

**SOME ASPECTS OF BIOLOGY,
OVARIAN HISTOPHYSIOLOGY AND EFFECT OF
HORMONES ON OVARIAN MATURATION IN
NOTOPTERUS NOTOPTERUS (PALLAS)**

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IN
AQUACULTURE

BY

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CERTIFICATE-I

This is to certify that the thesis entitled "Some aspects of biology, ovarian histophysiology and effect of hormones on ovarian maturation in *Notopterus notopterus* (Pallas)" submitted for the degree of Doctor of Philosophy in the subject of Aquaculture of the Orissa University of Agriculture and Technology, Bhubaneswar embodies a faithful record of bonafide and original research work carried out by *Sri Kamaleswar Kalita* under my guidance and supervision and that he has completed the period of research required under the regulations of the University. The content of the thesis does not form the basis of the award of any previous degree to Sri K. Kalita.

Considering the quality of the thesis, I recommend the same for the submission for the degree of Doctor of Philosophy in Fisheries Science (Aquaculture) of this University.

There is nothing in his habits and character which may debar him from being admitted to the degree of Doctor of Philosophy in Fisheries (Aquaculture) of the Orissa University of Agriculture and Technology.

The assistance and help received during the course of investigation have been duly acknowledged.

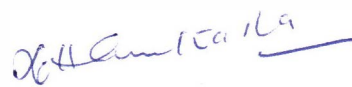
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CERTIFICATE-II

This is to certify that this thesis entitled "Some aspects of biology, ovarian histophysiology and effect of hormones on ovarian maturation in *Notopterus notopterus* (Pallas)" submitted by *Sri Kamaleswar Kalita* to the Orissa University of Agriculture and Technology, Bhubaneswar, in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Fishery Science in the subject of Aquaculture has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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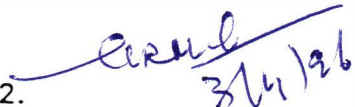
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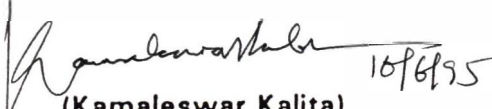
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(Kamaleswar Kalita) 10/6/95

*Dedicated
to
the Memory of
My Respected Parents*

*Late Shri Bhabendra Chandra Kalita
and
Shrimati Dharjyapriya Kalita*

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Section-I

Some Aspects of Biology and Biometry

INTRODUCTION

Notopterus notopterus commonly known as 'Falli' in Orissa and 'Kandulli' in Assam is widely distributed in the swamps, pools, ponds, beels, rivers and reservoirs in India. It has an extensive geographical distribution and commonly found in fresh and brackishwaters of Pakistan, Bangladesh, Burma, Thailand, Malaya, Indonesia, almost in whole of the Oriental region (cited Munshi and Srivastava, 1988). Dehadrai (1960 and 1962) has reported the distribution of fish species belonging to genus *Notopterus* in freshwater of Asia.

The genus *Notopterus* commonly called as featherback forms the mainstay of pond fishery in areas which are far removed from the sea. A wide variety of teleostean fishes belonging to different habit, while some use gills and skin, others have developed special accessory respiratory organs for aerial respiration. Moreover the featherbacks accessory respiratory function is the swimbladder (Dehadrai, 1962). With the help of swimbladder the fish can take up atmospheric air for which it can able to survive in both seasonal and perennial ponds.

Available in all the times of the year, it is a popular food fish in the country, particularly the economically downtrodden communities. Air-breathing in teleostean fishes is a typical example of convergent adaptation to the particular type of swampy environment to which many species of widely separated orders and families were exposed during the course of evolution. *Notopterus notopterus*, being an air-breathing fish is no exception to this. It can fairly thrive well in swamps (marshes or wet lands) for which these type of lentic water forms the link between terrestrial and aquatic ecosystems. Though its habitat is principally in freshwater,

it has also been found in brackishwater where the body colour varies according to ecological conditions. Specimen from clear streams and rivers are silvery. Those from the thick vegetation are dark greenish black (cited Munshi and Srivastava, 1988).

These fishes have tremendous potential for improved productivity in the freshwater pools, ponds, swamps not only in Orissa but also in Assam for which the state is bestowed with myriads of swampy areas locally called as beels. These are extensive watersheets connected to the river Brahmaputra, the Barack and their tributaries. The total water area covered by beel fishery in Assam is 1.0 lakh ha. which alone constitute 80% of the total lentic areas which considered to be a fishmines of the state (Dutta and Lahon, 1987).

Notopterus notopterus a major groups of the air-breathing fish in the country, are known for their nutritive, invigorating and therapeutic qualities and also the tastes. These group of fishes are given preference by the consumers particularly in Assam and in the country in general. Besides being consumed in fresh and dry state, the species has many potential uses and have great aquaculture value especially on account of their ability to survive in low oxygen swampy water bodies, which is not tolerated by conventional carp species. The studies made by earlier workers was mainly to assess the possibility of its culture as a compatible species alongwith the major carps.

Super-order osteoglossmorphs contains only single order osteoglossiformes having one family Notopteridae of genus *Notopterus* that exist in India (cited Jayaram, 1981). In contrast, Dehadrai (1960 and 1962) reported that genus *Notopterus* belongs to single order clupeiformes. However, all are in view that this genus has two species, viz. *Notopterus chitala* (Hamilton) and *Notopterus notopterus* (Pallas).

Though both the species have their identical characteristic, some of the key identification makes them distinct from each other. The key to species of the genus *Notopterus* are:

- i) Opercular scales much larger than those on the body. Maxilla not extending beyond the hind edge of the orbit. No black spot at the tail end. Dorsal profile of the body less humped, 28-33 scutes along the abdominal edge- *N. notopterus* (Pallas).
- ii) Opercular scales not larger than those on the body. Maxilla extending far beyond the hind edge of the orbit. A few black spots at the tail end. Dorsal profile of the body much humped, 50-51 scutes along abdominal edge- *N. chitala* (Hamilton).

Regarding the feeding habits of these species, it is planktophagous upto 30 mm in length, thereafter *N. notopterus* switches to a carnivorous habit. At the fry stage it feeds on zooplankton like *Arcella*, *Moina*, *Bosmina*, *Brachionus*, *Diaptomus*, *cyclops* and *cypris*. The juveniles prefer notonectides, insect larvae and small shrimps. Adult stages consumed aquatic beetles. Anisops, small fishes and part of aquatic weeds though not in appreciable quantity (Parameswaran and Sinha, 1966).

Often in fishery research, it is not possible to get the whole fish during gut analysis and one has to compute the length and weight etc. based on the available fins which are more resistant to digestion and decompositions. Workers studying on food habits of animals which eat fish, often depend on the size of the fins in the stomach to determine the length and weight of fish.

Therefore, it was felt that, it is necessary to derive these relationship so one can establish, the growth equation in production computations by computing the length-weight etc. based on the measurement of the fins only.

Although some fragmentary literatures are available on the biology of this species (Parameswaran and Sinha, 1966; Hamza, 1980) but to utilize and manage this species judiciously in cultured system that requires an understanding of its inter-relationship with physical and biological environment, the present study was envisaged for indepth study of its biology that includes length-weight and other biometrical relationships, length frequency distribution, gonosomatic index, relative condition factor (Kn), ponderal index, size at first maturity, fecundity etc.

REVIEW OF LITERATURE

The existing knowledge on *Notopterus notopterus* is fragmentary and scanty. Some of the literatures are available on this fish particularly on academic aspects such as taxonomy, swimbladder, brain, genital papillae, osmoregulatory, physiology, enzymology and few endocrinology by some workers. Toxicity of different pesticides on *N. notopterus* have also been recorded (Verma *et al.*, 1981, Gupta *et al.* 1994). Some of the earlier works documented on this fish relates to taxonomy, bionomics, occurrence and distribution, embryology and development of early stages in great detail (Hamza, 1980).

2.1 LENGTH-WEIGHT AND BIOMETRICAL RELATIONSHIPS

Although enough of literatures are accumulated on length-weight relationship on varied groups of fishes, but few literature are available on *N. notopterus* (Parameswaran and Sinha, 1966; Hamza, 1980). The other fish groups comprising *G. chapra* (Banerjee and Venkateswarlu, 1968); in *L. calbasu* (Rao and Rao, 1972); in *L. fimbriatus* (Rao, 1974); in *Ambassis gymnocephalus* (Raman *et al.* 1975); in scale carp (Pandey and Sharma, 1995) were also documented. The work referred in Mahseer *Tor khudree* has also been reported (Ogale, 1993). The studies on air breathing and catfish groups such as in *H. fossilis* (Thakur and Das, 1974); in *M. gulio* (Rao, 1981); in *Gerres lucidus* (Kaliyamurthy *et al.*, 1986); in *O. bimaculatus* (Sivakami, 1987); in *R. hastate* (Gotate, 1993) were recorded. Length-weight relationship studies were also available on some of the brackishwater fishes, such as in *M. cephalus* (Rangaswami, 1976); in *M. corsula* (Fatima *et al.*, 1989); in *E. suratensis* (Jayaprakas *et al.*, 1990). Length-weight relationship of different marine fish groups in Gulf of Thailand (Yanagawa, 1994) and in *N. bipunctatus* in the Gulf of Manaar were studied (Abdul Hameed, 1994).

