea, but the area in a past period of greater rainfall in all probability drained into the Río Panuco system—the home of the other species of the genus.

As indicated in the key (pp. 30-31), this species bridges over the gap between the large-headed \textit{X. erro} and the small-headed \textit{X. captivus}, in respect to size of head. The anterior profile as in \textit{X. captivus} is little concave, not becoming strongly sigmoid in adult males as it does in \textit{X. erro}. It differs on the average from both species in the slenderer caudal peduncle and more posteriorly inserted anal fin; also in having with rare exceptions 13 or 14 instead of 14 or 15 pectoral rays. The dorsal fin averages larger than in \textit{X. erro}. Later collections may indicate further intergradation of characters, calling for the reduction of the 3 species as here differentiated to subspecific rank.

\textbf{Holotype.}—An adult female 45 mm, in standard length, collected with many paratypes by C. L. Lundell and party on July 21, 1934, in Agua del Medio, a cold mountain stream with rock and mud bottom, midway between Venado and Moctezuma, San Luis Potosí; U.M.M.Z. No. 118122. Numerous other paratypes were collected by the same party at Venado on July 11, 1934, in a small, cold, clear, spring-fed stream with rock and mud bottom, and with sedges, grasses, and algae; and at Moctezuma on July 20, 1934, in a cold mountain stream with rock and mud bottom.

The description just given for \textit{X. erro} is to be taken as applicable in full to this species, except as indicated by the following figures and annotations.

Depth, 2.65 (2.6 to 3.2 in adult female paratypes, 2.4 to 2.8 in adult male paratypes). As noted above, the anterior profile is scarcely concave in adult females and only weakly concave in the highest males, in which the muzzle does not become conspicuously upturned. Least depth of caudal
peduncle, 1.7 (1.6 to 1.9, usually about 1.75; 1.5 to 1.8, usually about 1.65) in length of peduncle, 2.15 (2.1 to 2.5, usually about 2.3; 2.0 to 2.2) in head. Distance between origins of dorsal and anal fins, 3.4 (3.4 to 3.7, 2.75 to 3.1).

Head, 3.4 (3.4 to 3.8, 3.2 to 3.5). Width of head, 1.5 (1.4 to 1.6 in each sex). Interorbital width, 2.3 (2.2 to 2.5 in each sex). Orbit, 1.4 (1.2 to 1.6, 1.2 to 1.7) in interorbital, 3.6 (3.3 to 4.3, 3.3 to 4.0) in head. Snout, 3.5 (3.2 to 3.8). Width of mouth, 2.8 (2.6 to 3.4). Gill-rakers, 21 to 24 (in 5 paratypes). Intestine with 4 to 7 transverse folds. Ovarian and trophotaenial characters not showing any consistent differences from those of *X. erro* as indicated by Turner's description for that species and by our analytical key.

Fin rays: dorsal, 13 (12 to 14); caudal, 16 (16 to 19, very rarely 19); anal, 14 (14 or 15), lacking a small first ray (occasionally represented by a mere stub, not included in the count); pelvic, 6; pectoral, 13 (13 or 14, very rarely 15, 13 in about half the specimens, the lowest ray more or less rudimentary when 14 rays are counted), with rudimentary uppermost ray seldom evident (not counted). Measurements into predorsal length: distance from end of caudal to origin of dorsal, 1.25 (1.15 to 1.35, usually about 1.25; 1.05 to 1.2, usually about 1.1); from base of caudal to origin of dorsal, 1.8 (1.7 to 1.9, 1.5 to 1.7). Length of depressed dorsal, 1.2 (1.1 to 1.3, 0.8 to 1.1). Distance from origin of anal to base of caudal, 3.1 (2.6 to 2.9, 2.7 to 3.2) in standard length. Length of caudal, 1.5 (1.4 to 1.6, 1.3 to 1.5).

Scales, 35 (35 to 39, usually 36 to 38)–14 (14 to 17, this count seemingly higher in males than females).

Coloration changes as in *X. erro*. Young about 15 mm. in standard length with indistinct dark spots on the dusky back; one row of irregular blackish spots down the otherwise nearly clear sides; a spot at base of caudal fin at each edge of peduncle, the lower one the larger; an irregular streak along lower edge of peduncle and a more or less disrupted horizontal blackish stripe running hence horizontally forward above anal base.

The name *exsul*, exile, refers to the lonely occurrence of the species beyond the ancestral territory of the family.

**Genus Allotoca Hubbs and Turner**

*Allotoca*—[Hubbs and Turner], in Turner, 1937b: 498–99, 501, 511 (name *Allotoca dugesi* used, and indicated as taken from the manuscript for the present paper; trophotaenial characters described).

Genotype, *Fundulus dugesi* Bean.

This genus can be distinguished readily from the other cone-toothed genera of goodeids by the posterior insertion of the dorsal fin, far behind middle of total length including caudal fin; also by the highly distinctive
coloration of the single species. The more fundamental characters of \textit{Allotoca}, however, are ovarian and trophotaenial—as described in items 1b, 2b, 3d, 4c, and 5f of the analytical key (pp. 24–31).

\textit{Allotoca}, different offspring (embryo); from \&Humes, other or different and \textit{vicinity}, offspring.

14. \textit{Allotoca dugesi} (Bean)

(Pl. II, Fig. 4, trophotaenia.)

\textit{Fundulus dugesi}.—Bean, 1887: 273–74, Pl. 20, Fig. 5 (original description; comparison; probably from streams of Guanajuato). Eigenmann, 1893: 56 (spelled \textit{dugesi}; listed). Garman, 1895: 109–10 (spelled \textit{dugesi}; description, after Bean).


\textit{Adinia dugesi}.—Jordan and Evermann, 1896: 660–61 (description, after Bean; Guanajuato); 1896a: 213 (listed); 1900: 3556, Pl. 108, Fig. 290 (Guanajuato).


\textit{Allotoca dugesi}.—Turner, 1937b: 498–99, 501, 511, Pl. 1, Fig. 5 (trophotaenia).

The material of this species studied by us was collected by Duges and by Meek.

\textbf{SUBFAMILY CHARACODONTINAE}

\textbf{GENUS CHARACODON GÜNTHER}


Haplotype, \textit{Characodon lateralis} Günther.

The ovarian and trophotaenial characters of \textit{Characodon}, described as items 1b, 2c, 3f, and 5g (pp. 24–32), are so distinctive that we have erected the subfamily \textit{Characodontinae} for its sole reception (see also p. 12). The
isolated systematic position of the genus is correlated with its apparent restriction to the Sonoran plateau (in the interior drainage basin and in the headwaters of the Rio Mezquital), where it occurs alone, and farther north than any other goodeid.

The genus *Characodon* is here restricted to the single species *lateralis* (with *garmani* as a synonym). On the basis of the structures of ovary and trophotaeniae, other species commonly placed in *Characodon* are now set apart in the genera *Xenotoca*, *Chapalichthys*, *Ilyodon*, and *Lermichthys*.

15. *Characodon lateralis* Günther

*(Pl. I, Fig. 8, section of ovary; Pl. II, Fig. 9, trophotaeniae.)*

*Characodon lateralis*—Günther, 1866: 308 (original description; "Central America" — no doubt by error); 1869: 480, Pl. 82, Fig. 2 (description; "Southern Central America.")—Bean, 1887: 370–71 (comparisons). Eigenmann, 1895: 56 (listed). Garman, 1895: 36, Pl. 1, Fig. 9 (description; teeth described and figured; part of synonymy excepted; Parras, Coahuila). Jordan and Evermann, 1896: 668 (description, after Günther); 1896a: 314 (listed); 1898: 2831 (synonymy). Meek, 1902: 97, 98; and 1903: 179 (anal fin); 1904: xi, 1, 119, 121 (description, after Günther). Philippi, 1906: 235–37 (viviparous; anal wrongly said to be unmodified). Regan, 1907: 88–89, 90 (description; *garmani* as a synonym; distribution). Eigenmann, 1909: 304; and 1910: 455 (listed; range). Jordan, Evermann, and Clark, 1920: 183 (listed). Turner, 1937b: 496, 506, 512, Pl. 3, Fig. 14 (trophotaeniae).

*Characodon garmani*—Jordan and Evermann, 1898: 252–262 (original description— based on material recorded as *C. lateralis* by Garman, 1895: 36, Pl. 1, Fig. 9, from Parras, Coahuila). Meek, 1903: 778 (distribution); 1904: xxxiv, xxxvii, 119, 121–22, 127 (description; Durango and Labor, Durango). Eigenmann, 1910: 455 (range). Jordan, Evermann, and Clark: 1930: 183 (listed).

Our study of this species has been based on Meek's material from the headwaters of the Rio Mezquital. We find no reason to doubt the correctness of Meek's reference of this material to *C. garmani*, or of Regan's synonymizing of *garmani* with *lateralis*. Probably the types of *lateralis*, like all other known specimens of this form, came from the Sonoran plateau rather than from "Central America" or "Southern Central America." Pellegrin's record (1901: 205) of *C. lateralis* from the state of Jalisco needs confirmation; we suspect it was based on specimens of *Xenotoca variata*. The occurrence of the species in the headwaters of the Rio Mezquital as well as in the interior drainage basin—both on the Sonoran plateau—is in line with the distribution of other fishes (Meek, 1904: xxxviii).

**GIRARDINICHTHYINAE, NEW SUBFAMILY**

**GENUS ILYODON EIGENMANN**


*See pp. 12, 15–16, and 33.*
roundish anterior bars to a length of 53 mm. or more. The remnants of these bars, together with a crowding of the specklings, form a usually indistinct and irregular lateral dark band in adult males. In the females the bars show the same variations, are usually retained until the fish is 55 mm. long, and can be seen faintly in even the largest females (86 mm. in standard length). The dorsolateral spots usually become obsolete in the smaller females (as in males), but occasionally persist rather strongly to a length of at least 56 mm. The speckling which is more characteristic of males is usually little developed in the smaller females (to about 40 mm.), but gradually increases in intensity so that old females are rather distinctly speckled—though more faintly and in a finer pattern than the males. The larger females, like the males, show a rather indistinct and irregular dusky stripe.

The coloration of the vertical fins has somewhat similar variations.

In the 17 mm. young these fins are clear. At a length of about 24 mm. black specks or spots on the dorsal and anal fins represent the posterior portions of a future submarginal bar, and occasionally some specks appear near the margin of the caudal fin. In the males the dorsal fin markings at a length of about 35 mm. either fade out or become a marginal band, which when present in the adult males is always marginal and narrow and usually dusky; the basal three-fourths of the fin is either plain or weakly speckled or reticulated with dusky. In the females the dorsal stripe remains submarginal, and varies in both young and adult fish from dusky to black, narrow to wide, and short (at posterior part of fin); to long (rarely almost complete); the major basal part of the dorsal is uniform dusky or very faintly speckled—never so strongly as in many males. The anal fin in the males is not boldly marked, but often has small, faint to blackish, irregularly spaced specks, and sometimes a narrow marginal or submarginal blackish band, which is almost never conspicuous. The females at all sizes usually have a narrow to wide and typically intense, often irregular, submarginal band on the anal fin, and occasionally a few blackish dashes on the median part of the fin. The caudal fin in the males usually bears a blackish band of variable width, usually submarginal in the smaller males, but marginal in the larger ones; within this is a usually inconspicuous submarginal light band, then a series of vertical rows of dusky to blackish spots of variable development, but seldom very bold, grading to a smaller size toward the base of the fin and becoming smaller in the adults. In the females the main caudal bar tends to be more disrupted and remains submarginal throughout life; usually lacking or very faint in smaller females, which seldom have the median or basal blackish bars which are developed on this fin in some of the larger females.

In formalin the fins showed relatively little yellow, as compared with
specimens of *Balsadichthys xantusi* in the same collections. The females were lemon on the posterior lower half of the body.

**HYBRIDS BETWEEN *ILYODON FURCIDENS* AND *BALSADICHTHYS XANTUSI***

The intimate relationship of *Ilyodon* and *Balsadichthys*, as indicated by their common ovarian and trophotaenial characters, is further evidenced by the discovery that these genera commonly hybridize in nature. This circumstance might even be considered a reason for synonymizing *Balsadichthys* and *Ilyodon*, but to do so would violate the consistent judgment of authors that the species with weak teeth movably set in loosely conjoined jaws of a wide, transverse mouth should be separated generically from those with stronger teeth tightly set in the firmly joined jaws of narrower mouths with better-developed lateral gape.

These natural hybrids, the first to be reported in the family Goodeidae, are intermediate in all characters of teeth, jaws, and mouth, as these are contrasted in items 7k and 7l of the key (pp. 33–34). For example, the overall width of the mouth as measured into the head is just intermediate, as shown by the data in Table III. The extreme variability and the slight overlap shown by this ratio is due more to age than to individual variation; the differences indicated for the 2 series of *I. furcidens* are due to the same factor—young predominate in the first set, adults in the latter. The hybrids, of course, also have other differences.

In coloration and color the hybrids have age and sexual differences similar to those exhibited by the parent species, but, as often in hybrids, the approach is greater toward the more deeply and brightly colored parent form, in this case *B. xantusi*. A male 25 mm. long has the bars rather weak, the body speckling already evident, a submarginal black band on each vertical fin (posteriorly on dorsal and anal, medially on caudal), and also a basal black bar on the caudal. In larger males (largest 78 mm.) the bars gradually fade out, the speckling becomes more prominent, the anal markings break up, and more or less conspicuous black dashes develop over the basal three-fourths of each fin—most prominently on the caudal. On the dorsal and caudal a bright lemon yellow band separates the marginal black band from the area covered by dashes. In the smaller females (about 33 mm. long), the bars are prominent, the dorsolateral spots scarcely evident, the speckling of the body hardly developed, the dorsal fin with a few spots posteriorly or a submedian black band, and anal with a submedian black band posteriorly, and the caudal with a few dusky specklings. In grading to the largest female (81 mm.), the bars weaken but do not wholly disappear; the body speckling (or striping) becomes more evident, though not so conspicuous as in males; the dorsal fin becomes uniformly dusky; the anal usually retains a narrow, disrupted, submarginal black band; the caudal
into distance forward to tip of upper lip, 0.9 to 1.0 in males, 0.95 to 1.1 in females. Distance from caudal base to dorsal origin, 1.35 (1.25 to 1.4, 1.35 to 1.6) in predorsal length. Dorsal fin rounded posteriorly and low anteriorly, especially in males; failing to reach procurent caudal rays by nearly an orbital length in males and by more than an orbital length in females; basal length of dorsal a little greater than distance from end of dorsal base to origin of caudal in males, about an orbital diameter less than that distance in females. Length of depressed dorsal fin in head, 0.7 (0.65 to 0.85, 0.9 to 1.2). Distance from origin of rather squarish anal fin to caudal base, 2.7 (2.65 to 2.9, 2.6 to 2.9) in standard length. Caudal fin slightly concave medially and with a broadly rounded lower lobe and a somewhat narrower, sharper, and longer upper corner; length of middle ray, 1.35 (1.2 to 1.4, 1.3 to 1.5). Characters of pelvic fin, of anal lobe in adult male, and of swollen area between anus and genital opening, all as described in item 71 of key (p. 34).

Scales in 47 (43 to 50) transverse and about 18 longitudinal rows.

In age and sexual variation this species agrees remarkably well with its apparent relative *Ilyodon furcidens* (see pp. 59-61), but is brighter in color and typically bolder in coloration.

Young males, 26 to 30 mm. long, already transforming, retain the bars in variable intensity, number, shape, and position (in some best developed anteriorly, in others posteriorly), but the speckling, strongest on the lower median sides, is already beginning to dominate the pattern. This speckling, on a light background, becomes finer with age, but remains on the average coarser and bolder than in *Ilyodon furcidens*. In the adult males (largest 88 mm.) the speckling tends to be concentrated along the middle of the sides, in an irregular band of variable intensity. This band is reinforced by a diffusion of pigment (starting along the axial streak of the young) and by the remnants of the vertical bars, which almost disappear at a length of about 40 mm. The dorsolateral row of spots is weakly evident, and only in the smallest males.

Young females of 25 to 40 mm. are considerably less modified than the males of like size. The 6 to 11 bars are developed along the entire length of the sides, are usually high, and vary in width inversely with the number; the dorsolateral spots are conspicuous in some specimens, though often absent; the speckling is inconspicuous. The bars remain conspicuous to a length of 60 mm., and are faintly discernible in some of the largest females (to 88 mm.). The largest specimen showing dorsolateral spots is 46 mm. long. The speckling becomes more conspicuous with age, but at all stages is fainter and finer than in males. In large females the specklings on the trunk tend to form zigzag lines between the scale rows.

