BIOLOGY AND STOCK ASSESSMENT OF *LABEO FIMBRIATUS* (BLOCH, 1795) AND *LABEO CALBASU* (HAMILTON, 1822) ALONG THE LOWER STRETCHES OF TAMIRAPARANI RIVER

Thesis submitted in part fulfillment of the requirements for the Degree of ***Master of Fisheries Science in Fisheries Resource Management*** *to the Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam.*

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CERTIFICATE

This is to certify that the thesis entitled, **Biology and stock assessment of *Labeo fimbriatus* (Bloch,1795) and *Labeo calbasu* (Hamilton,1822) along the lower stretches of Tamiraparani River** submitted in part fulfillment of the requirements for the degree of **Master of Fisheries Science** in **Fisheries Resource Management** to the Tamil Nadu Dr.J.Jayalalithaa Fisheries University, Nagapattinam is a record of bonafide research work carried out by **K.L.BREMA MFT16095(FRM)** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or similar titles or prizes and that part of the thesis has been published in peer reviewed journal(s) and copy / copies appended.

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Dedicated to my

Beloved

Parents, Preethi,

Sudhan and Hari

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(K.L.BREMA)

Abstract

Title	:	**Biology and Stock Assessment of *Labeo fimbriatus* (Bloch,1795) and *Labeo calbasu* (Hamilton,1822) along the lower stretches of Tamiraparani river**
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The present investigation was carried out to study the landings, biology and stock assessment of selected species of *Labeo* particularly *Labeo fimbriatus* and *Labeo calbasu* along the lower stretches of Tamiraparani river of Thoothukudi and Tirunelveli districts. The landing was high during the months of June, 2017 to September, 2017. The highest length recorded for *L. fimbriatus* was 305 mm total length (TL) whereas for *L. calbasu,* it was 420 mm TL. The food and feeding analysis indicated that both the species were found to be Herbi-Omnivorous. The index of preponderance revealed that phytoplankton was dominant in their diet. The major food item in the stomach of both the species, were diatoms and decayed organic matter. Rare occurrence of species found

were copepods, rotifer and protozoa of *L. calbasu*. The sex ratio of female and male of *L. fimbriatus* was 2:1 and for *L. calbasu* it was 3:1. The Von Bertalanffy's growth parameters, asymptotic length (L_∞), growth coefficient (K) and age at zero length (t_0) for *L. fimbriatus* were 323.22 mm, 0.108 per year and -0.3241 years, respectively. Similarly for *L. calbasu* these values were 548.94 mm, 0.247 per year and -0.4241 years respectively. Both the *Labeo* spp were checked for its characters including morphological, merestic and morphometeric variance identified were statistically interpreted with paired t test and ANOVA and concluded that, both the species were positive correlated. The total instantaneous mortality co-efficient (Z) of *L. fimbriatus* and *L. calbasu* was found to be 0.60 and 0.88 and natural mortality (M) was 0.28 and 0.51 respectively. The fishing mortality was relatively lower than the natural mortality and it was estimated as 0.37 for *L. fimbriatus* and 0.29 for *L. calbasu*. The present exploitation rates were 0.62 (*L. fimbriatus*) and 0.33 (*L. calbasu*). Virtual Population analysis of these two species revealed variation in the mortality levels at different length groups. The natural mortality was high in the length group of less than 200 mm for both the species. The present result indicates that *L. calbasu* were under exploited which *L. fimbriatus* catch was found to be higher than the estimated MSY.

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1. INTRODUCTION

Fisheries is one of the most important sources of revenue and socio-economic industry of our country and serves as an important food sector next to agriculture in human nutrition. However, the freshwater capture fisheries place a vital role in cheap protein food supply for human beings. India blessed with good water resources like many rivers, dams, floodplains *etc*. Since time immemorial, freshwater fishing has been a common avocation among people and the communities in villages and towns wherever water bodies with fish are available. Moreover Tamil Nadu is in the forefront of research and development of rivers and lacustrine fisheries in the country.

Tamiraparani river is the one of the major perennial river in southern India, it orginates Pothigai hills of western Ghats. It flows through Tirunelveli and Thoothukudi districts of the southern Tamil Nadu and drains into the Gulf of Mannar. The fish assemblage structure and function are also primarily associated with geographic variation and understanding the pattern is crucial effective assessment, monitoring of rivers. Southern districts where the richest of the river contribute many variety of fish gene pools combination. But in the case of capture fisheries is declining sharply and several have collapsed, inspite of having a great potential to grow. As a result, the current riverine fishing industry is below subsistence level with an average yield 0.78 tonne/km, which is about 15% of their actual potential. More than 60.3% of the primary freshwater fishes of India are endemic to the country, with the highest endemicity found in Western Ghats biogeographic zone. As per the IUCN (2015) Red Data List, 17.25% among primary freshwater fishes are in threatened category.

The riverine fishery is one of the mirrors in riverine health. It resembling, the rivers in India are facing multiple problems designed for severe water pollution, over extraction, encroachment, dams and barrages which cut off the connectivity of the river with its associated ecosystems, climate change, deforestation in catchment areas, *etc*. Though the increasing hydrological modification, absence of water in rivers, obstacle to migration, changes in salinity, sediment alteration, loss of riparian areas and floodplains brought about by dams perhaps the most important reason behind the dismal scenario of riverine fisheries. Severe and drastic changes of the entire hydrological cycle, particularly in rivers and dams water abstraction has affected by more species recruitment. In India, natural flow of major rivers have been regulated for fulfilling water demand of agriculture and power sector, giving less attention to fisheries sector. As a result, rivers have lost their character and fisheries have suffered huge losses.

The fishery of most of the fish stocks in Indian rivers exploited over and reached the maximum sustainable yield (MSY) due to excess fishing effort. The discharge of toxic waste effluents from the industries is also major concern in the health of the riverine ecosystem. Fish population are natural control processes that continually modify situation adjust with structure, function, abundance and restoration. The crucial factors which affect the fishing community are overfishing, change in species composition and structure,ecosystem degradation, incessant seasonal fluctuations in rainfall, pesticide applicants and aquatic pollution, diseases occurrence, introduction of exotic species, destruction of breeding grounds and unlawful fishing practices.

Cyprinidae is one of the largest families of freshwater fish and is well represented in India with species ranging from few milimeter in length (minnows) to more than a metre (major carps). Under this family having 53 genera, 345 species and 219 endemic fish species are there (Gopi *et.al*.,2017). Most of the Cyprinids, especially carps, are both widely captured and also form the mainstay of culture operations

Labeo genus is coming under cyprinidae family having high diversity of species in all over India with very good consumer preference because of their taste and acceptance. At present, there are 25 species are available throughout India (Gopi *et al.,* 2017). In our Tamil Nadu commonly 5 species are available in southern districts: *Labeo rohita*, *Labeo calbasu* and *Labeo fimbriatus* are widely available.

During the early 2000, *Labeo calbasu* and *Labeo fimbriatus* was a great commercial important species throughout Tamiraparani river stretches and their fishery was similar to the three other Indian Major Carps such as Catla (*Gibelion catla*), Rohu (*L. rohita*) and Mrigal (*Cirrhinus mrigala*), while the availability of *L. calbasu* and *L. fimbriatus* fishes are in declining stage. Although fish farmers lost interest due to the unavailability of seeds either natural or artificial sources. It is one of the most important causes for these two species along with other cyprinids going to reach threatened level in Indian freshwater ecosystem. Not only that the above said reasons for threatened state. Wide variations in water flow under natural conditions in the river is also one of the reason for the threatened state of the species. Physical changes in the ecosystem like soil erosion, land reclamations, land alteration for construction purpose, deforestation in the catchment area and alters in the riparin vegetation have caused major changes in the river as a result natural habitats of fish species have been under threat.

L. fimbriatus (Bloch,1795), the fringed-lipped peninsula carp belongs to the family Cyprinidae. The distinguishing characters of this fish are: elongated body, its dorsal profile more convex than the ventral, blunt swollen snout slightly overhanging the mouth, devoid of lateral lobe studded with minute pores. Eyes are moderate, not visible from underside of the head. Mouth moderate and sub inferior; lips thick, fringed and continuous having an inner fold above and below. *L. fimbriatus* has two short pairs of barbels (rostral and maxillary). Dorsal fin inserted nearer to the snout tip than to the base of caudal fin. Pectoral fins nearly as long as head. Deeply forked cadual fin. Moderate cycloid scales with 43-47 scales along lateral line; lateral transverse scale-rows 6 or 7 between lateral line and pelvic fin base; pre-dorsal scales 13 to 18. The fish is dark brown on the back, silvery on flanks and abdomen, has a diffused black blotch often present (invariably present in juveniles) at the base of caudal fin and a red spot on each scale on about 8 to 10 horizontal rows on flanks, from behind the tip of pectoral fin to above anal fin, dorsal, pectoral and caudal fins are dark and anal and pelvic fins black (Rajanna,2015).

The fish is locally called “Selkendai” in southern Tamilnadu. It contributes a part of inland fish production and also plays a role in rural economy in major carp deficient regions of India. *L. fimbriatus* is mainly distributed in rivers and reservoirs of peninsula India and has good consumer preference. Hora and Pillay (1962) recommended this fish for cultivation in confined waters. However, the species has not been much utilized in aquaculture due to its slow growth and limited knowledge in its aquaculture potential and diversity. It is a bottom feeder and it feeds on diatoms, Myxophyceae, Bacillariophyceae and Chlorophyceae especially *Spirogyra*, plant tissue, Copepods, insects and lower crustacean eggs (David and Rajagopal, 1975). Fecundity of the fish ranged from 64770 to 525893, in a length range of 336-740 mm and the maturation and breeding is confined to the upper part of the river (Ramamohan, 1976).

L. calbasu(Hamilton,1822) locally called kakka kendai belongs to the family Cyprinidae. The width of the head equals its length excluding the snout. They have very short gill rakers. The dorsal fin commences in advance of the ventral and midway between the snout and the base of the deeply forked caudal. Pectoral fins are as long as head length, snout is pointed; depressed; devoid of the lateral lobe; no pores on their snout. Colour is blackish but occasionally the upper lobe of the caudal is white. Eyes moderate, not visible from underside of the head. The mouth is rather narrow with obtuse and depressed snout; lips are thick and fringed and each continuous having an inner fold above and below. It has two pairs of barbels (rostral and maxillary). Scales moderate; lateral line with 40-44 scales; lateral transverse scale-rows 5 or 6 between lateral line and pelvic fin base; 20 rows of scales before dorsal fin and 22 rows of scales before the cadual peduncle. pre-dorsal scales 10 to 14. Cadual fin is deeply forked. The fish is dark brown on the back, silvery on flanks and abdomen, has a diffused black blotch often present (invariably present in juveniles), It occurs in rivers and ponds; in slow-moving waters of rivers and it is essentially a bottom feeder that feeds on plants, filamentous algae and diatoms. Studies on proportion of 50% maturity (Lm50) attained in 251-300 mm in males and 301-350 mm for females. Fecundity ranged between 1,93,000-2,38,000 ((Jhingran, 1982; Talwar and Jhingran, 1991; Alam et al., 2000)

Both the above species form a good fishery (Talwar and Jhingran, 1991) in the river systems of Tamil Nadu. It is cultivated along with other carp species also. There is no specific conservation action plan directed towards the wild populations of *L. fimbriatus and L.calbasu*, therefore, research is essential to analyse the current distribution pattern, population status and harvest trends of the species, to find out the global IUCN (International Union for Conservation of Nature) Red List threatened nature of species. The fringe - lipped carp (*L. fimbriatus*) and the Black carp (*L. calbasu*) have been hunted almost extinction or loss of this fish species in the freshwater ecosystems. There is a need to educate fishermen in scientific harvesting of freshwater fishes. The present study on fishery and population biology would provide valuable information for conservation and management of this indigenous fish species.

The objectives of this study is to explore better scientific understanding on the threatened status of *L. calbasu* and *L. fimbriatus* to their conservation and resource management.

Objective:

1. To collect and identify *Labeo* spp along the lower stretches of Tamiraparani river.
2. To investigate biology of *Labeo fimbriatus* and *Labeo calbasu* along the lower stretches of Tamiraparani river.
3. To study the stock assessment and assess current status of *Labeo fimbriatus* and *Labeo calbasu*

II Review of Literature

2.1 Taxonomical studies of Labeo spp:

The pioneering studies on taxonomy of Indian fishes began at 18th century onwards, the important works during this period with regard to the taxonomy of fishes of the Indian waters were described by Munro (1955), Talwar and Kacker(1984) and the recent compilation is that of Talwar and Jhingran (1991) who published description of a total of 930 species of inland (fresh and brackish water) fishes of India.

Nelson (1994) studied in detail about the members of the family: Cyprinidae are characterized by, jaws and palate that are always toothless; pharyngeal teeth in one or two rows, with not more than eight teeth per row; usually thin lips; absence of an adipose fin; an upper jaw usually protrusible; an upper jaw bordered only by premaxilla; and the head almost always scaleless.

Labeo calbasu and *Labeo fimbriatus* are freshwater fish species belonging to the family Cyprinidae which is under the order Cypriniformes. It is the most important carp species next to the three Indian major carps (Chondar, 1999)

2.2 Distribution of Labeo spp in world:

Carps are a large freshwater fish native to central Asia. Introductions in many countries have helped to make carp the most widely distributed freshwater fish in the world. They are extensively farmed in Europe, Asia and the Middle East, and are a popular angling fish in Europe. However, in North America, Canada and Australia, carp are considered a significant pest. Carp are very versatile, and can live in a great variety of habitats including highly degraded areas. Over the past few decades carps have spread across most of South-eastern Australia. However *Labeo fimbriatus* recorded its distribution in Sind, Punjab, the Deccan and probably N.E. Bengal; also from Southern India at least up to Orissa, not recorded from Malabar or Canara (Day,1889). *L. rohita* occurs widely in northern and central India, Bangladesh, Nepal, Myanmar and Pakistan (Talwar and Jhingran, 1991). It was introduced into some of the rivers of peninsula India and Sri Lanka. *L. calbasu* was widely distributed in India, Bangladesh, Pakistan, Myanmar, Nepal, South China and Thailand (Day 1878; Talwar and Jhingran 1991; Chondar,1999). *L. fimbriatus* is mainly distributed in rivers and reservoirs of peninsular India and Eastern ghats. It has good consumer preference because of its good taste (Talwar and Jhingran,1991).

2.3 Distribution in India:

The fringe lipped peninsular carp, *Labeo fimbriatus* (Bloch) is a potential and an abundant fish species of rivers and reservoirs of peninsular India. It occurs chiefly in Tamilnadu, Andhra Pradesh and Karnataka, extending North through Orissa and Maharastra up to Punjab. It contributes a part of inland fish production and also plays a role in rural economy in major carp deficient regions of India. The fish is locally called as "selkendai" in Tamilnadu. This species is widely distributed almost throughout the central and peninsular India.It was recorded from the Mahanadi (Job *et al*., 1955; David, 1953), the middle and the lower stretches of Krishna and Godavari as well as the freshwater regions of Collair lake on the east coast (David, 1963), the upper stretches of Krishna (Kalawar and Kelkar, 1956), the Tungabhadra (Bimachar, 1942) and the Cauvery (Chacko *et al*., 1954). Among the Westerly flowing rivers, it was reported in Narmada (Hora and Nair, 1941; Karamchandani *et al*., 1967) and Tapti

(Karamchandani and Pisolkar, 1967). Further from North, it was reported from Gujarat at Mahi and perhaps in Rajasthan (Senta and Kulkarni, 1945).

2.4 Fishery

As much sought-after delicacy found in abundance in Godavari and Krishna rivers, figuring in the global IUCN Red List of threatened species, the fringe-lipped carp (*L. fimbriatus*) has been hunted almost to extinction. A serious effort is hence being made by the Andhra Pradesh Biodiversity Board to revive the once-popular fish species by introducing fingerlings, to start with, in the Godavari river system in Adilabad district (Venkateshwarlu,2012). The importance of *L. fimbriatus* in the fishery of river Narmada and its wide distribution in India have already been indicated by Bhatnagar and Karamchandani (1971). It is one of the major carps and has a good fishery value (Talwar and Jhingran,1991).It is being cultivated along with other carp species. Over exploitation is suggested as a reason for decrease in the wild population of this species in Mula-Mutha rivers of Pune (Wagh and Ghate, 2003). Manisha and Jatin (2014) studied on ichthyo-diversity of Jia Bharali River, Assam, India and the study indicated that, order Cypriniformes was the most dominant group represented by 23 species contributing 41.07% of the total species. Subhendu (1995) reported that Narmada river harbours 84 fish species belonging to 23 genera. The contribution of carps in commercial fishery was in the order of 57.47-62.4 % (Mahseer 23.7- 27%, *Labeo fimbriatus* 18.2-19.2% and *L. calbasu* 5.2-6.4%). The commercial fishery mainly consisted of *Tor tor; Labeo fimbriatus, L. boggut* and *L. calbasu* among carps. The headwater harbours a variety of game fishes, but do not support commercial fishery. It was observed that during 1990, the river was maintaining a fish production of 1 tonne/km/annum. However, the commercial fisheries consisted of carps (major carps and *L. fimbriatus*) and large catfishes. Sarwade and Khillare (2010), while studying on the Fish Diversity of Ujani Wetland, Maharashtra, India reported the occurrence of 60 fish species belonging to 6 orders, 15 families and 36 genera. Among the collected species, order Cypriniformes was most dominant constituting 66.66 % including *Labeo fimbriatus*.

Sarya *et al.* (2001) studied the Biodiversity and fishery potential of Narmada basin western zone (M.P., India) with special reference to fish conservation. They made assessment of fishery output from the fish landing centers at Punasa, Omakareshwar, Maheshwar and Barwani, during the year 1993-94. Twenty two commercially important fish species were identified. The most dominant carp group contributed up to 57.47 to 62.4%. This mainly included the Mahseer, *Tor* spp. (23.7 to 27.0%), *L. fimbriatus* (18.2 to 19.2%), *L. calbasu* (5.2 to 6.4%), *Cirrhinus mrigala* (2.4 to 3.0%), *Labeo bata* (1.2 to 1.6%), *Labeo dyocheilus* (1.0 to 1.5%), *Puntius* spp. (2 to 2.4%), *Cirrhinus reba* (0.4 to 0.6%) and *Catla catla* (0.6 to 1.1%). The cat fish landing ranged from 34.6 to 38.1%. This study identified the problems related to endangered fish of Narmada River due to extensive construction of reservoirs. *Tor tor, Tor khudree, Labeo fimbriatus* and *Notopterus notopterus* were identified as endangered fish species of this basin.

2.5 Habitat and Ecology:

Both *L. calbasu* and *L. fimbriatus* are freshwater species. They mainly inhabits rivers can also present well established natural lakes, reservoirs, streams, ponds, beels, baors, haors and canals (Chondar, 1999). Its favourite habitat is the deep pools of rivers, where it largely remains localized during the winter and summer months, and ascend to adjacent shallower region of the river for breeding during monsoon months (Chondar,1999). Mookerjee and Mazumdar (1944) have reported that it is fond of living in mud of the pond and occasionally comes to the surface and near the edge of the pond for feeding. The larvae and post-larvae mainly shoal on the surface and sub-surface regions of the water (Chondar,1999).

2.6 Morphological characters:

It is a popular food fish having good taste, less intramuscular bones and high protein content (Talwar and Jhingran, 1991; Chondar, 1999). This fish species supports an important commercial fishery in rivers and reservoirs of different countries mainly in India (Pathak and Jhingran, 1977; Gupta and Tyagi 1992; Singh *et al*., 1998; Chondar, 1999; Dwivedi *et al*., 2004). The natural populations of this fish species has seriously declined due to overfishing, habitat degradation, aquatic pollution, dam construction and several other anthropological reasons which are affecting its feeding migration and spawning (CAMP, 1998).This species locally called as kalbasu in India (Chondar,1999).

Vladykov (1934) opined that in fish species showing restricted distribution, the majority of morphometric characters show narrow range of zoogeographical distribution and most of the characters are strongly influenced by the environment. However, some workers have observed few more characters from the different species and have found that some of the characters are intermediately and environmentally controlled. With regard to genetic variability no sub-species or variety of *L. calbasu has* been reported so far. However, Kalbasu shows a strong affinity to the Barbus *(Cyprinus barbus)* of England, but is deeper in the form (Hamilton, 1822). In larval and early post larval stages, it has a confusingly similarity with *Labeo angra* in general appearance and colouration, especially for zebra like bands on the body. But *L. angra* can be distinguished easily for its short dorsal fin (0.13 or less) from *L. calbasu,* which has a large dorsal fin with 16-18 rays.

2.7 Food and feeding habit:

2.7.1 *Labeo calbasu*:

Food and feeding habit of *L. calbasu* earlier has been studied by number of workers (Mookerjee and Mazumdar, 1944; Mookerjee *et al*.,1946; Chacko and Kurian, 1949; Alikunhi, 1952 & 1957; Pathak, 1975; Vinci and Sugunan, 1981; Khumar and Siddiqui 1989; Chondar, 1999; Dasgupta, 2001) and all of them have reported it as a bottom feeder.

Mookerjee and Mazumdar (1944) had documented in details the food and feeding habit of hatchling, fry, fingerling, immature young and mature adult of *Labeo calbasu* from West Bengal. They have reported that 5.6- 5.8 mm pro-larvae imbibe unicellular organisms such as protozoa (*Paramoecium* sp., *Chaenia* sp. *Etc.*) and unicellular algae (*Chlorococcus* sp., *Closterium* sp. *etc*.) while the spawn and early fry (6.5-15 mm) subsist on small crustaceans (Daphnia sp.,Cyclops sp.,Cypris sp.), multicellular blue green algae (*Oscillatoria* sp., *Vaucheia* sp. etc) and protozoa (both ciliates and flagellates). Fry and fingerlings (16-80 mm) are used to consume varieties of food of both animal and plant origins like ciliates, flagellates, copepods, ostracoda, malacostraca (shrimps), mosquito larvae, green algae (*Chlorella* sp.,*Closterium* sp., *Chaetophora* sp. Etc.), blue-green algae *(Oscillatoria* sp., *Lyngbya* sp. Etc.), diatoms (*Synedra* sp.)

and some vegetable debris. With advancement in growth, the juvenile, immature young and adult (180 - 480 mm) start to take semi - rotten aquatic vegetable debris (parts of petiole of *Nymphaea* sp., leaves of *Vallisneria* sp., *Lemna* sp., *Hydrilla* sp. etc. And some vegetable debris in the form of gelatinous mass); mosquito and other insects larvae (Agrionid larvae, Ephemerid larvae, parts of some insects larvae. Das and Moitra (1955), Chondar (1999) and Dasgupta (2001) were observed that the total length of fish to the total length of the gut has a definite ratio depending upon the amount of vegetable food ingested in *Labeo kontius* and *Labeo fimbriatus*. Its herbivorous feeding habit has been reported by Chondar (1999) has documented decaying organic matter as the main food; he has also reported that the omnivorous feeding habit of early fry of *calbasu* used to gradually change to herbivorous dietary habit through advanced fry and early fingerling stages and become fully herbivore in juvenile. Das and Srivastava (1979) earlier have confirmed this changing feeding habit with growth in calbasu observing the Relative Length of Gut (RLG) values. Dasgupta (2001) has reported vegetable matter (60%), macrophyte tissue (10%), filamentous algae (5%), green algae (3%), roots of macrophytes (20%) and detritus (2%) in its gut content. Change in feeding intensity with spawning periodicity has been reported by Pathak(1975), Das and Srivastava (1979),Khumar and Siddiqui (1989) and Vinci and Sugunan (1981). All of them have reported low feeding activity in adults during the breeding season and recovery of the same after the spawning season.

2.7.2 *Labeo fimbriatus*:

Menon *et al.* (1955) studied the gut contents of *Labeo fimbriatus* and inferred that unicellular and filamentous algae were most favoured food items. Hora and pillay (1962) stated that the adult fish feeds on filamentous algae together with protozoans, rotifers and copepods and that the zooplanktonic organisms constitute about quarter of the gut contents and Bacillariaceae and Desmidiaceae form the main food of the fry. Bhatnagar *and* Karamchandani (1970) made observations on the food and feeding habits of *Labeo fimbriatus* in river Narmada near Hoshangabad. They observed that Bacillariaceae, Chlorophyceae and Myxophyceae decline considerably in monsoon and early post- monsoon months. The cycle of occurrence of mud mixed with sand was just reverse during these months, when this item was predominant in the guts, and also they noticed that many of the forms of green and blue-green algae which contribute to the food of *Labeo fimbriatus* around the sandy bottom and the shallow marginal pockets of the river where the water current is feeble during post and pre-monsoon months from November to June. The presence of large quantities of decayed organic matter and mud mixed with sand, together with algal forms in the guts of this species indicates that the fish feeds at river bottom and in the pockets of shallow marginal areas. They observed low feeding activity even in immature fish with undeveloped gonads due to inadequate available of food organisms in the flooded river, and also the fish exhibits poor condition during monsoon and post-monsoon months from July to October, evidently because of its restricted feeding activity. Further, they reported that the gut contents of *Labeo fimbriatus* mainly consisted of phytoplankton, decayed organic matter, miscellaneous matter and mud mixed with sand. They also studied the size related variations in the food of *Labeo fimbriatus* and reported that food of young fish comprised fine mud with little or no sand particles and was predominant in the size range from 100 – 200 mm, followed by fine mud was the next dominant food item in the size group of 200 – 300 mm. The food items with mud and decayed organic matter in the gut were more dominant in the size range 300 – 400 mm and in the size range from 400 – 500 mm as the major food items were sand particles were mixed up in larger proportions with mud which occurred in relatively lesser quantity in the guts and the last size group from 500 – 600 mm this group represented by highest quantity of proportion of mud mixed with sand together with decayed organic matter was considerably high. They also stated that there was no appreciable change in the nature of the diet of *Labeo fimbriatus* as it grows in size. The intensity of feeding was high during April and from November to January and lowest feeding intensity during July to September.