The studies on age and growth, length and scale radius in *L. calbasu* (Rao and Rao, 1972) and *L. fimbriatus* (Rao, 1974) have been reported.

Besides length-weight, other biometrical relationships on the length of fish with that of length upto dorsal, pectoral, pelvic, anal and pectoralis has been studied in *G. chapra* (Banerjee and Venkateswarlu, 1968) in *C. punctata* (Rath, 1980).

2.2 PONDERAL INDEX (PI)

Scanty literatures are available on the information of ponderal index on *N. notopterus*. However, ponderal index of *N. notopterus* has been studied (Parameswaran and Sinha, 1966; Hamza, 1980). Ponderal index of some cyprinid fishes of Kashmir were studied by Yousuf *et al.* (1993). Other information on this aspects have also been reported in *L. rohita* (Raizada *et al.*, 1986); in scale carp (Pandey and Sharma, 1995); in *H. fossilis* (Bhatt, 1968, 1970); in *C. punctata* (Rath, 1980); in *G. lucidus* (Kaliyamurthy *et al.*, 1986); in *O. bimaculatus* (Sivakami, 1987). Moreover, Desai and Shrivastava (1986) has studied the ponderal index of brackishwater fish *Rhinomugil corsula*.

2.3 RELATIVE CONDITION FACTOR (Kn)

'Condition' of fish is indicative of its growth and environmental suitability and therefore its estimation is of great importance in studying the biology of fish. Information on the relative condition factor is very scarce. Very few workers have done on this aspect. The relative condition factor (Kn) in *L. calbasu* showed fluctuations during different months corresponding with the feeding activity and maturity of the fish (Rao and Rao, 1972). Similar observation was also reported in *L. fimbriatus* (Rao, 1974). The fluctuations in relative condition value at different

length groups and season in *M. gulio* has been studied (Rao, 1981). Moreover, in *C. punctata* (Rath and Hejmadi, 1979); in *A. testudineus* (Azad, 1990) have studied the relative condition factors. Accuracy of relative condition (kn) over condition factor (K) of fish species *Rhinomugil corsula* has been studied (Desai and Srivastava, 1986). The work on relative condition factor of *M. cephalus* (Rangaswami, 1967) has also been reported.

2.4 GONOSOMATIC INDEX (GSI)

Gonosomatic index is one of the important methods for studying the spawning seasons. Usually, gonads undergo regular seasonal cyclical changes in weight, particularly in female. Such cyclical changes are indicative of the spawning season (Qasim, 1973). Some of the literatures are available on the cyclical changes of gonosomatic index in various fish groups. The ovarian activity and its relationship to the gonadal condition has been dealt in great detail under ovarian histophysiology and effect of hormones on ovary sections of the present study. Moreover, the increased gonosomatic index during spawning activity has been reported in *O. bimaculatus* (Rao, 1990). The value of gonosomatic index increased with the approach of spawning season and recede at the end of spawning season has been reported in freshwater teleosts such as in *B. luteus* (Al-Daham and Bhatti, 1979); in *C. punctata* (Belsare, 1962, Qayyum and Quasim, 1964; Rath and Hejmadi, 1979), in *G. giuris* (Saksena, 1976); in *A. scandens* (Misra and Verma, 1991); in *C. gachua* (Misra, 1991); in *M. gulio* (Rao, 1981); in *M. cavasius* (Sharma, 1987). Kuo and Nash (1975) studied the gonosomatic index of brackishwater fish, *Mugil cephalus*.

The studies on the interpretation of gonosomatic index with that of spawning activity of *N. notopterus* were studied (Parameswaran and Sinha, 1966; Hamza, 1980, Sahu, 1983).

2.5 FECUNDITY

Fecundity, the reproductive potential of a female population has been well studied in carps, catfishes, airbreathing fishes and majority of marine fishes. Various terminology are used in defining fecundity on the basis of breeding behaviour of the fish groups. The earlier studies on fecundity in carps, catfishes and air-breathing fishes are well cited (Das, 1964; Parameswaran and Sinha, 1966; Hamza, 1980; Rath, 1993). Therefore, in the present study restricted literatures are referred under fecundity.

The studies on fecundity of carp groups such as in *L. calbasu* (Rao and Rao, 1972); in *L. fimbriatus* (Rao, 1974); in *L. rohita* (Sehgal and Toor, 1989; Tripathi, 1989); in *C. mrigala* (Tripathi, 1989); in *C. mrigala* (Tripathi, 1989); in *L. boggut* (Patil and Kulkarni, 1995) have been reported. The studies on fecundity of air-breathing and catfish groups such as in *C. striata* (Alikunnnhi, 1953); in *C. punctata* (Rath and Hejmadi, 1976); in *M. gulio* (Rao, 1981); in *M. cavasius* (Sharma, 1987); in *M. cuchia* (Nasar, 1989); in *W. attu* and *M. armatus* (Saxena, 1990); in *O. bimaculatus* (Rao, 1990); in *A. testudineus* (Pandey, 1987; Azad, 1990); in *C. gachua* (Misra, 1991; Routray and Nanda, 1993), in *W. attu* (Dasgupta *et al.*, 1991) have also been reported.

Fecundity study on brackishwater fish *E. suratensis* has been reported (Jayaprakas *et al.*, 1990). An extensive study on comparative fecundity in six species such as *W. attu*, *C. marulius*, *R. rita*, *M. bleekeri*, *Gonialosa manminna* and *C. specularis* have been reported (Das, 1964).

The impact of manure on the gonosomatic index and fecundity of *L. rohita*, *C. mrigala* and *C.c. communis* have been studied (Singh *et al.*, 1989). The

effect of vitamin E on the fecundity and maturity of *H. fossilis* has also been reported (Dube, 1993). Besides, the impact of running water and nutritional diets have been studied in different teleosts (cited Rath, 1993).

The studies on fecundity of *N. notopterus* has been reported (Parameswaran and Sinha, 1966; Hamza, 1980; Sahu, 1983). Even some observations on breeding, growth and fecundity of *N. chitala* has also been studied (Singh *et al.*, 1979).

MATERIAL AND METHODS

3.1 COLLECTION SITE

Notopterus notopterus for this study was collected from nearby ponds and swamps around Bhubaneswar and its surrounding villages such as Santharapur, Uttara, Dhauli, Kumbhardia, Balakati within the radius of 20 km. Sometimes the fishes were collected from nearby fish market such as Ravi talkies, Uttara, Balakati etc. whenever necessary (Fig.1). Bhubaneswar is located from 20°12'-20°10'N latitude and 85°48'-85°53'E longitude. The climatic condition of Bhubaneswar and its surrounding area is of tropical monsoon type with dry evergreen forest with vegetation of wide variety and bush forest with cultivable lands, ponds and ditches filled with floating water weeds or submerged water plants. In the villages i.e., near human habitation, shrubberies of semispontaneous type are common.

The fishes were collected at a regular intervals of every month from August to July 1993-94. One of the major problems faced for the study is to collect the fish in live condition. As the fishes were somewhat scarce and not much available in the locality, a special care have taken to ensure of get the live specimens from the spot of fishing. Only the live fishes were collected and transported to the laboratory. These were treated with potassium permanganate (KMnO_4) solution, so as to heal up any injury thereof. After sexually identified as per the procedure described by Mookerjee and Majumdar (1946) the females were transferred to the aquaria for acclimation. Then the fishes were measured for biological study. For each female fish, body weight and length from snout to the base of caudal fin were determined. Data on length of pectoral, pelvic, dorsal, anal