The fins of the male are very boldly marked with black. Almost without
exception the males have a jet-black band on the caudal, changing from a subterminal position to a marginal one at a length of about 50 mm. In young males 26 to 30 mm. long there is a prominent basal bar or row of spots on this fin, and often some submedian spots or dashes, which at larger sizes become conspicuous while the basal mark often fades. To a length of about 50 mm. the jet-black dashes are usually in 1 or 2 vertical rows, but in larger fish these break up into numerous blackish to jet-black specks and dashes covering the fin from the base to a clear submarginal streak of variable width. In life this submarginal band is very characteristically colored bright lemon yellow. Smaller males (to about 50 mm.) have the dorsal variably colored, in some fish plain, or with a few black spots more or less aligned in a submarginal or a subbasal band, or both. At larger sizes and in some smaller fish the outer band becomes marginal and narrow, bordering a wide band of bright lemon yellow, below which the fin is spotted or reticulated with blackish. The smaller males have a few submarginal spots or a band of jet-black. At lengths greater than 30 mm. the fin has an increasing number of dusky to black dashes scattered over its whole surface, and in some large adults the dorsal shows a black margin of spots or band.

In females 25 to 35 mm. long the caudal fin is usually plain dusky; the dorsal fin is commonly plain, or marked with a few black specks or spots in a submarginal position; and the anal fin consistently has a submarginal band or spots in the same position. Medium-sized females, about 50 to 65 mm. long, have the caudal plain, or commonly marked over the whole surface with about 4 rows of jet-black dashes, usually without a submarginal band; the dorsal is usually plain, occasionally with a submarginal row of spots or scattered spots; and the anal has a submarginal black band partially disrupted into dashes in some specimens. Larger females (70 to 88 mm.) usually have a submarginal row of spots on caudal, within which is a trace of a yellowish streak, and faint dashes about the basal three-fourths of fin; the dorsal tends to develop a dusky to black, almost marginal band, with dusky base and with dusky rays separating clear areas on the membranes submedially.

The adult females have little of the lemon yellow on the vertical fins, but are strongly washed with lemon yellow on the pelvic fin and the lower sides, especially posteriorly. The males are only weakly so colored on the body. Both sexes are dark above, light below.

This species is named *xantusi* in honor of John Xantus, who collected the first specimens long ago.

Haplotype, Girardinichthys innominatus Bleeker.

Limnurgus.—Günther, 1866: 309 (original description; replacing the "barbarous name" Girardinichthys). Regan, 1907: 76, 87 (description).

Haplotype, Limnurgus variatus Günther = Girardinichthys innominatus Bleeker.

This is the oldest and one of the best-known genera of the Goodeidae.

19. Girardinichthys innominatus Bleeker

(Pl. II, Fig. 7, trophotaeniae.)

Lucania [species].—Girard, 1859: 118-19 (description; "vicinity of the city of Mexico").

Girardinichthys innominatus.—Bleeker, 1860: 684-85 ("= Lucaniace sp. Proc. Acad. Philad., 1859, p. 119. Am. sept., Mexico"). Jordan and Gilbert, 1883: 343. Eigenmann, 1885: 56 (listed). Garman, 1886: 39, Pl. 1, Fig. 11 (description; synonymy; teeth figured; "City of Mexico"). Jordan and Evermann, 1896: 666 (description; "vicinity of City of Mexico"); 1896a: 313 (listed). Seulat, 1898-25-26; and 1900: 404-6 (records in Valle de Mexico; viviparous). Meek, 1902: 87-88, 94, 124 (description; viviparity; Chalco; Texcoco; Xochimilco); 1903: 1778 (distribution); 1904: xlii, 116-19 (synonymy; description; early account of viviparity quoted; Viga Canal, etc.). Eigenmann, 1910: 455 (synonymy). Jordan and Evermann, 1910: 502 (comparison). Jordan, Evermann, and Clark, 1930: 182 (synonymy). Gordon, 1933a: 260, 1 fig. (Lago de Xochimilco and Lago de Texcoco). Turner, 1933c: 218, 230, 234, 236-31, Pl. 1, Fig. 7, Pl. 6, Fig. 24, Pl. 7, Fig. 31, and Pl. 8, Fig. 30 (viviparity and related structures). Stovy, 1935: 77, 230 (introduction as aquarium fish). Del Campo, 1936: 272 (Laguna de Xochimilco). Mendoza, 1937: 97-98, 100, 105-6, Pl. 1, Fig. 3 (trophotaeniae). Turner, 1937b: 496, 504, 507, Pl. 2, Fig. 12 (trophotaeniae).

Limnurgus innominatus.—Girard, 1859: 118-19 (description; synonymy; records).

Limnurgus variatus.—Günther, 1866: 309 (original description; synonymy; "vicinity of the city of Mexico").

Lemichthys.—Gill, 1882: 8 (identification of early account, quoted, of viviparity).

Lucania Eichi.—Girard, in Goode, 1891: 85 (this specific name, not referred to by subsequent authors, was intended to have been used by Girard, 1859, for his new Lucania; the name disappeared from the text as the paper was going through the press).

Characodon Goldschi.—Regan, 1904: 257 (original description; Lago de Texcoco).

This synonymy though rather complex involves no apparent uncertainties. The species shows exceptional variation, but the different types occur together through its limited range (Valle de México). Color variants in newly collected material will be illustrated in a forthcoming contribution by Hubbs and Gordon.

GENUS LEMICHTHYS HUBBS

Lemichthys.—Hubbs, 1926: 38 (original diagnosis; comparison). Jordan, Evermann, and Clark, 1930: 183 (listed). Turner, 1933c: 93 (spelled Lemichthys; structure
Orthoty whole, Characidusos multiradiatus Meek.

The erection of this new genus for Characodon multiradiatus has been well justified by the discovery and application of the trenchant ovarian and trophotaenial characters. As indicated in the analytical key, Lernichthys is a close relative, and probably a derivative, of Girardinichthys, and shows no very close affinity with Characodon and other genera having similar dentition.

20. Lernichthys multiradiatus (Meek)

(P1. II, Fig. 8, trophotaenias.)

Girardinichthys 1nominatus (erroneous identification).—Evermann and Goldsborough, 1903b: 209, 211, 218-19 (classification; distribution; viviparity and related structures); 1937b: 503, 507, 512 (trophotaeniae).

Lernichthys 1nominatus. — Meek, 1904: xli, 118-19 (original description; based on specimens referred by Evermann and Goldsborough to Girardinichthys 1nominatus; Lago de Lerma). Evermann, 1907: 89, Pl. 13, Figs. 3-4 (description; same locality). Eigenmann, 1909: 304; and 1910: 455 (listed).

Lernichthys multiradiatus. — Hubbs, 1926: 19 (synonymy); 1927: 66 (Girardinichthys limnopagus as a synonym). Jordan, Evermann, and Clark, 1906: 183 (synonymy). Gordon, 1933b: 90 (Rio Lerma). Turner, 1933a: 93, 219-20, 236-51, Pl. 1, Figs. 1-4, Pl. 3, Figs. 14-15, Pl. 6, Fig. 25, and Pl. 8, Figs. 29 (viviparity and related structures); 1937b: 496, 504, 507, Pl. 2, Fig. 13 (trophotaeniae).

Girardinichthys limnopagus. — Jordan and Evermann, 1927: 502 (original description; based on specimens referred by Evermann and Goldsborough to Girardinichthys 1nominatus; Lago de Lerma).

New records for this species will be given, with an illustration of its varying color phases, in a paper by Hubbs and Gordon.

Genus Skiffia Meek


Orthoty whole, Skiffia lernae Meek.

The distinction of Skiffia from Goodea is abundantly justified by the ovarian and trophotaenial characters, on the basis of which the two genera are now placed in different subfamilies. In the Girardinichthyinae, Skiffia represents the limnopagous type with long intestine and bifid teeth movable set in weak and loosely conjoined jaws.

Largely on the basis of superficial characters, we set 2 species of Skiffia apart in distinct genera, Olentodon and Neotoca (see following pages).

21. Skiffia variegata Meek

Skiffia variegata. — Meek, 1902: 71, 94, 104-5, 124, Pl. 25, lower fig. (original description; comparison; Lago de Zirahuen, Zirahuen, Michoacan; also Chalco); 1903: 778
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(Valle de México); 1904: x-xi, 141, 145, Fig. 44 (description). Eigenmann, 1909: 304; and 1910: 459 (listed). Hubbs, 1924b: 8 (a doubtful synonym of lermae); 1926: 19 (characters; probably a distinct species). Jordan, Evermann, and Clark, 1930: 183 (listed). Turner, 1937b: 503, 507, Pl. 2, Fig. 10 (trophotaeniae).

Goea lermae (probably unjustified synonymizing).—Regan, 1907: 90, 92 (in part; description).

We provisionally separate this species from S. lermae on the somewhat dubious distinctions given in our key (p. 37).

22. Skijfia lermae Meek

(Pl. III, Fig. 1, trophotaeniae.)

Goea lermae.—Meek, 1902: 71, 102-5, Pl. 25, upper and lower figs. (original description; comparisons; Lago de Pátzcuaro, Pátzcuaro, Michoacán, also Celaya); 1903: 777, 1 fig.; 1904: x, 141, 142-43, Pl. 8 (description). Eigenmann, 1909: 304; and 1910: 459 (listed). Hubbs, 1924b: 8 (variegata as a doubtful synonym); 1926: 19. Jordan, Evermann, and Clark, 1930: 183 (listed). Turner, 1937b: 503, 507, Pl. 2, Fig. 11 (trophotaeniae).

Goea lermae.—Regan, 1907: 90, 92 (in part; description).

Only Meek's types of this species and of S. variegata have been available for study.

GENUS OLLENTODON HUBBS AND TURNER

Ollentodon.—[Hubbs and Turner], in Turner, 1937b: 503, 507, 512 (name Ollentodon multipunctatus used, and indicated as taken from the manuscript for the present paper; trophotaenia described).

Genotype, Xenodon multipunctatus Pellegrin.

On the basis of ovarian and trophotaenial characters, Ollentodon shows relationship with the other genera grouped in the Girardinichthyinae. The fact that the trophotaenia number 3 separates it from Iyodon and Balasichthys, which have many of these embryonic nutritional organs, and from Girardinichthys and Lermichthys, which have 4 trophotaeniae. Ollentodon also differs from these genera in the external characters of the adult, as indicated in the analytical key (pp. 33-38) as well as in the artificial key (pp. 74-76).

Ollentodon differs from Skijfia in having the teeth of the inner band mostly bicuspid, instead of conic or round-tipped; the dorsal fin larger (with 15 to 17 in place of 12 or 13 rays); the median posterior trophotaeniae about as long as the lateral ones, rather than about three-fourths as long. The single species differs markedly from both forms of Skijfia in coloration and slightly in the number of gill-rakers (approximately 29 instead of 25).

Ollentodon, referring to the largely obsolescent inner teeth, from ἀνάω, to lose or occasion a loss, to, within, and ὀδὸς, tooth.

22. Ollentodon multipunctatus (Pellegrin)

Xenodon multipunctatus.—Pellegrin, 1901: 206-7 (original description; comparisons; "Sources, mares et fosses d l'Aguaz Azul. Environs de Guadalajara, Jalisco").
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Goodea multipunctata.—Regan, 1907: 90, 92, Pl. 12, Figs. 5-6 (description).

Ollentodon multipunctatus.—Turner, 1937b: 503, 507, Pl. 2, Fig. 9 (trophotaenae).

Of this interesting species we have re-examined the material recorded by Meek.

GENUS Neotooa HUBBS AND TURNER

Neotooa.—[Hubbs and Turner], in Turner, 1937b: 496-97, 503, 507, 512 (name Neotooa bìlineata used, and indicated as taken from the manuscript for the present paper; trophotaeniae described).

Genotype, Characodon bìlineata Bean.

The single species of this rather well-marked genus has often been placed either in Characodon or Goodea, and indeed is somewhat intermediate in the differential mouth structures which have been grossly overemphasized in the classification of the group. The ovarian and trophotaenial characters, as given in the analytical key (pp. 24-36), indicate no very close affinity with either Characodon or Goodea. These characters point toward relationship with S1ciffia, to which genus Meck referred the type species. In our opinion there are enough differences, however, to warrant a generic separation.

Neotooa differs from S1ciffia in having the inner band of teeth well developed instead of obsolete medially; the teeth of this band uniformly bifid rather than conic or blunt-tipped; the teeth of the outer row less loosely set and the mouth less definitely transverse; the intestine shorter, with 3 or 4 instead of 6 to 8 transverse elements; the median trophotaenia distinctly longer, not shorter than the lateral ones; the inner pelvic rays free from body rather than largely bound down; the dermal pouch on the front of the anal fin of the adult male only slightly instead of very well developed; the anterior anal lobe of the male half or slightly more than half, instead of less than one-third as high as the longest anal ray; and the transverse genital opening of male convex rather than concave medially.

Neotooa bìlineata differs very strikingly from the species of S1ciffia in coloration, particularly in the much greater sexual dimorphism, and slightly in the size of the scales (29 to 33 vs. 33 to 37); number of gill-rakers (about 20 vs. about 25); and number of dorsal rays (13 to 15 vs. 12 or 13).

Neotooa differs sharply from Ollentodon in the characters of the teeth, jaws, mouth, intestine, pelvic fin, and the sexual characters associated with the anal fin, in the same way that it differs from S1ciffia (except that the inner teeth are bifid as in Ollentodon). There are also marked distinctions in coloration and slight differences in the various counts.

Neotooa, new [type of] offspring (embryo), from nios, new, and tanos, offspring.
24. Neotoca bilineata (Bean)

(Characodon bilineatus.—Bean, 1887, 571-72, Pl. 20, Fig. 2 (original description; comparison; probably streams of Guanajuato). Eigenmann, 1893: 56 (Guanajuato). Jordan and Evermann, 1896: 668-69 (description, after Bean; Rio Lerma, Guanajuato); 1896a: 314 (listed); 1898: 2831 (not a synonym of C. lateralis); 1900: 3256, Pl. 109, Fig. 293 (Guanajuato).

Skiffia bilineata.—Meek, 1902: 102, 105 (spelled both bilineatus and bilineata; description; comparison; Huingo); 1904: 141, 144, Fig. 45 (description; synonymy). Eigenmann, 1899: 304; and 1910: 459 (listed). Hubbs, 1924b: 7-8 (sexual dimorphism; Lago de Cuitzeo; Huingo). Jordan, Evermann, and Clark, 1930: 183 (listed). Mayer, 1936: 51-52, 1 fig. (as aquarium fish). Mendoza, 1937: 97-116, Pl. 1, Fig. 2, and Pls. 2 and 4 (trophotrans).

Goodea bilineata.—Regan, 1907: 90, 92 (comparisons). Turner, 1933a: 94; and 1933b: 225-45, Pl. 1, Figs. 5-6, Pl. 2, Figs. 10, 12, Pl. 3, Fig. 16, Pl. 4, Fig. 21, and Pl. 7, Figs. 26-28 (viviparity and related structures).

Neotoca bilineata.—Turner, 1937b: 496-97, 505, 507, Pl. 2, Fig. 9 (trophotrans). Characodon lateralis (erroneous synonymizing).—Garman, 1895: 36 (synonymy in part).

Of this species we have re-examined the type and Meek's material. Other specimens were collected by Turner and Dildine in Rio Grande de Santiago, between Ocotlán and Laguna de Chapala, and an aquarium stock was obtained there. Aquarium specimens, having the remarkable sexual dimorphism of this species (Hubbs, 1924b: 8), were figured on the back cover of The Aquarium for August, 1935.
APPENDIX

ARTIFICIAL KEY TO THE GENERA AND SPECIES OF GOODEIDAE

1a. - Teeth not bifid (a few to most may be weakly forked in Girardichthys), firmly attached to the jaws.

2a. - Teeth all more or less sharply conical. Mouth with a wide lateral gape. Dorsal and anal fins each with 11 to 10 rays. Pelvic fins in contact, and more or less bound down to body by membrane (except in Allodontichthys).

3a. - Origin of dorsal fins close to middle of total length including caudal fin. Coloration: body not crossed by regular blackish bars extending on the back.

4a. - Teeth regularly conic, everywhere round in cross section, without trace of keel at either edge of anterior face. Coloration: a scapular mark; no black bands on dorsal fin; no definite rounded dark spots above pectoral fin.

5a. - Sixth pelvic rays of the two fins in contact (Allophorus) or rather widely separated (Neophorus). Coloration: no posteroventral row of black bars or spots, and none at base of caudal.


2. Allophorus robustus

6b. - Dorsal rays, 15 to 19. Scale rows, 32 to 39. Coloration: several irregular, narrow dusky bars, and some speckling.

10. Neophorus diasci

6c. - Fifth pelvic rays of the 2 fins in contact, forcing the sixth ray to lie between fifth ray and body. Coloration: a posteroventral row of black bars or spots, and a pair at base of caudal.

8. Zoophoneticus quietoconnais

6d. - Teeth compressed and shouldered within the slender conic tip, with a low keel at either edge of anterior face. Coloration: a black, comma-shaped scapular mark; several black bands on dorsal fin; rounded dark spots above and behind pectoral fin.