David and Rajagopal (1975) reported on the feeding habits of *Labeo fimbriatus*, the food mainly composed of diatoms, Myxophyceae, Bacillariophyceae, Chlorophyceae especially Spirogyra, plant tissue, Copepods, insects and lower crustacean eggs. *L. fimbriatus* with ventrally placed mouth and fimbriated horney lips is highly adapted to bottom browsing. Its stenophagic feeding on sessile diatoms indicates its selectivity in feeding. Irrespective of lotic or lentic environments the fish feeds on similar food. The gut content of *Labeo calbasu* also was studied by them from Tungabhadra reservoir of karnataka showed that this fish was bottom feeder, closely resembles *Labeo fimbriatus* in its feeding habits. According to them this species is mainly a herbivore, feeding on Bacillariophyceae which formed the main food item, besides Chlorophyceae, plant tissue, other miscellaneous items, decayed organic matter and mud were the commonly found food items. They examined the food and feeding habits of *L. fimbriatus* from Tungabhadra reservoir of Karnataka. They reported that the monthly fluctuations in the food constituents. Myxophyceae found in very low quantities in all the months except in January and July and Bacillariophyceae was the second major basic food except in May –July, forming 50% in October and 0.4% in May and the decayed organic matter was the largest food item was contributed by semi- decayed and decayed matter forming 37.5% of the average food and the miscellaneous items like lower crustacean like eggs, annelidan setae and other unidentifiable forms noticed throughout the year.

Madhusoodana (1993) reported on the food and feeding habits of *Labeo dussumieri* (Valencies,1998) from the river Pampa. The study revealed that this species is herbivorous and illiophagic in its feeding habit, they feeds mainly on mud, detritus matter, Bacillariophyceae, Chlorophyceae and submerged aquatic plants. The intensity of feeding was very poor during June to September due to synchronization with the spawning season of *Labeo dussumieri* in river Pampa.

From the Cochin backwaters, Joseph and Pillai (1975) noted the food analysis of *Labeo dussumieri* and they reported that fish fed mostly on Bacillariophyceae and Chlorophyceae from November onwards suggesting a re-establishment of feeding ground and improvement of other conditions facilitating the feeding activity of the fish. The food and feeding habits of *L. dussumieri* are almost identical with that *L.fimbriatus.* Venkateshwarlu, (2012) was reported that the *Labeo fimbriatus* is mainly herbivorous, bottom feeder,feeds on diatoms, blue green algae and green algae, higher aquatic plants, insects and detritus.

2.8 Sex ratio:

Not much work has been done on this aspect except Pathak and Jhingran (1977) who have reported female dominance in their studied population of *Labeo calbasu* also in *L.fimbriatus* reported same result in Rajanna,2015; Nikolsky (1956 and 1980); (Wely and Booth, 1999).

2.9 Fecundity:

Labeo calbasu is a highly fecund fish, reported to have 1,09,700 – 9,80,700 eggs by Sukumaran, (1969). Rao and Rao(1972) reported 40,200 - 517,500 (1972), 93,972 - 466,400 (Pathak and Jhingran (1977), 67,500 - 572,460 (Vinci and Sugunan,1981) respectively.

2.10 Breeding periodicity

L. calbasu is a seasonal breeder, it breeds in monsoon months (Qasim and Qayyum 1961). The breeding season used to vary in different regions coinciding with the monsoon floods of those regions. Khan (1924) and Qasim and Qayyum (1961) have reported July and August as spawning months for *L. calbasu* in Punjab waters. In Loni reservoir, Madhya Pradesh it breeds in between June to September with peak spawning occurs in July (Pathak, 1975; Pathak and Jhingran, 1977). In south India, breeding season used to start by the end of May with the commencement of south west monsoon and continue till the end of October (Chacko and Kurian, 1949). In Godavari river system, the peak breeding month was during June (Rao and Rao, 1972). Vinci and Sugunan (1981) have reported July- September as its breeding season with spawning peak in August at Nagarjunasagar reservoir, Telangana.

2.11 Length – weight relationship:

2.11.1 *Labeo calbasu* :

Anees *et al.* (2012) studied the growth parameters, length-weight relationship and condition factor of *Labeo calbasu* at the Guptar Ghat of Ghaghra River. They studied 193 specimens which included 98 females, 90 males and 5 juveniles. The von Bertalanffy growth parameters L_∞ and K for the species were 667 mm and 0.249 per year, respectively. Regression coefficient and correlation coefficient of the fishes were higher in males (3.0561 and 0.9602) than that of females (3.00497 and 0.909). The study indicated that condition factor value was highly affected by gonadal maturation than feeding. Pathak (1975) observed the value of b to be 3.0 of *L. calbasu* from Loni reservoir. Value less than 3 (2.797) was reported by Khan (1988) from Tilaiya reservoir and exceeding value of 3.0 was reported by Singh (2006) from Ganga River at Allahabad. The length-weight relationships of *L. calbasu* in Bangladesh water for the two sexes together, were reported by several researchers. Alam *et al*. (2000) reported as Log W = - 2.0330 + 3.109 log L (r = 0.992) and Haroon *et al.* (2002) observed exponent b value for *L. calbasu* >3.0. Both the studies indicated that exponential b to be more than 3, indicating allometric growth of this species. In the present study the value of b calculated as 3.0531 (for male), 3.00497 (for female) and 3.0256 (pooled) respectively show allometric growth of the fish at Guptar Ghat of Ghaghra River.

2.11.2 *Labeo fimbriatus:*

Le Cren (1951) reported that the length - weight relationship of fishes is vital importance to the fishery, in setting up yield equation in the study of population dynamics, taxonomic differences, events in life history like metaphorphosis, maturity. Ramamohan (1976) studied the length - weight relationship and relative condition factor (K_n) of *Labeo fimbriatus* (Bloch) in river Godavari. He explained the species length -weight relationship, it was expressed as W = 10–8x 6120 L 2.7347. In this study, sexes were not considered separately since the detailed examination was not possible in the field. The curvilinear relationship between weight and length was established. The correlation coefficient(r) was found to be 0.9260, which showed a highly significant relationship. According to him the relative condition of the species was high in the size range 187.5 mm, this may be due to the feeding in the juvenile group of fish. Further, all the length groups up to 362.5 mm showed minor fluctuation in K_n values, which appeared to be coincided with normal metabolic fluctuations. The increase in K_n values from the length group 362.5 mm to 437.5 mm may probably be attributed to the increase in gonad weight at first maturity. Maximum Kn value was noticed in the size range of fish from 487.5 mm to 587.5 mm associated with maturation. Further, relative condition of fish in different months showed a definite trend in fluctuation corresponding with maturity of the gonad from April to June and maturation and spawning from July to October, November only spent fish were encountered.

Alam *et al.* (2000) investigated the population parameters of *Labeo calbasu* using FiSAT software with length – frequency data collected from different areas of Sylhet basin, north – eastern part of Bangaladesh. The von Bertalanffy growth parameters $L\infty$ and K for the species were 49.30 cm and 0.63 $^{y-1}$ respectively.

Bhatnagar(1972) have reported the condition factor of *Labeo fimbriatus*. They correlated the high condition in fish with high feeding activity and also mentioned that the condition factor in all size groups was low during July to September which is incidentally concomitant with the breeding season, and he studied the length-weight relationship and condition factor of *the species* as Log W = 3.1449 Log L -5.3171 (r =0.95) and for female, Log W = 3.2138 Log L – 5.4884(r = 0.95) from Narmadha river. They noted that the value of n, which is normally expected to be 3 according to the cube law, was greater in case of fishes measuring more than 130 mm in length but less than 3 in smaller fishes.

Up to a length of 310 mm the males weighed lightly more than the females but once this length was attained the females became heavier. He also studied maturity, fecundity, spawning season and certain related aspects of *Labeo fimbriatus*. The females were significantly more abundant in all the higher size groups. The test of heterogeneity revealed significance at 0.01 level. It was observed that before the fish commences spawning both the sexes were equally abundant, but once it attained a size of maturity, the females predominated in the catch. Whereas from December to February and March to May, it was significant only at 0.05 level, being non-significant from September to November. He also studied the various stages in the development of the ovary of *Labeo fimbriatus,* the length at first maturity was determined. No females less than 310 mm in total length were found to be matured, about 50 % mature at 423 mm and almost all were matured at 475 mm. The fish spawns only once during July –September with peak in August. The fecundity of the fish was estimated to be 1,42,558 to 5,08,988 with a size range of 427 to 582 mm. Bhat (2011) investigated on the length-weight relationship and condition factor of *Labeo rohita* in Pahuj reservoir, Jhansi. The value of regression coefficient for the length-body weight relationship was calculated to be 2.97±0.063 (±95% CL). This indicated almost an isometric growth because the values were very close to 3. The coefficient of correlation (r^2) was calculated to be equal to 0.98 (i.e. >0.9), which suggested that the two variables, (length and weight) are highly correlated. The P value was <0.0001, which meant that the correlation between the two variables is highly significant in all samples. The mean condition factor (K) of the species was computed to be equal to 1.60 suggesting that the specimens were in good condition or health.

Weatherley (1972) stated that even among the members of one population, sampled on the same single date, there may be considerable variation in condition with length. In the present investigation the value of condition factor was recorded as 1.324. Umesh (2012) studied length weight relationship and condition factor of *Labeo rohita* in Govindgarh Lake, The length - weight relationship revealed that the weight increased rapidly with the increase in length of fish. From the data collected it was calculated that the weight increased with a factor of 2.97, which is very close to the cube law value of 3.0 for an ideal fish. Ramamohan (1976) reported that *L. fimbriatus* spawned during the southwest monsoon in the Western Ghats, and other workers reported that of fecundity varied from 64800 to 526000 in a length range of 336-740mm. While *Labeo calbasu* fecundity ranged between 193,000 and 238,000 (Jhingran,1982; Talwar and Jhingran, 1991; Alam *et al*., 2000).Hora and Pillay (1962) reported that *L. fimbriatus* could be cultured in confined waters. This species does not spawn in natural water but easy to induce to spawn using inducing agents during the second year. Though this species occurs widely in peninsula rivers, but has not been widely utilized for aquaculture due to lack of information on its growth potential.

Shailja and Saksen (2012) conducted studies on gonadosomatic index and fecundity of Indian major carp, *Labeo calbasu.* Ovarian weight of the carp ranged from 140±320 g with a mean value of 201±16.56 g. The ovarian weight was almost 20% of the body weight in fully mature fishes. In this study, it was observed that the fecundity of fish increase with the increased in size, weight of fish and gonad weight. The average weight and length of fish were 1006±75.22 g and 38.85±1.29 cm respectively. The average fecundity was measured as 402217±30661 ova per fish with an average fecundity of 400.5±8.40 ova per gram of body weight and 10241±401.8 ova per cm of fish length. The fish attained sexual maturity when the fish was about 25 cm long and the fecundity was found to be 435 eggs/g of body weight. The largest specimen of *L. calbasu* had a body weight 1600 g and it was found to carry highest number of eggs (657600) while minimum number of egg (312100) were observed in the specimen having a weight of 750 g.

Monika *et al.* (2013) studied the reproductive biology of *Labeo dyocheilus,* reared under captivity in cold water conditions. The GSI value of *L. dyocheilus* ranged from 1.264 to 15.365. Average GSI value was at its peak in July (13.672±2.026) and lowest was recorded in the month of December (1.542±0.400). Absolute fecundity ranged from 42233 to 172887 ova with an average of 99216 ± 42292 ova per fish. The ovarian weight was almost 15% of the body weight in fully mature fishes. This study, showed that *L. dyocheilus* was able to attain sexual maturity in cold water conditions even if reared under captivity. Fecundity increased with the increase in weight of fish and that of ovary. Mohammad and Pathak (2010) studied fecundity and gonadosomatic index of *Labeo rohita* collected from Ramganga river of western Uttar Pradesh during June, 2005 to May, 2008. The mean value of fecundity was estimated at 66823.70 ± 4312.39 eggs with a mean total length of 183.06 ± 5.60 mm and mean total body weight of 315.64 ± 16.59 grams. The relationship of fecundity with other parameters such as total length, total weight, ovary length and ovary weight were found to be linear and the values of correlation coefficient (r) was 0.97, 0.97, 0.99 and 0.95 respectively. The average relative fecundity was calculated as 202.78 ± 3.75. Highest value of GSI was recorded in the month of August, 2010 indicating spawning period of *Labeo rohita.*

Gadekar (2013) studied the gonadosomatic index (GSI) of an Indian major carp, *Labeo rohita*. The fish had only one spawning season of short duration, running from July to August as indicated by the peaks of GSI and the diameter of oocytes and testicular lobules. Both males and females mature simultaneously. The minimum GSI for female was 0.74 ± 0.12 in resting phase and maximum was observed in the spawning phase (16.49 ±1.70). The GSI for males was minimum in resting phase (0.087 ± 0.004) and maximum in spawning phase (2.02 ± 0.181)

2.12 Maximum length:

Day (1878) explained about maximum length of *Labeo calbasu* growth rate which is 91.2 cm, the highest growth rate recorded by him. Apart from this, specimens with maximum length of 50.5 cm (Pathak and Jhingran,1977); 64 cm (Khumar and Siddiqui,1989); 76 cm (Alikunhi, 1957); and 90 cm (Talwar and Jhingran, 1991; Menon, 1999) have been documented by different workers in their studies.

2.13 Sexual dimorphism:

Male and female of *Labeo calbasu* & *Labeo fimbriatus* can be identified by observing the secondary sexual characters which are used to appear only during the breeding season. The roughness of the pectoral fin, sandy texture on the scale, large size of the pectoral fin and the freely oozing milt coming out by putting slight pressure on the abdomen are the identifying morphological characters for the male. Whereas the smoothness of the pectoral fin and the scales, smaller size of the pectoral fin, bulging abdomen and the extrovert vent are the identifying characters for the female of this fish species (Chondar,1999). In the case of Chaudhuri (1959), who has documented another identifying character for analysing the sexual dimorphisum of above species, has reported that when the pectoral fin is being extended backwardly and dorsally it reached the lateral line scale; 10^{th} or 11^{th} in male and 8^{th} or 9^{th} in female.

2.14 Growth and pattern:

Maximum of the earlier workers (Chatterji et al., 1980; Vinci and Sugunan, 1981; Alam et al., 2000; Haroon *et al.* 2002) have reported allometric growth pattern in *Labeo calbasu* though few authors (Pathak, 1975; Khan,1988) also have documented isometric growth pattern.

2.15 Length and age at first maturity

Pathak and Jhingran (1977) have documented 40 cm (male) and 33.6 cm (female) at Loni reservoir, Madhya Pradesh and Vinci and Sugunan (1981) have documented 30.6 cm (male) and 37.1 cm (female) from Nagarjunasagar reservoir, Telangana for the same. It used to mature in the third year of life (Gupta and Jhingran 1973) and Bhatnagar (1972) studied maturity stages, ovary development of *Labeo fimbriatus* was determined, they said about 50 % mature at 423 mm and almost all were matured at 475 mm and peak spawning season during August. Ramamohan (1976) reported that *L. fimbriatus* spawned during the southwest monsoon in the Western Ghats

2.16 Mortality parameters, Total catch and MSY:

Amitabh and Prakash (2012) studied the stock assessment of *Labeo rohita*, *Tor tor* and *Labeo calbasu* in the rivers of Vindhyan region, India. Asymptotic length was found to be maximum in *L. rohita* (946, 833 and 962 mm) as compared with *T. tor* (822, 787 and 946 mm) and minimum in *L. calbasu* (567, 612 and 692 mm) in the Ken, the Paisuni and the Tons Rivers, respectively. The growth coefficient and total mortality was maximum in *T. tor* compared to *L. rohita* and minimum in *L. calbasu*. Fishing mortality was maximum in *T. tor* (2.9, 4.57 and 3.44) and minimum in *L. calbasu* (0.51, 1.21 and 1.18), while natural mortality was maximum in *L. rohita* (0.74, 0.94 and 1.86) and minimum in *L. calbasu* (0.47, 0.65 and 0.68). Natural mortality indicated that the habitat was more suitable for *L. calbasu*. Comparatively, fishing pressure was very high in *T. tor* than *L. rohita* and *L. calbasu*. Exploitation rate was maximum in *T. tor* (0.71, 0.82 and 0.84) compared to *L. rohita* (0.77, 0.74 and 0.56) and minimum in *L. calbasu* (0.52, 0.65 and 0.63) in the Ken, Paisuni and Tons rivers, respectively.

Alam *et al.* (2000) investigated the annual rate of natural (M) and fishing (F) mortality were found to be 1.11 and 3.48, respectively. The ratio of exploitation (E) was estimated as 0.76. Recruitment of this species in to the fishery takes place during August to October with peak during August – September. Emax was found to be 0.449. The present investigation clearly showed the over fishing (E >0.50) condition for *L. calbasu* in the Syhelt basin.

Amin *et al.* (2001) studied the population dynamics of *Labeo rohita* in the Sylhet basin Bangladesh. They reported on the length - frequency based population dynamics and stock assessment studies of *Catla catla* (Ham.), *Labeo rohita*, *L. calbasu* and *Cirrhinus mrigala* from the Sylhet basin, Bangladesh using FiSAT software. Estimated fishing mortality and exploitation values of *L. rohita, C. catla* and *L. calbasu* were much higher than the optimum level of 0.5 and remarkably higher than Emax values which indicated that their stocks were under heavy fishing pressure. Mean annual catch of *L. rohita, C. catla* and *L. calbasu* were much higher than their maximum sustainable yield (MSY). Immediate necessary steps needed for judicious and sustained exploitation by reducing the present fishing pressure gradually to 0.82 for *L. rohita*, 1.07 for *C. catla* and 1.28 for *L. calbasu*. Fishing pressure and exploitation values for both *L. rohita* and *L. calbasu* were lower in the Sylhet basin as compared to the adjoining Mymensingh basin.

Yousuf *et al.* (2001) estimated fishing mortality and exploitation values for *L. rohita* and *L. calbasu.* The study indicated that their stocks were under heavy fishing pressure. Exploitation values were much higher than the optimum level of 0.5 and remarkably higher than the Emax values. Mean annual catch of *L. rohita* in 1999 and *L. calbasu* in both 1998 and 1999 were much higher than their estimated maximum sustainable yield (MSY). Whereas the exploitation values for *L. gonius* were below the optimum level in 1998 and just at optimum in 1999. The stock of *L. gonius* was almost under optimum fishing level. Mean annual catch of *L. gonius* were lower or almost equal to its estimated MSY value in both the years. The Lc/L and M/K values also confirmed the above conclusion for *L. rohita, L. calbasu and L. gonius*.

2.17 conservation status resource management:

In India the above species were documented as Lower Risk near Threatened (CAMP, 1998), while in the case of ICUN, 2014 status *L. fimbriatus* reported as threatened species, it has been hunted almost to extinction or loss of this fish species in Karnataka. There is a need to educate fishermen in scientific harvesting. The study on fishery and population biology would provide valuable information for conservation and management of this indigenous fish species. Based on IUCN catagories (2015,Version.2), the CAMP Workshop (Molur & Walker,1998) reported *L. fimbriatus was* Threatened category and *L. calbasu* was LRnt (Least Concern and Near Threatened) in Tamil Nadu. In previous authors Ramasamy and Rajangam, 2016 reported that *L.calbasu* under vulnerable status. Gopi *et.al,* 2017 report showed that *L.calbasu* and *L.fimbriatus* were under Least concern(Nt) categories. D. Karl et.al.,2006 was reported that *L.calbasu* was Moderately abundant in Assam.

III. Materials and Methods

The present investigation was conducted along the lower stretches of Tamiraparani river to study the biology and stock assessment of *Labeo calbasu* and *Labeo fimbriatus* for a period of one year from June, 2017 to May, 2018.

3.1 Study area:

The Labeo samples covering different length groups were collected on weekly intervals from the sampling centers viz. Manimuthar (8º 44' 28''N & 77º 41' 40''E) Tirunelveli (8º 46' 53'' N & 77º 43' 6''E),Srivaikundam (8º 37' 35''N & 77º 54' 44''E), for a period of one year interval. The samples were kept in insulated ice box with ice cubes to maintain the quality of fishes until it reaches the laboratory. The morphometric and meristic characters were taken for the Labeo species identification using the key by Jayaram (1999) and Talwar and Jhingaran (1999).The total length (in mm) and total weight (in gm) of specimens were taken and species were dissected out for making observation on the sex of species, weight of gut content taken of respective species. The gut content of the fish were preserved in 5% formaldehyde for further analysis.

3.2 Length – Weight relationship:

The data on total length (length from the tip of snout to the tip of caudal fin) and weight of the fish was collected. The Length – Weight relationships were estimated from the allometric formula proposed by Le-Cren (1951).

$$W = a\,L^{b} \quad \text{(or)} \quad \text{Log } W = \text{Log } a + b * \text{Log } L$$

Where, W is total body weight (gm), L is the total length (mm), ‘a’ and ‘b’ are the co-efficient of the functional regression between W and L.

3.3 Growth index:

3.3.1 Hepato-Somatic Index (HeSI):

Variations in the liver weight were evaluated quantitatively as hepato somatic index (Hopkins, 1979).

HSI = weight of the liver/weight of the body X 100

3.3.2 Gonado-Somatic Index (GnSI):

Gonado somatic index values were used as indicator of degree of Gonadal development. It was found out by employing the following formula (Roff, 1983):

GnSI = weight of the gonad / total weight of the fish X 100

3.3.3 Gastro-Somatic Index:

It is the measure of the gastric weight in relation to total body weight of fish. The gastro-somatic index was calculated following standard procedure as follows (Desai,1970):

Gastro - Somatlc Index (GaSI) = weight of the foregut / weight of the body X 100

3.4 Food and Feeding:

The Index of Preponderance method is used for gut content analysis. This method gives a summary picture of frequency of occurrence as well as bulk of various food items. In order to take into account both qualitative and quantitative estimation together, Index of Preponderance was employed (Natarajan and Jhingran, 1961). The index was calculated using the following equation:

$$\text{Index of preponderance (IP)} = [\, V_iO_i / \sum V_i\, O_i \,] \ X\ 100$$

Where IP = index of preponderance, V_i and O_i are the volume and occurrence index of the food items in percentage. The volume (V_i) of each food item is expressed as percentage of the aggregate volume. The occurrence (O_i) is obtained as the percentage occurrence of a food item in relation to the total occurrence of all food items present in all the fishes examined. The Index provides a definite and measurable basis for grading the various food elements as it gives a combined picture of frequency of occurrence as well as bulk.

The various stomach conditions based on degree of fullness are expressed as gorged, full, ¾ full, ½ full ,¼ full,trace and empty as suggested by Pillay (1952).

3.5 Von Bertalanffy growth parameters:

Von Bertalanffy growth parameters like asymptotic length (L_∞) and growth co-efficient (K) were estimated using the ELEFAN I (Electronic Length Frequency Analysis) module of FISAT software (Gayanilo *et al.,* 2005).

$$L_t = L_\infty \left(1 - e^{-k\,(t\,-\,t0)}\right)$$

Where $L\infty$ = Asymptotic length, K= Growth coefficient t = age at given length and t_0= age at length zero

3.5.1 Growth performance index (Ø)

The growth performance index was calculated from final estimates of asymptotic length (L_∞) and growth coefficient (K) (Pauly and Munro, 1984) using the formula:

$$\text{Phi } (Ø') = \log K + 2 \log L_\infty$$

Where Phi (Ø) = Growth performance index, L_∞ = Asymptotic length, K = Growth coefficient.

3.6 Estimation of mortality Parameter:

The total mortality (Z) was estimated by using the Beverton and Holt (1956) method, where von Bertalanffy parameters K and L_∞ were used. The relationship as following

$$Z = K * (L_\infty - L_{mean} / L_{mean} - L')$$

Where, L_{mean} is the mean length of fish in sample population, L' is the lower limit of the corresponding length interval. The value was correlated with 'Z' derived from length converted catch curve. The natural mortality of the fish was estimated by using the Pauly's (1980) empirical equation considering the mean annual habitat temperature K and L_∞ which were taken from VBGF. The co-efficient of fishing mortality (F) was calculated using the following relationship

$$Z = M + F$$

Exploitation ratio (E) was estimated from the equations:

$$E = F / Z$$

Where F= Fishing Mortality, Z = Total Mortality, E = Exploitation ratio

3.7 Estimation of Catch and effort:

Catch and data effort of *Labeo calbasu* and *Labeo fimbriatus* species were collected from the selected sampling sites of Thoothukudi and Tirunelveli districts. The collected data were expressed in terms of numbers and weight randomly during each sampling days. Each sampling day was multiplied by the number of boats engaged in fishing on the day of sampling to obtain the average daily catch. The average daily catch was multiplied by the number of fishing days in particular month to obtain the monthly catch. The effort was expressed as number of boat days per month. The Catch Per Unit Effort (CPUE) was calculated for one fishing day.

3.8 Maximum sustainable yield:

The total stock (Y/U) and the annual Stock (Y/F) were estimated for the species using annual catch (Y). The exploitation ratio is defined as the fraction of fish present at the start of a year that is caught during the year. The exploitation rate (U) was estimated using following equation

$$U = F / Z * (1-e^{-Z})$$

The maximum sustainable yield was estimated by using annual stock and total mortality described by Gulland (1969). Total stock (P) and biomass (B) (annual catch) were estimated from the ratios Y/U and Y/F respectively; where Y is the annual average yield in tons. Maximum sustainable yield was calculated by the equation for exploited fish stocks given by (Troadec, 1977):

$$MSY = 0.5 * Z * (Y/F)$$

Where Z = Total Mortality, Y = annual catch and F = Fishing Mortality

IV. RESULT

The study was undertaken for the period from June 2017 to May 2018 to analyse *Labeo calbasu* and *Labeo fimbriatus* fishery along the lower stretches of Tamiraparani river in Thoothukudi and Tirunelveli districts of Tamil Nadu. Present investigation detailed with the *L. calbasu* and *L. fimbriatus* landing pattern along the Thoothukudi and Tirunelveli district, length-weight relationship and the general biology of both the species. Stock assessment of the selected Labeo spp and the fishing pressure in terms of the natural mortality, total mortality and fishing mortality were also estimated to assess the current status of the fishery of *L. calbasu* and *L. fimbriatus*.

4.1 Taxonomic position of both the Labeo species landed along the lower stretches of Tamiraparani river:

The morphometric and meristic characters were taken for the *Labeo* species for identification using key prescribed by Jayaram (1999), Talwar and Jhingaran (1999) was used in the present study.