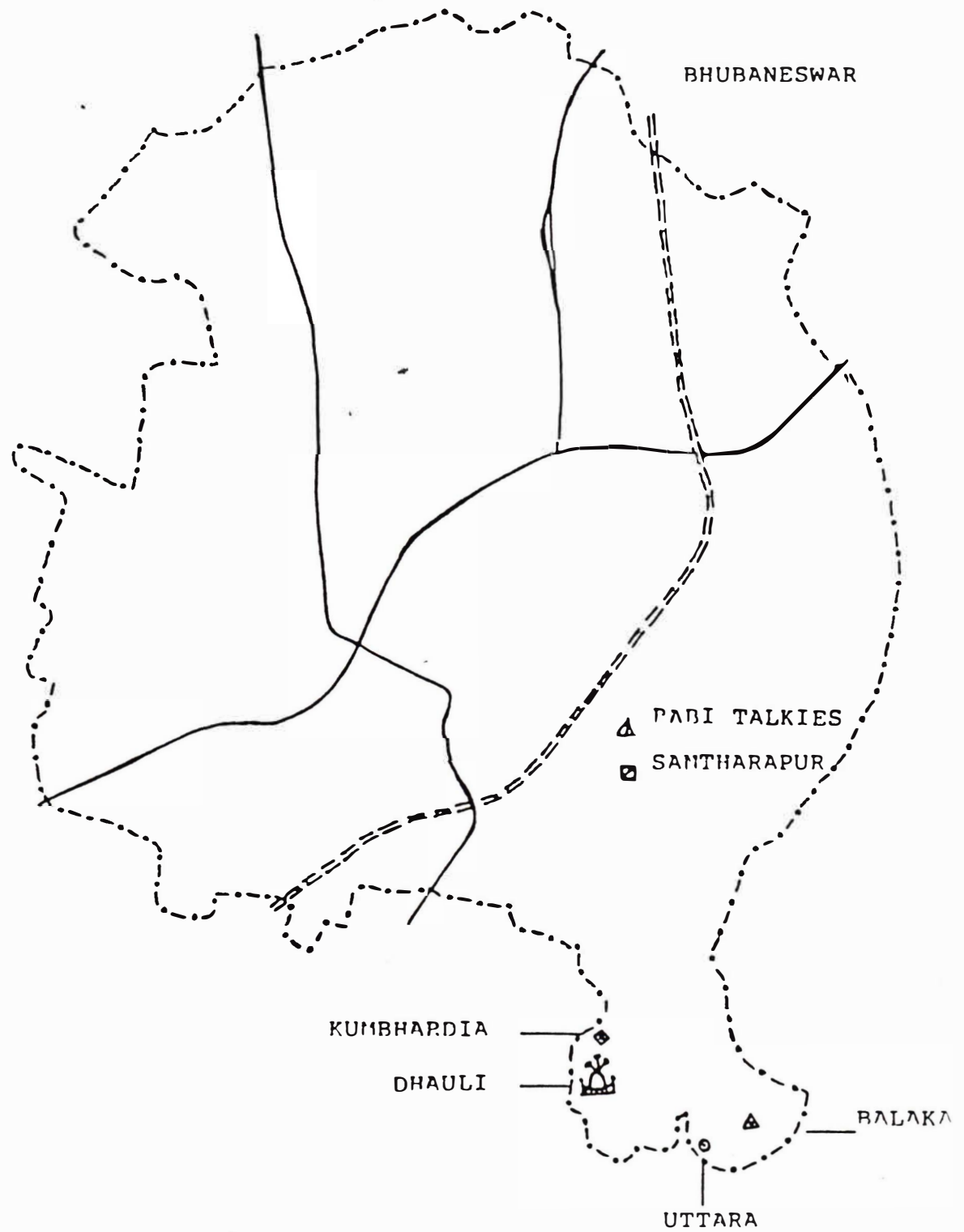


Fig. 1. Map showing the fish procurement area for the experiment.

and pectoralis etc. (the region from snout to the base of opercular region) for 112 fishes were recorded for this study following the method of Choudhury *et al.* (1975). After obtaining all the required biometric measurements of different parts of body, these fishes were dissected for ovarian fecundity and histophysiological studies.

Immediately after removing the ovary and the liver from the fishes the corresponding weight were recorded and the ovary were preserved in modified Gilson's fluid for fecundity study. Fecundity with that of the length, weight of body and ovary weight were determined by the method of least squares and a regression line fitted to the data according to the method of Jhingran (1961) and Swarup (1961). Ponderal index (PI), relative condition factor (Kn), gonadosomatic index (GSI) at different months of the year 1993-94 were calculated according to the following methods.

3.2 PONDERAL INDEX (PI) (HILE, 1948)

The general well being of fish is measured by the unit called "Ponderal Index". The equation describing the condition factor is $PI = \frac{W}{L^3} \times 100$ where W represents the weight of fish and 'L' represents the length of fish.

3.3 RELATIVE CONDITION FACTOR (LeCren, 1951)

$$Kn = \frac{W_0}{W_c}$$

where 'W₀' is the observed weight of the fishes and 'W_c' is the calculated weight, predicted after determining the length-weight relationship in different month groups.

3.4 GONOSOMATIC INDEX (GSI)

The gonosomatic index is yet another method for studying the spawning season by following the seasonal changes in the gonad weight in relation to body weight. The equation:

$$GSI = \frac{GW}{TW} \times 100$$

is used for the purpose, where 'GW' represents the weight of gonads and 'TW' is the total weight of the fish. Gonads undergo regular seasonal cyclical change in weight, particularly in females. Such cyclical changes are indicative of the spawning season (Qasim, 1973).

3.5 FECUNDITY DETERMINATION

Altogether 120 females were examined mostly by observing the stouter urinogenital papillae and bulging abdomen. The weight of the fishes were taken by a balance to nearest gram. The ovary weight was recorded to the nearest miligram by electrically operated single pan balance. The ovary after treated with Gilson's fluid were taken to count the number of eggs visually. In some cases the eggs were counted from a piece of ovary and then converted according to ovary weight. From these observations, the relationship between fecundity and other aspects of fish were converted to their log value for calculation and determined by the methods of least squares and regression line fitted to the data as reported (Jhingran, 1961; Swarup, 1961).

3.6 STATISTICAL TREATMENT OF DATA

Relationship for the various groups of fish in different months of the year have been expressed as $Y = a + bX$, where 'X' and 'Y' are the two variances of two different samples, a is constant and b is an exponent. The morphometrical

difference in gonadosomatic index and between the morphometric parameters was established using the least square method. The correlation analysis and regression analysis of the variable parameters were made. The test of significance 't' test (Isdt) were found out at 5% level of population at $n-2$ degree of freedom to evaluate the significance of these relationship (Gupta, 1987).

RESULTS

4.1 LENGTH WEIGHT RELATIONSHIP OF FEMALE *N. NOTOPTERUS* (PALLAS)

While presenting the results of investigation made on the biology of the Perch, *Perca fluviatilis*, LeCren (1951) gave a critical review of the method employed in the length-weight study and the fundamental bases for the concepts of length weight relationship and condition in fishes. He pointed that the analysis of length weight data has usually been directed towards two different objects viz. (i) towards describing mathematically the relationship between length and weight so that one may be converted into other; and (ii) to measure the variation from the expected weight for length of individual fish or relevant group of individuals as indication of fatness, general 'well being' gonadal development, etc.

Thus the knowledge of relationship between weight of the fish and its total length is essential to establish growth equation in production computation. The general theoretical relationship between length and weight follows the cube law relationship, which was first enunciated by Herbert Spencer in 1871 as 'Cube Law'. According to this law, the weight of the fish equals the cube of the body length, multiplied by a constant.

$$W = aL^3 \text{ where } W = \text{Weight,} \quad L = \text{Length} \quad a = \text{constant}$$

However, since a fish or any animal is continually prone to change its body proportion during its life history, the simple cube law expression does not hold good throughout its life history (Rounsefell and Everhart, 1960). Hence the length weight relationship of one hundred eleven female in the length range group of Log 1.12 cm to Log 1.48 cm was determined by the method of least square (Table 1, Fig. 2), where weight and length of the fishes were converted to their log value for calculation. The statistical formula was found to be $\text{Log} Y = 0.9333 + 0.2240 \log X$. The coefficient correlationship (r) was found to be 0.5806 which is higher positive value. The calculated 't' was found to be 7.445 which is higher than the tabulated 't' value at $n-2$ degree of freedom at 5% level of population. Hence it assumes that weight of the fish has positive relationship with the length of body. The regression line was found to be linear, indicating that when length increases, weight of the fish increases proportionately.

4.2 RELATIONSHIP BETWEEN LENGTH UPTO BASE OF CAUDAL FIN AND LENGTH UPTO DORSAL FIN IN *N. NOTOPTERUS* (PALLAS)

The statistical formula for the relationship between the length of fish and length upto dorsal fin in *N. notopterus* was found to be $Y = 0.0717 + 0.5505 X$ (Table 2, Fig. 3). The coefficient correlationship (r) was found to be 0.9590 suggesting positive relationship between these two parameters. The calculated 't' value was found to be 35.013 which is much higher than tabulated 't' value at $n-2$ degree of freedom at 5% level of population. Hence they possess positive sign of relationship. The exponential regression line was indicating that when the length of the fish increases the length upto dorsal fin also increases.

Table 1: Length-weight relationship of *N. notopterus* (Pallas)

Number of Observations	Log weight of body (g) x	Log length of body (cm) y	X ²	Y ²	XY
1	2.0	1.34	4.0	1.80	2.68
2	1.90	1.27	3.62	1.61	2.41
3	1.70	1.21	2.89	1.46	2.04
4	1.90	1.26	3.62	1.59	2.39
5	2.00	1.37	4.00	1.87	2.74
6	2.20	1.44	4.86	2.07	3.17
7	1.90	1.34	3.62	1.81	2.55
8	1.85	1.31	3.40	1.72	2.42
9	1.70	1.29	2.89	1.66	2.19
10	1.83	1.30	3.36	1.70	2.38
11	1.81	1.35	3.29	1.83	3.31
12	1.85	1.34	3.40	1.80	3.33
13	1.54	1.23	2.38	1.51	1.89
14	1.85	1.32	3.40	1.75	2.42
15	1.92	1.35	3.70	1.83	2.59
16	2.00	1.37	4.00	1.88	2.74
17	1.82	1.34	3.31	1.79	2.44
18	1.93	1.34	3.72	1.80	2.59
19	1.23	1.16	1.51	1.33	1.43
20	1.93	1.38	3.72	2.35	2.95
21	2.05	1.40	4.20	1.96	2.87
22	2.00	1.38	4.00	1.90	3.80
23	1.78	1.35	3.16	1.83	2.40
24	2.04	1.39	4.17	1.92	2.84
25	1.18	1.17	1.38	1.36	1.38
26	1.78	1.32	3.16	1.75	2.35
27	1.60	1.28	2.57	1.63	2.05
28	1.93	1.34	3.72	1.79	2.59
29	1.81	1.32	3.29	1.74	2.39