5c. - Sixth pelvic rays of the 2 fins closely approximated.

6d. - Dorsal rays, about 13. Scale rows, about 40.

9. Allodontichthys varius

5b. - Origin of dorsal fin far behind middle of total length including caudal fin. Coloration: body crossed by regular blackish bars extending onto the back.

4c. - Teeth regularly conic.

5d. - Sixth pelvic rays of the 2 fins approximated.

6c. - Dorsal rays, 15 to 17. Scale rows, 29 to 35.

14. Allotoma dupsisi

2b. - Teeth conic to truncate, and some arrow-shaped or slightly bifid or trifid. Mouth with reduced lateral gape. Dorsal and anal fins each with 18 to 26 rays. Pelvic fins well separated, and not bound down to body.

3c. - Origin of dorsal fin slightly before middle of total length including caudal fin in females, decidedly before that point in adult males. Coloration: breeding males jet black; a dark blotch often developed above anus; sides speckled, barred, or streaked.

19. Girardichthys inominae
1b.—Teeth regularly bisected, either firmly or loosely attached to jaws.

7a.—Dorsal and anal fins each with fewer than 18 rays.

8a.—Teeth firmly attached to strong, well-united jaws. Mouth with lateral gape more or less well developed. Intestine short to long.

9a.—Dorsal fin inserted far behind middle of total length including caudal fin. Coloration: females with short, irregular black bars; males with a black longitudinal stripe.

10a.—Scale rows, 31 to 33. Intestine short, with about 4 short transverse segments. Dorsal rays, 11 to 13. Teeth of inner band conic.

15. Characodon lateralis

9b.—Dorsal fin inserted near middle of total length including caudal fin. Coloration: crossbars lacking or merely dusky.

10b.—Scale rows, 33 to 38. Intestine short, with only 1 extra coil about second bend. Dorsal rays, 13 or 14. Mouth with wide lateral gape. Teeth of inner band conic. Coloration: females spotted; males with an irregular blackish stripe.

3. Xenotooa variata

10c.—Scale rows, 46 to 50. Intestine long, with 8 to 12 high transverse segments. Dorsal rays, 14 to 17. Mouth with reduced lateral gape. Teeth of inner band bisected. Coloration: females with irregular dark stripe and dusky bars; males spotted.

16. Lyodon furcidentis

9c.—Dorsal fin inserted well in advance of total length including caudal fin. Coloration: body crossed by regular (occasionally irregular) blackish bars, in both sexes.

10d.—Scale rows, 34 to 37. Intestine considerably elongate and coiled, with about 5 transverse segments. Dorsal rays, about 15. Mouth with much reduced lateral gape. Teeth of inner band conic. Coloration: strongly barred along middle of sides in both sexes.

3. Chapalichthys eousatus

8b.—Teeth loosely attached to weakly joined jaws. Mouth essentially transverse.

Intestine elongate.

11a.—Dorsal fin smaller, with 10 or 11 rays, and placed farther back, beginning distinctly behind origin of anal fin, more than twice as far from tip of snout as from base of caudal fin. Inner teeth bisected.

1. Atractichthus toreri

11b.—Dorsal fin larger, with 12 to 17 rays, and placed farther forward, beginning approximately over origin of anal fin (Goodea granulata and G. airipinna), or in advance of anal origin, about twice as far (G. granulata and G. airipinna) or less than twice as far from tip of snout as from base of caudal, much less than twice as far in the genera (Baladichthys, Olloentodon, and Neotooa) having the inner teeth bisected.

12a.—Sclerotic area between anus and genital opening of males wholly scaleless. Caudal fin symmetrically truncate or rounded. Scales, 32 to about 45. Coloration: females without diffuse dark axial stripe (with an even black stripe in Neotooa bilineata); vertical fins never with a black bar.
15a.—Gill-rakers on first arch, about 40 to 45. Origin of dorsal fin distinctly nearer end of caudal fin than tip of snout (not much nearer caudal tip in Goodea lutipoldii). Anterior lobe of anal fin of males about three-fourths as high as highest anal ray, with rays relatively little crowded. Innermost pelvic rays in contact. 

Goodea (For characters of species see items 9 and 10 in the analytical key, on pp. 27-28.)

15b.—Gill-rakers on first arch, about 20 to 30. Origin of dorsal fin a little nearer end of caudal fin than tip of snout, or nearer tip of snout. Anterior lobe of anal fin of males at most little more than half as high as main lobe, with rays much crowded. Innermost pelvic rays slightly (Xenoophorus) or considerably separated.

16a.—Origin of dorsal fin a little nearer end of caudal fin than tip of snout in females, about equidistant between these points in adult males. Swollen area between anus and genital opening of males wider than long. Innermost pelvic rays slightly separated. 

Xenoophorus (For characters of species see items 11a to 11o in the analytical key, on pp. 90-91.) 

16b.—Dorsal rays, 12 or 13. Gill-rakers, about 25. Teeth of inner band (developed at sides) conic to blunt. Coloration: densely variegated with dusky in each sex. 

Shiria (For characters of species see items 14 and 15 in the analytical key, on p. 37.)

16b.—Dorsal rays, 15 to 17. Gill-rakers, about 29. Teeth of inner band (developed at sides) mostly bifid, some conic. Coloration: upper
and posterior sides with definite rows of blackish spots in each sex.

23. *Gillistodus multipunctatus*

15b.—*Inner band of teeth not obsolescent medially, forming a narrow, moderately curved band; teeth of outer row rather loosely attached to moderately strong jaws. Mouth with considerably reduced lateral gape (forming a wide arch). Intestine not much elongated, kinked but not evenly coiled on right side, with about 3 or 4 transverse segments. Scales in 29 to 33 rows. Transverse genital opening of males convex medially. Anterior lobe of anal fin of males one-half or a little more than one-half as high as highest anal ray, with a moderately developed dermal thickening near base forming only a trace of a pocket. Innermost pelvic rays not bound down to body by membrane.

16c.—Dorsal rays, 13 to 15. Gill-rakers, about 20. Teeth of inner band uniformly bifid. Coloration: females with a black axial stripe and a shorter, lower stripe over the belly in advance of a black blotch or bar above the anus; males with a single dark band more or less broken into bars.

24. *Neoscar bilineata*

12b.—Swollen area between anus and genital opening of males covered with scales on anterior half (except for a median strip). Caudal fin asymmetric: upper angle more or less produced and pointed; lower angle cut off and rounded. Coloration: females with a diffuse axial stripe and more or less evident and definite dark crossbars; one or more of the vertical fins with a marginal or submarginal black stripe.

*Bolandichthys*

(For characters of species see items 12b and 12c in the analytical key, on p. 54.)

7b.—*Dorsal and anal fins each with more than 25 rays.*

20. *Lermichthys multiradiatus*
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Diagrammatic cross sections of gravid ovaries of goodeid fishes, after removal of embryos. Ovigerous tissue is indicated by black spots.

Fig. 1. *Allophorus robustus* (applicable also to *Xenotoca variata*).
Fig. 2. *Gooeia laiptoldii* (drawn facing backward).
Fig. 3. *Xenoophorus captivus*.
Fig. 4. *Neoophorus diast* (drawn facing forward).
Fig. 5. *Zoogoneticus quitoensis*.
Fig. 6. *Atamobius toweri* (drawn facing backward).
Fig. 7. *Neoabca biliacata*.
Fig. 8. *Characodon lateralis*.
PLATE I

REVISION OF THE GOODEIDAE
PLATE II

Outline drawings of trophotaeniae of embryos of goodcid fishes. The anus is indicated by a black circle or ellipse.

Fig. 1. Goodea atripinnia, 15 mm. embryo.
Fig. 2. Goodea kentfeldi, 16 mm. embryo.
Fig. 3. Xenoophorus diaphus, 13 mm. embryo.
Fig. 4. Allotoca dugesi, 3 mm. embryo.
Fig. 5. Xenoophorus captivus, 8 mm. embryo.
Fig. 6. Xenoophorus erro, 8 mm. embryo.
Fig. 7. Girardinichthys isomminatus, 13 mm. embryo.
Fig. 8. Lermaichthys multiradiatus, 7 mm. embryo.
Fig. 9. Characodon lateralis, 9 mm. embryo.
PLATE III

Outline drawings of trophotocenia of embryos of goodeid fishes. The anus is indicated by a black circle or ellipse.

FIG. 1. Skiffia lermae, 4 mm. embryo.
FIG. 2. Balasichthys whitei, 11 mm. embryo.
FIG. 3. Xenotoca variata, 10 mm. embryo.
FIG. 4. Ailophorus robustus, 15 mm. embryo.
FIG. 5. Chapalichthys encaustus, 11 mm. embryo.
FIG. 6. Zoogeneticus guizhouensis, 8 mm. embryo.
PLATE IV

Fig. 1. *Gooden gracilis*—holotype. An adult female, 39 mm. in standard length.

Fig. 2. *Allodontichthys zonistius*—paratype. An adult male, 48 mm. in standard length.

Fig. 3. *Balantichthys zentneri*—holotype. An adult male, 78 mm. in standard length.
FIG. 1. *Xenophonus caudiceps*—paratype. An adult female, 44 mm. in standard length.

Fig. 2. *Xenophonus caudiceps*—holotype. An adult female, 49 mm. in standard length.

Fig. 3. *Xenophonus caudiceps*—holotype. An adult female, 45 mm. in standard length.
Fig. 1.

Fig. 2.

Fig. 3.
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MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 48

A REVISION OF THE BLACK BASSES (*MICROPTERUS* AND *HURO*)
WITH DESCRIPTIONS OF FOUR NEW FORMS

BY
CARL L. HUBBS and REEVE M. BAILEY

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
JULY 27, 1940
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FREDERICK M. GAIGE
Director of the Museum of Zoology
A REVISION OF THE BLACK BASSES (MICROPTERUS AND HURO) WITH DESCRIPTIONS OF FOUR NEW FORMS

BY

CARL L. HUBBS and REEVE M. BAILEY

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**Fig. 1.** A theoretical phylogeny of the seven recognized forms of black bass   37

**Maps**

(Maps 1 and 2 follow Plate VI)

**Map**

1. Distribution, by record stations, of the subspecies of Micropterus punctulatus.
2. Distribution, by record stations, of Micropterus dolomieu and M. coosae.
A REVISION OF THE BLACK BASSES (MICROPTERUS AND HURO), WITH DESCRIPTIONS OF FOUR NEW FORMS

INTRODUCTION

Until recently the North American fresh-water centrarchids known as black bass had long been referred to 1 genus and 2 species, Micropterus dolomieu and Micropterus salmoides. In 1926 the largemouthed species salmoides was set apart in a distinct genus, Aplites (Hubbs, 1926: 69 and 71), and in the following year a third species, Micropterus pseudaplites, was described (Hubbs, 1927). Except for differences of opinion regarding the generic and specific nomenclature of the largemouthed bass, this classification of the black basses has been generally followed. It has now become evident, however, that the spotted bass (Micropterus pseudaplites) was in all probability described by Rafinesque, and it is proposed that the name Micropterus punctulatus be used for this species.

There is evidence indicating the existence of a fourth species of black bass, here named Micropterus coosae, and of 3 new subspecies: M. punctulatus wichiita, M. p. henshalli, and M. dolomieu velox. The 4 new black basses described in this paper are compared with the 3 forms previously recognized. The largemouthed bass is characterized in the key and is discussed nomenclatorially. According to present interpretations, its name should stand as Huro salmoides (Lacépède). No analysis has been made of the local variations of this species, although there are indications that it is a complex of subspecies.

Even after the separation of the 4 additional species and subspecies, the classification of the forms of Micropterus in certain regions appears to be confused or incomplete. In the southern part of the Ohio River drainage basin Micropterus dolomieu differs considerably from the typical subspecies, and in several characters approaches M. d. velox. In the southern states the characters of the forms of Micropterus are confused, which suggests that other localized variants remain unnamed (see Map 1) or that interspecific hybridization has caused the observed variation (pp. 19–20, 28 and 41).

Two specimens are definitely indicated as hybrids between M. dolomieu and M. p. punctulatus, and another is interpreted as a hybrid between M. coosae and M. p. henshalli (pp. 39–41).

The group of the black basses (Micropterus and Huro) is regarded as a tribe (Micropterini, new name) of the subfamily Lepominae.

In summary, the proposed classification and nomenclature of the black basses is as follows:
Family Centrarchidae Cope¹

Subfamily 1. Lepominae Gill²

Tribe 1. Micropterini,³ new name

Genus 1. *Micropterus* Lacépède

1. *M. punctulatus* (Rafinesque), spotted bass
   1a. *M. p. punctulatus* (Rafinesque), northern spotted bass.

2. *M. coosae*, new species, reedyed bass

3. *M. dolomieu* Lacépède, smallmouthed bass
   3a. *M. d. velox*, new subspecies, Neosho smallmouthed bass
   3b. *M. d. dolomieu* Lacépède, northern smallmouthed bass

Genus 2. *Huo* Cuvier

4. *H. salmoides* (Lacépède), largemouthed bass
   (Subspecies not yet delimited)

**Materials and Acknowledgments**

This revision of the black basses is based on a critical examination of the extensive material deposited in the following collections:

- University of Michigan Museum of Zoology (U.M.M.Z.)
- United States National Museum (U.S.N.M.)
- Museum of Comparative Zoology (M.C.Z.)
- Academy of Natural Sciences of Philadelphia (P.A.N.S.)
- University of Oklahoma Museum of Zoology (U.O.M.Z.)
- Alabama Polytechnic Institute (A.P.I.)
- Iowa State College (I.S.C.)
- Southern Biological Supply Company (S.B.S.C.)
- Illinois State Natural History Survey (material of *Micropterus punctulatus*)

We are very grateful to the directors and curators of these institutions for their generosity in making the material in their care available to us.

F. E. Guyton, of Alabama Polytechnic Institute, has graciously granted us priority in the naming of *Micropterus coosae*, which he also recognized as a new species. A. I. Ortnerberger, of the University of Oklahoma, has

¹ Cope (1868: 216).
² Gill (1864: 92); Jordan (1877b: 31).
³ This group has been called Micropterinae by Gill (in Jordan, 1877b: 31) and others, and the name Micropteridae was proposed for the family by Fowler (1906: 513).
given us permission to describe *M. punctulatus wichitae*, almost all of the specimens of which were collected under his supervision. Records and other information of material value in rounding out our treatment of the basses have been freely placed at our disposal by Milton B. Trautman, David H. Thompson, Edward C. Raney, Percy Viosca, Jr., Eugene R. Kuhne, and other ichthyologists.

**METHODS USED IN COUNTING AND MEASURING**

In the vertebral count the hypural is included as 1 vertebra, and the first caudal vertebra with a well-developed haemal spine is treated as the first caudal vertebra. The scales are counted: (a) along the lateral line, from the last one in contact with the shoulder girdle to the structural base of the caudal fin; (b) above the lateral line, downward and backward from the origin of the dorsal fin to but not including the lateral-line row, and including the small scales near the origin of the fin; (c) below the lateral line, from the origin of the anal fin, including the small scales, upward and forward to but not including the lateral-line row; (d) around the caudal peduncle, enumerating the minimum number of rows around the slenderest point of the caudal peduncle; and (e) on the cheek, counting the rows which cross the shortest line from the eye to the postroventral angle of the preopercle. The last ray of the dorsal and anal fins is always treated as a double ray divided to the base of the fin. In the pectoral fin all rays are enumerated, including the short uppermost ray which closely adheres to the second one (the first well-developed ray) and all small rays at the ventral end of the fin.

The measurements, made with dividers and read to the nearest 0.1 mm., on a steel rule, are expressed as thousandths of the standard length (the length from the anterior end of the upper jaw to the structural base of the caudal rays; distinguished from the total length, which is measured from the tip of the mandible to the end of the caudal fin). For the type specimens only, the proportions are also expressed as the number of times each given measurement enters either the standard length or the length of the head, when the measurement is stepped over the curve of the body or head. The length of the caudal peduncle is taken from the posterior end of the anal base to the base of the caudal rays at the lateral line. The length of the pectoral fin is the distance from the base of the uppermost ray to the tip of the fin; that of the pelvic fin is the distance from the base of the spine to the tip of the fin. The head is measured from the front end of the upper jaw to the tip of the opercular membrane. The length of the orbit is obtained by placing the tips of the dividers at the edges of the eye and spreading them with a gentle pressure. The interorbital width is measured by pressing the points together to approximate as nearly as
practicable the least bony width. The length of the lower jaw is taken
from its anteriormost tip to the posterior end of the angular.

In the description of each new form, the measurements and counts of
the holotype are given. Ranges and averages of the measurements are
presented in Table III, and frequencies and averages for the counts in
Tables IV–VII. The body proportions are expressed as the number of
times each measurement, as taken with dividers, may be stepped into
the standard length, and as thousandths of this length. The head proportions
are similarly expressed with the head length as the base.