The systematic position of the two species studied are described below:

Phylum: **Chordata**

Sub Phylum : **Craniata**

Super Class : **Pisces**

Class : **Osteicthyes**

Sub Class : **Actinopterygii**

Order: **Cypriniformes**

Division : **Cyprini**

Sub Order: **Cyprinoidei**

Family : **Cyprinidae**

Sub Family : **Cyprininae**

Genus: ***Labeo***

Species :

1. *Labeo fimbriatus* (Bloch, 1795)

2. *Labeo calbasu* (Hamilton, 1822)

4.2. Distribution:

The present study on *Labeo* spp. revealed that *Labeo fimbriatus* and *Labeo calbasu* are available throughout the year. The peak landing was observed during the months of June to September. Traditional fishing boats were used for exploiting the *Labeo* spp. along the Thoothukudi and Tirunelveli districts. The length composition, the length frequency data and catch and effort details were collected. The landings of *Labeo* species exhibited variation in fishing, the *Labeo fimbriatus and Labeo calbasu* were available almost throughout the year however the low catches were observed in the heavy monsoon months of November and December, while other species like *L. rohita* was available throughout the year.

The smallest size of *L. fimbriatus* was recorded with 110 mm TL and 26.34 gm weight. The largest size was recorded with the TL of 305 mm and the weight of 523.05 gm. The smallest size recorded for *L. calbasu* was with 121 mm TL and 180.65 gm weight. The largest specimen recorded had 420 mm TL with 467.05 gm weight.

4.3 Length – Weight Relationship:

The relationship between the total length and total weight of *L. fimbriatus* and *L. calbasu* were estimated. The parabolic and logarithmic equations are given in Table 4.3.1. The logarithmic relationship between the length and weight *L. fimbriatus* and *L. calbasu* are given in Figure.2 and Figure.3, respectively.

The 'b' value for *L. fimbriatus* was 2.8185 which was lesser than the ideal cubic 'b' (3) value which means that this species exhibits negative allometric growth pattern. Similarly in the case of *L. calbasu,* the negative allometric growth pattern was observed with the 'b' value of 2.1655.

Table 4.3.1 Length weight relationship of *L. fimbriatus* and *L. calbasu:*

Species	Parabolic	Logarithmic equations
L. fimbriatus	$W = 0.0394\ L^{2.8185}$	$Log\ W = -1.4045 + 2.8185\ Log\ L$
L. calbasu	$W = 0.0999\ L^{2.1655}$	$Log\ W = -1.0004 + 2.1655\ Log\ L$

Figure.2. Length-weight relationship of *Labeo fimbriatus*

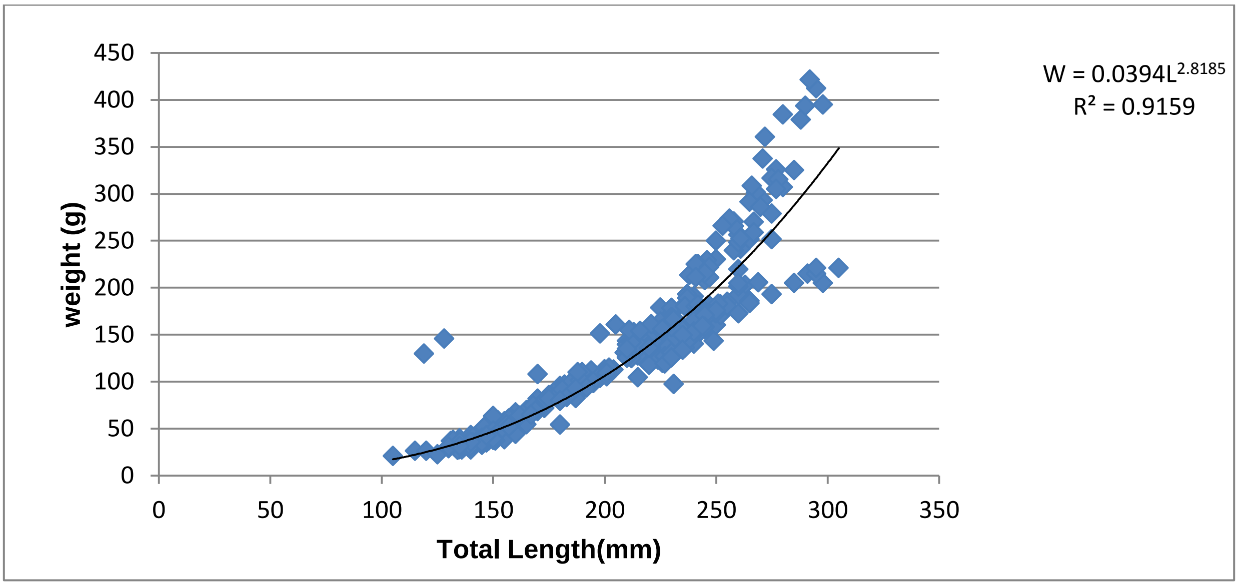
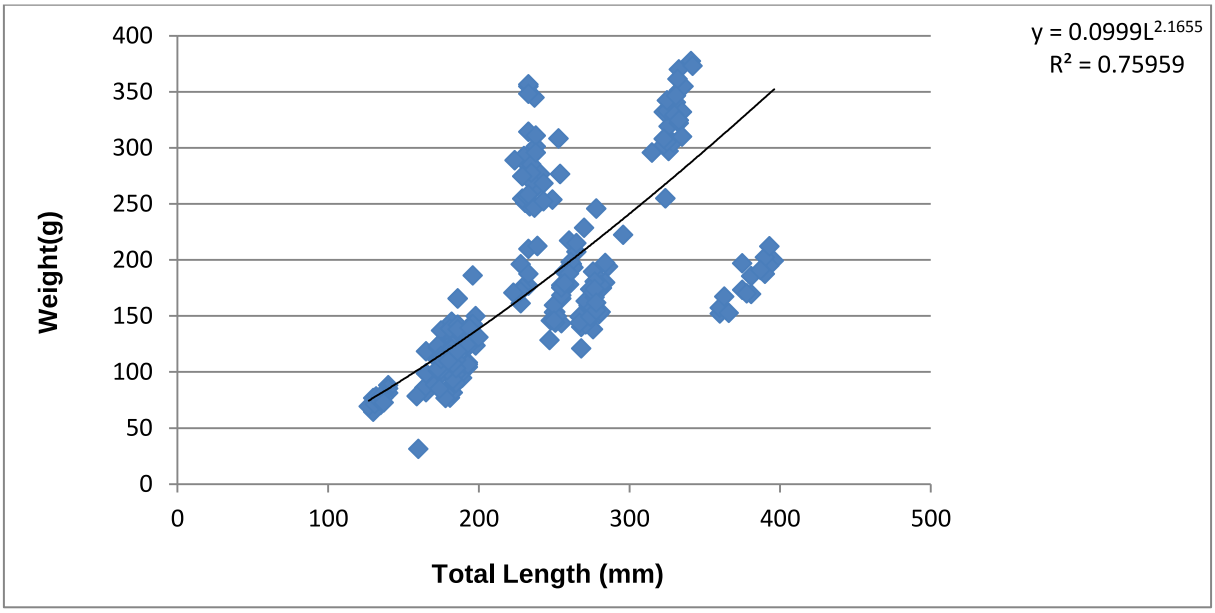


Figure.3. Length-weight relationship of *Labeo calbasu*



4.4 Food and Feeding Habit:

4.4.1. *Labeo fimbriatus:*

The study was based on the stomach analysis of *L. fimbriatus* collected along the lower stretches of Tamiraparani River. The food items were broadly grouped under four categories as (i) mud and sand particles, (ii) diatoms, (iii) decayed organic matters and (iv) algae.

The results of the analysis of the percentage occurrence of stomach with food component in various degrees of fullness of *L. fimbriatus* are shown in Table 4.1 and Figure.4. The analysis of stomach content of these species revealed that invariability diversity of all the months of observation, mud and sand particles dominated with 29.92% in June month. However, during the month of August, 9.85% of the gut content was contributed by mud and sand particles. Diatoms were found to be predominant food items among the planktonic organisms. Their percentage composition ranged from minimum of 31.24% during April to the maximum of 64.98% in October. Decayed organic matter contributed to the stomach content in good quantity throughout the year, with maximum during August with 35.02% and the minimum quantity of 9.89% was recorded during the month of December. Other than that, semi-digestive matter placed minor quantity in the gut which was high in March with 3.22%and minimum in the month of August with 1.19%.

Index of preponderance was calculated for the food components of the stomach of *L. fimbriatus.* This index gives the summary picture of frequency of occurrence as well as bulk of various food items. Results of index is presented in Table 4.3. The result showed that mud and sand particles contributed the first rank, while diatoms got the second rank. The decayed organic matter showed third place followed by semi-digestive materials and miscellaneous food items.

4.4.2 *Labeo calbasu:*

The details on the analysis of the percentage occurrence of stomach with food item in various degrees of fullness of *L. calbasu* stomach are presented in Table 4.2 and Figure 5. The study revealed that *L. calbasu the* mostly feeds on the decayed organic matter and planktonic algae. Diatom was the most dominant food item with the average percentage forty five of the Diatom in the total food items. The second dominant food item found in the stomach content was decayed plant materials followed by small quantities of protozoans, copepods and rotifers. Apart from them, mud and sand particles, were also noticed in very high amount.

The index of preponderance was calculated for the food components of the gut content of *L. calbasu.* Mud and sand particles ranked first. Decayed organic matter ranked second, followed by planktonic algae, diatom, protozoan, copepods and rotifers.

4.5 Growth Index:

The growth index values are presented in the Table 4.5.a & 4.5.b and 4.6 and Figures 6,7,8,9,10 and 11.

4.5.1 Gastro somatic Index (GaSI) for *Labeo fimbriatus* and *Labeo calbasu:*

In *L. fimbriatus*, the GaSI the showed highest value in May, 2018 followed by April, 2018. Minimum value was noticed during the month of July. While in *L. calbasu* the maximum value of GaSI recorded in December and minimum value was noticed during April month.

4.5.2 Hepato-Somatic Index (HeSI) for *Labeo fimbriatus* and *Labeo calbasu:*

The highest HeSI value for *L. fimbriatus* was recorded during October followed by December and the minimum value was recorded in the month of August. In case of *L. calbasu,* the highest value was recorded during January while the minimum value recorded in the month of April.

4.5.3 Gonado-somatic Index (GnSI) for *L. fimbriatus* and *L. calbasu:*

The highest GnSI was recorded during the month of September and minimum value was recorded in the month of February for *L. fimbriatus.* In *L. calbasu* the highest record of GoSI was recorded during November and minimum value during June.

4.6 Growth parameters:

The growth parameters, asymptotic length (L_∞) and Growth coefficient (K) were estimated using the ELEFAN I programme for *Labeo calbasu and Labeo fimbriatus*. The estimated growth parameters were given in the Table 4.6.1 for both species. Based on von Bertalanffy growth parameters the estimated length at different ages for both species were given in Table 4.11 and growth curves derived based on Von Bertalanffy growth parameters derived based on Appeldoorn's method are given in the Table 4.6.2 and fig.12 and 13. The growth parameters obtained by the Gulland-Holt plot, (L_∞ = 448 mm, K = 0.40 for *L. calbasu* and L_∞ = 373.22, K= 0.27 for *L. fimbriatus*) were reasonably good and fell within 95% confidence limit with other methods and therefore, considered for describing the growth of the both species were found affect due to seasonal variation, which reveals that seasonal oscillations are significant and strong (C<0.60) for the species studied(Figure 14,Figure 15, Figure 16,Figure 17).The results of the Powell weatherall plot graph shown in Figure 18, Figure 19 for and VBGF growth curve based on ELEFAN data are shown in Figure.20, Figure.21.

The von Bertalanffy growth equation *L. fimbriatus* and *L. calbasu* are:

$$L_t = 323.22\ [1\text{-}e^{-0.108}(t - (-0.3241)]$$

$$L_t = 548.94\ [1\text{-}e^{-0.247}(t - (-0.4241)]$$

Table 4.6.1 Growth Parameters of *Labeo calbasu and Labeo fimbriatus* based on ELEFAN-I

Species	L_∞ (mm)	K	Ø'
L. calbasu	441.98	0.160	4.512
L. fimbriatus	325.50	0.210	4.347

Table 4.6.2 Growth Parameters of *Labeo calbasu and Labeo fimbriatus* based on Appeldoorn's method

Species	L_∞ (mm)	K	Ø'
L.calbasu	548.94	0.247	4.060
L.fimbriatus	323.22	0.108	4.872

Table 4.6.3 Growth Parameters of *Labeo calbasu and Labeo fimbriatus* based on Gulland-Holt method

Species	L_∞ (mm)	K	Ø'
L.calbasu	448.94	0.407	4.914
L.fimbriatus	373.22	0.270	4.019

4.7 Sex ratio:

The sex ratio of a fish population has been used as an indicator of the population's ability to sustain on going recruitment. The average sex ratio of male to female *L. calbasu* in the present study was 1:3 and for *L. fimbriatus* it was 1:2.The difference was significant at 5% level. Chi-square values showed significant difference at 5% level with respect to the sex ratio in all the monthly catch data as well as the pooled data.

4.8 Mortality Parameters:

The estimated mortality parameters and exploitation ratio for *L.calbasu* and *L. fimbriatus* are given in Table 4.8.1 and Figure 29, 27.The total instantaneous mortality (Z) of *L. calbasu* and *L. fimbriatus* was 0.88 and 0.60 respectively. The respective natural mortality (M) was 0.51 and 0.28. The fishing mortality 0.29 of *L. calbasu* was lower than the fishing mortality of *L. fimbriatus* (0.37). The estimated exploitation ratio of *L. calbasu* and *L. fimbriatus* was 0.33 and 0.62 respectively. The natural mortality obtained from the Pauly's method was low, revealing less impact of mortality due to predation and environmental impacts.

Table 4.8.1 Mortality parameter and exploitation ratio of *Labeo calbasu* and *Labeo fimbriatus*

Species	Natural Mortality (M)	Fishing Mortality (F)	Total instantaneous Mortality (Z)	Exploitation ratio (E = F/Z)
L. calbasu	0.51	0.29	0.88	0.33
L. fimbriatus	0.28	0.37	0.60	0.62

4.9 Virtual Population analysis:

The length structured virtual population analysis (VPA) helped to know the level of mortality on various length groups of *L. calbasu* and *L. fimbriatus* are shown in Figure. 28 and 26.The fishing pressure on *L. calbasu* was more found to be more in the length group 248 mm to 310 mm and the natural mortality was seemed to be low in the length group 120 mm onwards. For *L. fimbriatus* the fishing pressure was found to be more in the length group 205 mm to 310 mm and the natural mortality seemed to be low in the length group 128 mm onwards. The natural mortality was observed high in the small size length groups in the both species studied.

4.10 Total stock, Annual stock and Exploitation rate:

The annual catch, total stock, annual stock and exploitation rate estimated for *L. calbasu* and *L. fimbriatus* are presented in Table 4.10.1. The total stock of *L. calbasu* and *L. fimbriatus* were estimated at 27.18 tonnes and 13.61 tonnes. The annual catch was worked out 7.2 tonnes and 5.8 tonnes against the annual stock of 8.10 tonnes and 6.15 tonnes respectively. While the respective exploitation rate of 0.125 and 0.426.

4.11 MSY and exploitation status

The estimated MSY and the exploitation ratio for *L.calbasu* and *L.fimbriatus* were estimated and presented in the Table 4.10.2. The MSY of the two species were 7.53 and 3.91 tonnes respectively. The difference between the annual catch and MSY catch for *L. calbasu* was 0.33 tonnes. In case of *L. fimbriatus,* the difference was 1.9 tonnes. Hence the current study indicates that *L. calbasu* is less exploited as the current catch is lesser than estimated MSY level. Hence there is possibility to increase the effort marginally to certain level to exploit the species at MSY. Incase of *L. fimbriatus* the exploited and current catch were found to be higher than the estimated MSY, hence a need is there to decrease the effort marginally to exploit *L. fimbriatus* at MSY.

Table 4.10.1 Exploitation rate, Total stock and Annual stock of *L. calbasu* and *L. fimbriatus*

Species	Annual catch (tonnes)	Exploitation rate (U)	Total Stock (Y/U) (tonnes)	Annual stock (Y/F) (tonnes)
L. calbasu	7.2	0.125	27.18	8.10
L. fimbriatus	5.8	0.426	13.61	6.15

Table 4.10.2 Maximum sustainable yield of *L. calbasu* and *L. fimbriatus*

Species	Catch (tonnes)	Effort (coracle days)	CPUE (tonnes)	MSY (tonnes)	Difference b/w Catch and MSY
L. calbasu	7.2	1782	0.040	7.53	0.33
L. fimbriatus	5.8	1782	0.046	3.91	1.9

4.12 Morphological identification in *Labeo fimbriatus* and *Labeo calbasu*:

Following the taxonomical imperative information of the present species can be distinguished by morphological measurements. The Table 4.12.1 Figure 30 and 31 representing the characters. And their values are presented in the Tables 1 to 4 annexured.

During the present investigation, fifty different morphometric characters were taken for both *L. fimbriatus* and *L. calbasu.* The analysis of significance and correlation were estimated using paired 't' test and the result of ANOVA showed the significant variance between *L.calbasu* and *L.fimbriatus*.

Paired 't' test showed that all the morphometric measurements were significantly different between each other at $P<0.05$ including some variance. The graphical description of parameters such as Total Length, Standard Length, Head Length, Body width, Relative Eye Height, Head Height**,** Cadual Peduncle Length and Width of Mouth are shown in Fig. 41 to Fig. 45

4.13 Conservation status:

The present study, *L. calbasu* was found to be under exploited condition and *L. fimbriatus* is reached over exploition stage as the present catch of *Labeo fimbriatus* has increased just above its MSY level particularly along the lower stretches of Tamiraparani river.

4.14 Conservation managements:

Conservational measures including stopping of illegal fishing, poisoning, identifying crucial breeding habitats and creating mass awareness are needed to save the *L.fimbriatus* in lower stretches of Tamiraparani River. Similar studies are required for related fish species. Many freshwater fish species might become endangered or even extinct in the lower stretches of Tamiraparani river.

Raising awareness and actively conserving species through conservational programmes with the participation of local stakeholders and scientific communities will pave the way for protection of *L. fimbriatus* stock. Several programmes such as species enhancement, stock enhancement, environmental enhancement, culture based capture fisheries, cage and pen culture installation may be adopted for *Labeo fimbriatus* along the lower stretches of Tamiraparani river.

Table 4.1 Percentage occurrence of stomachs in various degrees of fullness of *Labeo fimbriatus* (June, 2017 – May, 2018)

Month (2017-2018)	No.of fish examined	Feeding intensity (%)					
		Empty	1/4 Full	3/4 Full	1/2 Full	Full	Trace
June-17	25	9	17	17	24	14	19
July-17	30	7	15	20	24	12	22
Augest-17	32	5	12	16	22	21	24
September-17	30	4	9	17	18	20	32
October-17	30	4	11	20	12	22	31
November-17	31	4	12	19	13	25	27
December-17	30	5	14	23	15	24	19
January-18	30	9	18	20	24	20	10
February-18	31	9	31	13	30	9	8
March-18	31	13	30	11	29	10	7
April-18	30	15	31	12	25	8	9
May-18	31	18	29	6	28	9	9

Table 4.2 Percentage occurrence of stomachs in various degrees of fullness of *Labeo calbasu* (June, 2017 – May, 2018)

Month (2017-2018)	No.of fish examined	Feeding intensity(%)					
		Empty	1/4 Full	3/4 Full	1/2 Full	Full	Trace
June-17	20	15	33	8	24	10	10
July-17	31	19	27	10	28	8	8
August-17	32	14	29	12	29	9	7
September-17	30	9	29	14	30	10	8
October-17	30	10	18	22	23	18	9
November-17	32	6	15	20	14	24	21
December-17	30	5	11	19	11	28	26
January-18	32	4	8	20	13	23	32
February-18	31	3	10	18	17	21	31
March-18	30	4	13	15	19	23	26
April-18	30	5	14	19	24	17	21
May-18	31	9	19	18	23	13	18

Figure.4 Stomach fullness of *Labeo fimbriatus* from June, 2017 to May, 2018

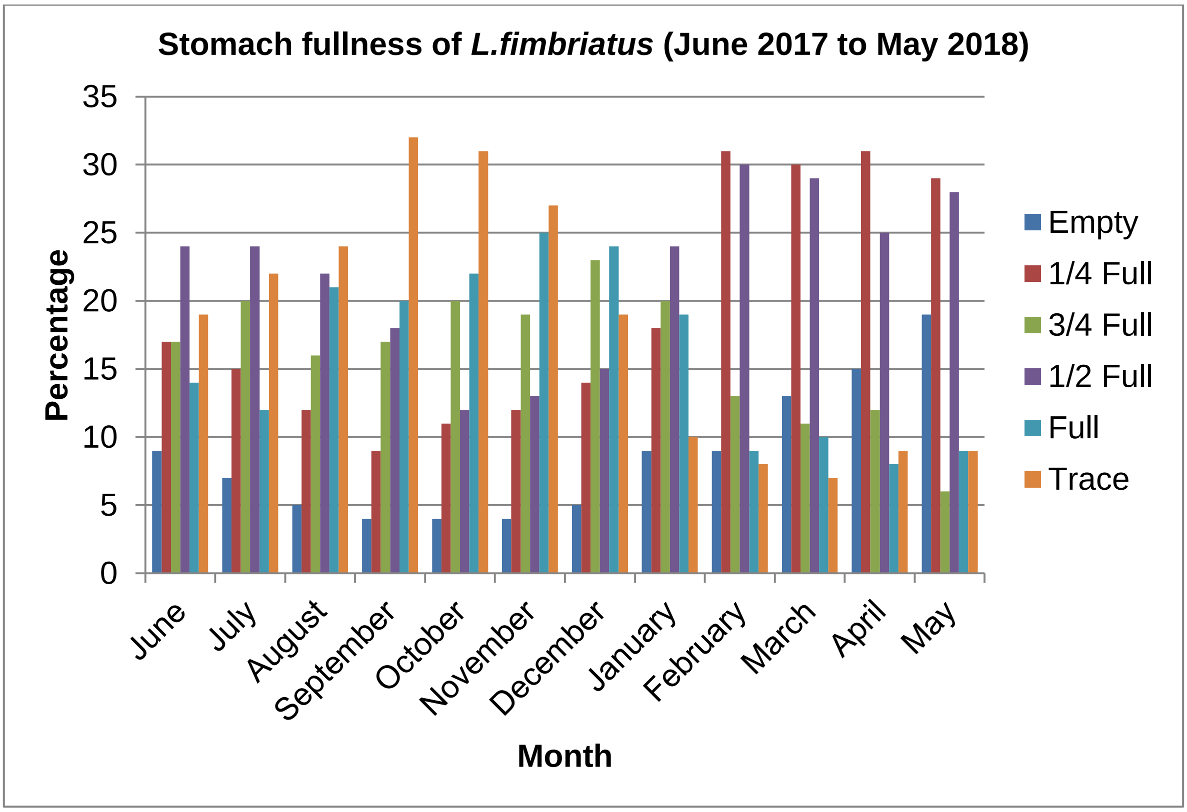


Figure.5 Stomach fullness of *Labeo calbasu* from June, 2017 to May, 2018

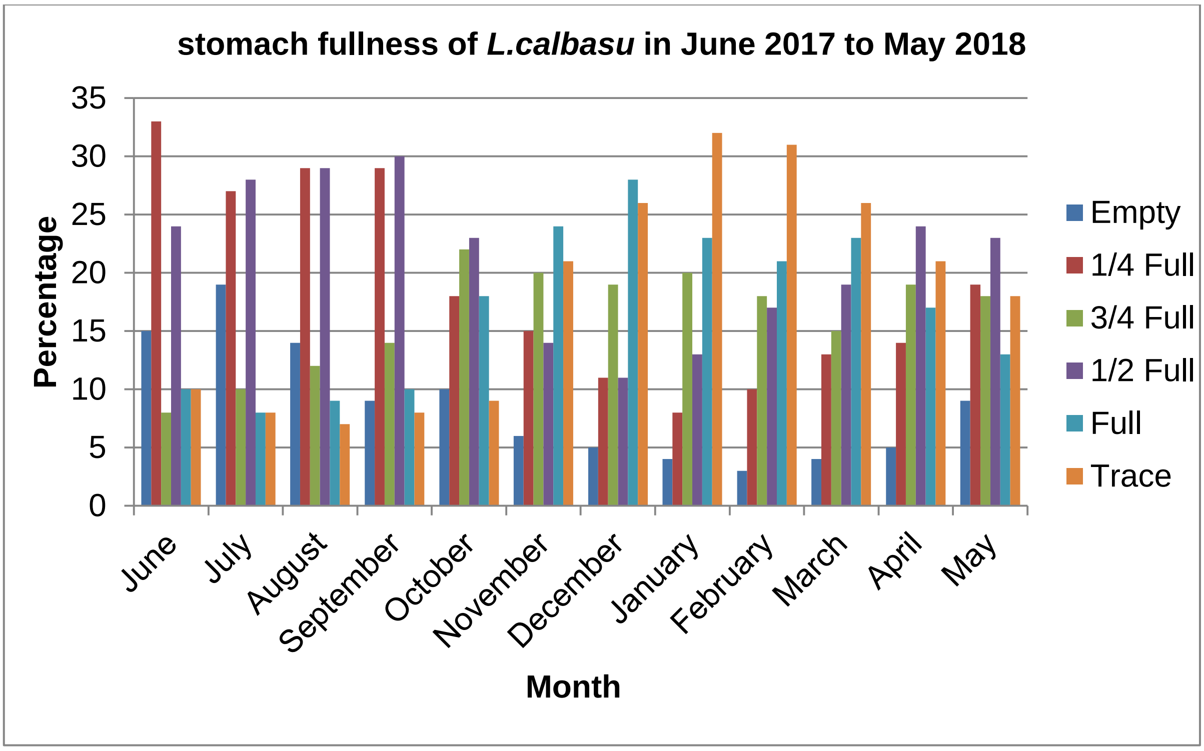


Table 4.3 Index of preponderance of *Labeo fimbriatus*

Food item	Percentage of volume(VI)	Percentage of occurance(OI)	VI*OI	Index	Rank
Mud and Sand particles	38.20	31.78	1213.996	48.38	1
Diatom	25.70	23.45	602.665	24.02	2
Decayed Organic Matter	17.60	21.8	383.68	15.29	3
Algae	12.40	19.3	239.32	9.54	4
Semi-Digested Matter	6.20	4.30	26.66	1.06	6
Miscellaneous	8.10	5.30	42.93	1.71	5
total			2509.25	100.00	