Number of Observations	Log weight of body (g) x	Log length of body (cm) y	X ²	Y ²	XY
30	1.48	1.24	2.18	1.55	1.84
31	2.04	1.40	4.17	1.97	2.86
32	2.00	1.40	4.00	1.95	2.80
33	1.62	1.30	2.63	1.68	2.11
34	2.22	1.45	4.94	2.09	3.22
35	2.06	1.42	4.25	2.01	2.93
36	1.90	1.36	3.62	1.85	2.58
37	1.30	1.19	1.69	1.42	1.55
38	1.81	1.33	3.29	1.78	2.41
39	1.30	1.19	1.69	1.42	1.55
40	1.30	1.14	1.69	1.30	1.48
41	1.48	1.21	2.18	1.48	1.79
42	1.40	1.17	1.95	1.38	1.64
43	1.34	1.12	1.80	1.25	1.50
44	2.36	1.48	5.58	2.20	3.49
45	2.36	1.48	5.58	2.20	3.49
46	2.08	1.41	4.32	1.98	2.93
47	2.08	1.42	4.32	2.07	2.95
48	2.18	1.45	4.74	2.10	3.16
49	2.06	1.39	4.25	1.93	2.86
50	2.00	1.40	4.00	1.95	2.80
51	1.98	1.38	3.91	1.89	2.73
52	1.95	1.37	3.82	1.87	2.67
53	2.15	1.43	4.61	2.06	3.07
54	1.93	1.36	3.72	1.85	2.64
55	1.70	1.29	2.89	1.67	2.19
56	1.54	1.27	2.38	1.61	1.96
57	1.48	1.22	2.18	1.48	1.81
58	2.06	1.42	4.25	2.01	2.93
59	1.90	1.37	3.62	1.87	2.60

Number of Observations	Log weight of body (g)	Log length of body (cm)	X^2	Y^2	XY
	$\bar{x}$	$\bar{y}$			
60	2.04	1.40	4.17	1.97	2.86
61	1.93	1.37	3.72	1.87	2.64
62	1.88	1.36	3.52	1.85	2.56
63	1.90	1.34	3.62	1.81	2.55
64	1.38	1.22	1.90	1.48	1.68
65	1.91	1.35	3.64	1.82	2.58
66	2.11	1.41	4.47	1.99	2.98
67	2.24	1.45	5.03	2.09	3.25
68	2.00	1.38	4.00	1.91	2.76
69	1.95	1.39	3.82	1.92	2.71
70	2.26	1.45	5.11	2.11	3.28
71	2.48	1.53	6.14	2.35	3.79
72	2.02	1.39	4.09	1.92	2.81
73	2.11	1.41	4.47	2.00	2.98
74	1.92	1.36	3.70	1.85	2.61
75	2.10	1.40	4.40	1.95	2.94
76	1.65	1.28	2.73	1.64	2.11
77	1.70	1.30	2.89	1.70	2.21
78	2.00	1.37	4.00	1.88	2.74
79	2.00	1.39	4.00	1.92	2.78
80	1.90	1.36	3.62	1.85	2.58
81	2.10	1.43	4.40	2.05	3.00
82	1.72	1.32	2.94	1.74	2.27
83	2.08	1.44	4.32	2.09	3.00
84	2.26	1.47	5.09	2.16	3.32
85	2.32	1.48	5.39	2.19	3.43
86	2.18	1.45	4.74	2.10	3.16
87	2.26	1.47	5.09	2.16	3.32
88	2.04	1.40	4.17	2.97	2.86
89	2.02	1.39	4.09	1.92	2.81

Number of Observations	Log weight of body (g) x	Log length of body (cm) y	X ²	Y ²	XY
90	2.11	1.41	4.47	1.99	2.98
91	1.88	1.34	3.52	1.80	2.52
92	1.88	1.35	3.52	1.83	2.54
93	1.78	1.32	3.16	1.75	2.35
94	1.81	1.32	3.29	1.75	2.39
95	1.70	1.31	2.89	1.70	2.23
96	1.70	1.30	2.89	1.68	2.21
97	2.08	1.35	4.32	1.83	2.81
98	2.02	1.40	4.09	1.96	2.83
99	1.98	1.39	3.91	1.93	2.75
100	2.02	1.37	4.09	1.88	2.77
101	1.85	1.36	3.40	1.85	2.52
102	1.65	1.28	2.73	1.65	2.11
103	1.88	1.34	3.52	1.81	2.52
104	1.65	1.33	2.73	1.78	2.19
105	1.85	1.32	3.40	1.75	2.44
106	1.88	1.35	3.52	1.81	2.54
107	1.85	1.31	3.40	1.72	2.42
108	1.78	1.31	3.16	1.72	2.33
109	1.74	1.30	3.03	1.69	2.26
110	1.85	1.34	3.40	1.81	2.48
111	2.10	1.41	4.40	2.00	2.96
Total	209.59	150.54	402.61	202.86	288.59
Mean	1.8882	1.3562	3.627	1.8276	2.599

Coefficient correlationship ' r ' = .5806

Calculated ' t ' value = 7.445

Log Y = 0.9333 + 0.2240 log X

Table 2: Relationship between length up to base of caudal fin with length upto dorsal fin in *N. notopterus* (Pallas)

Number of observations	Length of fish up to base of caudal fin (cm) (X)	Length upto dorsal fin (cm) (Y)	X ²	Y ²	XY
1	21.0	10.9	441.00	118.81	228.90
2	17.0	9.2	289.00	84.64	156.40
3	15.9	8.6	252.81	73.96	136.74
4	17.4	9.5	302.76	90.25	165.30
5	22.0	12.0	484.00	144.00	264.00
6	26.6	14.7	707.56	216.09	391.02
7	21.0	11.0	441.00	121.00	231.00
8	19.7	10.9	388.09	118.81	214.73
9	18.3	9.6	334.89	92.16	175.68
10	19.3	10.5	372.49	110.25	202.65
11	21.2	11.5	449.44	132.25	243.80
12	21.00	11.5	441.00	132.25	241.50
13	15.5	8.7	240.25	75.69	134.85
14	20.0	11.0	400.00	121.00	220.00
15	21.8	12.2	475.24	148.84	265.96
16	22.0	12.0	484.00	144.00	264.00
17	20.5	11.3	420.25	127.69	231.65
18	21.0	11.9	441.00	141.61	249.90
19	13.3	6.9	176.89	47.61	91.77
20	22.5	13.0	506.25	169.00	292.50
21	23.4	13.0	547.56	169.00	304.20
22	22.0	11.4	484.00	129.96	250.80
23	24.0	13.0	576.00	169.00	312.00
24	13.6	7.6	184.96	57.76	103.36
25	19.5	10.9	380.25	118.81	212.55
26	18.3	9.3	334.89	86.49	170.19
27	20.5	11.9	420.25	141.61	243.95
28	19.5	11.0	380.25	121.00	214.50
29	16.5	9.0	272.25	81.00	148.50

Number of observations	Length of fish up to base of caudal fin (cm) (X)	Length upto dorsal fin (cm) (Y)	X ²	Y ²	XY
30	24.1	13.2	580.81	174.24	318.12
31	23.5	12.8	552.25	163.84	300.80
32	18.5	10.5	342.25	110.25	194.25
33	26.6	15.0	707.56	225.00	399.00
34	24.5	13.5	600.25	182.25	330.75
35	21.3	11.5	453.69	132.25	244.95
36	14.0	7.6	196.00	57.76	106.40
37	19.6	10.6	384.16	112.36	207.76
38	14.5	7.6	210.25	57.76	110.20
39	12.6	6.5	158.76	42.25	81.90
40	15.0	8.2	225.00	67.24	123.00
41	14.0	7.6	196.00	57.76	106.40
42	12.0	7.0	144.00	49.00	84.00
43	28.5	16.1	812.25	259.21	458.85
44	24.00	14.0	576.00	196.00	336.00
45	24.1	13.8	580.81	190.44	332.58
46	26.4	14.2	696.96	201.64	374.88
47	22.9	13.7	524.41	187.69	313.73
48	23.0	12.5	529.00	156.25	287.50
49	22.1	12.3	488.41	151.29	271.83
50	21.3	12.3	453.69	151.29	261.99
51	25.5	14.0	650.25	196.00	357.00
52	21.6	11.5	466.56	132.25	248.40
53	18.1	10.1	327.61	102.01	182.81
54	17.5	9.6	306.25	92.16	186.00
55	15.5	8.4	240.25	70.56	130.20
56	24.5	13.3	600.25	176.89	325.85
57	22.0	12.0	484.00	144.00	264.00
58	23.1	12.5	533.61	156.25	288.75
59	22.0	12.0	484.00	144.00	264.00
60	21.2	11.2	449.44	125.44	237.44