KEY TO THE FORMS OF MICROPTERUS AND HUBER

1a.—Centrarchidae with 3 anal spines (very rarely 2 or 4); 6 branchiostegals (very rarely
7); villiform teeth on palatines and entopterygoids, but none on eoptopterygoids,
present or absent on glossohyal; bifid opercle (with lower lobe much longer than
upper, especially in adult), rigid to tip; large mouth (maxillaries extending at
least to below center of pupil); well-developed supramaxillary; entire pre­
opercle; 31–33 vertebrae; 14 or 15 precaudal vertebrae (very rarely 13 or 16);
55–81 scales along lateral line; 9–20 scale rows on cheek; 9–11 dorsal spines;
anal base less than half dorsal base; moderately compressed, elongate body
(depth about one-third to one-fifth standard length in juveniles, but increasing
with age); size, large (greater than 12 inches as the maximum in all species).—

Table Micropterus (new name) of the subfamily Lepomineae.

2a.—Pyloric caeca typically simple (occasionally 1 or 2 branched). Outline of
spinous dorsal weakly curved to moderately angulate; spinous and soft
portions of fin well connected; the shortest spine at emargination of fin
(typically the ninth spine), 1.1 to 2.5 in longest spine. Anal and soft
dorsal with scales on interradial membranes near their bases. Check
scales, usually in 12 or more rows (occasionally 10 or 11 in conosoc and 11
in punctulatus); mouth, moderate (upper jaw extending little or not at
all beyond eye in adult).

Genus Micropterus

3a.—Dorsal soft rays, 12 (infrequently 11 or 13); anal soft rays, 10 (occasional­
ly 9 or 11); pectoral rays, 15 or 16 (very rarely 14 or 17).
Scales above lateral line, 7–18; below lateral line, 14–19. Verte­
brae, normally 14 + 18 = 32. Larger individuals with a dark streak
along each ventrolateral scale row. (See alternatives 3b and 3c.)

4a.—Color pattern consisting chiefly of a lateral series of dark
blotches which tend to be confluent, so as to form an irregu­
lar longitudinal stripe; basal caudal spot (and opercular
spot) prominent; dark band on caudal lobes of young con­
spicuous. Caudal peduncle typically more slender and elon­
gate. Precordial contour flatter; the muzzle more produced.
Shortest dorsal spine at emargination of fin, not more than
0.6 as long as the longest spine (see also 3b).

1. Micropterus punctulatus

This key is purportedly natural, with a single exception: The characters of Micropt­
terus punctulatus viciniae (a form highly localized in Oklahoma) call for its separation
from the other subspecies of punctulatus.

On 1 side of 1 specimen (of Heros salmoides), out of 146 counts for the tribe.
A REVISION OF THE BLACK BASSES

Scales along lateral line, usually 60-68 (extreme range, 55-72); around caudal peduncle, usually 23-26 (extreme range, 22-27). Pectoral rays, more frequently 15 than 16. Typically less elongate (at comparable size). Southern Ohio and West Virginia to southern Illinois, southeastern Kansas, eastern and southern Oklahoma, and eastern Texas; east to Mississippi and to the Tennessee River drainage of Tennessee, Alabama, and Virginia; recently introduced into California and South Africa. 1b. M. p. punctulatus

Scales along lateral line, usually 68-75 (extreme range, 68-77); around caudal peduncle, usually 27-28 (extreme range, 26-29). Pectoral rays, more frequently 16 than 15. Typically more elongate (at comparable size). Alabama River system of Mississippi, Alabama, and Georgia, intergrading with typical punctulatus near the coast along the eastern part of the Gulf of Mexico. 2a. M. p. henshalli

Color pattern consisting principally of vertical dark bars, which are frequently faint and always obscured with age, and on the caudal peduncle are often modified into light-centered rhombs; basal caudal spot not prominent; band on caudal lobes of young faint or obsolete. Caudal peduncle typically deeper and shorter. Predorsal contour more rounded (simplifying that of M. d. dolomieu). Shortest dorsal spine at emargination of fin, typically more than 0.6 as long as the longest spine (about as in M. d. dolomieu).

Scales along lateral line, usually 67-72 (extreme range, 63-77); around caudal peduncle, usually 26-30 (extreme range, 25-31). Typically robust. Southeastern streams from the Alabama to the Savannah, generally in the uplands. 3b. Micropterus coosa

Dorsal soft rays, 12-14, usually 13; anal soft rays, 10 (frequently 11, rarely 9); pectoral rays, 14-17, usually 15 or 16. Scales above lateral line, 8-11, usually 9; below lateral line, 15-19. Vertebrae, 14 or 15 + 17 or 18 + 32 (occasionally 21 or 23). Larger individuals with or without streaks along ventral scale rows.

Color pattern very variable, in the young approaching that of M. dolomieu, with age becoming banded as in punctulatus or very much speckled; basal caudal spot well developed in young, sometimes disrupted in adult; dark band on caudal lobes of young conspicuous. Caudal peduncle about as in M. p. punctulatus. Predorsal contour variable, but generally flattish and the muzzle produced. Shortest dorsal spine at emargination of fin, typically less than 0.6 as long as the longest spine.

Note that the items 3b, 4c, and 5d apply only to a form confined to a very small area in Oklahoma.
HUBBS AND BAILEY

5d.—Scales along lateral line, 62–70; around caudal peduncle, 23–29. Typically rather elongate. *West Cache Creek* in *Wichita Mountains, Oklahoma*.

5c.—*Micropterus punctulatus wichitae*

5.—Dorsal soft rays, 13–15 (very rarely 12); anal soft rays, 11 (occasionally 10 or 12, very rarely 9); pectoral rays, 16–18 (almost never 15). Scales above lateral line, 12 or 13 (rarely 11 or 14); below lateral line, usually 20–23 (range, 19–25). Vertebrae, normally 15 + 17 = 32. No regular streaks along ventrolateral scale rows.

4d.—Color pattern consisting of bars (but note differences described in items 6a and 6b); basal caudal spot moderately developed in young, obsolete with age; dark bands on caudal lobes of young conspicuous. Caudal peduncle typically deep and short. Shortest dorsal spine at emargination of fin more than half as long as longest spine.

5c.—Scales along lateral line, usually 69–77 (extreme range, 67–81); around caudal peduncle, usually 29–31 (extreme range, 28–32). ... 3. *Micropterus dolomieus*

6a.—Dorsal rays, usually X, 13; ranging from IX (commonly) to XI (rarely), 11–15 (2 counts of 11, 4 of 10); sum of dorsal spines and soft rays, 21–23 in about 76 per cent of specimens counted. Predorsal contour straighter and form more slender, especially in young; depth, 3.8–4.3 in young less than 75 mm. long. Lower jaw projecting so that the teeth are visible from above. Teeth developed on tongue in more than half the specimens. Dark bars of young generally less elevated and broader, in large young tending to form hollow rhombs. *Tributaries of the Arkansas River system in northeastern Oklahoma and western Arkansas and the headwaters of the same streams in Missouri (and presumably in Kansas)*.

3n. *M. d. velox*

6b.—Dorsal rays, usually X, 14; ranging from IX to XI (rarely varying from X), 13 (rarely; 1 count of 12) to 15; sum of dorsal spines and soft rays, 24 or 25 in more than 90 per cent of specimens counted. Predorsal contour more rounded and form more robust; depth, typically 3.3–3.8 in young less than 75 mm. long. Lower jaw typically little projecting, with the teeth scarcely or not visible from above. Teeth usually lacking on tongue (except toward the south). Dark bars of young typically very high and narrow, not tending to form hollow rhombs. *Originally from Quebec to northern Minnesota, south to Arkansas and the*
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Tennessee River drainage of Alabama; not east of the Allegheny Mountains.

3b. *M. d. dolomieu*

2b.—Pyloeric caeca mostly bifid near base. Outline of spinous dorsal sharply angulate; spinous and soft portions of fin almost separated; the shortest spine at emargination of fin, 2.4-3.9 in longest spine, and membranes between short spines deeply incised. Anal and soft dorsal without scales on interradial membranes (not considering the basal sheath of scales). Check scales in 9-12 rows. Mouth, large (upper jaw extending beyond eye in adults).

**Genus Huro**

3b.—Dorsal soft rays, usually 12 or 13 (rarely 11 or 14); anal soft rays, 11 (rarely 10 or 12); pectoral rays, usually 14 or 15 (extreme range, 13-17). Scales above lateral line, 7-9; below lateral line, 14-17. Vertebrae usually 15 + 17 = 32. No regular streaks along ventrolateral scale rows.

4c.—Color pattern consisting chiefly of a rather regular longitudinal dark stripe; basal caudal spot small, but distinct, especially in young; dark band on caudal lobes of young usually faint, varying from absent to rather well developed (best developed in south). Caudal peduncle rather robust. Predorsal contour rather strongly elevated, and becoming concave with age.

5f.—Scales along lateral line, usually 59-68 (extreme range, 58-69); around caudal peduncle, usually 26-28 (extreme range, 24-30). Typically rather robust. Originally from southern Canada throughout the entire Great Lakes system and Mississippi Valley to northeastern Mexico and Florida, and north along the coastal plain to Virginia.

**Genus MICROPTERUS LACEPÈDE**


The synonymy given above includes references to the original description of *Micropterus* and its synonyms, with type designations. A full synonymy, with the characterizations given by subsequent as well as original describers, was elaborated by Henshall (1881: 65-79). Of the names listed by Henshall, *Huro* alone seems applicable to the genus now recog...
nized for the largemouthed bass. *Aplites* Rafinesque and *Gryastes* Cuvier have also been applied to that genus (see p. 36), but are now interpreted as synonyms of *Micropterus*.

We here recognize as referable to *Micropterus* 3 species and a total of 6 forms.

**SPOTTED BASS**

1. *Micropterus punctulatus* (Rafinesque)

   This name, as indicated in the synonymy of the typical subspecies, is accepted as applicable to the recently described species known as spotted bass or Kentucky bass. In addition to *M. p. punctulatus* we recognize 2 new subspecies.

**NORTHERN SPOTTED BASS**

1a. *Micropterus punctulatus punctulatus* (Rafinesque)

   (Map 1; Pl. I, Fig. 2; Pl. II, Fig. 1.)

   *Callius punctulatus.*—Rafinesque, 1819: 420 (original description; Ohio River); 1820: 26-27 (spelled *punctulatus*, presumably by misprint; locality more specifically stated as Falls of the Ohio and neighboring streams).


   *Micropterus punctulatus punctulatus.*—Kuhne, 1939: Fig. 66.

   *Leopone pallida.*—Rafinesque, 1820: 20-21 (original description; the Ohio River, Miami River, Hocking River, etc.; not clearly identifiable, but here interpreted as a complex of this species and *M. d. dolomica*, and as nomenclatorially referable to *punctulatus*).

   *Etheostoma callium.*—Rafinesque, 1820: 36 (original description; the Ohio River, Salt River, etc.; not clearly identifiable, but here interpreted as a complex of this species and *M. d. dolomica*, and as nomenclatorially referable to *punctulatus*).

   *Dioplites truncatus.*—Vaillant and Bocourt, 1874: Pl. 4, Fig. 2 (original indication by figure; San Antonio de Bexar, Texas).

   *Micropterus succedens* var. *truncatus.*—Vaillant and Bocourt, 1883: 142 (original text description).

   *Micropterus floridanus* (misidentification; not *Cichla floridana* LeSueur; see Hubbs, 1927: 3).—Cope, 1880: 31-32 (comparisons; Johnson Fork of Llano River, Texas).

   *Micropterus salmoides* (miscorrections; not *Lacopeka*; see Hubbs, 1927: 3-4).—Jordan and Gilbert, 1886: 21 (comparison; Rio Colorado, Texas). Henshall, 1889: 29, and 1904: 45 (in part; variants from St. Francis River, Arkansas).

   Goldsborough and Clark, 1908: 37 (in part; variants from Jaeger, West Virginia).

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Since this species was described by Hubbs (1927) as Micropterus pseudoplites, its distinctness has been abundantly confirmed by the subsequent authors cited above, in the last item of the synonymy. The work of Howland and of Wickliff and Trautman, as well as our own examinations, has shown that it is the most abundant bass of the upper Ohio River and of the parts of Ohio adjacent to that river. This discovery has led to a reopening of the question as to whether Rafinesque had this form when he described several nominal species of bass from the same region. Although the presumably clearer and certainly less impounded waters of Rafinesque's time would have favored the smallmouthed bass (M. d. dolomieu) rather than the spotted bass, it can hardly be questioned that the present form was common, and in all probability was handled by Rafinesque.

A re-examination of Rafinesque's descriptions in the light of this evidence indicates that his oldest name for a bass, Calliurus punctulatus (1819: 420), was based on the species named Micropterus pseudoplites by Hubbs. The original description was as follows:


This description applies best to the spotted bass with respect to the prominent black spots, which suggested the name, and to the number of anal and pectoral rays, but not to the number of dorsal rays. The supplementary description in Ichthyologia Ohioensis (1820: 26-27) applies, in the following characters, much better to the spotted bass than to the other species: “Lower jaw longer; body . . . crowded with blackish dots: head . . . flattened above: tail . . . base yellow . . . from four to twelve inches long . . . anal fin with 13 rays . . . Pectoral . . . with 15 rays.” Only the indicated number (14) of dorsal soft rays applies better to M. dolomieu. It seems sufficiently clear that the name Micropterus punctulatus (Rafinesque) belongs with the spotted bass, replacing M. pseudoplites Hubbs. We are told by Milton B. Trautman that the vernacular name “painted-tail,” attributed by Rafinesque to his C. punctulatus, may still be heard in Ohio.

Two of Rafinesque's names dating from 1820 may be associated nomenclatorially with this species (see synonymy), although the characters as given fit punctulatus in part and dolomieu in part. His other names seem to fit dolomieu better, and may be listed in the synonymy of that species.

The figure of Dioplites Treculii Vaillant and Bocourt and the subsequent description of "Micropterus naucensis var. treculii" agree somewhat better with Micropterus punctulatus than with Huro salmoides. A
gracious re-examination of the type specimen by Jacques Pellegrin confirms this indication. He reports the following characters: dorsal, IX, 12; anal, III, 10; pectorals, 15–15; scales, 8–60–15; lingual teeth present (as a small patch); small scales evident on membranes between dorsal soft rays; upper jaw, 2.2 in head; no dark lines visible [likely faded?] along scale rows below lateral line; standard length, 240 mm.; total length, 297 mm. The name *treaclei* will be available for a subspecies, if the variations exhibited by the species in the vicinity of San Antonio, Texas, be deemed sufficient to warrant nomenclatorial recognition.

The characters of this subspecies are stated in the key. Variational data are given in Tables II–VII. The distribution of the form is indicated by the numerous record stations plotted on Map 1.

R. W. Eschmeyer sends us information on a spotted bass larger than any previously reported. This fish, 17\(\frac{1}{2}\) inches long and weighing 3 pounds, 15 ounces, was caught in Norris Lake, Tennessee.

**ALABAMA SPOTTED BASS**

1b. *Micropterus punctulatus henshali*, new subspecies

(Map 1; Pl. I, Fig. 3; Pl. IV, Fig. 1.)

*Micropterus pallidus* (in part; misidentifications, not *Lepomis pallida* Rafinesque).—Jordan, 1877a: 314; and Jordan and Brayton, 1878: 46 (Coosa River system, Georgia).

*Micropterus pseudapaluteus*—Hubbs, 1927: 13 (in part; record for Etowah River, Georgia).

This form represents the species in the Alabama River system in Mississippi, Alabama, and Georgia, and intergrades with *M. p. punctulatus* in the lower Escambia River system in Escambia and Conecuh counties, Alabama, and from the Pascagoula and Pearl River systems in Mississippi to the tributaries of Lake Pontchartrain in Mississippi and Louisiana. It agrees with the typical subspecies in most respects and differs chiefly in the smaller size of the scales (see items 5a and 5b of the key and Tables V–VI) and in the more elongate form at comparable sizes (compare Figs. 2 and 3, Pl. 1). The pectoral rays average higher, and are more frequently 16 than 15, rather than the reverse (Table IV).

Inadequate material from the Chattahoochee, Apalachicola, Ocmulgee, and Savannah River systems (of Georgia, Alabama, Florida, and South Carolina) prevents a clear understanding of the black basses of these drain-age basins. It seems not improbable that at least 1 additional form may be represented in the southeast. A large specimen from the Chipola River in the Apalachicola River system in western Florida has distinctive features and remains unidentified (Map 1). The problem is receiving further study.

**HOLOTYPE.**—U.M.M.Z. No. 118297; an immature, yearling female 113
mm. in standard length, 138 mm. over all; collected by F. E. Guyton on
June 27, 1931, in Uphapee Creek, tributary to Tallapoosa River of the
Alabama River system, 4 miles east of Tuskegee, Macon County, Alabama.