Table 4.4 Index of preponderance of *Labeo calbasu*

Food item	Percentage of volume(VI)	Percentage of occurance (OI)	VI*OI	Index	Rank
Mud and Sand particles	39.6	33.9	1342.44	49.09	1
Decayed organic matter	28.9	32.5	939.25	34.35	2
plant matter	7.4	8.2	60.68	2.22	4
Diatoms	16.3	23.8	387.94	14.19	3
Protozoans	0.6	0.3	0.18	0.01	7
Rotifer	6.8	0.4	2.72	0.10	5
Copepod	1.2	1.0	1.20	0.04	6
total			2734.41	99.98	

Table 4.5 a. Gastro-somatic Index, Hepato Somatic Index, Gonado Somatic Index of *Labeo fimbriatus*

Month	GaSI	HeSI	GoSI
June, 17	3.837	0.881	0.263
July, 17	2.648	0.970	0.205
August, 17	3.346	0.354	0.427
September, 17	4.352	0.903	4.258
October, 17	4.176	1.760	1.572
November, 17	4.392	1.546	3.145
December, 17	4.340	1.669	3.469
January, 18	5.076	0.881	2.332
February, 18	3.293	0.875	0.115
March, 18	4.937	0.773	0.866
April, 18	5.378	1.181	1.070
May, 18	6.688	1.194	1.984

Figure. 6. Gastro-somatic Index of *Labeo fimbriatus* from June, 2017 to May, 2018

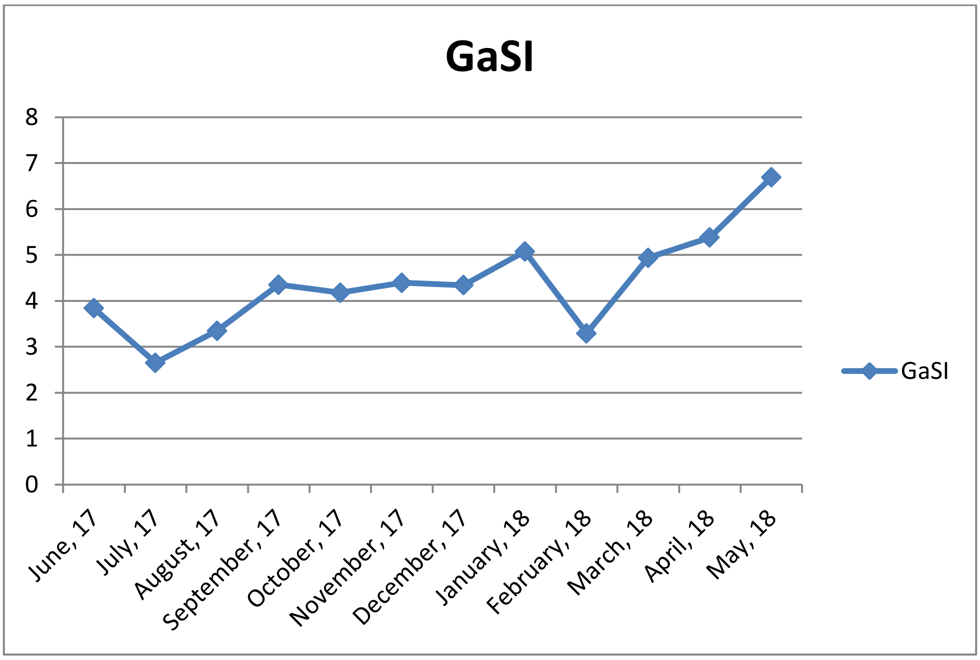


Figure. 7. Hepato-somatic Index of *Labeo fimbriatus* from June, 2017 to May, 2018

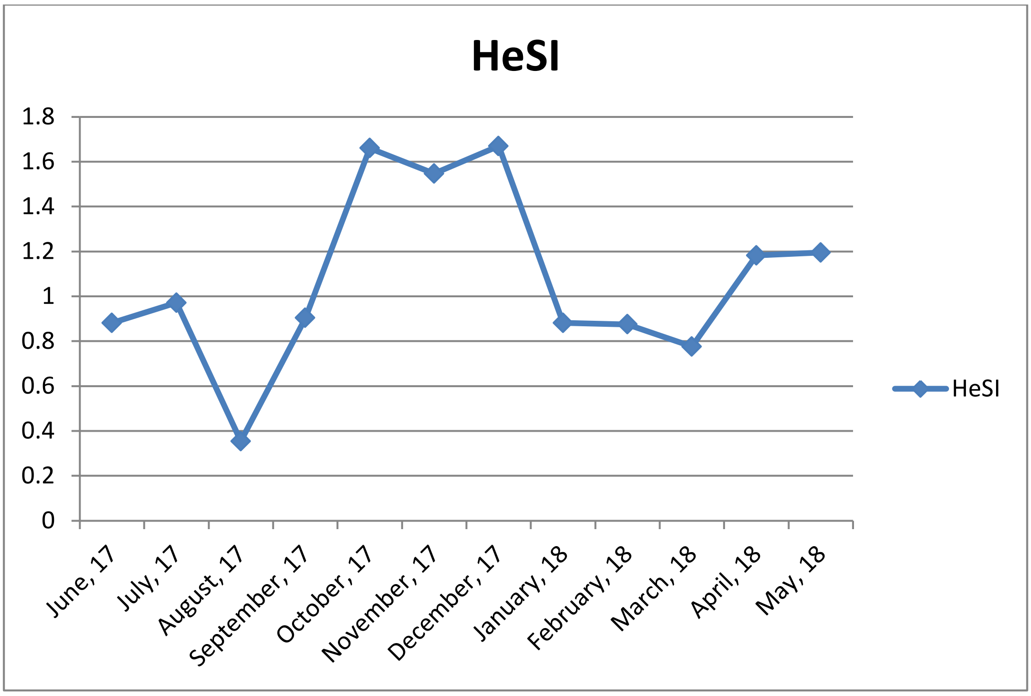


Figure.8. Gonado-somatic Index of *Labeo fimbriatus* in June 2017 to May 2018

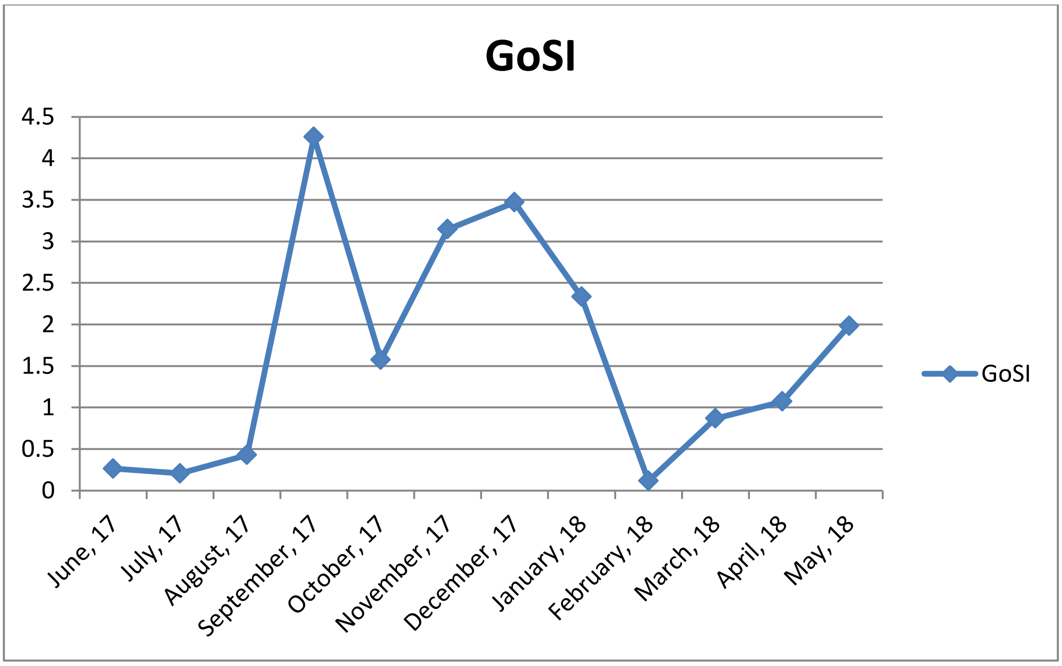


Table 4.5.b Gastro-Somatic Index, Hepato-Somatic Index, Gonado-Somatic Index of *Labeo calbasu*

Month	GaSI	HeSI	GoSI
June, 17	1.1911	1.1911	0.0746
July, 17	1.6053	1.5086	0.1593
August, 17	0.6204	1.0471	0.2005
September, 17	2.3995	0.1360	0.3955
October, 17	2.1276	0.1515	0.9321
November, 17	1.8080	0.7639	1.7109
December, 17	2.8153	1.9324	1.6716
January, 18	2.6055	2.5734	0.2202
February, 18	1.0554	0.1496	0.3102
March, 18	2.0543	0.2939	0.7866
April, 18	0.3454	0.0665	0.9660
May, 18	0.9236	0.1563	0.8721

Figure.9. Gastro-Somatic Index of *L.calbasu* from June, 2017 to May, 2018

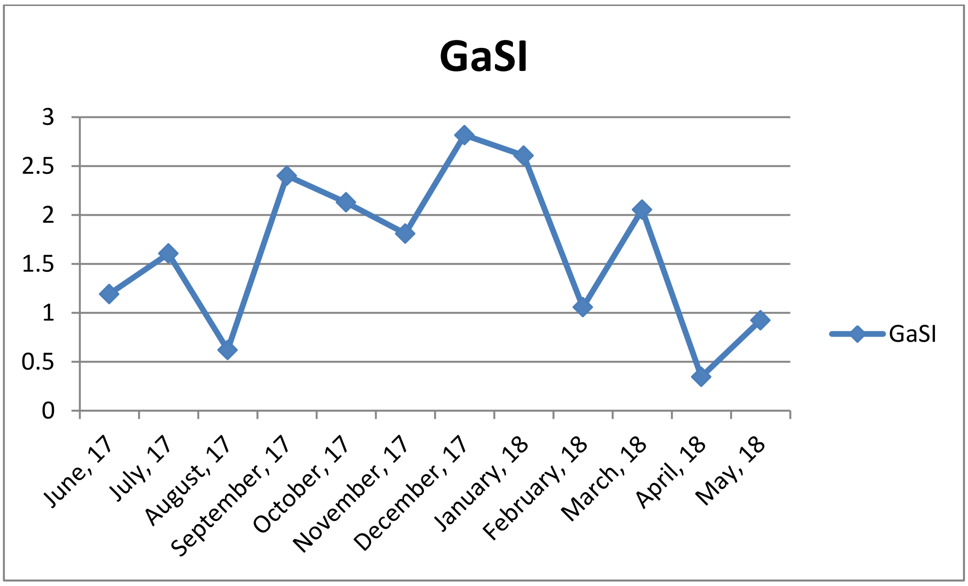


Figure.10. Hepato-Somatic Index of *Labeo calbasu* from June, 2017 to May, 2018

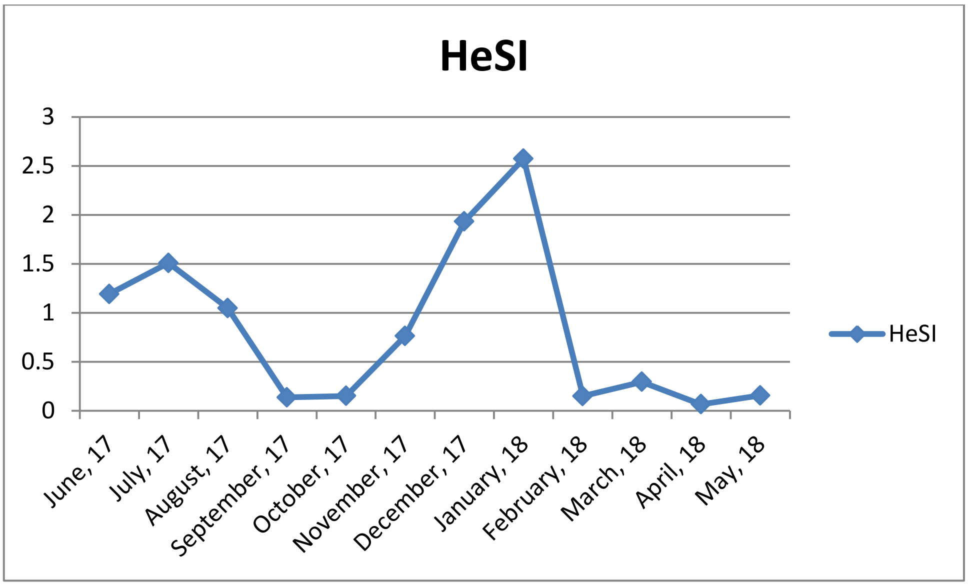


Figure.11. Gonado-Somatic Index of *Labeo calbasu* from June, 2017 to May, 2018

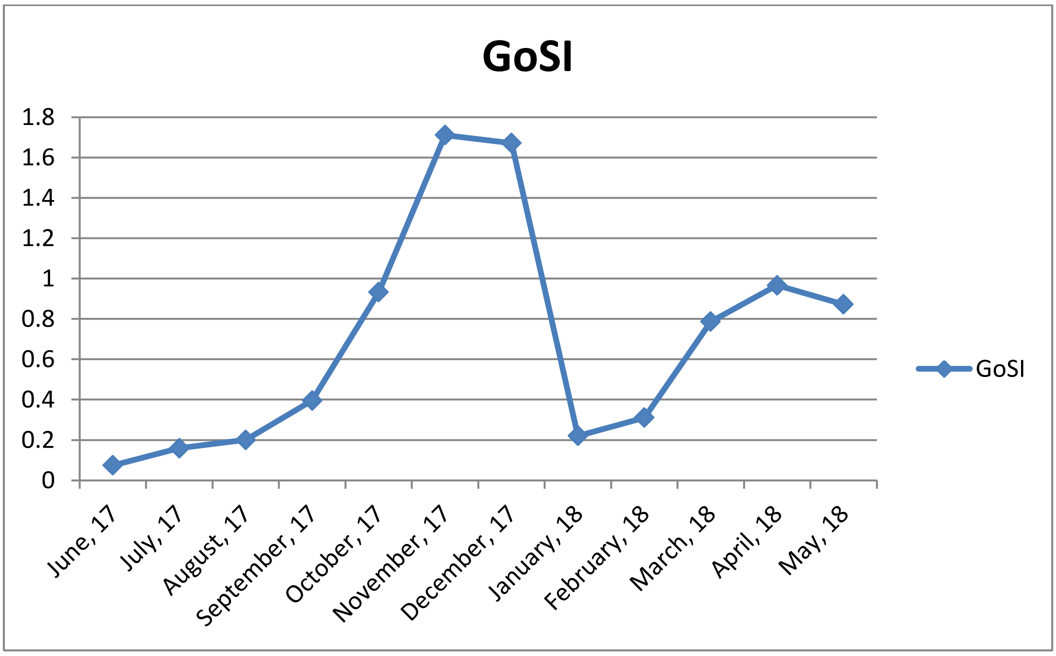


Figure.12. Growth curve of *Labeo calbasu* (Appeldoorns method)

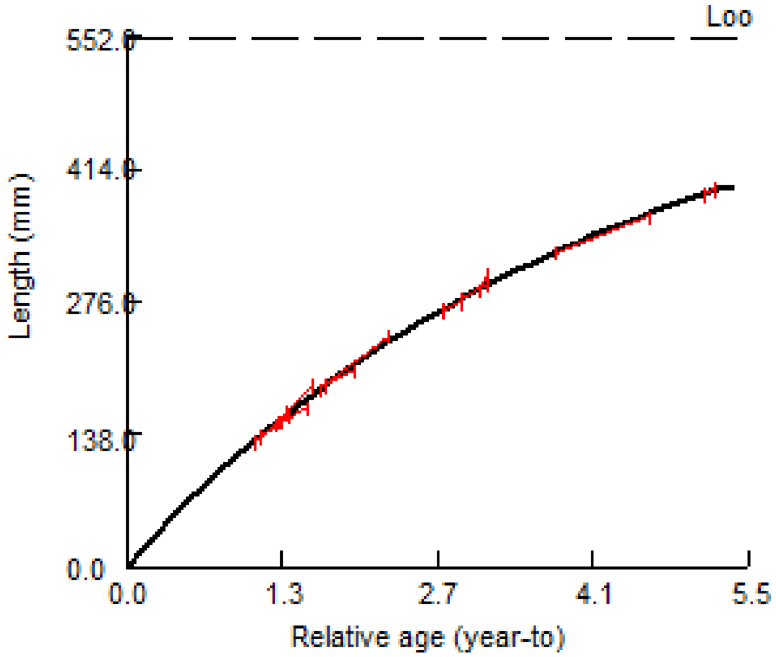


Figure.13. Growth curve of *Labeo fimbriatus* (Appeldoorns method)