Number of observations	Length of fish up to base of caudal fin (cm) (X)	Length upto dorsal fin (cm) (Y)	X ²	Y ²	XY
61	20.5	11.7	420.25	136.89	239.85
62	15.1	8.4	228.01	70.56	126.84
63	20.5	10.9	420.25	118.81	234.45
64	24.0	13.2	576.00	174.24	316.80
65	26.5	15.2	702.25	231.04	402.80
66	22.5	12.6	506.25	158.76	283.50
67	22.0	12.5	484.00	156.25	275.00
68	26.6	15.5	707.56	240.25	412.30
69	31.5	18.0	992.25	324.00	567.00
70	23.0	12.0	529.00	144.00	276.00
71	24.0	13.3	576.00	176.89	319.20
72	21.2	11.1	449.44	123.21	235.32
73	22.9	12.5	524.41	156.25	286.25
74	18.0	9.5	324.00	90.25	171.00
75	18.6	10.1	345.96	102.01	187.86
76	22.0	11.8	484.00	139.24	259.60
77	22.5	11.9	506.25	141.61	267.75
78	21.2	10.0	449.44	100.00	212.00
79	25.5	14.1	650.25	198.81	359.55
80	19.2	10.2	368.64	104.04	195.84
81	25.9	14.0	670.81	196.00	362.60
82	26.6	14.7	707.56	216.09	391.02
83	29.0	16.0	841.00	256.00	464.00
84	26.1	14.5	681.21	210.25	385.70
85	27.5	15.5	756.25	240.25	426.35
86	23.5	13.0	552.25	169.00	305.50
87	22.6	13.1	510.76	171.61	296.06
88	24.5	14.2	600.25	201.64	347.90
89	20.3	11.5	412.09	132.25	233.45
90	20.5	12.5	420.25	156.25	256.25
91	19.6	10.5	384.16	110.25	205.80

Number of observations	Length of fish up to base of caudal fin (cm) (X)	Length upto dorsal fin (cm) (Y)	X ²	Y ²	XY
92	19.9	11.0	396.01	121.00	218.90
93	19.0	10.0	361.00	100.00	190.00
94	17.7	9.7	313.29	94.09	171.69
95	22.0	13.0	484.00	169.00	286.00
96	23.5	13.0	552.25	169.00	305.50
97	22.8	12.6	519.84	158.76	287.28
98	22.1	12.5	488.41	156.25	276.25
99	21.0	11.4	441.00	129.96	239.40
100	18.0	9.5	324.00	90.25	171.00
101	12.6	11.5	158.76	132.25	144.90
102	19.6	11.1	384.16	123.21	217.56
103	19.6	11.0	384.16	121.00	215.60
104	20.1	12.0	404.10	144.00	241.20
105	19.0	11.0	361.00	121.00	209.00
106	19.0	10.6	361.00	112.36	201.40
107	18.1	10.6	327.61	112.36	191.86
108	20.5	11.1	420.25	123.21	227.55
109	24.0	13.6	576.00	184.96	326.40
Total	2289.70	1268.30	49620.61	15259.43	26977.37
Mean	21.0064	11.6358	455.235	139.95	247.499

Coefficient correlationship 'r' = 0.9590

Calculated 't' value = 35.013

Y = 0.0717 + 0.5505 X

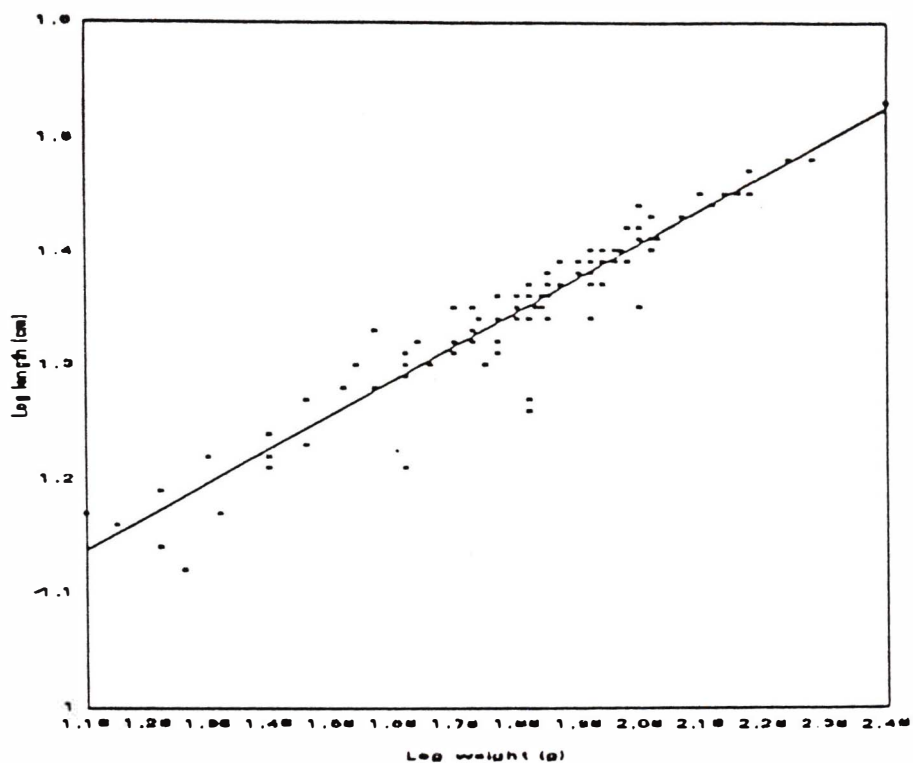


Fig. 2. Length-weight relationship of *Notopterus notopterus* (Pallas)

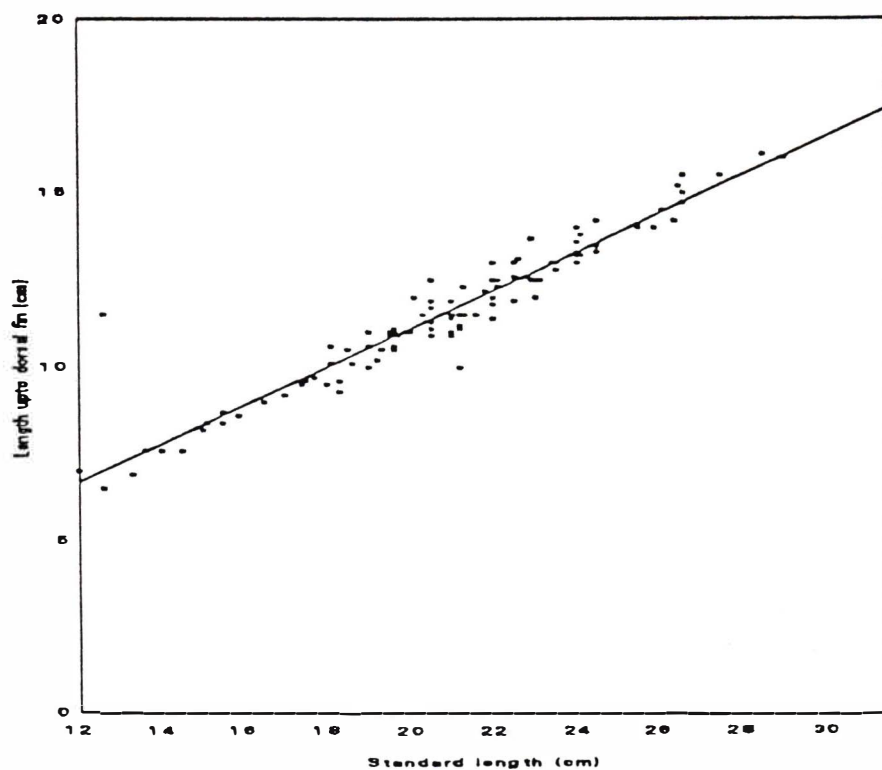


Fig. 3. Relationship between length up to base of caudal fin and length up to dorsal fin of *Notopterus notopterus* (Pallas)

4.3 RELATIONSHIP BETWEEN LENGTH UPTO BASE OF CAUDAL FIN AND LENGTH UPTO ANAL FIN IN *N. NOTOPTERUS* (PALLAS)

The statistical formula for the relationship between the length of fish and the length up to anal fin in *N. notopterus* was found to be $Y = 0.5623 + 0.2979 X$. (Table 3, Fig. 4). The coefficient correlationship (r) was found to be 0.9026 suggesting positive relationship between these two parameters. The calculated 't' value was found to be 21.690 which is greater than the tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence there is a positive relationship. The exponential linearity indicating that when length of fish increases the length upto anal fin also increases.

4.4 RELATIONSHIP BETWEEN LENGTH UPTO BASE OF CAUDAL FIN AND LENGTH UPTO PELVIC FIN IN *N. NOTOPTERUS* (PALLAS)

The statistical formula for the relationship between the length of the fish and the length upto pelvic fin in *N. notopterus* was found to be $Y = 0.6073 + 0.2650 X$. (Table 4, Fig. 5). The coefficient correlationship (r) was found to be 0.9202 suggesting high positive relationship. The calculated 't' value was found to be 24.549 which is higher than the tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence both these two parameters are interdependant. The regression line was found to be liner, indicating that when the length of the fish increases, the length upto pelvic fin also increases.