DESCRIPTION.—The form is elongate, becoming more robust with age;
greatest depth, 4.0 (238). Least depth of caudal peduncle, 9.1 (104). The
caudal peduncle is elongate; its length, 4.0 (248). The body is moder­
ately compressed; greatest width, 6.3 (158). Length of head, 2.95 (338);
relatively larger in young. The dorsal fin is rather deeply emarginate;
the shortest spine at the rather deep emargination of the dorsal fin is
contained 2.0 times in (is 51 per cent of) the longest; the fifth and longest
spine, 12.3 (80); the spinous part becomes relatively lower with age. The
rounded soft dorsal agrees with that of the genotype, *M. d. dolomieu,*
in having scales on the membranes near the base; its height is less than the
basal length and about equal to the height of the anal; longest ray, 7.5
(129). The graduated anal spines become relatively shorter with age; the
third and longest, 4.5 in head (73). The rounded anal fin becomes rela­
tively slightly lower with age; the membranes bear scales near the base;
longest ray, 7.1 (136). The pectoral fin is short and rounded; length, 6.3
(153). The pelvic is short and becomes relatively somewhat shorter with
age; length, 6.3 (154). Length of caudal fin from middle of base to tip
of longest ray, 4.3 (227); length of shortest median ray, 6.4 (146), or 1.6
in the length of the fin. Tip of snout to origin of dorsal, 2.3 (411); tip of
lower jaw to insertion of pelvic, 2.8 (359); thence to origin of anal, 3.5
(282).

Width of slender head, 2.0 (486); increasing with age. Length of
snout, 3.5 (289); increasing slightly with age. The orbit becomes rela­
tively much smaller with age; length, 4.9 (207). The flat interorbital
becomes wider with age; least bony width, 5.0 (202). The maxillary ex­
tends to below the posterior margin of the pupil; length of upper jaw, 2.1
(454); increasing with age. The lower jaw projects slightly; the length,
increasing with age, 1.7 (564).

Dorsal, X, 12; anal, III, 10; pectorals, 17-17 (usually 15 or 16).
Scales, 9-74-19; 29 rows around caudal peduncle and 15 rows on cheek.
Vertebræ, 14 + 18 = 32 in 17 paratypes, 14 + 17 = 31 in 1, and 13 + 19 = 32
in 1.

Glossohyal teeth forming a small patch in the holotype, but absent in
2 specimens of the 22 examined for this character. Gill-rakers on first
arch, 2 + 6 (usually 2 + 6 or 2 + 7, very rarely 2 + 8 or 3 + 7). Pyloric
cæca not branched at base.

Largest specimen examined, 166 mm. in standard length and 203 mm.
in total length.

The diamond-shaped, dark blotches forming a mid-lateral series on the
body of the young become confluent posteriorly in some specimens to form a rather regular stripe on the caudal peduncle. In older specimens the blotches become progressively more confluent, so that the lateral stripe is more regular, approaching that of *Huro*. The dorsal and dorsolateral region are irregularly blotched or mottled, in sharp contrast to the lighter color below the lateral band. The ventrolateral longitudinal streaks characteristic of the adult of *M. p. punctulatus* are imperfectly developed in the holotype of *M. p. henshalli*, but are well shown by other specimens. The characteristically dark basal caudal spot serves as one of the best criteria for distinguishing *M. p. henshalli* from *M. coosae*, which lives in the same region. The spinous dorsal, anal, and paired fins are immaculate. Two broken longitudinal streaks on the soft dorsal roughly divide the fin into thirds. The basal half of the caudal fin is immaculate, except for a dusky stain on the median rays. A conspicuous subterminal black band is evident on the tail fin of the young, and is still clearly recognizable in the holotype. Three brownish streaks radiate backward and downward from the eye; the uppermost streak is darkened posteriorly to form a pronounced black opercular spot.

The 66 type specimens were obtained at the following localities. The records are entered on Map 1. The abbreviations for the museums are explained on p. 8. F. E. Guyton, of Alabama Polytechnic Institute, has generously allowed us to study and record his material of this subspecies.


**GEORGIA.**—Tributary to Coosa River, east of Coosa, Floyd Co., September 1, 1929, Creaser and Becker: U.M.M.Z. No. 88235 (1). Armuchee Creek, tributary to Oostanaula River (tributary to Coosa River), Armuchee, Floyd Co., September 1, 1929, Creaser and Becker: U.M.M.Z. No. 88248 (3). Tributary to Coosa River, 5 miles northwest of Cedartown,
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We take pleasure in naming this form for the late James A. Henshall, to whom credit is largely due not only for raising the black basses to their position of high esteem in the minds of the sportsmen of the country, but also for determining their proper nomenclature.

WICHITA SPOTTED BASS

1c. Micropterus punctulatus wichitae, new subspecies (Map 1; and Pl. VI.)

*Micropterus dolomieu, Micropterus pseudoplites, and hybrids.—Hubbs and Ortenburger, 1929a: 42; and 1929b: 105-6 (preliminary identification of the types of wichitae).

As indicated in the synonymy, the type specimens of this subspecies were first interpreted as representing a local fusion through hybridization of *Micropterus dolomieu* and *M. pseudoplites (=punctulatus*). There is considerable evidence in favor of this view. The young (Pl. VI) are rather variably intermediate in color pattern, being less strongly barred than in *dolomieu* but more definitely barred than in *punctulatus*. Larger individuals exhibit greater variation in color pattern than is shown by any other form of black bass. Some resemble typical *punctulatus* so closely in all features of coloration as to be virtually indistinguishable in general view, whereas others, like the holotype, are peculiarly speckled on the body and caudal base and lack the well-defined lateral band and the regular row of spots on the ventrolateral scales (Pl. VI). As depicted in the same plate, there is considerable variation in the production of the muzzle and in the flattening of the predorsal contour—characters in which *punctulatus* differs from *dolomieu*. The vertebral formula, instead of being almost constantly 14 + 18 as in the other subspecies of *punctulatus* or 15 + 17 as in both forms of *dolomieu*, is 14 + 18 or 15 + 17 with almost equal frequency, thus varying much more than in any other form in the genus (Table VII). Similarly, the number of anal rays (Table IV) varies more than in other black basses: there are frequently 11 as in *dolomieu*, rather than almost consistently 10 as in the other forms of *punctulatus*. The typical number of dorsal soft rays, 13, is intermediate between the characteristic number of 12 for *punctulatus* and of 14 for typical *dolomieu*, but agrees with the usual number for *velox*. This subspecies of *dolomieu* is rather definitely approached by *M. punctulatus wichitae* not only in this and in other characters, but also in distribution (Maps 1 and 2).
Evidence accumulates, however, to indicate that the bass of West Cache Creek in the Wichita Mountains do not represent a partially fused complex of *dolomieu* and *punctulatus*. The variations in coloration and in form are not correlated, as they would probably be if that relationship held. For example, the larger paratype figured on Plate VI contrasts sharply with the holotype in that it has the typical coloration of *punctulatus*; yet it approaches *dolomieu* in that the muzzle is less produced and the anterodorsal profile is more rounded than in *punctulatus* or in the holotype of *wichita*. The number of soft dorsal rays is typically 13, whether the specimens otherwise approach *dolomieu* (with 13 or 14 rays) or typical *punctulatus* (with 12 rays). Perhaps the strongest evidence against the idea that the specimens represent either a fusing or a fused hybrid stock is that the number of scale rows (Table V), particularly in the series above and below the lateral line, corresponds rather well with that of the other subspecies of *punctulatus* and is notably lower than in either form of *dolomieu*. If either a complex of forms or hybrids were involved, it would be expected that the average scale-row counts would be definitely intermediate between the values for the 2 species suspected of being the parent forms. We find such intermediacy in characters to hold consistently for supposed hybrid basses (pp. 39–41) and for proved hybrids between other species of the family (Hubbs and Hubbs, 1933; Bailey and Lagler, 1938). Another reason against the theory that the bass we call *wichita* are hybrids is that the testes, when sectioned, showed normal spermatogenesis, which was never observed in hybrid centrarchids (Hubbs and Hubbs, 1933). As indicated in the paper just cited, hybrid centrarchids are typically infertile, whereas the Wichita spotted bass must be fertile.

A fish-culturist suggested to us that the Wichita bass may be the product of hybridization between native spotted bass [*punctulatus*] and smallmouthed bass [*dolomieu*], which he said had been stocked in Cache Creek. But the supposed stocking of smallmouths would have been too recent to explain the production of so homogeneous a stock, with some uniformly intermediate characters and other features as in typical *punctulatus*. No native stock of *dolomieu* occurs near the Wichita Mountains. The recent finding in the National Museum of a specimen of *M. p. wichitae* collected in 1906 argues strongly against the fish-culturist’s idea.

If hybridization produced the bass under discussion, the evidence indicates that the interbreeding took place long ago, that the original hybrids were fertile, and that the characters of the population have become stabilized through inbreeding. This hypothesis would be difficult to prove or disprove. It strikes us as no more plausible than the view that the similarities between *wichita* and *dolomieu* are caused by parallel development, or the view that *wichita* is a relict of a generally extinct transitional stage between *punctulatus* and *dolomieu*.
It should be noted that the range of *wichitae* is confined to a single creek system, and that its mountain habitat lies just within the western limit of the range of typical *punctulatus* (Map 1). Whether or not there is intergradation about the mountains has not been determined. There is some evidence of the presence in Texas of populations (subspecies?) intermediate between the 2 forms or combining their characters. This evidence is supported by few specimens, and for the time being will not be elaborated. In the Brazos River system there is a race with prominent light spangles on the upper sides and with 12 to 14 soft dorsal rays, but otherwise like typical *punctulatus*. In the Guadalupe River we have taken fingerling bass which approach *dolomieu* quite as much as do the fingerlings of *wichitae*, but which agree with typical *punctulatus* in having 12 dorsal soft rays.

Whether or not populations will be found with characters intermediate between those of the 2 forms, *wichitae* will probably be retained as only subspecifically distinct, because some of the specimens, standing at the end of a continuous series of variations, are indistinguishable from typical *punctulatus*. Furthermore, as noted above, the scale-row counts are in distinctive agreement.

**Holotype.**—U.M.M.Z. No. 118299; an immature, yearling female 122.5 mm. in standard length, 151 mm. over all; collected by an expedition of the Museum of Zoology of the University of Oklahoma on June 6, 1927, near the headwaters of West Cache Creek, in the Wichita Mountains, 9 miles northwest of Cache, Comanche County, Oklahoma. Cache Creek flows through Red Run into Red River.

**Description.**—The form is elongate and streamlined; greatest depth, 4.0 (249). Least depth of caudal peduncle, 9.0 (114). The body is moderately compressed; greatest width, 7.2 (140). Length of head, 2.9 (351). The shortest spine at the moderately depressed emargination of the dorsal fin is 55 per cent of the longest; the fourth and longest spine, 12.1 (83). The rounded soft dorsal is longer than it is high, and is about as high as the anal; longest ray, 7.0 (147). The weak anal spines are graduated; the third and longest, 5.1 in head (68). The anal fin is rounded; longest soft ray, 7.0 (147). Length of the short pelvic fin, 6.6 (155); the first soft ray is not produced. Length of the caudal fin from the middle of its base to the tip of the longest ray, 4.2 (240); length of shortest median ray, 5.9 (171), or 1.35 in the length of the fin. Tip of snout to origin of dorsal, 2.4 (441); tip of lower jaw to insertion of pelvic, 2.9 (351); thence to origin of anal, 3.4 (296).

Width of head, 2.35 (430). The predorsal contour is little curved, and the muzzle is produced; length of snout, 3.7 (279). Orbital length, 5.0 (198). Least bony interorbital width, 5.3 (188). The maxillary extends to below the posterior margin of the eye; length of upper jaw, 2.1 (468). The lower jaw projects; its length is 1.7 (572).
Dorsal, X, 13; anal, III, 10; pectorals, 16-16. Scales, 10—66—16; 23 rows around caudal peduncle and 15 rows on cheek. There are no embedded scales on either arm of the preopercle.

The glossohyal bears a well-developed median patch of teeth. Gill-rakers on anterior arch, 2—6.

The color of the holotype in alcohol is light brownish, shading to darker above. The sides are densely freckled with irregular dark brown spots, which are concentrated along the middle of the sides but do not form a conspicuous dark lateral band as in \( M. p. punctulatus \). No regular ventrolateral dark streaks are developed. The basal caudal spot is somewhat disrupted. The proximal part of the caudal fin is obscurely marked with small, dark speckles on the interradial membranes. There is no dark transverse band across the caudal lobes (but this mark is well developed in the young). Three oblique brownish lines cross the cheeks, as in other forms of the genus. The opercular spot is prominent.

The young vary confusingly in coloration, but fingerlings (Pl. VI) may usually be distinguished with confidence from those of related forms. In specimens shorter than about 30 mm. the pattern is similar to that of the young of \( M. p. punctulatus \); the strong, irregular, mid-lateral stripe terminates in a conspicuous basal caudal spot. Larger young exhibit a highly variable number of transverse bars, which simulate those of \( M. d. dolomieu \) but typically are not so deep and are frequently more or less confluent.

With the exception of 1 example in the National Museum, the 441 type specimens are all in the University of Michigan Museum of Zoology, and the University of Oklahoma Museum of Zoology. We owe thanks to A. I. Ortenburger, of the University of Oklahoma, for the privilege of studying and reporting on the types series.


Blue Beaver Creek (tributary to West Cache Creek), 4 miles east of Cache, Comanche Co., June 28, 1928, Oklahoma Biological Survey: U.M.M.Z. No. 108774 (2).

This species is named for the Wichita Mountains, Oklahoma, to which the subspecies seems to be confined.
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REDEYED BASE

2. Micropterus coosae, new species

(Map 2; Pl. I, Fig. 4; Pl. V.)

Micropterus salmoides (misidentifications; not Labeo salmoides Lacépède).—Jordan, 1877a: 314-15, 355, 358 (brief characterization as possible variety; Georgia records).

Micropterus salmoides var. salmoides.—Jordan and Brayton, 1878: 31-32 (diagnosis, as southern variety; Georgia records).

Micropterus dolomieu var. dolomieu (misidentifications; not M. dolomieu Lacépède).—Henshall, 1881: 36-37, 82; 1904: 11, 32 (after Jordan).

Micropterus dolomieu.—Jordan and Gilbert, 1883: 485, 918 (in part).


Micropterus pseudolatipes (misidentification).—Hubbs, 1927: 13 (records for Augusta and for Little River near Rome, Georgia).

Micropterus coosae (v. n. n. novum; name taken from manuscript for present paper).—Swingle and Smith, 1939: 334 (production in pond).

Despite the fact that some of the distinctions between this southeastern species and M. dolomieu were appreciated and published by Jordan as early as 1877, it has never been given a valid scientific name. Its early designation as Micropterus salmoides var. salmoides was all but lost sight of after it was shown that the name salmoides had been wrongly applied to M. dolomieu. The specific distinctness of the species, indicated by Hubbs (1932), is shown in the numerous features by which items 3e, 4b, and 5e (for coosae) are contrasted with items 3d, 4d, and 5d (for dolomieu).

In many structural features, coosae is more like punctulatus than dolomieu, and these resemblances are probably indicative of close relationship. It typically differs from punctulatus and simulates dolomieu in the well-rounded predorsal contour, rather robust caudal peduncle, and little-notched dorsal fin (Pl. I). From both punctulatus and dolomieu it differs sharply in color. (Contrast item 4b of key with, respectively, items 4a and 4d.) In some color features coosae strongly resembles dolomieu; in others it is unlike any form referred to the genus.

The ranges of coosae and dolomieu apparently do not overlap (unless it be through the stocking of the northern smallmouth within the range of coosae at some point unrepresented by collections at hand), but the characters of the 2 forms are so distinct as to lead to the belief that they would not intergrade. The distribution of coosae widely overlaps that of M. punctulatus henshallii. M. coosae is more of an upland form, however, and the mutual occurrences may have resulted from the recent immigration of the one form into the range of the other. They do not seem to intergrade,
although there is some evidence (p. 28) that they hybridize, at least occasionally. Distributional and structural evidence suggests that coosae may have been differentiated in situ from an ancient *punctulatus*-like form that was speciating in the direction of *dolomieu*, and that *punctulatus* later invaded the same territory, becoming modified there into subspecies *henshalli*.

**HOLOTYPE.**—U. M. M. Z. No. 97729; a subadult female, 106.5 mm. in standard length, 131 mm. in total length (in the third summer of life); collected by H. R. Becker on July 3, 1928, in Fisher Creek, tributary to Big Will’s Creek of the Coosa River system, along the old highway between Attalla and Boaz, Etowah County, Alabama.