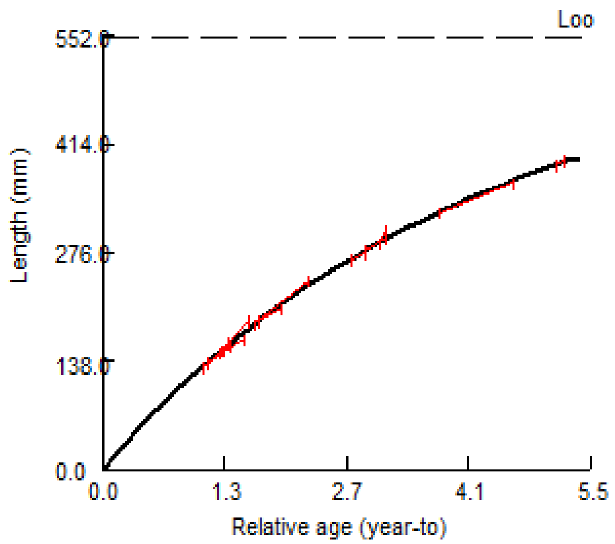


Figure.14. Gulland-plot curve for *Labeo fimbriatus*

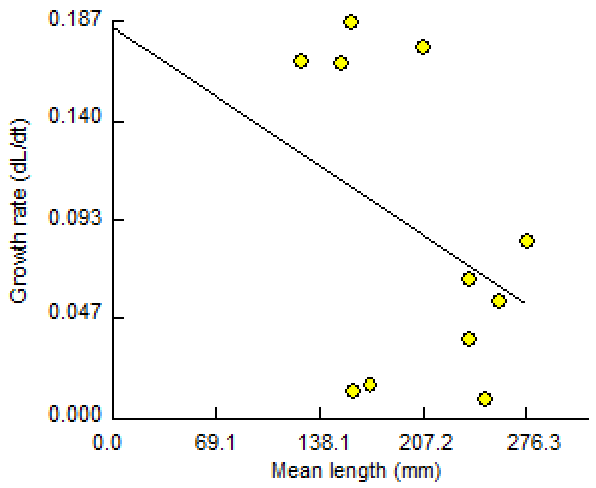


Figure.15. Seasonal growth curve of *Labeo fimbriatus*

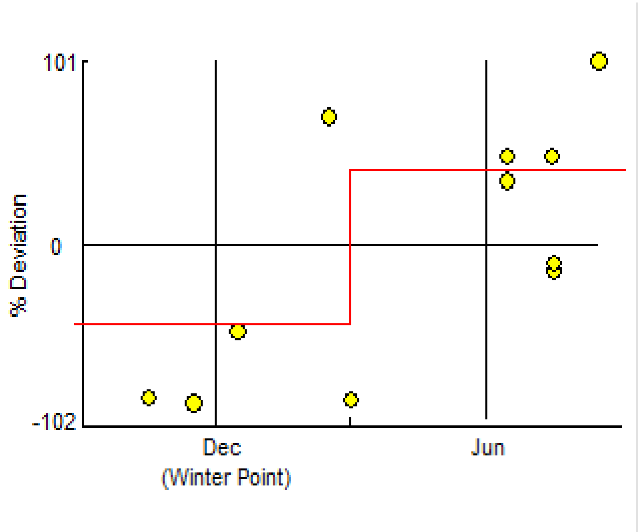


Figure.16. Gulland-Holt curve of *Labeo calbasu*

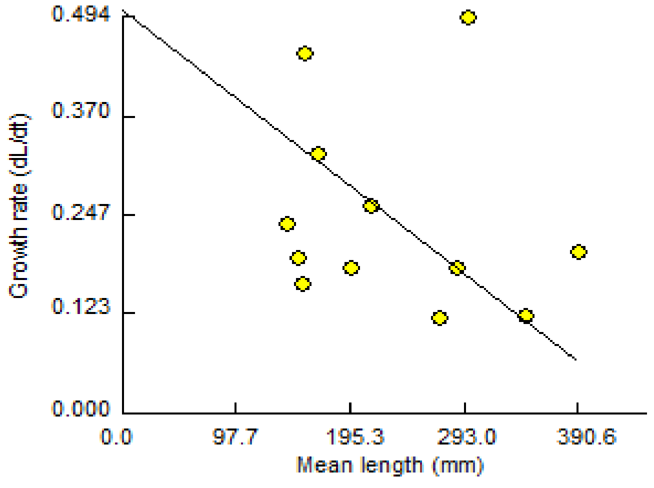


Figure.17. Seasonal growth curve of *L.calbasu*

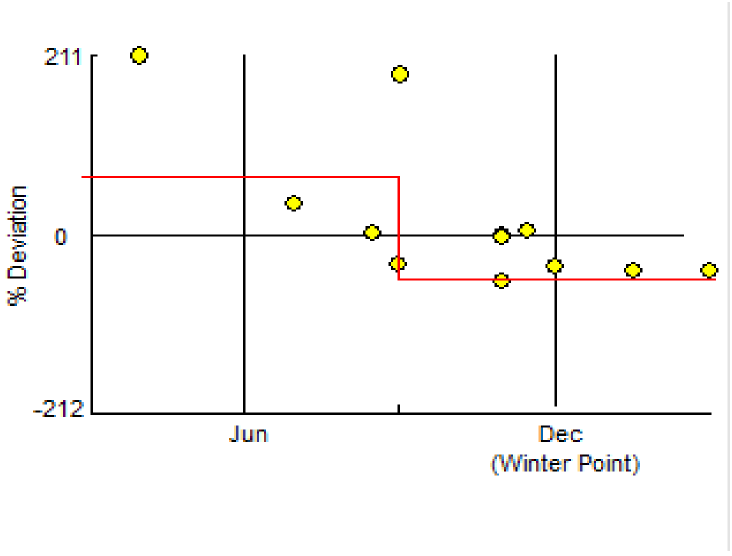


Figure.18. Powell weatherall method for *Labeo calbasu*

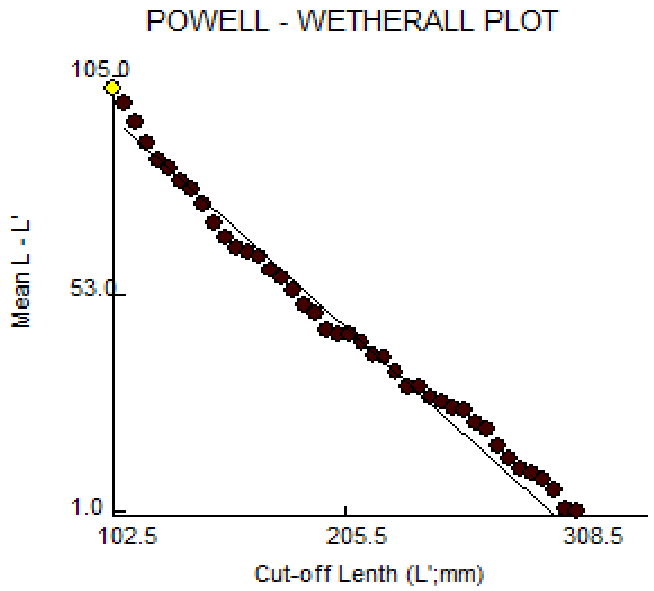


Figure.19. Powell weatherall method for *Labeo fimbriatus*

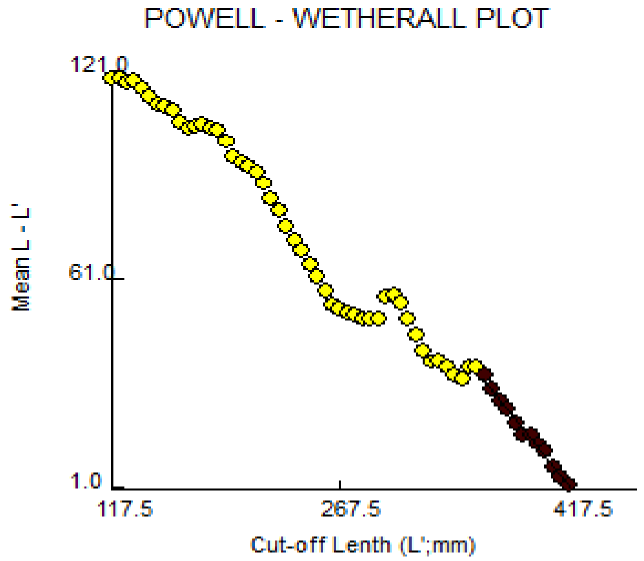


Figure.20. VBGF growth curve of *Labeo fimbriatus* by ELEFAN

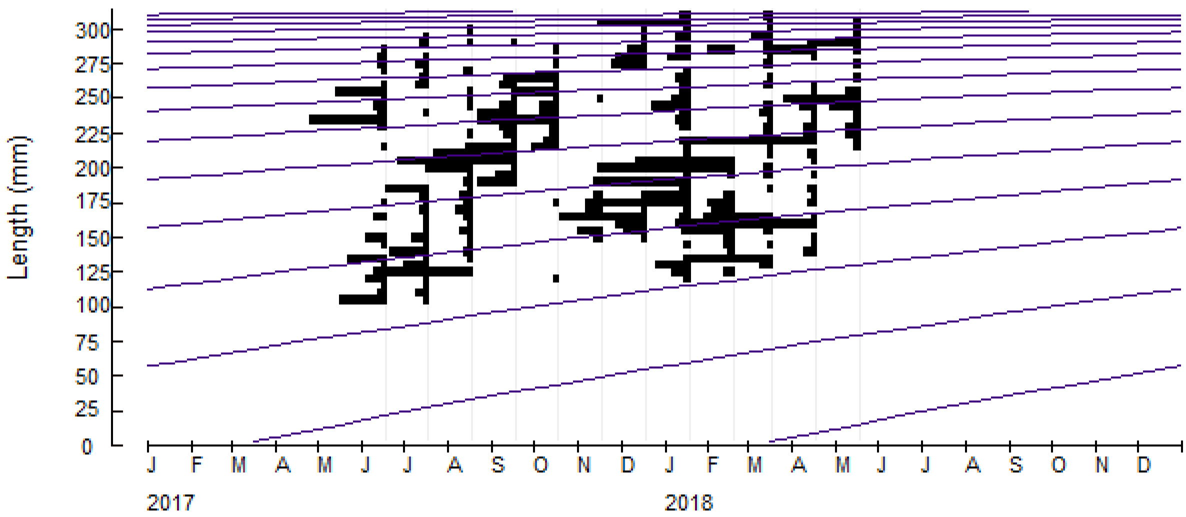


Figure.21. VBGF growth curve of *Labeo calbasu* by ELEFAN

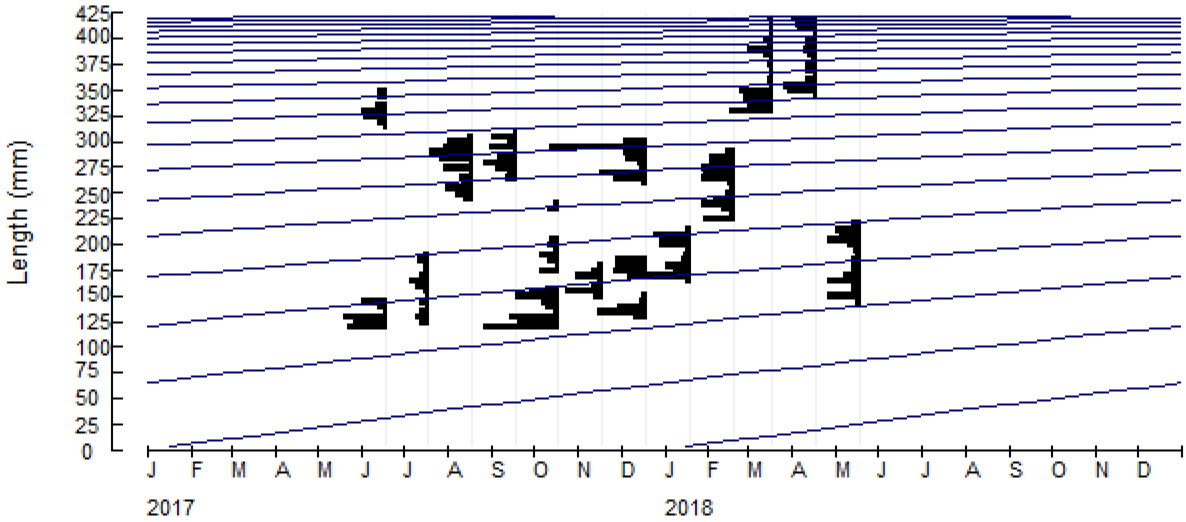


Figure. 22. Length at age data for *Labeo calbasu*

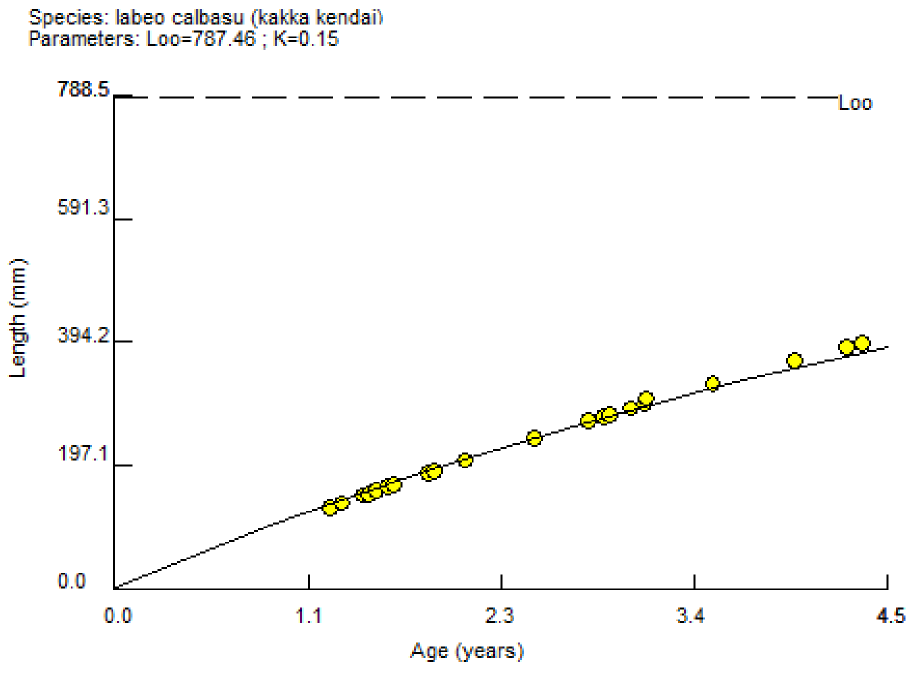


Figure. 23. Length at age data for *Labeo fimbriatus*

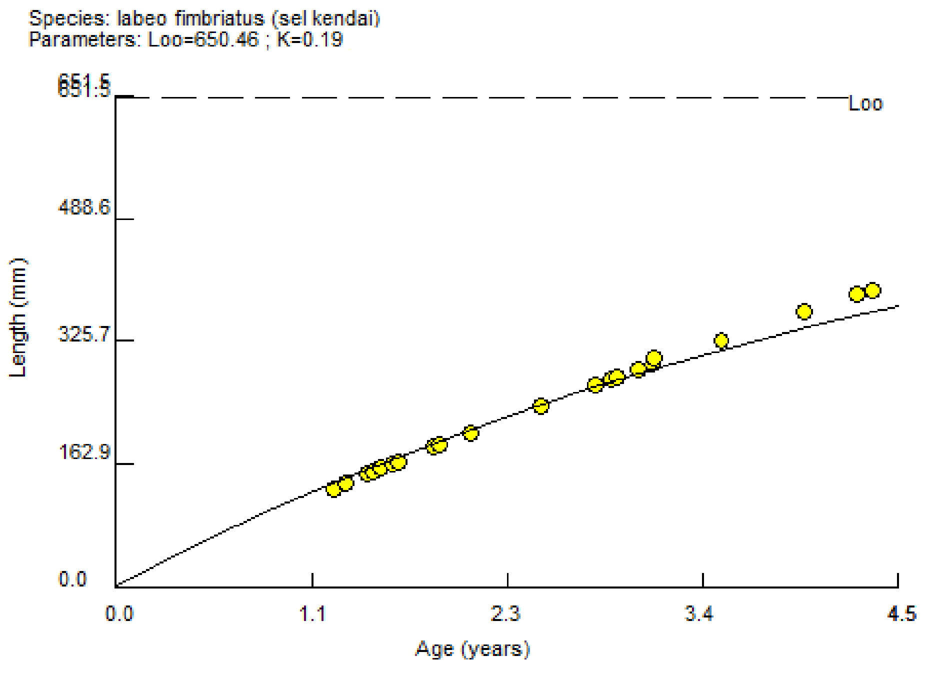


Figure. 24. Recruitment pattern of *Labeo fimbriatus*

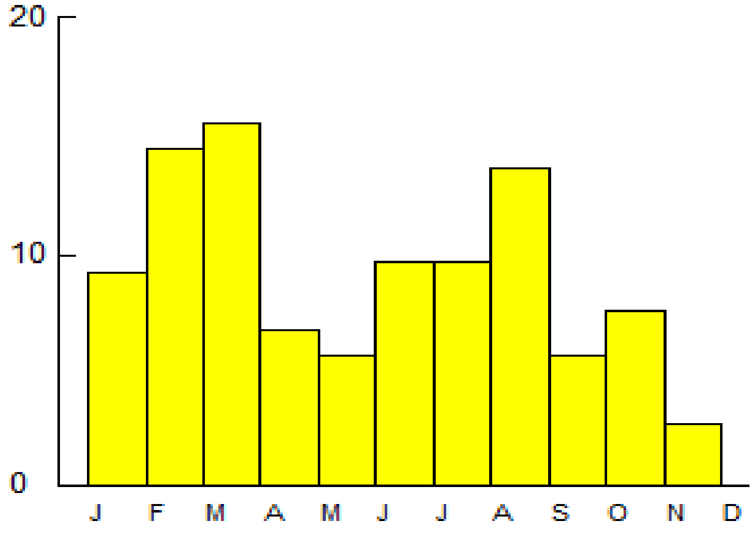


Figure. 25. Recruitment pattern of *Labeo calbasu*

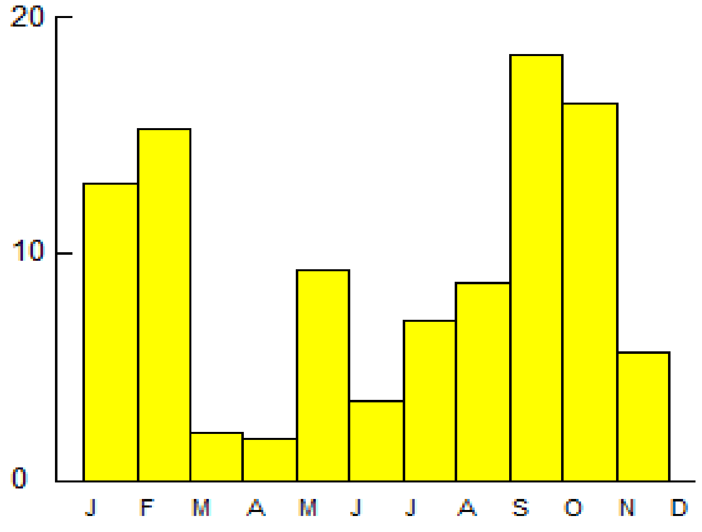


Figure. 26. Virtual population analysis of *Labeo fimbriatus*

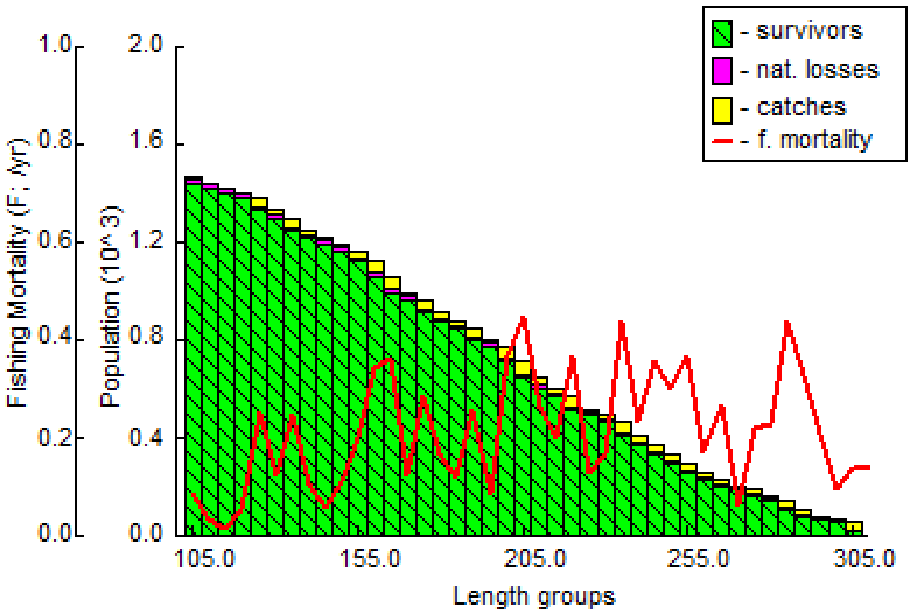


Figure. 27. Knife – edge selection curve of *Labeo fimbriatus*

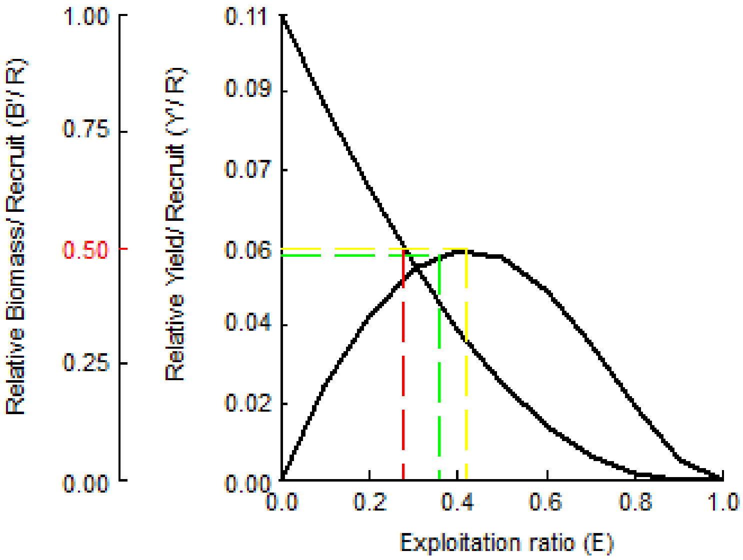


Figure. 28. Virtual population analysis of *Labeo calbasu*

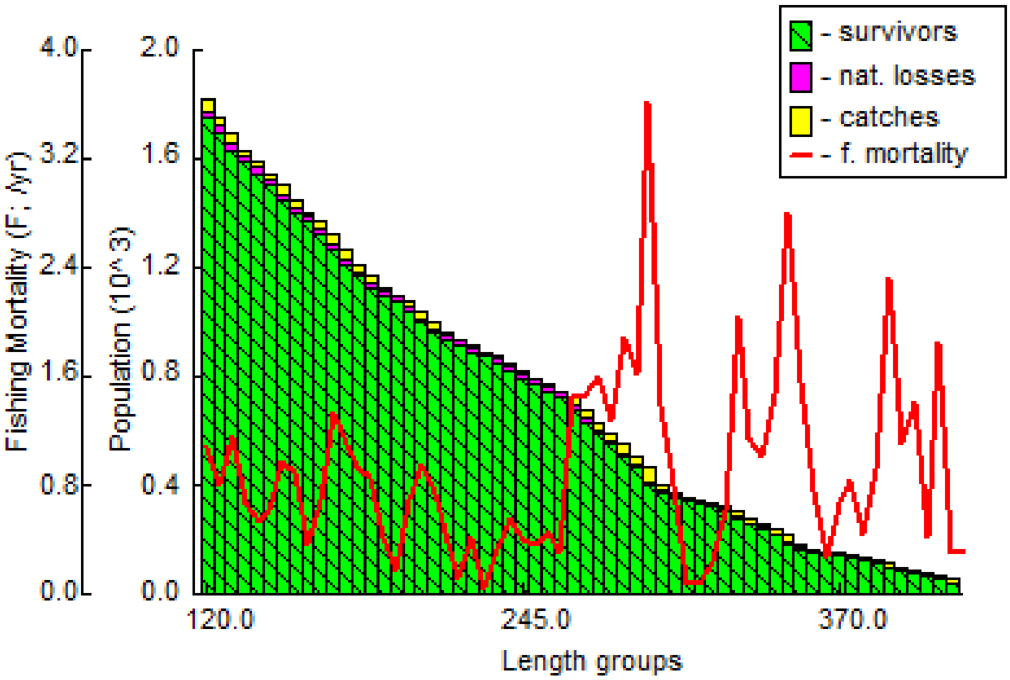


Fig. 29.Knife – edge selection curve of *Labeo calbasu*

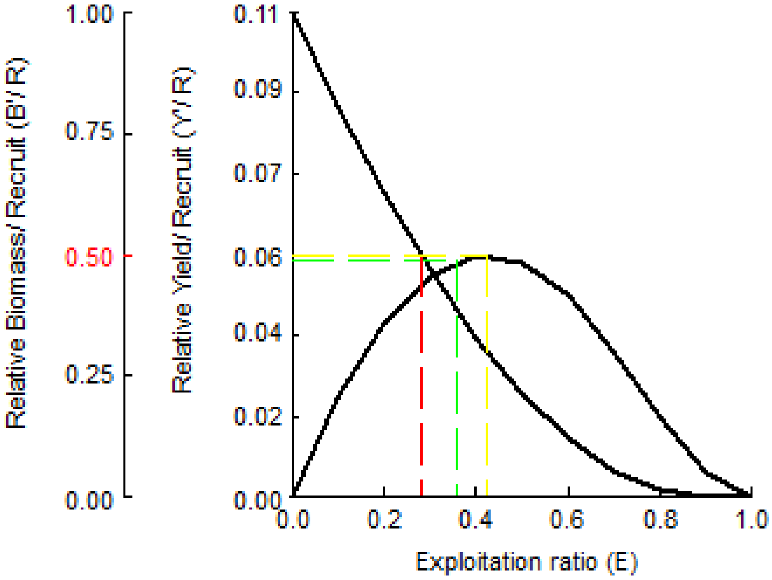
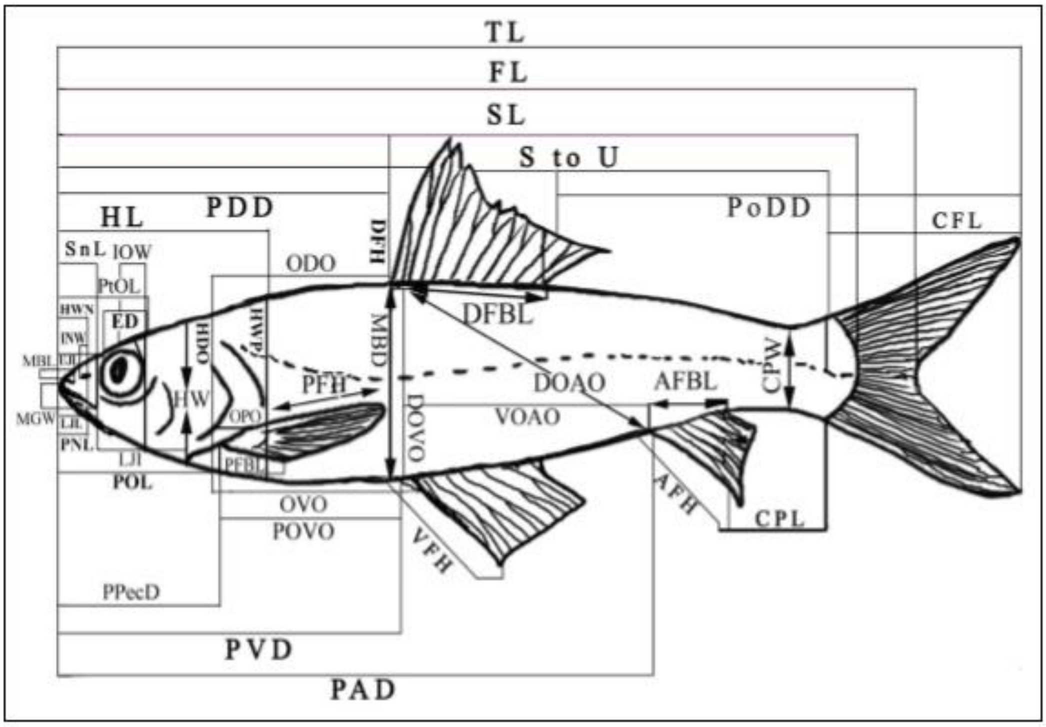
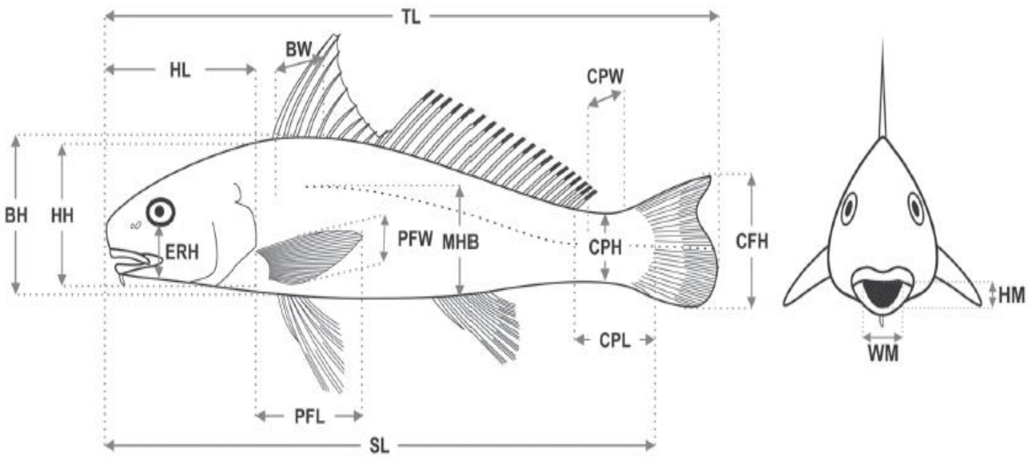


Fig.30. Representative Picture with Forty four morphological characters:



(Source - Mathialagan Ramasamy, Sivakumar Rajangam0

Figure. 31. Representative picture with sixteen morphological characters



(Sources - Sociedade Brasileira de Ictiologia)

4.9 Morphological variance for *Labeo fimbriatus* and *Labeo calbasu:*

Figure. 32. Total Length (TL) Vs Standard Length (SL) of *Labeo fimbriatus* and *Labeo calbasu*

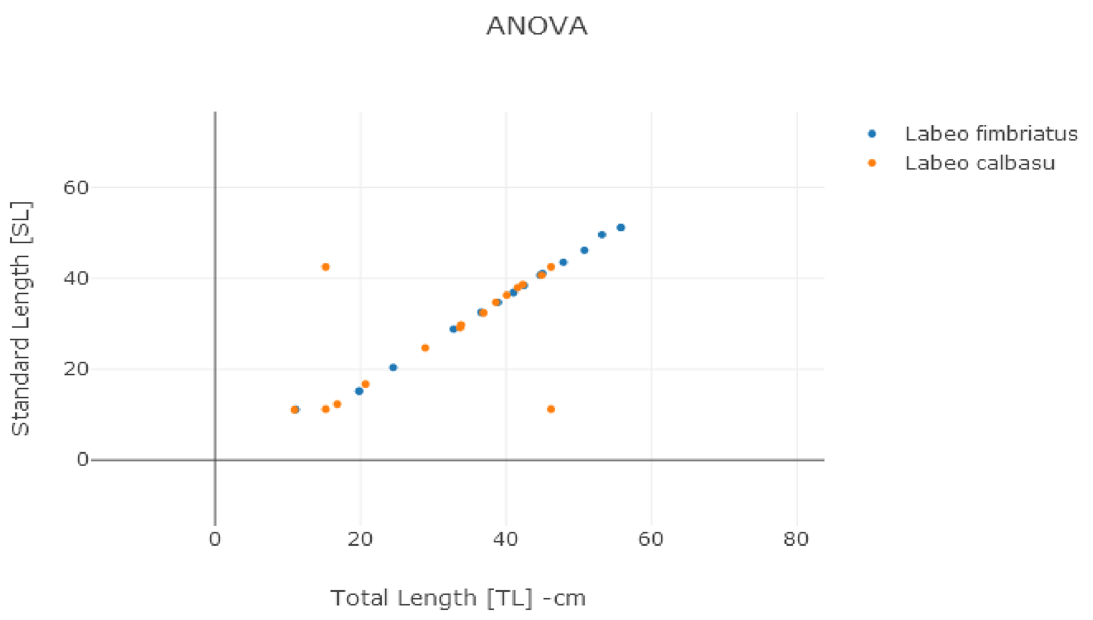


Figure. 33. Head Length (HL) Vs Body Width (BW) of *Labeo fimbriatus* and *Labeo calbasu*

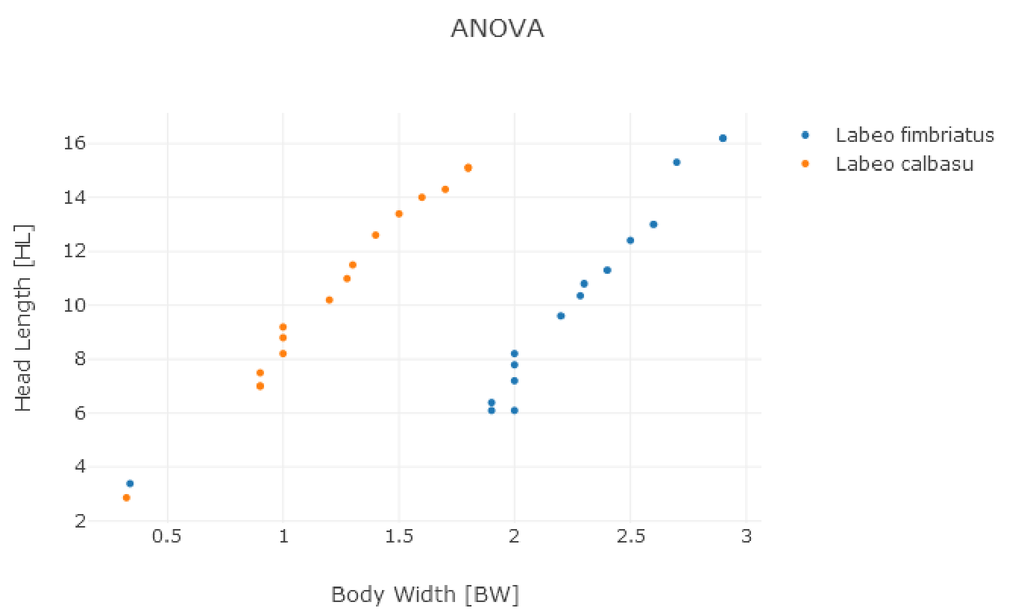


Fig. 34. Relative Eye Height (REH) Vs Head Height (HH) of *L.abeo imbriatus* and *Labeo calbasu*

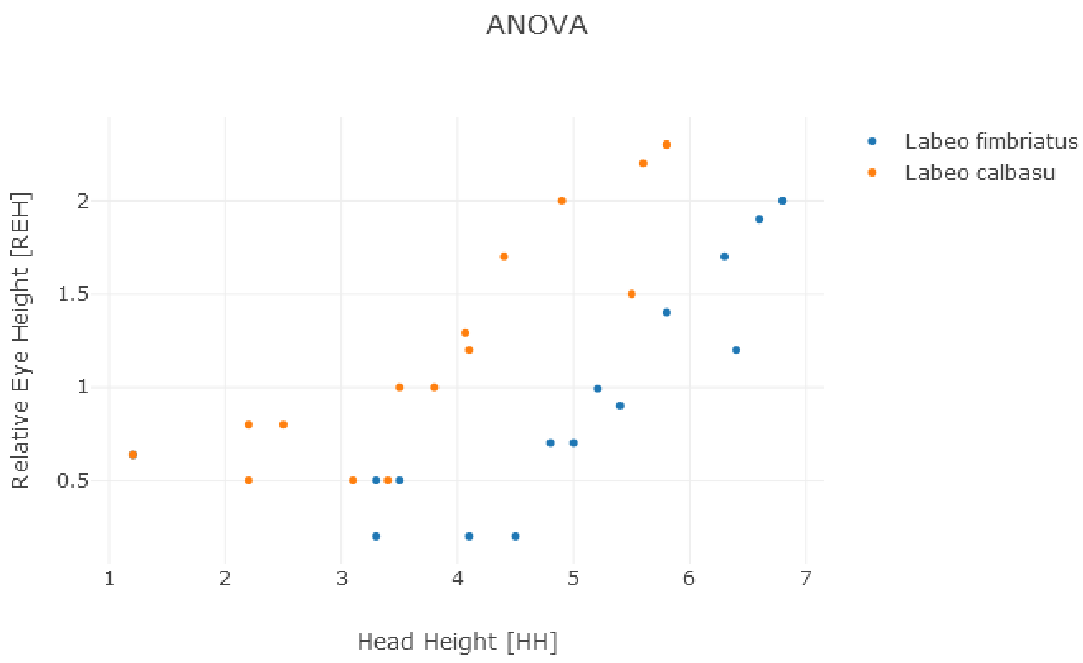


Figure. 35. Cadual Peduncle Length (CPL) Vs Width of Mouth (WM) of *Labeo fimbriatus* and *Labeo calbasu*