Table 3: Relationship between length upto base of caudal fin and length upto anal fin in *N. notopterus* (Pallas)

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto anal fin (cm) Y	X ²	Y ²	XY
1	21.0	6.5	441.00	42.25	136.50
2	17.0	5.2	289.00	27.04	88.40
3	15.9	4.7	252.81	22.09	74.73
4	17.4	5.5	302.76	30.25	95.70
5	22.0	6.7	484.00	44.89	147.40
6	26.6	8.3	707.56	68.89	220.78
7	21.0	6.6	441.00	43.56	138.60
8	19.7	6.6	388.09	43.56	130.02
9	18.3	5.5	336.89	30.25	100.65
10	19.3	5.7	372.49	32.49	110.01
11	21.2	6.0	449.44	36.00	127.20
12	21.0	6.6	441.00	43.56	138.60
13	15.5	4.6	240.25	21.16	71.30
14	20.0	6.2	400.00	38.44	124.00
15	21.8	6.8	475.24	46.24	148.24
16	22.0	6.6	484.00	43.56	145.20
17	20.5	6.6	420.25	43.56	135.30
18	21.0	6.8	441.00	46.24	142.80
19	13.3	4.5	176.89	20.25	59.85
20	22.5	7.3	506.25	53.29	164.25
21	23.4	7.5	547.56	56.25	175.50
22	22.0	7.0	484.00	49.00	154.00
23	24.0	8.0	576.00	64.00	192.00
24	13.6	4.6	184.96	21.16	62.56
25	19.5	6.5	380.25	42.25	126.75
26	18.3	5.9	334.89	34.81	107.97
27	20.5	6.9	420.25	47.61	141.45
28	19.5	6.0	380.25	36.00	117.00
29	16.5	5.0	272.25	25.00	82.50

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto anal fin (cm) Y	X ²	Y ²	XY
30	24.1	7.9	580.21	62.41	190.39
31	23.5	7.5	552.25	56.25	176.25
32	18.5	6.2	342.25	38.44	114.70
33	21.6	3.1	707.56	65.61	215.46
34	24.5	7.5	600.25	56.25	183.75
35	21.3	6.3	453.69	39.69	134.19
36	14.0	4.4	196.00	19.36	61.60
37	19.6	6.2	384.16	38.44	121.52
38	14.5	4.5	210.25	20.25	62.25
39	12.6	4.3	158.76	18.49	54.18
40	15.00	4.5	225.0	20.25	67.50
41	14.00	4.5	196.0	20.25	63.00
42	12.00	3.9	144.0	15.21	46.80
43	28.5	9.2	812.25	84.64	262.20
44	24.00	8.0	576.0	64.0	192.00
45	24.1	7.3	580.81	53.29	175.93
46	26.4	8.1	696.96	65.61	213.84
47	22.9	7.5	524.41	56.25	171.75
48	23.00	7.5	529.0	56.25	172.50
49	22.1	6.8	488.91	46.24	150.28
50	21.3	7.7	453.69	59.29	164.01
51	25.5	8.1	650.25	65.61	206.55
52	21.6	6.5	466.56	42.25	140.40
53	18.1	5.6	327.61	31.36	101.36
54	17.5	5.7	306.25	32.49	99.75
55	15.5	4.8	240.25	23.04	74.40
56	24.5	7.8	600.25	60.84	191.10
57	22.00	6.8	484.00	46.24	149.60
58	23.1	8.5	533.61	72.25	196.35
59	22.0	7.0	484.00	49.0	154.00
60	21.2	6.5	449.44	42.25	137.80

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto anal fin (cm) Y	X ²	Y ²	XY
61	20.5	6.5	420.25	42.25	133.25
62	15.1	4.8	228.01	23.04	72.48
63	20.5	6.7	420.25	44.89	137.35
64	24.0	9.2	576.0	84.64	220.80
65	26.5	8.3	702.25	68.89	219.95
66	22.5	7.3	506.25	53.29	164.25
67	22.0	6.7	484.0	44.89	147.40
68	26.6	8.5	707.50	72.25	226.10
69	31.5	10.5	992.25	110.25	330.75
70	23.0	8.5	529.0	72.25	195.50
71	24.0	8.5	576.0	72.25	204.00
72	21.2	7.5	449.44	56.25	159.00
73	22.9	8.2	524.41	67.24	187.78
74	18.0	6.5	324.0	42.25	117.00
75	18.6	6.5	345.96	42.25	120.90
76	22.0	7.6	484.0	56.76	167.20
77	22.5	8.2	506.25	67.24	184.50
78	21.2	7.0	449.44	49.0	148.40
79	25.5	8.2	650.25	67.24	209.1
80	19.2	6.1	368.64	37.21	117.12
81	25.9	8.0	670.81	64.0	207.2
82	26.6	6.2	707.56	38.44	164.92
83	29.0	9.0	841.0	81.00	261.00
84	26.1	7.9	681.21	62.41	206.19
85	27.5	8.3	756.25	68.89	228.25
86	23.5	7.5	552.25	56.25	176.25
87	22.6	6.6	510.76	43.56	149.16
88	24.5	8.0	600.25	64.00	196.0
89	20.3	7.2	412.09	51.84	146.16
90	20.5	7.0	420.25	49.00	143.50
91	19.6	6.6	384.16	43.56	129.36

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto anal fin (cm) Y	X ²	Y ²	XY
92	19.9	6.2	396.01	38.44	123.38
93	19.0	6.5	361.0	42.25	123.50
94	17.7	5.7	313.29	32.49	100.89
95	22.00	8.0	484.0	64.0	176.00
96	23.5	7.5	552.25	56.25	176.25
97	22.8	7.5	519.84	56.25	171.00
98	22.1	7.6	488.41	57.76	167.96
99	21.0	7.1	441.00	50.41	149.10
100	18.0	6.0	324.00	36.0	108.00
101	12.6	6.5	158.76	42.25	81.90
102	19.6	6.5	384.16	42.25	127.40
103	19.6	6.4	384.16	40.96	125.44
104	20.1	6.7	404.01	44.89	134.69
105	19.0	7.3	361.0	53.29	138.70
106	19.0	6.1	361.0	37.21	115.90
107	18.1	6.5	327.61	42.25	117.65
108	20.5	7.3	420.25	53.29	149.65
109	24.0	8.4	576.0	70.56	201.60
Total	2289.70	743.30	49622.45	5234.53	16067.5
Mean	21.0064	6.8193	455.25	48.02	147.408

Coefficient relationship ' r ' = 0.9026

Calculated ' t ' value = 21.690

$Y = 0.5623 + 0.2979 X$

Table 4: Relationship between length upto base of caudal fin and length upto pelvic fin in *Notopterus notopterus* (Pallas)

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pelvic fin (cm) Y	X ²	Y ²	XY
1	21.0	6.5	441.00	42.25	136.50
2	17.0	4.6	289.00	21.16	73.20
3	15.9	4.4	252.81	19.36	69.96
4	17.4	5.1	302.76	26.01	88.74
5	22.0	6.2	484.00	38.44	136.40
6	26.6	7.5	707.56	56.25	199.50
7	21.0	5.6	441.00	31.36	117.60
8	19.7	5.6	388.09	31.36	110.32
9	18.3	5.0	334.89	25.00	91.50
10	19.3	5.6	374.29	31.36	108.08
11	21.2	5.6	449.44	31.36	118.72
12	21.0	6.0	441.00	36.00	126.00
13	15.5	4.5	240.25	20.25	69.75
14	20.0	3.9	400.00	15.21	78.00
15	21.8	6.2	475.24	28.44	135.16
16	22.0	6.3	484.00	39.69	138.60
17	20.5	6.1	420.25	37.21	125.05
18	21.0	6.1	441.00	37.21	128.10
19	13.3	4.3	176.89	18.49	57.19
20	22.5	6.5	506.25	42.25	146.25
21	23.4	6.6	547.56	43.56	154.44
22	22.0	6.1	484.00	37.21	134.20
23	24.0	6.9	576.00	47.61	165.60
24	13.6	4.2	184.96	17.64	57.12
25	19.5	5.9	380.25	34.81	115.05
26	18.3	5.2	334.89	27.04	95.16
27	20.5	6.6	420.25	43.56	135.30

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pelvic fin (cm) Y	X ²	Y ²	XY
28	19.5	5.6	380.25	31.36	109.20
29	16.5	4.8	272.25	23.04	79.20
30	24.1	7.1	580.81	50.41	171.11
31	23.5	7.3	552.25	53.29	171.55
32	18.5	5.4	342.25	29.16	99.90
33	26.6	7.7	707.56	59.29	204.82
34	24.5	7.1	600.25	50.41	173.95
35	21.3	6.0	453.69	36.00	127.80
36	14.0	4.2	196.00	17.64	58.80
37	19.6	6.0	384.16	36.00	117.60
38	14.5	4.4	210.25	19.36	63.80
39	12.6	4.0	158.76	16.00	50.40
40	15.0	4.2	225.00	17.64	63.00
41	14.0	4.0	196.00	16.00	56.00
42	12.0	3.7	144.00	13.69	44.40
43	28.5	8.1	812.25	65.61	230.85
44	27.5	8.1	756.25	65.61	222.75
45	28.6	7.9	817.96	62.41	225.94
46	24.0	7.5	576.00	56.25	180.00
47	24.1	6.2	580.81	38.44	149.42
48	26.4	7.5	696.96	56.25	198.00
49	22.9	6.5	524.41	42.25	148.85
50	23.0	6.5	529.00	42.25	149.50
51	22.1	6.0	488.91	36.00	123.60
52	21.3	6.1	453.69	37.21	129.93
53	25.5	7.0	650.25	49.00	178.50
54	21.6	6.0	466.56	36.00	121.60
55	18.1	5.4	327.61	29.16	97.74
56	17.5	5.2	306.25	27.04	91.00