**DESCRIPTION.**—The moderately elongate form becomes more robust with age; greatest depth, 3.5 (294). Least depth of caudal peduncle, 7.9 (131); increasing slightly with age. The caudal peduncle is only moderately attenuate; length, 4.8 (219). The body is subterete; greatest width, 6.9 (155). Length of head, 3.0 (349); relatively larger in the young. The shortest spine at the slight emargination of the dorsal fin is 75 per cent of the longest (1.3 in longest), becoming relatively longer with age; fifth and longest spine, 14.6 (71); the spinous dorsal becomes relatively lower with age. The rounded soft dorsal agrees with that of the genotype, *M. d. dolomieu*, in having scales on its base; the height of this fin is less than its basal length and is equal to the height of the anal; longest ray of each fin, 7.1 (146). The graduated anal spines become relatively shorter with age; the third and longest, 5.2 in head (67). The rounded anal fin becomes relatively slightly lower with age; the membranes bear scales near the base. The pectoral fin is short and rounded; its length, 6.1 (172). The short pelvic becomes relatively somewhat shorter with age, 6.9 (153). The caudal fin has rounded lobes; length from base of fin to tip of longest ray, 4.5 (230); length of shortest median ray, 5.9 (177), or 1.3 in caudal length. Tip of snout to origin of dorsal, 2.5 (422); tip of lower jaw to insertion of pelvic, 2.9 (370); thence to origin of anal, 3.5 (313).

Width of head, 2.0 (478); increasing relatively with age. The predorsal contour is moderately curved. Length of snout, 3.7 (274); increasing relatively with age. The orbit becomes relatively much smaller with age; its length, 4.5 (226). The flat interorbital becomes wider with age; least bony width, 5.1 (191). The maxillary extends to below the posterior margin of the pupil; length of upper jaw, 2.3 (433); increasing with age. The lower jaw slightly projects; its length, 1.8 (543); increasing with age.

Dorsal, X, 12; anal, III, 10; pectorals 16-16.* Scales, 9–76–18; 28 rows around caudal peduncle, and 14 rows on cheek. Scales (of the holo-

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* One aberrant individual has 10 pectoral rays on one side and 16 on the other; the fin with 10 rays is apparently uninjured and is of normal shape, though much smaller than its mate.
type) from the pectoral region just below the lateral line are subquadrate (transverse diameter, 4.5 mm.; longitudinal diameter, 5.0 mm.); the focus lies apicad from the center; the apical margin is not distinctly dentate, but the apical field bears a narrow triangular patch of rather weak ctenii, extending almost from the focus; the basal corners are squarish; and there are 5–9 strong basal radii. Scales are well developed on the opercle, subopercle, and interopercle; there are a few embedded scales on the preopercle.

In 32 specimens counted there is no variation in the number of precaudal vertebrae, 14. The caudal vertebrae number 18 in 26 specimens, 17 in 3, and 19 in 3. This normal number, $14 + 18 = 32$, is characteristic, also, of $M. p. punctulatus$ and $M. p. henshalli$. $M. d. dolomieu$ and $M. d. veloz$ usually have $15 + 17 = 32$ vertebrae.

The bony margins of the lacrymal, suborbits, preopercle, and the opercular series are entire. The branchiostegals constantly number 6–8. The opercle ends in a flat, rigid, angular projection which is longer than a more rounded process on the upper posterior margin of the bone.

Depressible villiform teeth form broad bands on the dentaries and premaxillaries. Villiform teeth occur in a triangular patch on the head of the vomer and in an elongate band on each palatine; they are also developed, but are reduced in size, on the ectopterygoids. Weak glossophyal teeth form a small patch in the holotype, but are absent in 9 out of 42 specimens, without any apparent correlation with age or sex. The narrow and elongate lower pharyngeal bones bear acuminate teeth in a patch 3.25 times as long as wide (in an adult paratype). Gill-rakers, 2 + 6, the last a mere knob (1 + 5 in 1, 2 + 5 in 11, and 2 + 6 in 14). The pyloric caeca are typically unbranched (occasionally one is branched) and number about 7–9.

The largest specimen examined measures 215 mm. in standard length and 261 mm. (10.25 inches) in total length.

Transverse flexuous bands are more or less developed on the sides in the young, but disappear rapidly with age. The bands are often reduced to a mid-lateral series of distinct quadrato light-centered blotches on the caudal peduncle. (In the young of $henshalli$ these blotches are usually confluent and lack the light centers.) As in $M. punctulatus$, a series of longitudinal dark streaks becomes developed with age on the median lines of the ventrolateral scale rows. A small basal caudal spot is present in the young, but fades with age. (In $henshalli$ the spot is stronger, larger, and persists throughout life.) The subterminal black band across the caudal lobes, so prominent in the young of the other species in the genus, is very indistinct in the young of $coosae$. At all ages the posterior tip of the opercle is marked with a large dark spot similar to that of $punctulatus$ and $henshalli$. In the young of $coosae$ the soft dorsal, the caudal, and the anterior part of the anal are brick-red in life, and the margin of the soft dorsal, anal, caudal, and
pelvic fins are white. In 1 yearling the sides are bronzy olive and bright, metallic blue, in alternating streaks, grading on the back into an olive background, with blue spangles on the scales.

ECONOMIC IMPORTANCE.—A note by H. S. Swingle accompanying the specimens from Lake Auburn, Alabama, gives the following information:

Locally known as red-eyed bass. Highly regarded by local fishermen because of their gameness. Maximum recorded weight, 2 pounds. A stream fish, it apparently cannot reproduce in a pond; or if it reproduces the spawn die. The young after reaching a length of several inches can stand pond water and grow rapidly. Flesh of good quality, somewhat drier than that of the large-mouthed bass. Can be caught on worms, artificial lures, or live minnows.

From a naturalist’s point of view it seems highly advisable that the stocking of bass in the waters of the Alabama River system be restricted to that of the red-eyed bass, Alabama spotted bass, and largemouthed bass. These are the native species of the area. All too often the introduction of exotic species has exterminated the local forms.

The 134 type specimens of Micropterus coosae are all deposited in the University of Michigan Museum of Zoology, the United States National Museum, Iowa State College, the Southern Biological Supply Company, and in the Alabama Polytechnic Institute collection made by F. E. Guyton, who has generously allowed us to study and report on this bass, which he has also recognized as a new species. The records stations are plotted on Map 2.

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Auburn, September 19, 1938, Guyton: U.M.M.Z. No. 105529 (2) and December 12, 1938: U.M.M.Z. No. 105530 (2).


CHATTahoochee RIVER SYSTEM IN ALABAMA.—Turkey Creek, about 7 miles above its mouth, which is about 12 miles above Columbus, Georgia, July 5, 1932, Guyton: U.M.M.Z. No. 112559 (2) and A.P.I. (3).

CHATTahoochee RIVER SYSTEM IN GEORGIA.—Cane Creek, 1.25 miles west-southwest of Dalahonega, Lumpkin Co., August 25, 1939, Reeve M. Bailey: I.S.C. B39-60 (2). Nancy Creek, tributary of Chattahoochee River, about 10 miles north of Atlanta, September 2, 1929, Creaser and Becker: U.M.M.Z. No. 88290 (1). Fish pond formed by damming Mulberry Creek, on Blue
Spring Farm near Hamilton, October 2, 1930, Percy Viosca, Jr.: S.B.S.C. (5 aberrant adults not designated as paratypes; their aberrancy seems due to emaciation, caused by living in a pond overstocked with sunfish).

**SAVANNAH RIVER SYSTEM IN GEORGIA (on South Carolina line).—Augusta, March 17, 1877, William Phillips: U.S.N.M. No. 17112 (1).**

The few specimens examined from the upper or middle waters of the Chattahoochee and Savannah river systems appear typical of *coosae*, but 4 series of young to half-grown specimens from the drainage basin of the Black Warrior branch of the Alabama River (see next paragraph), and one large fish from Chipola River in the Apalachicola River system in Jackson County, western Florida (see p. 16), do not correspond perfectly with either *coosae* or *punctulatus henshalli*. To determine whether they represent variants, subspecies, species, hybrids, or intergrades will require further study (which is contemplated).

We have provisionally identified with this species 45 young specimens from Blount Springs Creek, tributary to Mulberry Fork of Black Warrior River, in Blount County, Alabama, about 10 miles north of Warrior (collected by E. P. Creaser and H. R. Becker: U.M.M.Z. No. 88850). In most characters these are identical with *coosae*; they differ chiefly in having the dorsal fin more deeply emarginate. The lowest dorsal spine is 42–61 (mean 52) per cent of the longest, rather than 62–77 (mean 71) per cent as in typical *coosae*. The relatively deep emargination of the dorsal fin can be explained only in part as due to the small size (31–60 mm.) of the Blount Spring specimens. In recently collected specimens from the Black Warrior system the corresponding index values vary according to the size of the fish, as follows:

- .615 in a 130-millimeter specimen from Duck Creek, 12.7 miles northeast of Cullman, Cullman Co., Alabama.
- .60 in a 55.5-millimeter fish from the same locality.
- .55–.59 in 8 bass 46-48 mm. long, from a creek 0.5 miles east of Cleveland, Blount Co., Alabama.
- .51 in 1 that is 74.5 mm. long, from a tributary to Locust Fork, 3 miles north-northeast of Oneonta, Blount Co., Alabama.

Subsequent material may indicate that a distinct subspecies or, at least, race, inhabits the Tombigbee and Black Warrior river systems, or possibly that the aberrant characters displayed by the specimens at hand are the result of hybridization between *coosae* and *henshalli*. The color pattern is somewhat intermediate in the Blount Creek series.

The name *coosae* refers to the Coosa River system, in which the holotype and most other type specimens were collected.
The smallmouthed bass is divisible into at least 2 subspecies. The most distinct of the variants from the typical or northern smallmouthed bass of the Great Lakes and adjacent regions is the southwestern form here named *M. d. velox*, which occurs with *M. p. punctulatus* in the tributaries of the Arkansas River in northeastern Oklahoma and western Arkansas, and in the headwaters of the same streams in Missouri and presumably in Kansas. Intergrades between *M. d. dolomieu* and *M. d. velox* occur elsewhere in the Ozark region—to be specific, in the drainage basins of the Red and Ouachita rivers in Arkansas and Oklahoma, and of the White River and its main tributary, the Black River, in Arkansas and Missouri, and in the upper part of the St. Francis River basin in Missouri (Map 2). These intergrades generally approach and at times agree with *velox* in form and color, but are closer to typical *dolomieu* in the number of dorsal rays (Tables I and IV). In some parts of the intergrade range the rays seem to be quite as numerous as in *M. d. dolomieu*. In the remainder of the range, 13 soft dorsal rays and a total of 23 dorsal rays are rather frequent, though nowhere are these numbers as often represented as are 14 soft dorsal rays and a total of 24 dorsal rays (the modal numbers in typical *dolomieu*). The intergrades tend, therefore, to show a combination of characters, rather than to be equally intermediate in all features. There is a possibility that an extended variational analysis would provide grounds for the recognition of an intermediate subspecies in place of what are here interpreted as intergrades.

Toward the southeast this species exhibits variations which may prove sufficient for subspecific recognition. In that region glossobyal teeth are more often developed than in the north, and the form tends to be more streamlined. The extreme of this variational trend apparently is in the mountains of the Tennessee River drainage basin, where the bass are especially slender and have somewhat produced muzzles, in this and some other respects approaching *M. d. velox*. In usually having 14 dorsal rays and in the coloration of the young, however, they remain more like typical *dolomieu*. In the form of the spinous dorsal, the more extreme of these southeastern variants approach *M. punctulatus*. Their ground color is more blue-gray than usual and the dark markings are dusky golden. The fins are bluish gray and dusky lemon-gold; the latter color becomes rather bright toward the lower border of the anal and pelvic fins and on the basal part of the soft dorsal.

**NEOSHO SMALLMOUTHEDBASS**

3a. *Micropterus dolomieu velox*, new subspecies

(Map 2; Pl. I, Fig. 5; Pl. IV, Fig. 2.)

*M. dolomieu* (incomplete identification).—Habbe and Ortenburger, 1929b: 105 (records from Arkansas River system).
Much has been written regarding the Ozark smallmouthed bass, but almost entirely from the sportsman’s viewpoint. It would seem to be an especially gamey fish, as one might have assumed from its streamlined form, strong dentition, and swift-water habitat.

The differences between *M. d. velox* and *M. d. dolomieu* are set forth as items 6a and 6b in the key (p. 12). The distinctions in form and color appear particularly clear when one compares the younger fish (Pl. I, Figs. 5 and 6). Average differences in measurements, given in Table III, are largely obscured by age variation. Overlapping differences in counts are indicated in the frequency tables IV–VII. The distinction in number of dorsal rays is best brought out by tabulating the sum of the spinous and soft rays (Table I). It will be seen that 76 per cent of the 411 specimens of *velox* counted have 21–23 total dorsal rays, whereas 93 per cent of the 229 individuals of *dolomieu* tabulated have 24 or 25 dorsal rays. In the terms of Ginsburg (1938), the index of intergradation is only 16 per cent—indicating, in his view (which we do not wish to champion), a subspecific rather than a racial distinction. On the sole basis of the total dorsal-ray count, if the line of separation be assumed to lie between the counts of 23 and 24, 82 per cent of the 640 specimens of both subspecies, as counted, could be correctly identified, and a much higher proportion (nearly 100 per cent) could be separated with the supplementary use of other characters.

Some of the limited overlap in characters may well have arisen through the stocking of one or both subspecies within the range of the other form. No typical specimens of *dolomieu* could be identified in the rather extensive material from the Neosho (Grand) River system and adjacent tributaries of the Arkansas River, but the characters of the populations in these waters may have been modified, at least locally, by an interbreeding of the local fish with introduced individuals of the northern smallmouthed bass.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>FREQUENCY DISTRIBUTION OF THE TOTAL NUMBER OF DORSAL RAYS (SPINES PLUS SOFT RAYS) IN THE SUBSPECIES OF <em>MICROPTERUS DOLOMICU</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL NUMBER OF DORSAL RAYS</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td><em>M. d. velox</em></td>
<td>2</td>
</tr>
<tr>
<td>Intergrades</td>
<td>1</td>
</tr>
<tr>
<td><em>M. d. dolomieu</em></td>
<td>1</td>
</tr>
</tbody>
</table>

Holotype.—U.M.M.Z. No. 118296; a subadult male 159 mm. in standard length, 197 mm. in total length (in the third summer of life), collected by Carl L. Hubbs and Milton B. Trautman on September 13, 1935, in Elk River, tributary to the Grand (Neosho) River of the Arkansas River system, at Turkey Ford, T. 25 N., R. 24 E., Delaware County, Oklahoma.
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DESCRIPTION.—The form is more elongate than that of typical dolomieu, especially in the young, and becomes more robust with age; greatest depth, 3.6 (292). Least depth of caudal peduncle, 8.0 (128). Length of the moderately attenuate caudal peduncle, 4.6 (224). Greatest width of the slightly compressed body, 6.7 (158). Length of head, 2.85 (367); relatively larger in young. The shortest dorsal spine at the slight emargination of the dorsal fin is 72 per cent of the longest (1.4 in longest); the fifth and highest spine, 13.1 (78); the spinous dorsal has a gently curved contour and becomes relatively lower with age. The interradial membranes of the rounded soft dorsal bear scales near the base; the height of the soft dorsal is less than the basal length of the fin, and is about equal to the height of the anal; longest ray, 7.2 (144). The graduated anal spines become relatively shorter with age; the third and longest, 6.5 in head (57). The rounded anal fin becomes relatively slightly lower with age; the membranes bear scales near the base; longest ray, 7.3 (143). Length of the short and rounded pectoral fin, 6.0 (169); relatively longer in young. The pelvis is short and becomes relatively somewhat shorter with age; its length, 6.3 (160). Length of the caudal fin from middle of base to tip of longest ray, 4.5 (230); length of shortest median ray, 6.0 (173), or 1.3 in caudal length. Tip of snout to origin of dorsal, 2.4 (438); tip of lower jaw to insertion of pelvic, 2.8 (377); thence to origin of anal, 3.6 (291).

Width of head, 2.2 (466); increasing with age. At comparable sizes the almost straight contour of the snout and frontal region forms a sharper angle with the lower contour of the head than in M. d. dolomieu. Length of snout, 3.5 (290). The orbit decreases much in relative size with age; its length, 6.0 (180). Bony interorbital width, 5.2 (192). The mouth increases in relative size with age (that of the holotype is larger than in specimens of dolomieu of like size, but this difference does not hold for young specimens); the maxillary extends to below the posterior margin of the eye; length of upper jaw, 2.1 (469). The lower jaw projects so far as to render the strong teeth visible from above; its length (increasing with age), 1.7 (379). Least suborbital width (increasing with age), 2.8 (360).