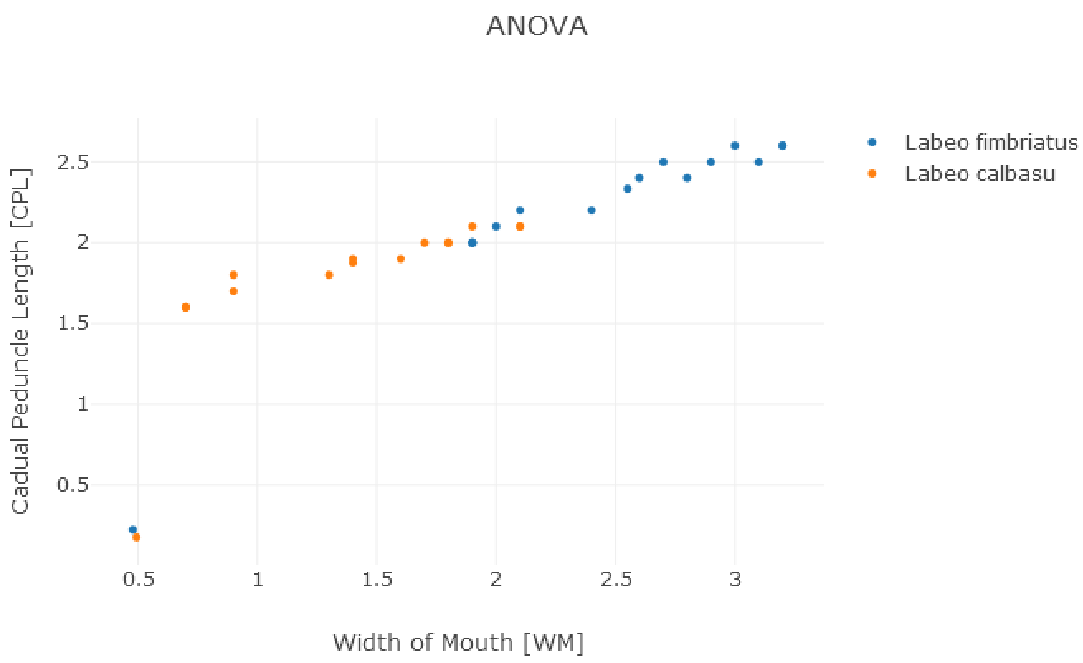


Figure. 36. Cadual Fin Length (CFH) VS Cadual Peduncle Width (CPW) of *Labeo fimbriatus* and *Labeo calbasu*

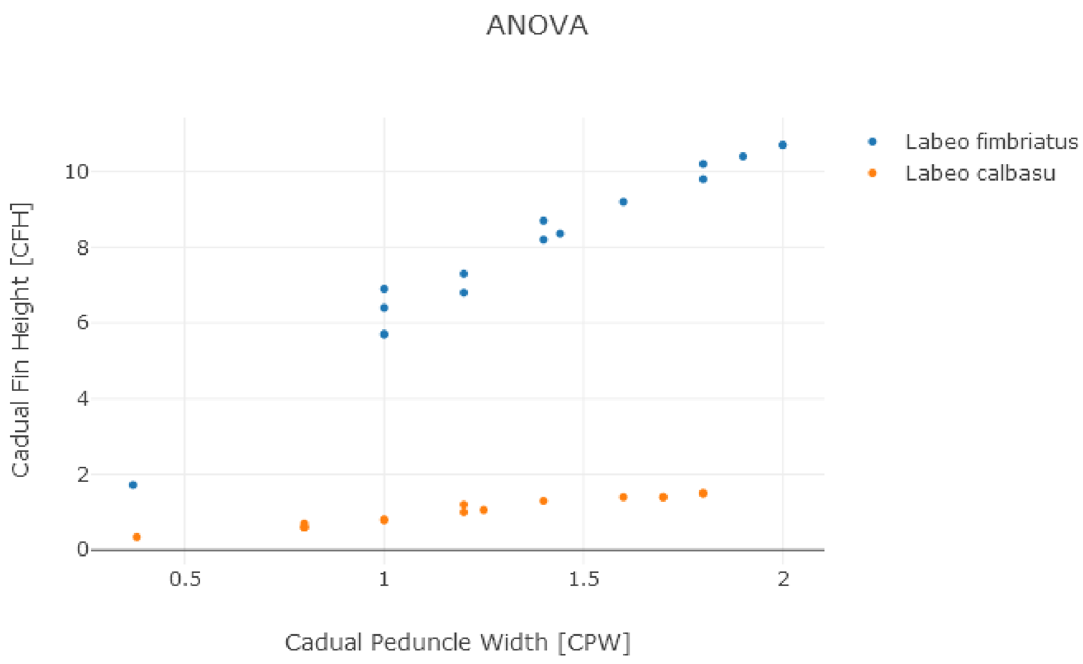


Table 4.12.1 Morphological identification of *Labeo fimbriatus* and *Labeo calbasu*

PAIRED SAMPLES TEST STATISTICS AND CORRELATIONS

S.No	Characters	Mean	SD	SD error mean	Correlation(r^2)	t	Significance (2-tailed) r
Pair 1	TL-LF	40.5786	12.4721	3.3332	0.370	1.978	0.009
	TL-LC	33.3786	11.8003	3.1537			
Pair 2	SL-LF	36.3357	12.5085	3.3430	0.952	6.846	0.006
	SL-LC	29.3429	11.9319	3.1889			
Pair 3	BW-LF	2.3070	0.3626	0.0969	0.994	9.753	0.009
	BW-LC	1.2857	0.346	0.0925			
Pair 4	HL-LF	10.4714	3.7045	0.9908	0.984	2.226	0.044
	HL-LC	10.9929	3.0745	0.8217			
Pair-5	HH-LF	5.1857	1.3049	0.3487	0.992	2.788	0.00
	HL-LC	4.0571	1.3138	0.3504			
Pair 6	REH-LF	1.0071	0.6855	0.18321	0.582	2.113	0.008
	REH-LC	1.3071	0.6538	0.18213			
Pair 7	WM-LF	2.5512	0.5081	0.1357	0.985	0.747	0.001
	WM-LC	1.4018	0.5306	0.1418			
Pair 8	CPL-LF	2.3286	0.2367	0.0632	0.995	3.307	0.000
	CPL-LC	1.8714	0.1898	0.0507			
Pair 9	CPW-LF	1.4511	0.3937	0.1052	0.998	2.706	0.000
	CPW-LC	1.2571	0.4013	0.1072			
Pair 10	CFH-LF	8.3357	1.8624	0.4977	0.987	8.21	0.000
	CFH-LC	1.0571	0.36314	0.0975			

SD = standard deviation, r^2-regression co-efficient with highly positive correlation at 0.9 and correlation in >0.5, r-Pearson's correlation co-efficient with significant at P<0.05 and highly significant at P<0.01. Univariate statistics (ANOVA) for testing differences among variables such as F and P- value probability at P<0.01 and P<0·001.

Plate 1a *Labeo calbasu* landed along the lower stercthes of Tamiraparani river

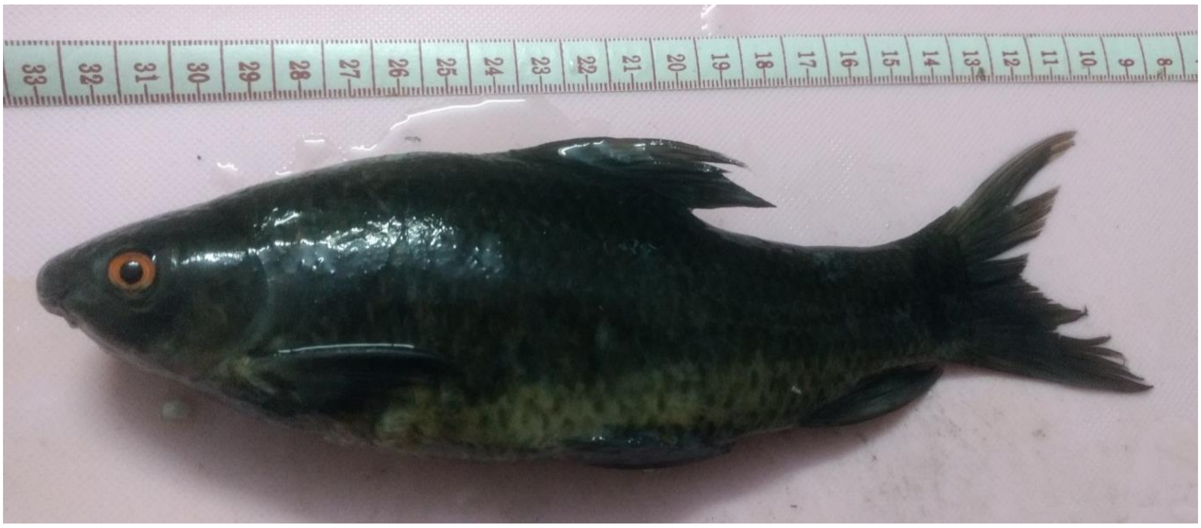


Plate 1b *Labeo fimbriatus* landed along the lower stercthes of Tamiraparani river

V. DISCUSSION

In the present study, *Labeo fimbriatus* and *Labeo calbasu* were collected and recorded in lower stretches of Tamiraparani river in Thoothukudi and Tirunelveli districts. In which three sampling sites such as Manimuthar, Srivaikundam, Tirunelveli were selected and with the help of inland fisher folk speciemens were collected. The specimens were analysed for biology and stock assessment studies, taxonomy, biology, population dynamics and stock assessment of *L. fimbriatus* and *L. calbasu* are discussed below.

5.1 Seasonal occurrence:

In general, both *L. fimbriatus* and *L. calbasu* were found available throughout the year**.** The peak landing was observed during the period from June,2017 to September,2017. Except during the rainy season, the landing was very less because of their nature of living habitat. Traditional fishing boats were used for fishing the *Labeo* spp. along the lower stretches of Tamiraparani river in Thoothukudi and Tirunelveli districts. In general Labeo spp. were found available in the lower stretches of the water, as their favourite habitat are deep pools of rivers where largely remains localized. During the winter and summer months, they ascend to adjacent shallower region of the river for breeding during monsoon months (Chondar, 1999). The landings of the *L. fimbriatus* and *L. calbasu* varied in region wise as well as seasonally.

Earlier studies suggest that *L. calbasu* has been available throughout in India (Day, 1878; Talwar and Jhingran, 1991; Chondar, 1999). Talwar and Jhingran, 1991 revealed that *L. fimbriatus* is mainly distributed in rivers and reservoirs of peninsular India and Eastern Ghats. The present study reveals that

Labeo spp. stock starts accumulating in the river during the month of June to September and after monsoon the stock disperse along the lower stretches of the Tamiraparani River.

5.2 Length - weight relationship:

The length-weight relationship of an ideal fish precisely follow the cube law and the value of exponent 'b' will become exactly 3 if the fish retains the same shape and specific gravity and grows iso-metrically during their life time. Allen (1938) reported that such an ideal fish with 'b' value 3 is very difficult to observe in the natural environment. In other words, a majority of fishes for which length-weight relation ship were calculated in the past, 'b' value was less than or greater than 3, representing negative or positive allometric growth, respectively. The change in the 'b' value mostly reflects the change in the body form when the weight of the fish affected by environmental factors likes temperature, food supply, and spawning condition.

Length-weight relationship of *Labeo rohita* (Jhingran, l952), *Labeo calbasu* (Pathak, 1975), *Labeo fimbriatus* (Rajanna, 2015) exhibit positive allometeric growth patterns. All these earlier reports are in compliance with the present findings while *L. fimbriatus* and *L. calbasu* were very close to the isometric value, *L. fimbriatus* and *L. calbasu* had a 'b' value of 2.815 & 2.1665 respectively. Slope value of less than '3' has been reported in the study. It showed negative allometric growth pattern. which is similar to the earlier reports of Haroon *et al*., 2002 and Rajanna,2015 in Karnataka, *Labeo dero* (Malhotra and Chauhan,l984), *Labeo dyocheilus* (Malhotra, l985).Females of *Puntius carnaticus* were found to surpass males in weight in relation to length as evidenced from the disparity in ‘b’ values. Similar trend was observed in other cyprinids too viz., *Puntius kolus* (Bhatnagar, l963), *Labeo fimbriatus* (Bhatnagar, l972). Where Pathak, 1975; Alam,2000; Singh, 2006 exhibited the positive allometric growth along the Ganga River and Loni reservoir respectively.

In present study maximum size of *L. fimbriatus* observed was 305 mm TL and 523.05 gm which is lower than the earlier report of Rajanna, 2015. While in *L. calbasu* the maximum size observed was 420 mm TL with 467.05 gm which is lower than the earlier report of Talwar and Jhingran, 1991; Rao and Rao, 1972.

5.3 Relative condition factor:

Individual variations from general length-weight relationship have been studied under general name ‘condition’ (Le Cren, l95l) such changes were usually analysed by means of condition factor ‘K-factor’ given by the formula K=100W/L3 (Hile, 1948), often it has been used to indicate the condition, fastness or general well-being of the fish. The value of Kn gets directly affected, if the fish does not obey the cube law. Le Cren (l95l) suggested that the calculation of relative condition factor (Kn), based on the length-weight relationship in order to eliminate the effects of the length and other factors such as age, sex, maturity, feeding intensity and selection in sampling on condition factor.

In the present study the data on seasonal variation in the condition of both male and female showed that the values were more or less similar in both the sexes, thus indicating almost identical metabolic activity. The high condition exhibited by both the sexes in *L. calbasu* during September (Kn = 1.4593 for male and female 1.5120) may be due to gonadal development and high feeding intensity. In *L. fimbriatus* the high K value exhibit both the sexes in November (Kn= 1.05231 and 1.13210 for male and female) Mature gonads appearing conspicuously from June onwards will further support and increase the Kn values. Thus available data suggest that the monthly variation in Kn values may be related to maturity or feeding intensity. It is also possible that some unknown factors may also be playing a role. The earlier report also has revealed the characters Fluctuations in the condition of the fish is related to reproductive cycle (Le Cren, l95l; Qayyum and Qasim, l964a), feeding rhythms (Hile, 1948; Qasim,1957),physicochemical factors of environment, age, physiological state of fish or some other unknown factors (Brown, l957; Kumar *et al*., 1979). Umesh *et al*.,(2012) observed an almost isometric pattern of growth in *L. rohita* and the condition factor values showed that it is in good condition or health and the condition existing was conducive for the feeding and optimum growth of fish.

In the present study the lowest Kn values was recorded for *L. calbasu* in February and January with the value of 0.07651 for male and 0.09234 for female. In the case of *L. fimbriatus* recorded in March with the value of male 0.7621 and 0.7986 for female which may be due to lowering of gonad weight or occurrence of immature and maturing fish as well as the decreased feeding intensity. Among other factors, which influence the co-efficient of condition are intensity of feeding, age and sex of the individuals (Everhart *et al.,* 1975), abundance and types of food available and physico-chemical characteristics of the environment. He observed that apart from seasonal variation, there could be a secondary variation related to the length of fish. However, with increase in age there could be a low level of condition through the seasonal cycle consequent upon the increased metabolic strain or spawning.

The fluctuations in the Kn values of this study with respect to size indicates that the condition of fish showed more or less an increasing trend with the increase in size of the fish. The highest Kn values in *L. calbasu* observed in male (320-380mm) and female (355-410 mm). In case of *L. fimbriatus* the increase in Kn value in male (250-280 mm) and female (245-310 mm), it can be inferred that the variation in the condition of *L. fimbriatus* and *L. calbasu* is due to feeding activity and probably other unknown factors. Renukadevi (2002) also related variation in Kn values to sexual cycle and feeding intensity as the known factors.

5.4 Food and Feeding Habit

The study of food and feeding habits of fishes is considered to be very important in fishery biology. Food is the main source of energy and plays a vital role in the life history of fishes. Nikolsky, 1963 was stated that the basic functions of life such as growth, development and reproduction take place at the expense of energy, which enters in to the organism in the form of food. Hyslop, 1980 reported that the feeding habits of fish and other animals based on analysis of stomach content has become a standard practice.

In the present study, based on gut content analysis of *L. calbasu* and *L. fimbriatus* found to be Herbi-omnivorous. The decayed organic matter and plant material are major food items in the food of *L. calbasu*, whereas in the stomach of *L. fimbriatus,* the decayed organic matter and diatom were the dominant food item. Mud and sand, semi digestive matter, rotifer, copepods, protozoans were also found in *L. calbasu* stomach in varying percentage. Mud and sand, decayed organic matter and algae are present in large quantities in the gut of both the species which indicates that the fish feeds at the bottom and in the pockets of shallow marginal areas. The inferiorly situated fringed lip helps in borrowing and feeding at the bottom. Jhingran (1991) also classified *Labeo fimbriatus* as bottom feeder. Similar observations were made by earlier workers Karamachandani and Pisolkar, (1967)

And also this present studied explained the greater percentage of both the fishes had stomachs with considerable food indicating active feeding during January to February. Moderate feeding was noticed during November and December. February month was found to be the active month of feeding during the entire study period. Poor feeding was observed during July to August and the percentage of empty stomach increased from June to August and decreased gradually after September. So it is evident that during the spawning season the feeding intensity was totally decreased and once the fishes complete the spawning process the feeding was rapidly increased. Bhatnagar and Karamchandani (1971) reported that the partial or even complete cessation of feeding was generally evinced in ripe and gravid fish during spawning season in *L. fimbriatus.*

Both *L. fimbriatus* and *L. calbasu* were found to have different feeding behaviour depending on the breeding and monsoon season in that present studied. Higher feeding intensity observed during the periods of May-June and September, might be attributed to the occurrence of spent fishes which tried to make good from the loss caused by the reduced rate of pre-spawning feeding and presence of immature individuals which require a rigorous feeding for the ensuring vitellogenesis for the subsequent breeding season. When compared to females the feeding intensity of males did not show much variation during pre-spawning and spawning periods. The low pre-spawning feeding intensity seen in females might be due to the pressure exerted on the alimentary canal by the voluminous ovary whereas in males, the testis do not grow much in size. But it appears that there exists a feeding rhythm in both males and females. A period of high feeding activity was found to alternate with a period of low feeding. Feeding intensity of fish has been related to maturity, spawning and the availability of food items (Malhotra, l967; Khan *et al*., l988; Gowda *et al*., 1988; Keshava and Joseph, l988; Geetha *et al*., l990; Das and Goswami, l997; Rao *et al*., 1998; Kiran and Waghray, l998; Pandian and Rahman, l999).

Fishes with actively fed (full, ¾ full and ½ full), poorly fed (¼ full and little) and empty stomachs were observed during most of the months. Both the sexes showed actively fed and poorly fed stomachs during 2017-18 which indicates that *L. fimbriatus and L. calbasu* were active feeder. The same studied done by previous authors said that, the emptiness percentage and stomach fullness indices are very important to assess feeding intensity (Prabha and Manjulatha, 2008). Feeding intensity is negatively related to the percentage of empty stomachs. Bowman and Bowman, 1980).The intestine of *L. calbasu* got enormously coiled.

5.5 Morphometric characters:

Morphometric characters play an important role in the identification of species and subspecies. Morphometric studies have been able to identify differences emphasizing them as helpful tools for the discrimination of fish populations by Jayaram (1981). And it plays an important role in the identification of species and subspecies.

During the present investigation, fifty different morphometric variable characters were taken to be analysed by both the *L. fimbriatus* and *L. calbasu,* where the significance, correlation co efficient calculated by paired ‘t’ test, and the result of ANOVA graph showed the variance with highly positive correlation.

Earlier studies also revealed the same level of correlation by Ramasamy.M and Rajangam.S, (2016) along the Cauvery river of Tamil Nadu. The variability in the morphometric and meristic characters of the adult calbasu recorded by the earlier workers including Jayaram (1981) are very negligent. The study revealed that *L. calbasu* and *L. gonius* showed differences with respect to morphological characteristics when collected from market from different geographical locations. Differences between the populations of the two species were based on the large number of morphological characteristics. In both the cases, characters that showed higher R-square value suggest that the population are a good model with respect to differences in the length of rostral barbel and maxillary barbel. The samples of *L. gonius* showed higher R-square values for interorbital distance, and snout length suggesting the influence of habitat differences between the populations. These characters are head related characters and feeding is a wellknown factor that influences head morphology (Hyndes *et al*., 1997). Thus, if different populations of a species show discordant pattern of head morphology, this is often due to the exploitation of different ecological niches. Specially, constrained by the availability and type of prey. These differences are based on physical characteristics of each habitat like water temperature, currents induced by geographical dissimilarities. All the body measurements observed exhibited a high degree of correlation coefficient and were significant (P<0001). A two factor ANOVA on all the body proportions individually suggested that almost all the parameters varied significantly, though there were different levels of variations in the two species for the different populations. The study of body proportions thus brings out a definite demarcation in the morphology and suggests that the stocks of the two species belong to different populations and not one. The statistics showed that the body proportions may not be due to the difference in the origin of the population but can also be due to some other reason. In present studies, also exhibit high level of positive correlation significant in both *L. fimbriatus* and *L. calbasu*.

5.6 Growth index

5.6.1 Gonado Somatic Index (GoSI)

The monthly changes in the GoSI reflect the ovarian activity of a fish. The dynamics of gonad maturation is a good tool to indicate the period during which females are capable of reproducing. GSI indicates gonadal development and maturity of fish which increases with the maturation of the fish and declines abruptly there after (Parameswarn *et al.,* 1974). Yeldan and Avsar,(2001) had also reported that GSI is widely used especially for the bony fishes in order to examine the spawning period because its value is directly related to the development of the gonad.

During, the present study period of June 2017 to May 2018 the GoSI values of *L. fimbriatus* ranged between 0.115 and 4.258. The lowest GoSI value was recorded in February, while, the highest in September. From June to August the GoSI values remained more or less constant and then from March to May there was a gradual increase in GSI from 0.8 to 1.9, and the result of *L. calbasu* GoSI values were ranged from 0.0732 to 1.732 with highest being in the month of November and December and lowest in June. A gradual increasing trend was recorded from March to May and a sharp increase in the month of October. The same study done by many authors of Mohammad and Pathak (2010) observed that the value of GoSI reached peak in the month of August, which indicated the spawning period of *L. rohita* and the estimation of GSI revealed that the fish spawned once in a year mainly from June to August. Rakesh (2013a) observed the maximum GoSI values for both the sexes of *L. dyocheilus* when the fish attained full maturity in the month of July. The fall in GoSI values was noticed during August indicating the completion of spawning of fish. In a similar study the GoSI was noticed in *L. rohita* (Alam and Pathak, 2010).

5.6.2 Gastro somatic Index (GaSI)

The present study revealed that GaSI of *L. calbasu* was calculated, the result shows highest record in December month followed by January minimum value noticed in the period of April month. Where in the case of *L. fimbriatus* was calculated the result shows highest record in September month followed by December, minimum value noticed in the period of July month. With this we can conclude planktonic green Algae and Diatom, which have been observed round the year in good quantity determine as a primary food. Secondary food (Sand and debris), occasional foods was Zooplankton. The basic food items were highest in the gut during winter season of October to December. The GaSI study concludes that the fish is herbi-omnivorous in nature and February is its favourable feeding month in both of the above species. It has also been reviewed that there is a variation of feeding intensity with the age of fish and is due to its gonadal maturation. This classification based on as per food quantity in the gut.

5.6.3 Hepato Somatic Index

Hepatosomatic index (HSI) has been often used as an indicator of energy status in relation to gonadal development and growth of fish. In the present study of HeSI, it showed the result in *L. fimbriatus* was high in October (1.760) and low in August (0.354), in the case of *L. calbasu* was high in January (2.5734) and low in April (0.0665). The HeSI showed negative relationship with GoSI in female of both the fishes of *L. fimbriatus* and *L. calbasu*. The same result obtained by the previous author of Singh, 2006 and Rakesh, 2013b.

5.7 Sex Ratio

Predominance of female was noticed throughout the study period and the pooled sex ratio (M:F) of *L. fimbriatus* was found to be 1:2 and *L. calbasu* was found to be sex ratio(M:F) of 1:3 which was significant at 5% level of significance. Chi-square values at 5% probability level showed no significant difference in the sex ratio during all the months including the pooled data. The same result was obtained by Rajanna,2015; Nikolsky (1956 and 1980); (Wely and Booth, 1999).

5.8 Growth parameter

A sound knowledge of the age and growth of fish species contributing to the fishery is essential in understanding, among others, the longevity of exploited stocks, the age composition of the stock, the age at sexual maturity, the sustainability of different environments for growth, other population dynamics and the possible identification of stocks on the basis of differences in growth rates. The present study revealed the following von-Bertanlanffy growth equation of *L.*

calbasu was Lt= 548.94 [1-$e^{-0.247}$(t - 0.4241)]. And in the case of *L. fimbriatus* was Lt= 323.22 [1-$e^{-0.108}$(t - 0.3241)].