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pelvic fin (cm) Y	X ²	Y ²	XY
57	15.5	4.6	240.25	21.16	71.30
58	24.5	6.8	600.25	46.24	166.60
59	22.0	6.2	484.00	38.44	136.40
60	23.1	7.	533.61	54.76	170.94
61	22.0	6.3	484.00	39.69	138.60
62	21.2	6.0	449.44	36.00	127.20
63	20.5	6.0	420.25	36.00	123.00
64	15.1	4.3	228.01	18.49	64.93
65	20.5	6.0	420.25	36.00	123.00
66	24.0	8.0	576.00	64.00	192.00
67	26.5	7.6	702.25	57.76	201.40
68	22.5	6.3	506.25	39.69	141.75
69	22.0	6.0	484.00	36.00	132.00
70	26.6	7.2	707.56	51.84	191.52
71	31.5	9.5	992.25	90.25	299.25
72	23.0	7.5	529.00	56.25	172.50
73	24.0	7.4	576.00	54.76	177.60
74	21.2	6.4	449.44	40.96	135.68
75	22.9	7.0	524.41	49.00	160.30
76	18.0	5.5	324.00	30.25	99.00
77	18.6	5.6	345.96	31.36	104.16
78	22.0	6.5	484.00	42.25	143.00
79	22.5	7.0	506.25	49.00	157.50
80	21.2	6.2	449.44	38.44	131.44
81	25.5	7.4	650.25	54.76	188.70
82	19.2	5.8	368.64	33.64	111.36
83	25.9	7.3	670.81	53.39	189.07
84	26.6	7.6	707.56	57.76	202.16
85	29.0	8.2	841.00	67.24	237.80

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pelvic fin (cm) Y	X ²	Y ²	XY
86	26.1	7.5	681.21	56.25	195.75
87	27.5	8.0	756.25	64.00	220.00
88	23.5	6.6	552.25	43.56	155.10
89	22.6	6.0	510.76	36.00	135.60
90	24.5	7.4	600.25	54.76	181.30
91	20.3	6.6	412.09	43.56	133.98
92	20.5	6.5	420.25	42.25	133.25
93	19.6	6.1	384.16	37.21	119.56
94	19.9	5.6	396.01	31.36	111.44
95	19.0	6.0	361.00	36.00	114.00
96	17.7	5.1	313.29	26.01	90.27
97	22.0	6.9	484.00	47.61	151.80
98	23.5	6.9	552.25	47.61	162.15
99	22.8	6.8	519.84	46.24	155.04
100	22.1	7.1	488.41	50.41	156.91
101	21.0	6.6	441.00	43.56	138.60
102	18.0	5.5	324.00	30.25	99.00
103	12.6	6.0	158.76	36.00	75.60
104	19.6	5.9	384.16	34.81	115.64
105	19.6	5.5	384.16	30.25	107.80
106	20.1	6.2	404.01	38.44	124.62
107	19.0	6.5	361.00	42.25	123.50
108	19.0	6.0	361.00	36.00	114.00
109	18.1	5.6	327.61	31.36	101.36
110	20.5	6.5	420.25	42.25	133.25
111	24.0	7.5	576.00	56.25	180.00
Total	2345.80	689.10	51195.30	4412.39	14979.38
Mean	21.13	6.21	461.22	39.75	134.95

Coefficient correlationship 'r' = 0.9202

Calculated 't' value = 24.549

Y = 0.6073+0.2650X

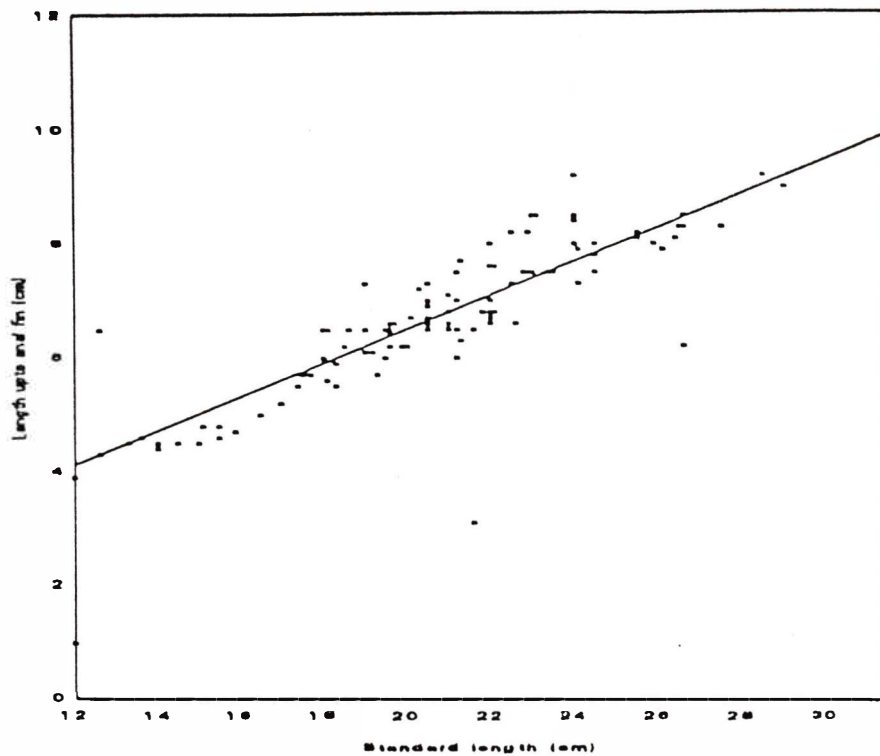


Fig. 4. Relationship between length upto base of caudal fin and length upto anal fin of *Notopterus notopterus* (Pallas)

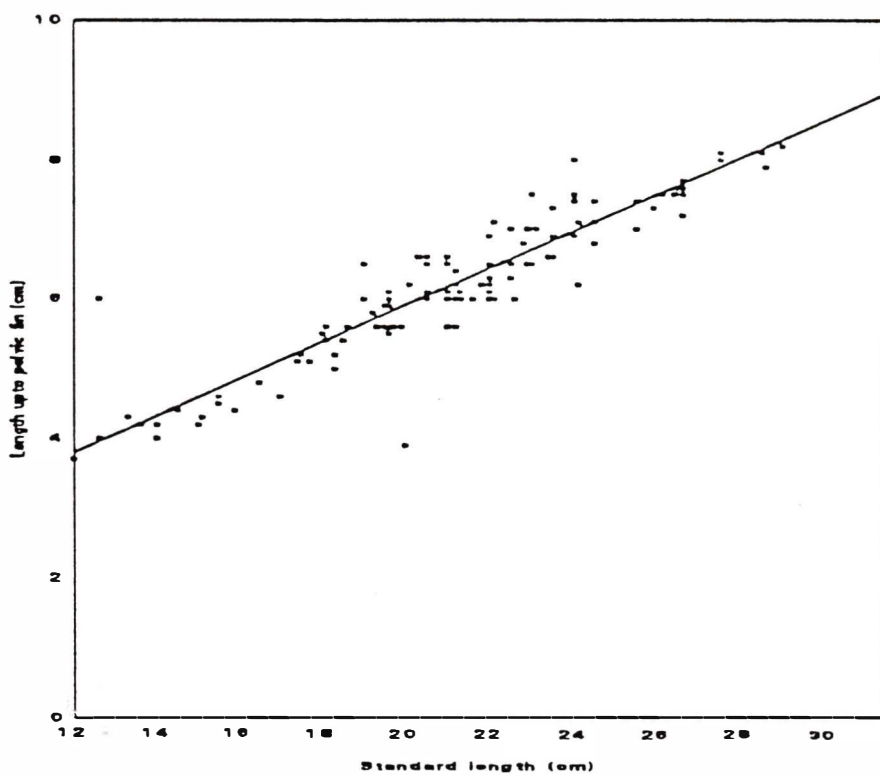


Fig. 5. Relationship between length upto base of caudal fin and length upto pelvic fin of *Notopterus notopterus* (Pallas)

4.5 RELATIONSHIP BETWEEN LENGTH UPTO BASE OF CAUDAL FIN AND LENGTH UPTO PECTORAL FIN IN *N. NOTOPTERUS* (PALLAS)

The statistical formula for the relationship between the length of the fish and the length upto pectoral fin in *N. notopterus* was found to be $Y = 0.7510 + 0.1658 X$. (Table 5, Fig. 6). The coefficient correlationship (r) was found to be 0.9353. The calculated 't' value was found to be 27.33 which is greater than the tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence they possess positive relationship. The regression line was linear, indicating that when the length of fish increases the length upto pectoral fin also increases.

4.6 RELATIONSHIP BETWEEN LENGTH UPTO BASE OF CAUDAL FIN AND LENGTH UPTO PECTORALIS IN *N. NOTOPTERUS* (PALLAS)

The statistical formula for the relationship between the length of the fish upto base of caudal fin and the length upto pectoralis was found to be $Y = 0.4393 + 0.2128 X$ (Table 6, Fig. 7). The coefficient correlationship (r) was found to be 0.9283. The calculated 't' value was 25.82 which is higher than the tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence they possess a positive relationship. The regression line was found to be exponential or linear suggesting that when length of the fish increases the length upto pectoralis also increases.