Dorsal, X, 13; anal, III, 10 (usually 11); pectorals, 17–17. Scales 14–73–25; 31 rows around caudal peduncle, and 19 rows on cheek. Vertebrae, 15 + 17 = 32 in 63 of the 79 paratypes counted. Occasional specimens have 14 or 16 precaudal and 16 or 18 caudal vertebrae. Glossohyal teeth are lacking in the holotype, but form a weak patch in 40 of the 67 specimens examined (without any apparent correlation with sex or size). These teeth on the tongue are rarely developed in specimens from the northern part of the range of typical dolomieu, but are commonly present in examples from the Tennessee and Ohio river systems. Gill-rakers on the first arch, 2 + 5 (usually 2 + 5, infrequently 2 + 6).
The holotype is the largest specimen examined, but the subspecies no doubt attains a much greater size, since the habitat of this form is famous for smallmouthed-bass fishing.

Larger specimens are rather uniformly colored, with the exception of a dark opercular spot and 3 oblique, brownish lines passing downward and backward from the eye. The back is dark greenish olive, fading gradually to the white belly. The transverse bands on the sides of the young are fainter than usual in the young of *M. d. dolomieu*, are not so deep, and are characteristically broader; some bars on the caudal peduncle are usually expanded to form open, light-centered rhombs. (The bars are seldom thus modified in *M. d. dolomieu*.) The young have a very dark transverse band on the caudal lobes; also a weak and often diffuse or broken basal caudal spot.

All 452 specimens examined are in the collections of the University of Michigan Museum of Zoology and of the University of Oklahoma Museum of Zoology, and all are designated as types. Those that are atypical of *velox* in number of dorsal rays are typical in form and coloration.


The specimens interpreted as intergrades between *M. d. dolomieu* and *M. d. veloz* are discussed under the species heading and are spotted on Map 2.
The name velox ("swift") refers to the streamlined form of this subspecies and to its fine reputation as a game fish.

**NORTHERN SMALLMOUTHED BASS**

3b. *Micropterus dolomieu dolomieu* Lacépède

(Map 2; Pl. I, Fig. 6; Pl. II, Fig. 2; Pl. III, Fig. 1.)


*Micropterus de Lacépède*—Cuvier, in Cuvier and Valenciennes, 1830: x-vi of introduction (*M. dolomieu* Lacépède = *Gristes salmoides* (Cuvier); name salmoides selected).

*Micropterus dolomieu dolomieu*—Bailey, 1928: 174. Kuhn, 1939: Fig. 65.

*Bolius* *achigan*—Rafinesque, 1817: 120 (original description; New York and Canada).

*Lepomis* *achigan*—Gill, 1869: 20.

*Micropterus salmoides* var. *achigan*—Jordan and Brayton, 1878: 20.

*Micropterus dolomieu* var. *achigan*—Henshall, 1881: 16, 82; 1904: 11, 22.

*Lepomis pallidus*—Rafinesque, 1820: 30-31 (original description; from the Ohio, Miami, Hockhocking, etc.; probably a complex of *M. d. dolomieu* and *M. p. punctulatus*; interpreted by us as nomenclatorially referable to *dolomieu*; name preoccupied by *Labrus pallidus* Mitchill, 1815, if the reference to *Lepomis* *pallidus* and of the emended name *pallidus* be interpreted as having made Rafinesque's name a homonym).

*Lepomis tri fusciata*—Rafinesque, 1829: 31 (original description; Ohio River and other streams).

*Lepomis* *fasciolaris*—Rafinesque, 1820: 31 (original description; Ohio River and tributary streams).

*Lepomis* *Salmonca*—Rafinesque, 1820: 32 (original description; Kentucky, Ohio, Green, and Licking rivers).

*Lepomis notata*—Rafinesque, 1820: 32 (original description; Ohio Valley).

*Ethostoma colliria*—Rafinesque, 1820: 36 (original description; the Ohio and Salt rivers, etc.; probably a complex of *M. d. dolomieu* and *M. p. punctulatus*; interpreted by us as nomenclatorially referable to *dolomieu*).

*Cichla* *fasciata*—LeSueur, 1822: 216-18 (original description; Lake Erie at Erie and Buffalo, and Lake George); Kirtland, 1838: 191 (*fasciata* and *Ohioensis* identical).


*Grutes* *fasciatus*—Agassiz, 1850: 295-96.

*Micropterus* *fasciatus*—Gill, in Cope, 1865: 83 (records). Cope, 1868: 216, 247
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(records); 1870: 450 (not found east of the great watershed in North Carolina).

Cichla Ohioensis.—LeSueur, 1822: 218-19 (original description; Ohio River).

Cichla minima.—LeSueur, 1822: 220-21 (original description; lagoons of Lake Erie).

Kirtland, 1838: 191.

Gyrates salmoides (misidentifications; not of Lacépède).—Cuvier, in Cuvier and Valenciennes, 3, 1829: 54-58, Pl. 45 (New York and Wabash River). De Kay, 1842: 26, Pl. 69, Fig. 223. Günther, 1859: 252.

Micropterus salmoides.—Jordain, 1876: 230; 1877b: 34.

Cichla variabilis.—LeSueur, MS (nomen nudum), in Cuvier and Valenciennes, 1829: 55. D’ioplis variabilis (LeSueur), in Vaillant and Bocourt, 1874: Pl. 4, Fig. 4.

Micropterus variabilis.—Vaillant and Bocourt, in Jordan, 1880: 224 (first description under this name: “This is the ordinary northern small-mouthed Black Bass, Micropterus salmoides, or var. salmoides of authors, Micropterus salmoides aekigen of the present writer”; Wabash River, Indiana; type specimen in Paris Museum examined). LeSueur, in Vaillant and Bocourt, 1883.

Centrarchus obsoletus.—De Kay, 1842: 30, Pl. 17, Fig. 48 (original description; Onondaga Creek, New York). Günther, 1859: 258.

The separation of Micropterus coosae and other forms of black bass calls for a more precise identification of the original type of Micropterus dolomieu (Paris Museum No. 5243), which is without known locality. After having examined this specimen, Jordan (1880: 219) identified it as the southern variety of the smallmouthed bass (“Micropterus salmoides var. salmoides” Jordan and Brayton, 1878: 31-32 = Micropterus coosae). Vaillant and Bocourt (1883), on the contrary, characterized dolomieu as having even smaller scales than the northern form, which they called variabilis. Confronted by this conflicting evidence, we asked Jacques Pellegrin to re-examine the type of dolomieu, in accordance with the methods we have followed (see pp. 9-10), so as to determine its diagnostic characters in terms of the present revision. He has reported the characters of the type to be as follows:

Dorsal, X, 7 + 3 (an accidental injury having widely separated the soft dorsal into 2 fins); anal, III, 11; pectorals, 18-18. Scales, 10—74—17. Lingual teeth present posteriorly. Rows of small scales evident between the dorsal soft rays. Upper jaw extending to below posterior border of eye; its length, 23 in head. Dark lines visible along the rows of scales below the lateral line. Standard length, 210 mm.; total length, 238 mm.

Considering these characters, we regard it as safe to continue the application of the name dolomieu to the northern smallmouthed bass. The pectoral-ray counts are entirely distinctive and preclude identification with coosae. Likewise, the number of lateral-line scales, the anal-ray count, and the indicated length of the soft dorsal, point to the northern smallmouth. The fact that the counts of the scale rows above and below the lateral line are lower than those which we give is probably without significance, as the minute scales near the fins would not likely be countable in the ancient type.
Since Micropterus dolomieu is not native to South Carolina, the suggestion of some authors that the type locality of the species lay in that state seems highly improbable. It is hypothecated that the type locality may have been Lake Champlain, which was the only readily accessible part of the range of the northern smallmouthed bass in the time of Dolomieu.

The typical subspecies of Micropterus dolomieu is diagnosed in the key (p. 12). Variational data are presented in Tables I–VII. Record stations are given on Map 2.

GENUS HURO CUVIER


Grapses.—Of authors; not of Cuvier.

Aplites.—Of authors; not of Rafinesque.

Micropterus.—Of authors, in part; not of Lacépède.

Until recently the largemouthed bass and smallmouthed bass were considered as congeneric, but Hubbs (1926: 71), primarily on the basis of differences in the structure of the pyloric caeca and in the squamation of the dorsal and anal fins, referred them to separate genera, Micropterus and Aplites. The recent discovery that there are not 2 but at least 4 species of black bass has necessitated a revision of the generic status. The 4 new forms described in this paper, as well as M. pseudaplit es Hubbs = M. punctulatus (Rafinesque), agree with M. dolomieu in the structure of the pyloric caeca and in the squamation of the fins, and are consequently assigned to the genus Micropterus. Huro is thus left with a single species, salmoides.

Recent additions to our distributional knowledge of the various species of black bass reopens the question of the generic name to be applied to the largemouthed species. Earlier workers generally confounded M. punctulatus with salmoides, and this confusion probably led to erroneous records of the largemouth in the Ohio Valley (the type locality of Lepomis pallida Rafinesque, which is the genotype of Aplites). The recent exhaustive fish survey of Ohio by Milton B. Trautman has revealed that the largemouth, despite intensive stocking, is rare and is almost wholly confined to man-made still waters in the southern part of the state, whereas punctulatus is abundant and is generally distributed there. We again turn to the original description of Lepomis pallida and find no statement diagnostic of the largemouth, other than the probably erroneous statement that the dorsal is almost divided into 2 fins. Since the characters given apply in part to Micropterus d. dolomieu and in part to M. p. punctulatus we consider the name as a complex, and as nomenclatorially referable to punctulatus. The name Aplites is thereby relegated to the synonymy of Micropterus Rafinesque, 1820, leaving Huro Cuvier, 1828, as the valid name for the present genus. (See also synonymy of Micropterus, on p. 13.)
The distinctive characters of *Huro* are given in the key on p. 13. It is believed that *Huro* represents a specialized offshoot of *Micropterus*, but that no living species of that genus is directly ancestral to *Huro* (Fig. 1). *Huro salmoides* is very similar in color pattern to *M. punctulatus*, and it is presumed that the common and probably primitive characters of color pattern preserved in these species are older than the structural differences which separate the genera.

**Fig. 1.** A theoretical phylogeny of the seven recognized forms of black bass.

**LARGEMOUTHED BASS**

4. *Huro salmoides* (Lacépède)

*(Pl. I, Fig. 1; Pl. III, Fig. 2.)*

*Labrus salmoides.*—Lacépède, 1802: 716-18, Pl. 5, Fig. 2 (opposite p. 158) (original description; "les rivieres de la Caroline"; Charleston, South Carolina, may be regarded as the probable type locality, since that city was the center of Bosc’s collecting).
Grystes salmoides.—Agassiz, 1850: 296. Holbrook, 1860: 28–31, colored Pl. 4, Fig. 3 (branched pyloric caeca noted; abundant in Florida, Georgia, and the Carolinas, but not found north of Virginia).

Dioptes salmoides.—Vaillant and Bocourt, 1874: Pl. 4.


Aplites salmoides.—Hubbs, 1926: 71 (removed from Micropterus).

Huso salmonoides.—Jordan, 1929: 145–46. Hubbs and Bailey, 1936: 13. Hubbs and Bailey, 1938: 15, 18–20, Pl. 1, Fig. 3. Kuhne, 1939: 94, Fig. 64.

Micropterus salmonoides.—Boulenger, 1895: 16–18 (emended spelling).

Perea trutta.—Bosc, MS, in Lacépède, 1802: 717 (based on same description and figure as L. salmonoides).

Cichla Floridana.—Le Sueur, 1822: 219–20 (original description; eastern Florida).


Huso floridanus.—Jordan, Evermann, and Clark, 1930: 297.

Huso nigricans.—Cuvier, in Cuvier and Valenciennes, 1828: 93 (125–26), Pl. 17 (original description; Lake Huron). De Kay, 1842: 15, Pl. 60, Fig. 224. Günther, 1859: 255.

Grystes nigricans.—Agassiz, 1850: 297.


Grystes nobilis.—Agassiz, 1854: 297–98 (original description; Tennessee River, Huntsville, Alabama).

Grystes succensis.—Baird and Girard, 1854: 25 (original description; Rio Frio and Rio Nueces, Texas).

Dioptes succensis.—Girard, 1858: 4–5; 1859: 5–8, Pl. 1, Figs. 1–4.

Micropterus pallidus (misidentifications; not of Rafinesque).—Jordan, 1877a: 314 (in part); 1877b: 34, 43.

Perea flavescens × Huso floridana (misidentification of a hunchbacked Huso as an interfamily hybrid).—Powell, 1935: 23, Fig. 51.

As indicated by Jordan (1880: 220), Labrus salmonoides was described by Lacépéde solely on the basis of the manuscript communication and drawing furnished by Bosc. Among the characters assigned to this fish in the original account, the toothless tongue, the large size (6 or 7 decimeters), the abundance, and the large mouth (clearly indicated in the figure) are so diagnostic of the largemouthed bass that it is difficult to understand how the name was ever thought applicable to M. dolomieu. The same characters preclude the identification of Labrus salmonoides with Micropterus coosae, the only other black bass native to South Carolina. Cichla floridana Le Sueur, Huso nigricans Cuvier, Grystes nobilis Agassiz, Grystes succensis Baird and Girard,

* Cotypes of Grystes nobilis, M.C.Z. Nos. 9661 (5) and 21786 (3) were found referable to Huso salmonoides.
and *Grystes megastoma* Garlick are all quotable as synonyms of *salmoides* on the basis of the characters indicated in the original descriptions and figures.

The specific characters and range of *Huro salmoides* are stated and compared with those of all recognized forms of *Micropterus*, in the key to the species of the 2 genera. Fin-ray, scale, and vertebral counts are given in Tables IV–VII.

Considerable evidence, including that presented by Viosca (1932), indicates that *Huro salmoides* will be found on careful study to be a complex of at least 2 subspecies or species. Such an investigation remains to be made.

CONCLUSIONS OF GENERAL SYSTEMATIC INTEREST

The increase in the number of recognized species and subspecies of black bass from 2 or 3 to 7 is a new confirmation of the richness of the fresh-water fish fauna of eastern North America. Evidence that at least 4 additional forms of *Micropterus* may prove worthy of nomenclatorial recognition constitutes one indication, among many, that the task of differentiating and naming the members of this fauna still remains incomplete.

The great variability of fresh-water fishes in numerical characters is well illustrated in *Micropterus* (Tables I–VII).

The phenomenon of peripheral differentiation is strikingly exemplified in the black basses. The evidence for this conclusion is briefly stated on pages 7, 16, 19–21, and 28–30, and is presented in part on the distributional maps (Maps 1 and 2).

Interspecific hybrids among the black basses appear to be extremely rare. No authentic hybrid involving *Huro* is yet known: Fowler's (1935: 23, Fig. 51) identification of a hunchbacked *Huro* as an interfamily hybrid ("*Perca flavescens* × *Huro floridana*") is too absurd for further comment. Specimens tentatively reported as hybrids between *Micropterus pseudoplotes* (= *M. punctulatus*) and *M. dolomieu* by Hubbs and Ortenburger (1929a: 42; and 1929b: 105) are now believed to represent an extremely variable form (*wickitae*) allied to *M. punctulatus*, and restricted to West Cache Creek in southwestern Oklahoma (p. 19). On the basis of its intermediate color pattern, a young bass collected in Talladega Creek, Talladega County, Alabama (Coosa River system), in association with series of *M. coosae* and *M. punctulatus henaulti*, is interpreted as a hybrid between these 2 species. Two which are almost certainly hybrids between *Micropterus d. dolomieu* and *M. p. punctulatus* were collected respectively in southeastern Missouri and in northern Alabama. The structural characters of these specimens are compared with those of the presumed parent species in Table II.

The hybrid from Missouri (U.M.M.Z. No. 115768), a young specimen 56.5 mm. in standard length, collected in Black River, Sec. 8, T. 25 N., R. 6 E.,
### Characters of Hybrids Between *Micropterus d. dolomieiu* and *M. p. punctulatus*

<table>
<thead>
<tr>
<th>Character</th>
<th><em>dolomieiu</em></th>
<th>Hybrid (Alabama)</th>
<th>Hybrid (Missouri)</th>
<th><em>punctulatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal soft rays</td>
<td>Usually 14</td>
<td>12</td>
<td>13</td>
<td>Usually 12</td>
</tr>
<tr>
<td>Anal soft rays</td>
<td>Usually 11</td>
<td>10</td>
<td>11</td>
<td>Usually 10</td>
</tr>
<tr>
<td>Scale rows in lateral line</td>
<td>Average, 74.4</td>
<td>66</td>
<td>67</td>
<td>Average, 63.7</td>
</tr>
<tr>
<td>Above lateral line</td>
<td>(usually 71-77)</td>
<td>10</td>
<td>10</td>
<td>(7) 8 (9)</td>
</tr>
<tr>
<td>Below lateral line</td>
<td>(19) 20 or 23 (23)</td>
<td>18</td>
<td>18</td>
<td>(14) 15-17 (18)</td>
</tr>
<tr>
<td>Around caudal peduncle</td>
<td>29-32</td>
<td>26</td>
<td>27</td>
<td>(22) 23-26 (27)</td>
</tr>
<tr>
<td>Pectoral rays</td>
<td>(16) 17 (18)</td>
<td>17-17</td>
<td>16-16</td>
<td>(14) 15 (16)</td>
</tr>
<tr>
<td>Vertebrae</td>
<td>15 ± 17</td>
<td>14 ± 18</td>
<td></td>
<td>14 ± 18</td>
</tr>
</tbody>
</table>

On July 22, 1937, is intermediate in color pattern between *M. d. dolomieiu* and *M. p. punctulatus*. The dark lateral band of *M. p. punctulatus* is disrupted into a series of distinct dark blotches which correspond in position to the intersections of the vertical bands of young *M. d. dolomieiu* and the longitudinal band of *M. p. punctulatus*, but do not extend so far dorsad and ventrad as do the bars in *M. d. dolomieiu*. A series of solid dark rhomboidal blotches extends along the lateral line on the caudal peduncle. A large basal caudal spot is present, and the caudal band is very dark.