The previous studies like Ramamohan (1976) studied the age and growth of *L. fimbriatus* from the river Godavari, Andhra Pradesh. He reported that this species grow to 172, 313, 390, 460 and 580 mm at the end of I year to V year. The von-Bertanlanffy growth parameter in length L∞ = 1090 mm, K= 0.1422/year and to= - 0.5091 years And Bhatnagar (1979) studied the age and growth of *L. fimbriatus* from river Narmada, the von-Bertalanffy growth parameters L∞ and K for the species were found to be 719.79 mm and 0.1827 per year, The von Bertalanffy equation for growth in length for this species was found to be Lt = 719.79[1-$e^{-0.1827}$ (t- 0.48)]. Anees *et al.* (2012) studied the of *L. calbasu* in the Riverine habitat, the von - Bertalanffy growth parameters L∞ and K for the species were found to be 667 mm and 0.249 per year, respectively. The von Bertalanffy equation for growth in length for this species was found to be Lt = 667 [1-$e^{-0.249}$ (t- 0.982)].

5.9 Mortality parameter

The present study inferred that the mortality parameter and the exploitation ratio for the *L. calbasu* and *L. fimbriatus* was 0.42 and 0.61.The total instantaneous mortality (Z) of *L. calbasu* and *L. fimbriatus* were 0.88 and 0.60 and the natural mortality (M) was 0.51 and 0.28 respectively. The fishing mortality of *L. calbasu* was (0.29) low where the fishing mortality of *L. fimbriatus* was (0.37). The estimated exploitation ratio of *L. calbasu* and *L. fimbriatus* were 0.42 and 0.61 respectively. The natural mortality obtained from the Pauly's method was low, which expected for a long lived fish.

In the case of previous studies, it also had a same results like total, natural and fishing mortality rates of *L. fimbriatus* were 0.60/year, 0.28/year and 0.37/year respectively. The estimated exploitation ratio (E) and exploitaion rate (U) for *L. fimbriatus* were 0.6793 and 0.426 respectively. And in the case of *L. calbasu* studied revealed that the total, natural and fishing mortality rates were 0.88/year, 0.51/year, 0.29/year respectively. The estimated exploitation ratio (E) and exploitaion rate (U) for *L. calbasu* were 0.4213 and 0.125 respectively. Based on the present condition of exploitation of the stock of *L. fimbriatus* from Vani Vilas Sagar Reservoir, the exploitation ratio (E) was 0.4793 (less than 0.5) indicating that the stocks are exploited below optimum level in recent years (Rajanna,2015).

Nurulamin *et al*. (2001) studied the population dynamics of *L. rohita* in Sylhet basin, Bangaledesh and the values for instantaneous total mortality (Z), natural mortality (M) and fishing mortality (F) coefficients and the exploitation rate (E) calculated were found to be 1.56, 0.73, 0.83 and 0.52 respectively.

In studies of Haroon *et al.* (2002); the total mortality was found to be 1.56 and 1.70 for *L. rohita*, 1.69 and 2.60 for *C. catla*, 1.64 and 2.89 for *L. calbasu.* The natural mortality was found to be 0.73 and 0.77 for *L. rohita*, 0.84 and 1.13 for *C. catla*, 0.88 and 1.18 for *C. mrigala* and 1.11 and 1.25 for *L. calbasu.* The fishing mortality was found to be 0.83 and 0.93 for *L. rohita*, 0.85 and 1.47 for *C. catla*, 0.76 and 1.27 for *C. mrigala* and 3.48 and 1.64 for *L. calbasu.* The contributing factors for variation in natural mortality could be due to the following factors such as spawning success, predation, diseases, pollution, environmental parameters and senility and the fishing mortality could be due to the following factors such as Fishing intensity, Fishing gears employed for exploitation, Recruitment pattern, Recruitment over fishing and Mesh size of the gear used.while same in the case of previous report in Exploitation rate was maximum (0.77) in the Ken compared to Paisuni (0.74) and minimum (0.56) in the Tons. *L. rohita* was over exploited in the Ken and the Paisuni compared with optimum exploitation in the Tons. The total mortality of *L. calabsu* varied from 1.86 to 0.98 yr^{-1} and the natural mortality was maximum in the Tons (0.68 yr^{-1}) and minimum (0.47 yr^{-1}) in the Ken. The fishing mortality was maximum(1.21 yr-^{1}) in the Paisuni compared to Tons (1.18 yr^{-1}) and the Ken (0.51 yr^{-1}). Exploitation rate was maximum (0.65) in the Paisuni compared to the Tons (0.63) and minimum (0.52) in the Ken. *L. calbasu* was over exploited in the Paisuni and the Tons, while optimally exploited in the Ken.

5.10 Virtual population analysis

The length structures virtual population analysis (VPA) helped to know the level of mortality on various length groups of *L. calbasu* and *L. fimbriatus* the present studies results of the fishing pressure on *L. calbasu* was more in the length group 248 mm to 310 mm and the natural mortality was seem to be low in the length group 120 mm onwards. For *L. fimbriatus* the fishing pressure is more in the length group 205 mm to 310 mm and the natural mortality seem to low in the length group 128 mm onwards. The natural mortality was observed high in the small size length group in both species. The same results showed by the following previous authors Ramamohan (1976); Nurulamin *et al*. (2001); (Rajanna,2015); Anees *et al.* (2012).

5.11 Total stock, annual stock and exploitation rate

In that present study, the total stock of *L. calbasu* and *L. fimbriatus* were estimated at 27.18 tonnes and 13.61 tonnes with annual catch being 7.2 tonnes and 5.8 tonnes against the annual stock of 8.10 tonnes and 6.15 tonnes at the exploitation rate of 0.125 and 0.426 respectively. The same studied done by *Labeo dero* (Malhotra and Chauhan,l984); *Labeo dyocheilus* (Malhotra, l985); *Labeo fimbriatus* (Bhatnagar, l972); *Labeo rohita* Umesh *et al*. (2012).

5.12 Conservation status

Both *L. fimbriatus* and *L. calbasu* are very common fish throughout India and in adjacent countries. Until now, those species population trends are exactly not known. Yet, the wild population of this species could be declining due to heavily harvested. However, no quantitative data are available turn over now. Presently, *L. calbasu* is regarded as in danger of extinction in India and Bangladesh (IUCN Bangladesh. 2000) one to need for and therefore there is an immediate need to protect and conserve it. One of the major actions to setup the Barnai River in Bangladesh this species *L. calbasu* was announced as the endangered one.

Based on IUCN categories (2015,Version.2), the CAMP Workshop (Molur & Walker,1998) reported *L. fimbriatus* was Threatened *category* and *L. calbasu* was LRnt (Least Concern and Near Threatened). In previous author reports Ramasamy.M and Rajangam.S, 2016 and IUCN,2014 said that *L. calbasu* under vulnerable status in Cauvery river of Tamilnadu. Gopi *et.al.,*2017 report showed that both the species were under Least concern(Nt) categories. Dahanukar, 2013 reported that *L. fimbriatus* was vulnerable species in India. Karl *et.al.,* 2006 said that *L.calbasu* was moderately abundant in north eastern India.

5.11 Conservation management

Conservational measures, includes stopping the illegal fishing, dynamiting, poisoning, identifying crucial breeding habitats and creating mass awareness are need to save the threatened fish fauna in lower stretches of Tamiraparani River. Without these efforts existing freshwater fish species would become endangered or even extinct in particular area.

Raising awareness and actively conserving species through conservational programmes along with local stakeholders including scientific communities will pave the way for protection of resources for future generations without causing detrimental to the stocks availed in the particular area. Several programmes such as species enhancement, stock enhancement, environmental enhancement, culture based capture fisheries, cage and pen culture installation also floor the root cause of the stock rejuvenation in inland waters.

VI. SUMMARY AND CONCLUSION

The present investigation was carried out to study the biology and stock assessment of the *Labeo fimbriatus* and *Labeo calbasu* along the lower stretches of Tamiraparani river in Thoothukudi and Tirunelveli districts in Tamil Nadu from June, 2017 to May, 2018. The salient findings of the present study are as follows:

- The length - weight relationship of *L. fimbriatus* and *L. calbasu* revealed that both the species exhibited a negative allometric growth. The length - weight relationship established for *L.calbasu and L.fimbriatus* were;

  $$W = 0.0999\ L^{2.1655}$$

  $$W = 0.0394\ L^{2.8185}$$

- The stomach content analysis of the *L. fimbriatus* and *L. calbasu* indicated that both the species are Herbi-Ominivorous in nature.
- The index of preponderance for *L. fimbriatus* and *L. calbasu* indicated that the diatoms form the major food item followed by decayed organic matter
- The index of preponderance for *L. calbasu* revealed rare occurrence of rotifers, copepods and protozoans.
- The sex ratio of female and male of *L. fimbriatus* and *L. calbasu* was 1: 2 and 1: 3. The Chi-square test revealed that the difference was significant at 5% level.
- Fifty different morphometric variable characters were studied for both the *L. fimbriatus* and *L. calbasu,* among that ten characters are the significance, correlation were estimated using by paired ‘t’ test and the result of ANOVA showed the significant variance between *L.calbasu* and *L.fimbriatus* respectively.

- The von Bertalanffy growth equation of *L. fimbriatus* and *L. calbasu* are:

$$Lt= 323.22\ [1-e^{-0.108}(t - 0.3241)]$$

$$Lt= 548.94\ [1-e^{-0.247}(t - 0.4241)]$$

- The total instantaneous mortality co-efficient (Z) of *L. fimbriatus* and *L. calbasu* was 0.60 and 0.88 and natural mortality (M) was 0.28 and 0.51 respectively.
- The exploitation rate (F/Z) *L. fimbriatus* was 0.62 and *L. calbasu* was 0.33. The exploitation rate estimate indicates that *L. calbasu* was under exploited but in the case of *L. fimbriatus*, it reaches exploitation stage along the lower stretches of Tamiraparani river.
- Virtual Population analysis of these two species revealed variation in the mortality levels of different length groups. The natural mortality was high in the length group less than 200 mm for both the species.
- Present study indicates that the higher natural mortality was observed in lower length groups whereas higher fishing mortality was observed in larger length groups of both the species.
- The CPUE was found to be high in the month of June, and July, 2017 for both the species and the second peak on CPUE was observed during the month of September and October, 2017 for *L. calbasu* whereas for *L.fimbriatus* second high peak on CPUE was observed during month of August, 2017 and February, 2018
- The present catch of the *L. calbasu* was lesser than the estimated MSY which indicates that the stocks of these species were underexploited but in the case of *L. fimbriatus* the catch it was higher than the estimated MSY

which indicates it reaches over exploiting stage along the lower stretches of Tamiraparani river.

- From the study, it could be understand that, the present fishing effort leads sustainably exploit of *L. calbasu*. Effort in terms of boat days as well as optimizing the mesh size of gill net for conserving the resources of *L.fimbriatus*.

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7.2 APPENDICES

TABLE -1 ANNUAL REPORT ON MORPHOLOGICAL PARAMETER ANALYSIS OF *LABEO FIMBRIATUS* (JUNE, 2017-MAY, 2018)

Annual Report on Morphological Parameter Analysis of*Labeofimbriatus* (June, 2017 to May, 2018)															
S. no	Variables	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	Length ranges	
														Minimum	Maximum
1	Standard Length [SL]	22.8	22	23.8	24.2	25.1	25.8	24.7	7.8	8.1	9.2	10.8	11.6	7.8	25.8
2	Body Height [BH]	5.5	5.8	6.3	6.7	7.4	7.9	6.1	3.2	3.8	4.2	4.8	5.3	3.2	7.9
3	Mean Body Height [MBH]	6.2	6.9	7.4	8.7	9.7	8.1	6.7	2.5	3.1	4.5	4.8	5.4	2.5	8.1
4	Body Width [BW]	2.2	2.3	2.4	2.5	2.6	2.9	2.7	1.9	1.9	2	2	2	2	2.9
5	Head Length [HL]	9.6	10.8	11.3	12.4	13	16.2	15.3	6.1	6.4	7.2	7.8	8.2	6.1	16.2
6	Head Width [HW]	1.2	1.4	1.2	1.5	1.9	2.4	1.8	1	1	1	1.2	1.2	1	2.4
7	Head Depth at Nostril [HDN]	1	1	1.1	12	1.3	1.5	1.3	0.9	1	1	1	1	0.9	1.1
8	Head Depth at Pubil [HDP]	0.9	0.9	0.9	0.9	0.9	1	0.9	0.7	0.7	0.7	0.7	0.8	0.7	1
9	Head Depth at Occiput [HDO]	1.9	1.9	1.9	2	2	2.2	2	1.1	1.5	1.8	1.8	1.8	1.1	2.2
10	occiput to dorsal orgin(ODO)	1.8	1.9	2	2	2.1	2.2	2	1.4	1.5	1.6	1.8	1.7	1.4	2.2
11	occiput to pectoral orgin(OPO)	0.6	0.7	0.75	0.7	0.7	0.8	0.6	0.1	0.2	0.3	0.4	0.5	0.1	0.8
12	Pre Orbital Length [POL]	1	1	1	1	1.2	1.3	1	0.9	0.9	1	0.9	1	0.9	1.3
13	Post Orbital Length [PTOL]	1	1	1	1	1	1.1	1	0.8	0.8	0.8	0.9	1	0.8	1
14	Head Height [HH]	5	5.4	5.8	6.3	6.6	6.8	6.4	3.3	3.5	4.1	4.5	4.8	3.3	6.8
15	Relative Eye Height [REH]	0.7	0.9	1.4	1.7	1.9	2	1.2	0.5	0.5	0.2	0.2	0.7	0.2	2
16	Inter Orbital Width [IOW]	1	1	1.3	1.4	1.8	1.8	1.2	0.9	0.9	0.9	1	1	0.9	1.8
17	Pre Nasal Length [PNL]	0.9	1	1	1	1	1.1	1	0.7	0.8	0.8	0.8	0.8	0.7	1.1
18	Inter Nostril Width [INW]	1	1	1	1.2	1.2	1.3	1.2	0.9	1	1	1	1	0.9	1.3

19	Upper Jaw Length [UJL]	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.6
20	Lower Jaw Length [LJL]	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.5
21	Maxillary Barbel Length [MxBL]	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.9
22	Mandible Barbel Length [MnBL]	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
23	Maximum Body Width [MBW]	4	4.1	4.3	4.3	4.5	4.5	4.2	3.1	3.4	3.6	3.8	4	3.1	4.5
24	Dorsal Fin Length [DFL]	3.8	3.8	4	4	4.1	4.2	4	2.3	2.8	3.1	3.3	3.7	2.3	4.2
25	Pectoral Fin Height [PFH]	3	3	3	3.1	3.1	3.2	3	2.1	2.4	2.6	2.8	2.8	2.1	3.2
26	Pectoral Fin Width [PFW]	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.7	0.6	0.8
27	Pectoral Fin length [PFL]	4.8	5	5.2	5.3	5.4	5.4	5	3	3.5	3.8	4.3	4.5	3	5.4
28	Ventral Fin Height [VFH]	2.7	2.7	2.8	2.8	2.8	2.8	2.7	2.2	2.3	2.4	2.5	2.6	2.2	2.8
29	Anal Fin Height [AFH]	2.7	2.7	2.9	3	3	3.1	3	2.2	2.3	2.4	2.5	2.6	2.2	3.1
30	Pre Dorsal Distance [PDD]	5.1	5	5.4	5.9	6.6	6.9	5.5	4.7	4.9	5	5	5.1	4.7	6.9
31	Post Dorsal Distance [PoDD]	4.6	4.6	4.8	5.3	5.5	5.7	5.5	3.1	3.5	3.9	4.1	4.5	3.1	5.7
32	Pre Pectoral Distance [PPD]	3.1	3.2	3.3	3.2	3.3	3.3	3	2.1	2.3	2.5	2.8	3	2.1	3.3
33	Pre Ventral Distance [PVD]	5	5.2	5.4	5.6	5.8	5.9	5.8	4	4.2	4.4	4.6	4.8	4	5.9
34	Pre Anal Distance [PAD]	8.8	9	9.4	9.8	10.4	10.8	9.5	6.7	7.1	7.8	8.2	8.7	6.7	10.8
35	Width of Mouth [WM]	2.6	2.8	2.9	2.7	3	3.2	3.1	1.9	1.9	2	2.1	2.4	1.9	3.2
36	Height of Mouth [HM]	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.8
37	Lower Jaw to Isthumus [LJI]	1	1	1.1	1.1	1.1	1.2	1	0.7	0.7	0.7	0.8	0.9	0.7	1.2
38	Dorsal Fin Base Length [DFBL]	2.3	2.3	2.3	2.3	2.4	2.6	2.4	1.9	2	2	2	2.1	1.9	2.6
39	Pectoral Fin Base Length [PFBL]	0.6	0.6	0.7	0.7	0.8	0.8	0.7	0.4	0.4	0.5	0.5	0.6	0.4	0.8
40	Ventral Fin Base Length [VFBL]	0.7	0.8	0.8	0.9	0.9	1	0.8	0.5	0.5	0.5	0.6	0.7	0.5	1
41	Anal Fin Base Length [AFBL]	0.7	0.8	0.	0.9	1	1.1	1	0.6	0.6	0.6	0.7	0.8	0.6	1.1

				8											
42	Dorsal Orgin to Anal Orgin [DOAO]	3.1	3.2	3.2	3.4	3.6	3.7	3.6	1.6	1.9	2.4	2.6	2.6	1.6	3.7
43	Dorsal Orgin to Ventral Orgin [DOVO]	3.4	3.7	3.7	3.8	4	4.1	4	2.2	2.4	2.8	3	3.2	2.2	4.1
44	Ventral Orgin to Anal Orgin [VOAO]	3.9	4	4	4	4.1	4.1	4	3.7	3.7	3.7	3.8	3.8	3.7	4.1
45	Cadual Peduncle Length [CPL]	2.4	2.4	2.5	2.5	2.6	2.6	2.5	2	2	2.1	2.2	2.2	2	2.6
46	Cadual Peduncle Width [CPW]	1.4	1.4	1.6	1.8	1.9	2	1.8	1	1	1	1.2	1.2	1	2
47	Cadual Peduncle Height [CPH]	1	1.2	1.3	1.4	1.4	1.5	1.4	0.6	0.6	0.7	0.8	0.8	0.6	1.5
48	Cadual Fin Length [CFL]	3.8	3.8	3.9	4	4	4.1	4	2.9	2.8	3	3.4	3.6	2.9	4.1
49	Cadual Fin Height [CFH]	8.2	8.7	9.2	9.8	10.4	10.7	10.2	5.7	6.4	6.9	7.3	6.8	5.7	10.7
50	Total Length [TL] -cm	26.5	26	27.2	28	29.8	30.5	30	11.9	12.4	14.8	23.5	25.3	11.9	30.5

TABLE-2 MERESTIC CHARACTERS OF LABEO FIMBRIATUS

S.no	Merestic characters of *Labeofimbriatus*	Minimum	Maximum
1	Dorsal fin rays	15	19
2	Dorsal fin spine	0	0
3	Pectoral fin rays	14	15
4	Pectoral fin spine	0	0
5	Gill rakers	27	41
6	Anal fin rays	4	5
7	Ventral fin rays	7	8
8	Pre dorsal scales	12	18
9	Pre anal scales	22	28
10	Lateral line scales	42	47
11	Circumpendicular scales	19	24

TABLE-3 ANNUAL REPORT ON MORPHOLOGICAL PARAMETER ANALYSIS OF *LABEO CALBASU (*JUNE, 2017-MAY,2018)

Annual Report on Morphological Parameter Analysis of *Labeocalbasu (June 2017-May 2018)*															
S.no	Variables	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	Length ranges	
														Min	Max
1	Standard Length [SL]	21.5	24.3	27.8	34.7	36.8	38.1	36.3	123.4	14.5	16.7	18.5	20.2	14.5	38.1
2	Body Height [BH]	5.5	5.8	6.3	6.7	7.4	7.9	6.1	3.2	3.8	4.2	4.8	5.3	3.2	7.9
3	Mean Body Height [MBH]	6.2	6.9	7.4	8.7	9.7	8.1	6.7	2.5	3.1	4.5	4.8	5.4	2.5	8.1
4	Body Width [BW]	1.2	1.3	1.4	1.5	1.6	1.8	1.7	0.9	0.9	1	1	1	0.9	1.8
5	Head Length [HL]	10.2	11.5	12.6	13.4	14	15.1	14.3	7	7.5	8.2	8.8	9.2	7	15.1
6	Head Width [HW]	1.2	1.4	1.2	1.5	1.9	2.4	1.8	1	1	1	1.2	1.2	1	2.4
7	Head Depth at Nostril [HDN]	1	1	1.1	12	1.3	1.5	1.3	0.9	1	1	1	1	0.9	1.1
8	Head Depth at Pubil [HDP]	0.9	0.9	0.9	0.9	0.9	1	0.9	0.7	0.7	0.7	0.7	0.8	0.7	1
9	Head Depth at Occiput [HDO]	1.9	1.9	1.9	2	2	2.2	2	1.1	1.5	1.8	1.8	1.8	1.1	2.2
10	occiput to dorsal Orgin(ODO)	1.8	1.9	2	2	2.1	2.2	2	1.4	1.5	1.6	1.8	1.7	1.4	2.2
11	occiput to pectoral Orgin(OPO)	0.6	0.7	0.75	0.7	0.7	0.8	0.6	0.1	0.2	0.3	0.4	0.5	0.1	0.8
12	Pre Orbital Length (or)Snout Length [POL] or [SL]	1	1	1	1	1.2	1.3	1	0.9	0.9	1	0.9	1	0.9	1.3
13	Post Orbital Length [PtOL]	1	1	1	1	1	1.1	1	0.8	0.8	0.8	0.9	1	0.8	1
14	Head Height [HH]	3.8	4.1	4.4	4.9	5.6	5.8	5.5	2.2	2.5	3.1	3.4	3.5	2.2	5.8
15	Relative Eye Height [REH]	1	1.2	1.7	2	2.2	2.3	1.5	0.8	0.8	0.5	0.5	1	0.5	2.3
16	Inter Orbital Width [IOW]	1	1	1.3	1.4	1.8	1.8	1.2	0.9	0.9	0.9	1	1	0.9	1.8
17	Pre Nasal Length [PNL]	0.9	1	1	1	1	1.1	1	0.7	0.8	0.8	0.8	0.8	0.7	1.1
18	Inter Nostril Width [INW]	1	1	1	1.2	1.2	1.3	1.2	0.9	1	1	1	1	0.9	1.3
19	Upper Jaw Length [UJL]	0.5	0.5	0.5	0.6	0.6	0.6	0.	0.4	0.4	0.4	0.4	0.4	0.4	0.6

								6							
20	Lower Jaw Length [LJL]	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.5
21	Maxillary Barbel Length [MxBL]	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.9
22	Mandible Barbel Length [MnBL]	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
23	Maximum Body Width [MBW]	4	4.1	4.3	4.3	4.5	4.5	4.2	3.1	3.4	3.6	3.8	4	3.1	4.5
24	Dorsal Fin Length [DFL]	3.8	3.8	4	4	4.1	4.2	4	2.3	2.8	3.1	3.3	3.7	2.3	4.2
25	Pectoral Fin Height [PFH]	3	3	3	3.1	3.1	3.2	3	2.1	2.4	2.6	2.8	2.8	2.1	3.2
26	Pectoral Fin Width [PFW]	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.7	0.6	0.8
27	Pectoral Fin length [PFL]	4.8	5	5.2	5.3	5.4	5.4	5	3	3.5	3.8	4.3	4.5	3	5.4
28	Ventral Fin Height [VFH]	2.7	2.7	2.8	2.8	2.8	2.8	2.7	2.2	2.3	2.4	2.5	2.6	2.2	2.8
29	Anal Fin Height [AFH]	2.7	2.7	2.9	3	3	3.1	3	2.2	2.3	2.4	2.5	2.6	2.2	3.1
30	Pre Dorsal Distance [PDD]	5.1	5	5.4	5.9	6.6	6.9	5.5	4.7	4.9	5	5	5.1	4.7	6.9
31	Post Dorsal Distance [PoDD]	4.6	4.6	4.8	5.3	5.5	5.7	5.5	3.1	3.5	3.9	4.1	4.5	3.1	5.7
32	Pre Pectoral Distance [PPD]	3.1	3.2	3.3	3.2	3.3	3.3	3	2.1	2.3	2.5	2.8	3	2.1	3.3
33	Pre Ventral Distance [PVD]	5	5.2	5.4	5.6	5.8	5.9	5.8	4	4.2	4.4	4.6	4.8	4	5.9
34	Pre Anal Distance [PAD]	8.8	9	9.4	9.8	10.4	10.8	9.5	6.7	7.1	7.8	8.2	8.7	6.7	10.8
35	Width of Mouth [WM]	1.4	1.6	1.7	1.8	1.9	2.1	1.8	0.7	0.7	0.9	0.9	1.3	0.7	2.1
36	Height of Mouth [HM]	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.8
37	Lower Jaw to Isthmus [LJI]	1	1	1.1	1.1	1.1	1.2	1	0.7	0.7	0.7	0.8	0.9	0.7	1.2
38	Dorsal Fin Base Length [DFBL]	2.3	2.3	2.3	2.3	2.4	2.6	2.4	1.9	2	2	2	2.1	1.9	2.6
39	Pectoral Fin Base Length [PFBL]	0.6	0.6	0.7	0.7	0.8	0.8	0.7	0.4	0.4	0.5	0.5	0.6	0.4	0.8
40	Ventral Fin Base Length [VFBL]	0.7	0.8	0.8	0.9	0.9	1	0.8	0.5	0.5	0.5	0.6	0.7	0.5	1
41	Anal Fin Base Length [AFBL]	0.7	0.8	0.8	0.9	1	1.1	1	0.6	0.6	0.6	0.7	0.8	0.6	1.1
42	Dorsal Orgin to Anal Orgin [DOAO]	3.1	3.2	3.2	3.4	3.6	3.7	3.6	1.6	1.9	2.4	2.6	2.6	1.6	3.7
43	Dorsal Orgin to Ventral Orgin	3.4	3.7	3.7	3.8	4	4.1	4	2.2	2.4	2.8	3	3.2	2.2	4.1

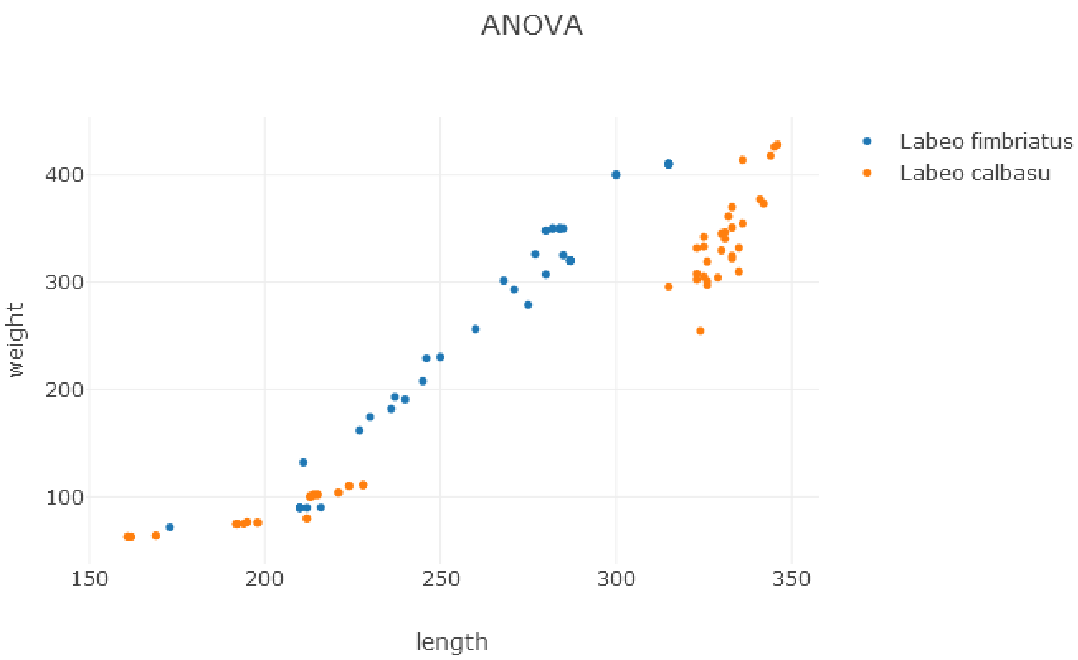
	[DOVO]														
44	Ventral Orgin to Anal Orgin [DOAO]	3.9	4	4	4	4.1	4.1	4	3.7	3.7	3.7	3.8	3.8	3.7	4.1
45	Caudal Peduncle Length [CPL]	1.9	1.9	2	2	2.1	2.1	2	1.6	1.6	1.7	1.8	1.8	1.6	2.1
46	Caudal Peduncle Width [CPW]	1.2	1.2	1.4	1.6	1.7	1.8	1.7	0.8	0.8	0.8	1	1	0.8	1.8
47	Caudal Peduncle Height [CPH]	1	1.2	1.3	1.4	1.4	1.5	1.4	0.6	0.6	0.7	0.8	0.8	0.6	1.5
48	Caudal Fin Length [CFL]	3.8	3.8	3.9	4	4	4.1	4	2.9	2.9	3	3.4	3.6	2.9	4.1
49	Caudal Fin Height [CFH]	6.2	6.7	7.2	7.8	8.4	8.7	8.2	3.7	4.4	4.9	5.3	5.8	3.7	8.7
50	Total Length [TL] - cm	25.8	28.5	31.2	38.9	40.8	42	40.1	12.7	18.9	20.4	22.8	24.3	46.2	15.2

TABLE 4 MERESTIC CHARACTERS OF LABEO CALBASU

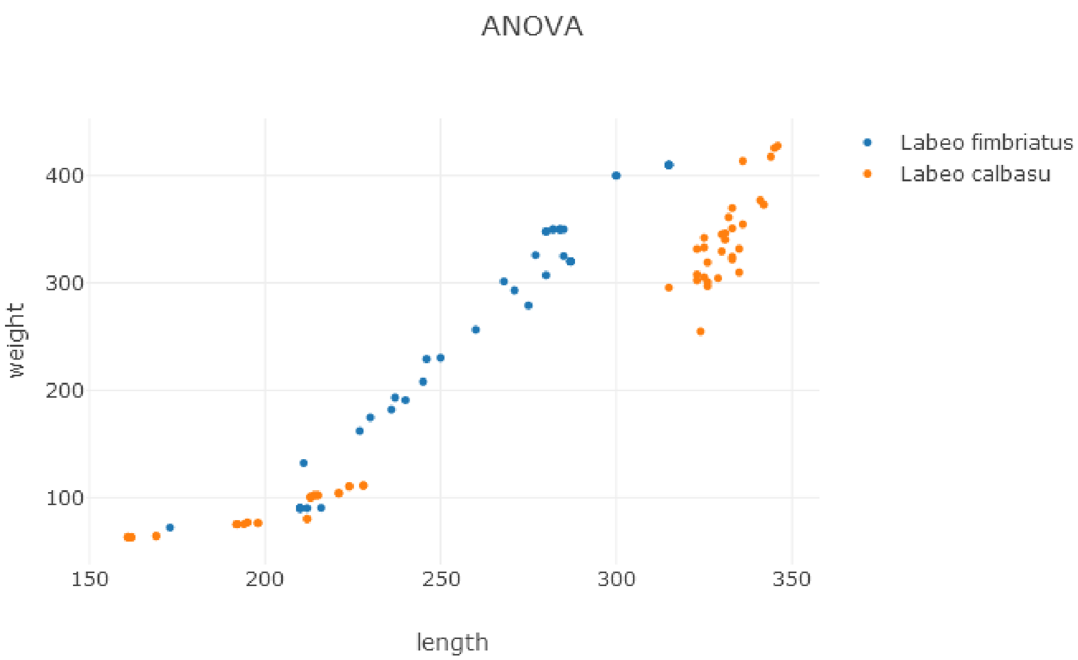
S.no	Merestic characters of *Labeocalbasu*	Minimum	Maximum
1	Dorsal fin rays	14	16
2	Dorsal fin spine	0	0
3	Pectoral fin rays	13	15
4	Pectoral fin spine	0	0
5	Gill rakers	19	36
6	Anal fin rays	6	8
7	Ventral fin rays	8	9
8	Pre dorsal scales	19	21
9	Pre anal scales	21	25
10	Lateral line scales	36	38
11	Circumpendicular scales	16	18

Length weight relationship for *L.fimbriatus* and *L.calbasu*

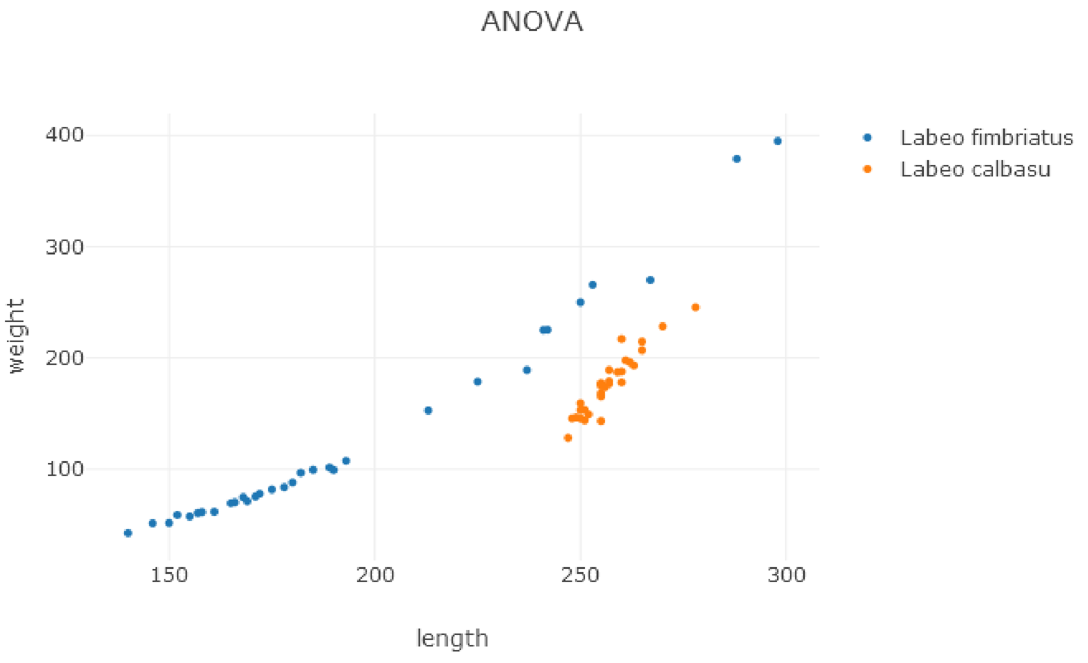
June -17-2017



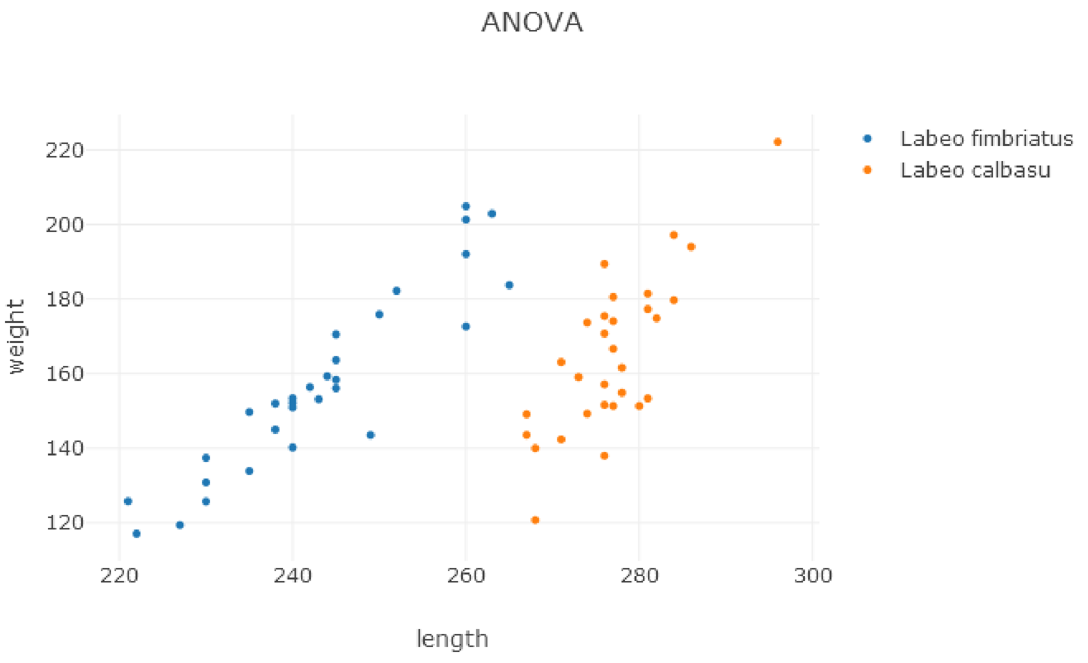
July 17-2017



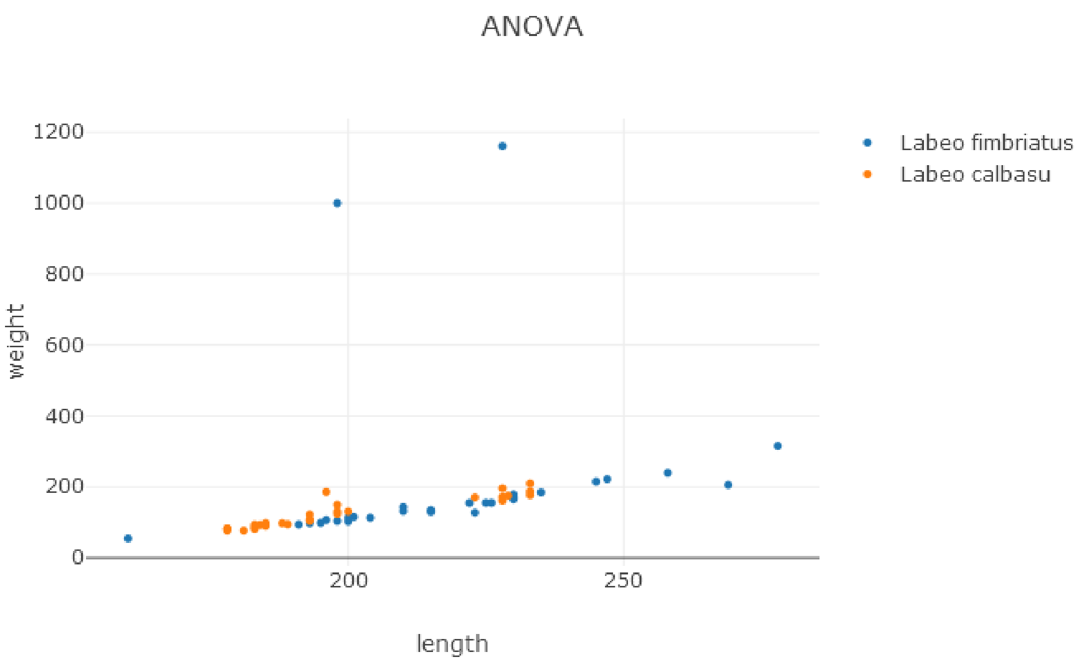
August 17-2017



September 17-2017



October 17-2017



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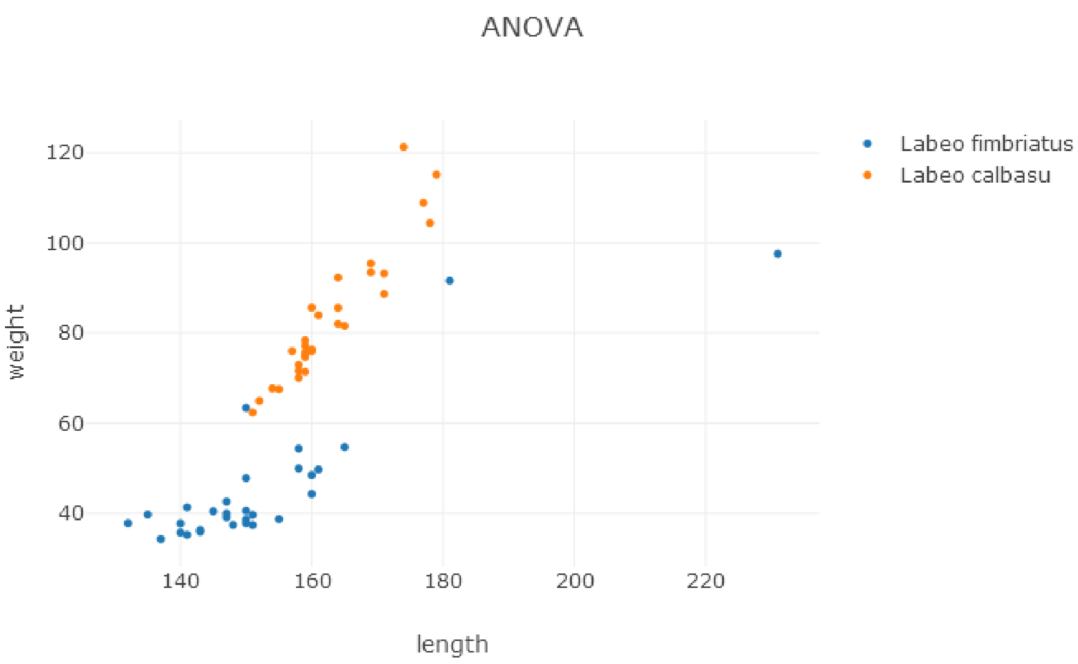

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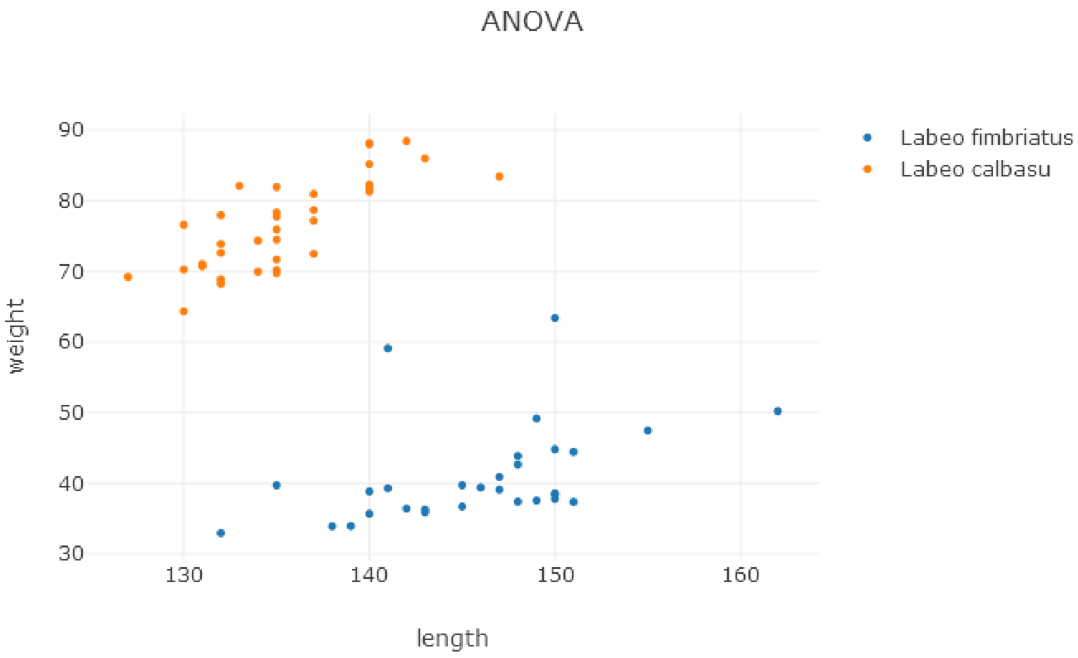
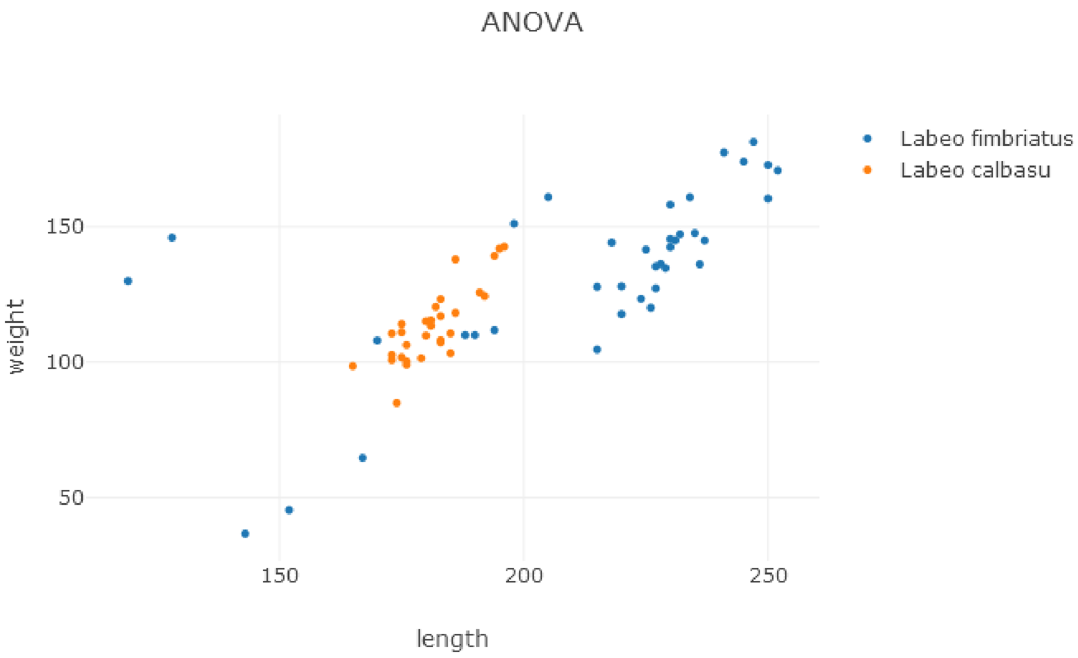
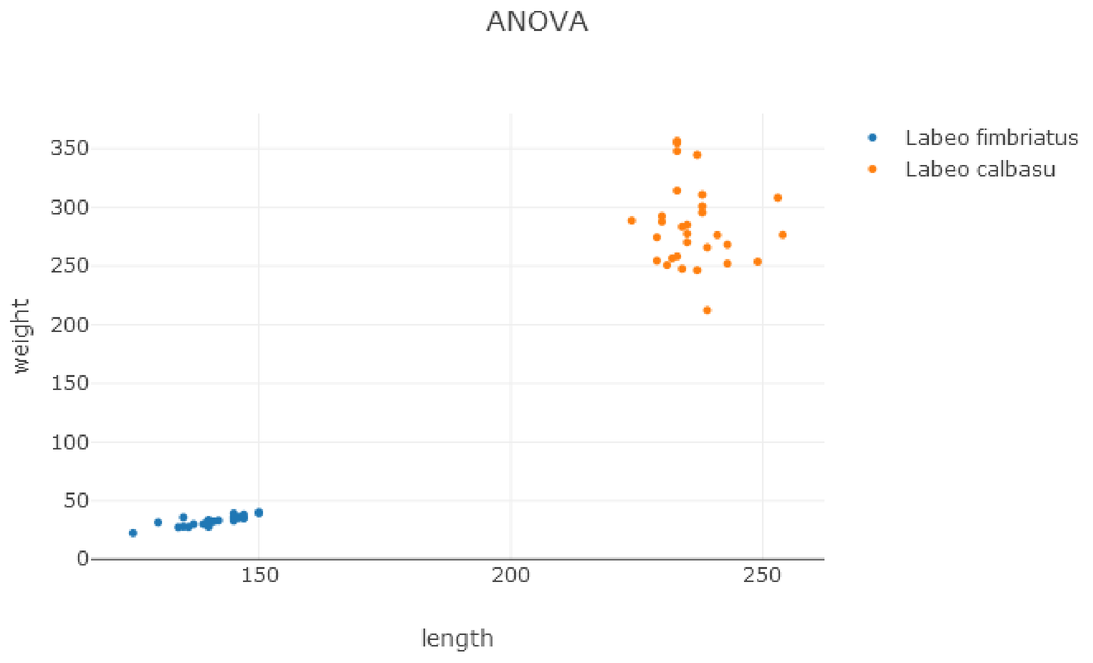


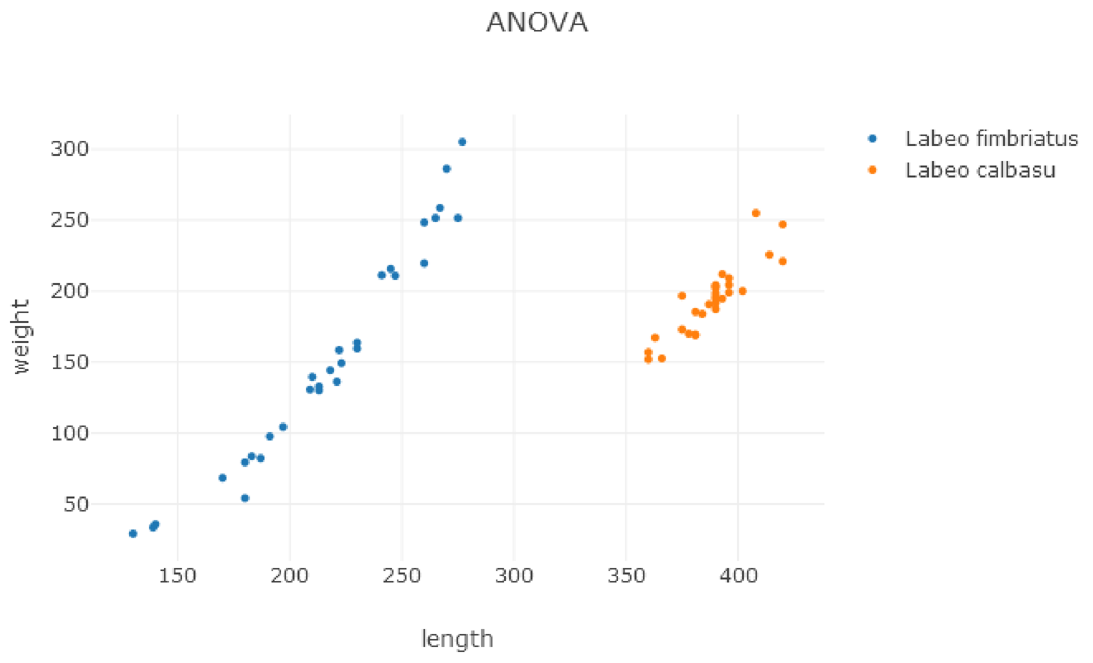
January 17-2018



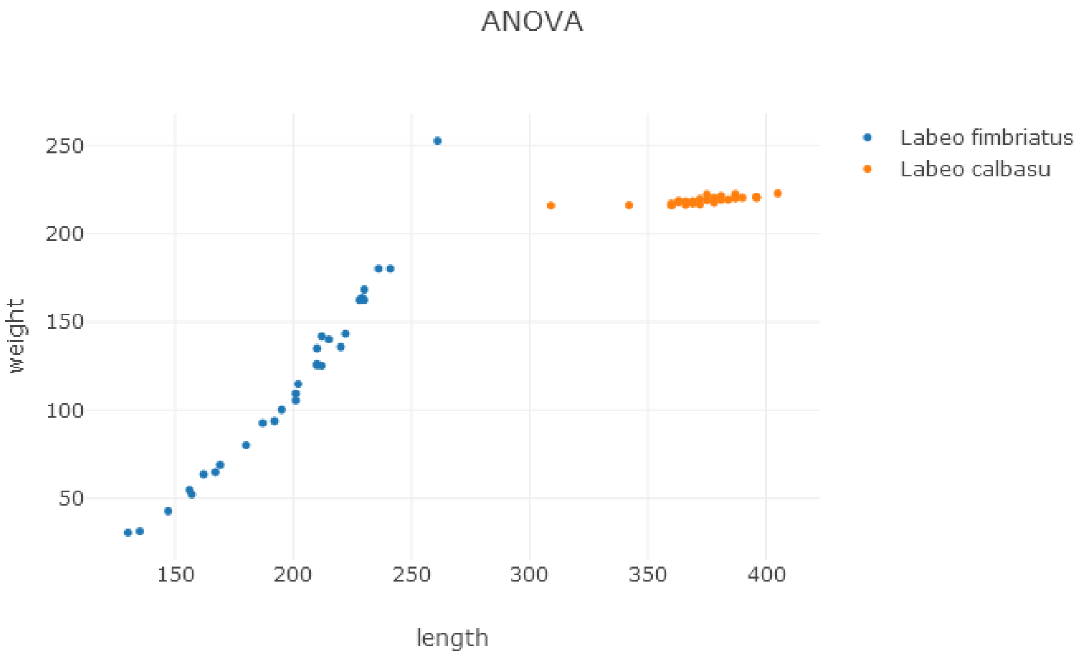
February 17-2018



March 17-2018



April 17-2018



May 17-2017