The *dolomieiu × punctulatus* hybrid from Alabama (U.M.M.Z. No. 117437), a young specimen 76.2 mm in standard length, collected in Elk River, tributary to Tennessee River, Limestone County, Alabama, during October, 1936, is very unlike the preceding specimen in color pattern, although agreeing well in structural features. A number of dark scales are scattered irregularly over the body, but, although the preservation is excellent, there is no characteristic pattern of vertical bars as in young *dolomieiu* nor any marked lateral band as in *punctulatus*. A number of faint, light-centered rhombs along the lateral line on the caudal peduncle are strongly suggestive of the pattern in *velox* and *coosae*. The basal caudal spot is obscure, and the caudal band is very faint (much more as in yearling than as in young specimens of either species).

There is some evidence, however, to support a view that hybridization is a frequent and significant phenomenon in *Micropterus*. Although the types of *M. punctulatus wichitae* almost certainly do not represent a fusing population of *M. p. punctulatus* and *M. dolomieiu*, as once thought, it may well be that the form *wichitae* is the product of earlier hybridization between the 2 species (see p. 19). Similarly, the aberrant specimens from the basin of Black Warrior River (p. 28) may represent *in toto* the product of the present or past hybridization between *M. p. henshalli* and *M. coosae*. At other localities *henshalli* and *coosae* may hybridize extensively. In the collection
from Talladega Creek, Alabama, several specimens are none too readily referable to either form, and the most intermediate example is definitely thought to be a hybrid. In the Wichita Mountains of Oklahoma, as well as in Blount Springs and Talladega Creek in Alabama, the color pattern and other characters vary in such a way as to suggest the possibility of extensive hybridization, past or present.

The characters of the various forms of black bass suggest the possibility that hybridization may have played an important part in the process of their speciation. As noted in the original description of Micropterus pseudoplites (= M. p. punctulatus), this form in most characters is intermediate between Micropterus dolomieu and Huro salmoides, or combines the characters of the 2 species (Hubbs, 1927). In most of the distinctive features, M. d. velox approaches M. punctulatus, so that one might assign its origin theoretically to past hybridization between M. punctulatus and M. d. dolomieu, followed by backcrossing with dolomieu and inbreeding (plus selection!) to produce constant characters. M. p. wichitae, the intermediacy of which between M. p. punctulatus and M. dolomieu has already been stressed, might have been differentiated by an almost identical process, involving, however, a backcrossing with M. p. punctulatus before inbreeding set in to standardize the characters imperfectly. M. coosae might have been produced through the complete amalgamation of a small southeastern population of M. dolomieu into a more abundant stock of a punctulatus-like form; with subsequent changes after the characters became stabilized through inbreeding.

At present it can neither be proved nor disproved that the speciation of the black basses has been the result of hybridization. An alternative explanation is that the intermediate characteristics of some forms reflect independent speciation, resulting perhaps from parallel mutation or atavism. A second alternative is that the intermediacy of such forms is due to their origin from ancestors which in the phylogeny of the group intervened between the 2 other forms concerned. A theoretical phylogeny in line with this explanation of the characters of the several black basses is given in Figure 1. We do not venture to choose between these alternative theories concerning the origin of the species of black bass, but plan to study the problem further.

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A REVIEW OF THE BLACK BASSES


Kirkland, James P.


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La Cépède [Lacépède]


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### Table III

**Measurements of the Six Recognized Forms of Micropterus**

The proportions are expressed as thousands of the standard length, of the head length, or of the length of the highest dorsal spine. For each character there is given in italics the average value and in parenthesis the range of variation. Proportions which increase with age are designated (\(\times\)); those which decrease with age by (\(\div\)).

<table>
<thead>
<tr>
<th>Species or Subspecies</th>
<th>M. p. punctulatus 30-32</th>
<th>M. p. henshalli 27-34</th>
<th>M. p. wickliffe 9-10</th>
<th>M. coosae 23-26</th>
<th>M. d. velox 32-38</th>
<th>M. d. dolomieii 19-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Measurements</td>
<td>357 (318-79)</td>
<td>356 (333-86)</td>
<td>551 (228-67)</td>
<td>558 (326-75)</td>
<td>568 (336-81)</td>
<td>558 (234-74)</td>
</tr>
<tr>
<td>Proportions of standard length</td>
<td>248 (216-330)</td>
<td>231 (214-67)</td>
<td>558 (243-85)</td>
<td>578 (253-99)</td>
<td>578 (262-345)</td>
<td>578 (232-97)</td>
</tr>
<tr>
<td>Leath depth ((\div))</td>
<td>116 (99-135)</td>
<td>107 (98-114)</td>
<td>139 (110-28)</td>
<td>126 (116-38)</td>
<td>126 (106-32)</td>
<td>126 (111-32)</td>
</tr>
<tr>
<td>Body width ((\div))</td>
<td>144 (121-66)</td>
<td>148 (123-66)</td>
<td>146 (125-85)</td>
<td>146 (143-69)</td>
<td>144 (139-71)</td>
<td>144 (148-86)</td>
</tr>
<tr>
<td>Caudal peduncle length ((\div))</td>
<td>340 (208-69)</td>
<td>334 (215-54)</td>
<td>258 (204-42)</td>
<td>258 (312-43)</td>
<td>268 (195-254)</td>
<td>268 (186-225)</td>
</tr>
<tr>
<td>Pectoral length ((\div))</td>
<td>327 (152-204)</td>
<td>190 (152-204)</td>
<td>179 (121-39)</td>
<td>183 (165-97)</td>
<td>188 (157-211)</td>
<td>172 (165-97)</td>
</tr>
<tr>
<td>Pelvic length ((\div))</td>
<td>176 (155-91)</td>
<td>164 (151-81)</td>
<td>156 (155-73)</td>
<td>169 (159-85)</td>
<td>172 (159-92)</td>
<td>167 (154-75)</td>
</tr>
<tr>
<td>Highest dorsal spine ((\div))</td>
<td>55 (78-109)</td>
<td>56 (89-106)</td>
<td>59 (75-97)</td>
<td>86 (68-101)</td>
<td>91 (76-103)</td>
<td>97 (72-96)</td>
</tr>
<tr>
<td>Lowest dorsal spine ((\div))</td>
<td>55 (38-63)</td>
<td>46 (33-58)</td>
<td>53 (44-58)</td>
<td>60 (44-74)</td>
<td>76 (45-87)</td>
<td>84 (44-67)</td>
</tr>
<tr>
<td>Highest dorsal soft ray ((\div))</td>
<td>147 (125-65)</td>
<td>143 (112-66)</td>
<td>151 (128-67)</td>
<td>155 (136-73)</td>
<td>161 (135-65)</td>
<td>159 (128-62)</td>
</tr>
<tr>
<td>Highest anal spine ((\div))</td>
<td>78 (65-80)</td>
<td>90 (67-90)</td>
<td>77 (64-89)</td>
<td>70 (52-96)</td>
<td>77 (57-93)</td>
<td>72 (56-89)</td>
</tr>
<tr>
<td>Highest anal soft ray ((\div))</td>
<td>148 (129-65)</td>
<td>147 (132-72)</td>
<td>148 (141-57)</td>
<td>156 (141-73)</td>
<td>144 (130-57)</td>
<td>141 (125-52)</td>
</tr>
</tbody>
</table>

| Proportions of head length | 446 (390-572) | 447 (416-501) | 457 (430-533) | 481 (442-534) | 490 (401-502) | 510 (468-565) |
| Head width (\(\div\)) | 258 (167-281) | 272 (199-315) | 226 (178-254) | 254 (173-289) | 241 (180-283) | 209 (142-247) |
| Interorbital width (\(\div\)) | 210 (182-281) | 218 (188-238) | 216 (188-245) | 199 (182-216) | 203 (167-226) | 213 (196-249) |
| Snout length (\(\div\)) | 275 (248-95) | 285 (243-307) | 284 (261-300) | 275 (244-99) | 287 (271-305) | 294 (272-310) |
| Upper jaw length (\(\div\)) | 454 (410-513) | 459 (392-461) | 453 (343-49) | 459 (385-470) | 448 (407-69) | 439 (416-66) |
| Lower jaw length (\(\div\)) | 569 (526-613) | 550 (496-581) | 557 (539-89) | 540 (481-579) | 566 (515-99) | 551 (522-76) |

| Proportion of length of highest dorsal spine | - | - | - | - | - | - |
| Lowest dorsal spine (\(\div\)) | 533 (452-600) | 480 (364-578) | 585 (485-707) | 707 (617-722) | 631 (488-746) | 652 (542-837) |

* Only 21 measurements for the length of the caudal peduncle.

† The 34 measured specimens of *M. p. henshalli* averaged only 53.4 mm. in standard length (range, 26-135 mm.).

‡ More measurements were used for 3 characters: 145 for the greatest depth, 141 for the least depth, and 139 for the body width.
TABLE IV

FREQUENCY DISTRIBUTION OF THE NUMBER OF FIN RAYS IN *MICNOPTERUS* AND *HEBO*

(For method of counting, see p. 9.)

<table>
<thead>
<tr>
<th>Number of Dorsal Spines</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>Number</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. p. punctulatus</em></td>
<td>18</td>
<td>195</td>
<td>7</td>
<td>219</td>
<td>9.95</td>
</tr>
<tr>
<td><em>M. p. henshalli</em></td>
<td>4</td>
<td>48</td>
<td></td>
<td>52</td>
<td>9.92</td>
</tr>
<tr>
<td><em>M. p. wichitae</em></td>
<td>15</td>
<td>86</td>
<td>6</td>
<td>107</td>
<td>9.91</td>
</tr>
<tr>
<td><em>M. coeae</em></td>
<td>7</td>
<td>98</td>
<td>12</td>
<td>109</td>
<td>10.05</td>
</tr>
<tr>
<td><em>M. d. veloz</em></td>
<td>62</td>
<td>330</td>
<td>3</td>
<td>395</td>
<td>9.85</td>
</tr>
<tr>
<td><em>M. d. dolomieu</em></td>
<td>20</td>
<td>311</td>
<td>5</td>
<td>336</td>
<td>9.96</td>
</tr>
<tr>
<td><em>M. d. dolomieu</em></td>
<td>11</td>
<td>211</td>
<td>7</td>
<td>229</td>
<td>9.98</td>
</tr>
<tr>
<td><em>H. salmoides</em></td>
<td>2</td>
<td>67</td>
<td>7</td>
<td>76</td>
<td>10.07</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Dorsal Soft Rays</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>Number</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. p. punctulatus</em></td>
<td>29</td>
<td>159</td>
<td>25</td>
<td>1</td>
<td>214</td>
<td>11.99</td>
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<tr>
<td><em>M. p. henshalli</em></td>
<td>1</td>
<td>43</td>
<td>8</td>
<td></td>
<td>52</td>
<td>12.13</td>
<td></td>
</tr>
<tr>
<td><em>M. p. wichitae</em></td>
<td>18</td>
<td>80</td>
<td>10</td>
<td></td>
<td>108</td>
<td>12.83</td>
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</tr>
<tr>
<td><em>M. coeae</em></td>
<td>9</td>
<td>92</td>
<td>8</td>
<td></td>
<td>109</td>
<td>11.99</td>
<td></td>
</tr>
<tr>
<td><em>M. d. veloz</em></td>
<td>2</td>
<td>13</td>
<td>255</td>
<td>149</td>
<td>4</td>
<td>214</td>
<td></td>
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<tr>
<td><em>M. d. dolomieu</em></td>
<td>1</td>
<td>64</td>
<td>249</td>
<td>25</td>
<td>356</td>
<td>13.87</td>
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</tr>
<tr>
<td><em>H. salmoides</em></td>
<td>1</td>
<td>13</td>
<td>55</td>
<td>7</td>
<td>76</td>
<td>12.89</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Anal Spines</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Number</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. p. punctulatus</em></td>
<td>1</td>
<td>211</td>
<td>2</td>
<td></td>
<td>214</td>
<td>3.00</td>
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</tr>
<tr>
<td><em>M. p. henshalli</em></td>
<td></td>
<td>51</td>
<td></td>
<td></td>
<td>51</td>
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<tr>
<td><em>M. p. wichitae</em></td>
<td>1</td>
<td>100</td>
<td></td>
<td></td>
<td>100</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td><em>M. coeae</em></td>
<td>1</td>
<td>105</td>
<td></td>
<td></td>
<td>106</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td><em>M. d. veloz</em></td>
<td>2</td>
<td>213</td>
<td></td>
<td></td>
<td>215</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td><em>M. d. dolomieu</em></td>
<td></td>
<td>137</td>
<td></td>
<td></td>
<td>137</td>
<td>3.00</td>
<td></td>
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* One count of 11, not entered in the table, was used in computing the average.
### TABLE V

**Frequency Distribution of the Number of Scales in *Microstomus* and *Huo***

(For method of counting, see p. 9.)

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* Counts of the lateral line scales for specimens from the upper Kanawha (New) River system in West Virginia and Virginia are excluded, because in this region the count is somewhat higher than over the remainder of the range; the highest count for the subspecies is 72.
### TABLE VII
Frequency Distribution of the Number of Vertebrae in *Micropterus* and *Huso*

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Premedullar Vertebrae</th>
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<th>14</th>
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<th>16</th>
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<table>
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<th>Species</th>
<th>Total Number of Vertebrae</th>
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<th>32</th>
<th>33</th>
<th>Number</th>
<th>Average</th>
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<td>41</td>
<td>2</td>
<td></td>
<td>46</td>
<td>31.98</td>
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<td><em>Huso salonoides</em></td>
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<td>69</td>
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<td>71</td>
<td>31.97</td>
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</table>

*Note: Numbers are rounded to the nearest whole number.*
Fingerlings of six forms of black bass

**Fig. 1** (uppermost). *Levo salmoides*: U.M.M.Z. No. 111890, a specimen 46 mm. in standard length, from Blanche Lake, Newaygo County, Michigan.

**Fig. 2**. *Micropterus punctulatus punctulatus*: U.M.M.Z. No. 97998, a specimen 49 mm. in standard length, from Caneville Creek, 32 miles north of Parsons, Kansas.

**Fig. 3**. *Micropterus punctulatus kenaufi*: U.M.M.Z. No. 118280, a paratype 47 mm. in standard length, from Talladega Creek, Talladega County, Alabama.

**Fig. 4**. *Micropterus cosnoc*: U.M.M.Z. No. 118280, a paratype 55 mm. in standard length, from a stream 7.5 miles south of Dalton, Georgia.

**Fig. 5**. *Micropterus dolomieu relax*: U.M.M.Z. No. 103196, a paratype 52 mm. in standard length, from Elk River, at Turkey Ford, Oklahoma (type locality).

**Fig. 6**. *Micropterus dolomieu dolomieu*: U.M.M.Z. No. 69948, a specimen 44 mm. in standard length, from West Twin Lake, Montmorency County, Michigan.

**Note**: Fingerlings of *Micropterus punctulatus wickiata* are illustrated on Plate VI.

(Photographs by F. W. Ohradnik.)
PLATE II

Adult bass from Tennessee

Fig. 1. Micropterus punctulatus punctulatus.

Fig. 2. Micropterus dolomieu dolomieu (southeastern race).

(Photographs furnished by Eugene R. Kuhne.)
PLATE III

Adult bass from Michigan and Tennessee

Fig. 1. Micropterus dolomieu dolomieu; U.M.M.Z. No. 122276, a specimen 267 mm. in standard length, from Wolf Lake Hatchery, Michigan (photograph by F. W. Osburn).  

Fig. 2. Hora salmoides: from a Tennessee specimen (photograph furnished by Eugene R. Kohne).
PLATE IV

Two new subspecies of black bass

Fig. 1. Micropterus punctulatus heShalli: U.M.M.Z. No. 111265, a paratype 96 mm. in standard length, from Uphaee Creek, near Tuskegee, Alabama (type locality).

Fig. 2. Micropterus dolomiee relax: U.M.M.Z. No. 118236, the holotype, 150 mm. in standard length, from Elk River, at Turkey Ford, Oklahoma.

(Photographs by F. W. Gurney.)