Table 5: Relationship between length upto base of caudal fin and length upto pectoral fin in *N. notopterus* (Pallas)

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pectoral fin (cm) Y	X ²	Y ²	XY
1	21.0	4.3	441.00	18.49	90.30
2	17.0	3.2	289.00	10.24	54.40
3	15.9	3.0	252.1	9.00	47.70
4	17.4	3.2	302.76	10.24	55.68
5	22.0	4.2	484.00	17.64	92.40
6	26.6	5.0	707.56	25.00	133.00
7	21.0	4.0	441.00	16.00	84.00
8	19.7	4.0	388.09	16.00	78.80
9	18.3	3.6	334.89	12.96	65.88
10	19.3	3.8	372.49	14.44	73.34
11	21.2	3.9	449.44	15.21	82.68
12	21.0	4.1	441.00	16.81	86.10
13	15.5	3.2	240.25	10.24	49.60
14	20.0	3.9	400.00	15.21	78.00
15	21.8	4.3	475.24	18.49	93.74
16	22.0	4.1	484.00	16.81	90.20
17	20.5	4.1	420.25	16.81	84.05
18	21.0	4.3	441.00	18.49	90.30
19	13.3	3.0	176.89	9.00	39.90
20	22.5	4.3	506.25	18.49	96.75
21	23.4	4.6	547.56	21.16	107.64
22	22.0	4.2	484.00	17.64	92.40
23	24.0	4.5	576.00	20.25	108.00
24	13.6	3.0	184.96	9.00	40.80
25	19.5	4.1	380.25	16.81	79.95
26	18.3	3.6	334.89	12.96	65.88
27	20.5	4.5	420.25	20.25	92.25
28	19.5	4.0	380.25	16.00	78.00
29	16.5	3.1	272.25	9.61	51.15

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pectoral fin (cm) Y	X ²	Y ²	XY
30	24.1	4.3	580.81	18.49	103.63
31	23.5	4.9	552.25	24.01	115.15
32	18.5	4.0	342.25	16.00	74.00
33	26.6	5.4	707.56	29.16	143.64
34	24.5	5.0	660.25	25.00	122.50
35	21.3	4.4	453.69	19.36	93.72
36	14.0	2.9	196.00	8.41	40.60
37	19.6	4.0	384.16	16.00	78.40
38	14.5	3.3	210.25	10.09	47.85
39	12.6	2.7	158.76	7.29	34.02
40	15.0	3.2	225.00	10.24	48.00
41	14.0	2.9	196.00	8.41	40.60
42	12.0	2.6	144.00	6.76	31.20
43	28.5	5.5	812.25	30.25	156.75
44	24.0	5.0	576.00	25.00	120.00
45	24.1	4.7	580.81	22.09	113.27
46	26.4	5.3	696.96	28.09	139.92
47	22.9	4.5	524.41	20.25	103.05
48	23.0	4.6	529.00	21.16	105.80
49	22.1	4.9	488.91	24.01	108.29
50	21.3	4.7	453.69	22.09	100.11
51	25.5	5.1	650.25	26.01	130.05
52	21.6	4.2	466.56	17.64	90.72
53	18.1	3.8	327.61	14.44	68.78
54	17.5	3.6	306.25	12.96	63.00
55	15.5	3.4	240.25	11.56	52.70
56	24.6	4.5	600.25	20.25	110.25
57	22.0	4.5	484.00	20.25	99.00
58	23.1	4.6	532.01	21.16	106.26
59	22.0	4.6	484.00	21.16	101.20
60	21.2	4.6	449.44	21.16	975.92

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pectoral fin (cm) Y	X ²	Y ²	XY
61	20.5	4.2	420.25	17.64	86.10
62	15.1	3.3	228.01	10.89	49.83
63	20.5	4.5	420.25	20.25	92.25
64	24.0	5.0	576.00	25.00	120.00
65	26.5	4.9	702.25	24.01	129.85
66	22.5	4.3	506.25	18.49	96.75
67	22.0	4.2	484.00	17.64	92.40
67	26.6	5.0	707.56	25.00	133.00
69	31.5	6.0	992.25	36.00	189.00
70	23.0	4.5	529.00	20.25	103.50
71	24.0	5.0	576.00	25.00	120.00
72	21.2	4.1	449.44	16.81	86.92
73	22.9	4.5	524.41	20.25	103.05
74	18.0	3.9	324.00	15.21	70.20
75	18.6	4.1	345.96	16.81	76.26
76	22.0	4.3	484.00	18.49	94.60
77	22.5	4.6	506.25	21.16	103.50
78	21.2	4.2	449.44	17.64	89.04
79	25.5	5.2	650.25	27.04	132.60
80	19.2	4.0	368.64	16.00	76.80
81	25.9	4.9	670.81	24.01	126.91
82	26.6	5.2	707.56	27.04	138.32
83	29.0	5.5	841.00	30.25	159.50
84	26.1	5.2	681.21	27.04	135.72
85	27.5	5.4	756.25	29.16	148.50
86	23.5	4.3	552.25	18.49	101.05
87	22.6	4.5	510.76	20.25	101.70
88	24.5	5.0	600.25	25.00	122.50
89	20.3	4.5	412.09	20.25	91.35
90	20.5	4.6	420.25	21.16	94.30
91	19.6	4.1	384.16	16.81	80.36

Number of observations	Length of fish up to base of caudal fin (cm) X	Length upto pectoral fin (cm) Y	X ²	Y ²	XY
92	19.9	4.2	396.01	17.64	83.58
93	19.0	4.0	361.00	16.00	76.00
94	17.7	3.6	313.29	12.96	63.72
95	22.0	4.5	484.00	20.25	99.00
96	23.5	4.5	552.25	20.25	105.75
97	22.8	4.6	519.84	21.16	104.88
98	22.1	4.6	488.41	21.16	101.66
99	21.0	4.0	441.00	16.00	84.00
100	18.0	3.6	324.00	12.96	64.80
101	12.6	4.1	158.76	16.81	51.66
102	19.6	4.0	384.16	16.00	78.40
103	19.6	3.6	384.16	12.96	70.56
104	20.1	3.8	404.01	14.44	76.38
105	19.0	3.9	361.00	15.21	74.10
106	19.0	4.1	361.00	16.81	77.90
107	18.1	3.8	327.61	14.44	68.78
108	20.5	4.2	420.25	17.64	86.10
109	24.0	4.9	576.00	24.01	117.70
Total	2289.70	461.80	51036.88	2000.78	10020.77
Mean	21.0064	4.2367	468.2282	18.3557	91.93

Coefficient correlationship 'r' = 0.9353

Calculated 't' value = 27.33

Y = 0.7510 + 0.1658 X

Table 6: Relationship between length upto base of caudal fin and length upto pectoralis in *N. notopterus* (Pallas)

Number of observations	Length of fish up to base of Caudal fin (cm) X	Length upto pectoralis (cm) Y	X ²	Y ²	XY
1	21.0	4.5	441.00	20.25	94.50
2	17.0	3.4	289.00	11.56	57.80
3	15.9	3.1	252.81	9.61	49.29
4	17.4	3.5	302.76	12.25	60.90
5	22.0	5.0	484.00	25.00	110.00
6	26.6	6.1	707.56	37.21	162.26
7	21.0	4.6	441.00	21.16	96.60
8	19.7	4.4	388.09	19.36	86.68
9	18.3	4.3	334.89	19.49	78.69
10	19.3	4.5	372.49	20.25	86.85
11	21.2	4.5	449.44	20.25	95.40
12	21.0	4.7	441.00	22.09	98.70
13	15.5	3.7	240.25	13.69	57.35
14	20.0	4.5	400.00	20.25	90.00
15	21.8	4.7	475.24	22.09	102.46
16	22.0	4.4	484.00	19.36	96.80
17	20.5	4.6	420.25	21.16	94.30
18	21.0	5.0	441.00	25.00	105.00
19	13.3	3.2	176.89	10.24	42.56
20	22.5	4.5	506.25	20.25	101.25
21	23.4	5.5	547.56	30.25	128.70
22	22.0	5.0	484.00	25.00	110.00
23	24.0	5.3	576.00	23.09	127.20
24	13.6	3.2	134.96	10.24	43.52
25	19.5	4.5	380.25	20.25	87.75
26	18.3	4.5	334.89	20.25	82.35
27	20.5	5.4	420.25	29.16	110.70
28	19.5	4.8	330.25	26.04	93.60
29	16.5	3.6	272.25	12.96	59.40
30	24.1	5.9	580.81	34.81	142.19

Number of observations	Length of fish up to base of Caudal fin (cm) X	Length upto pectoralis (cm) Y	X ²	Y ²	XY
31	23.5	6.0	552.25	36.00	141.00
32	18.5	4.5	342.25	20.25	83.25
33	26.6	6.3	707.56	39.69	167.53
34	24.5	5.9	600.25	34.81	144.55
35	21.3	4.5	453.69	20.25	95.85
36	14.0	3.4	196.00	11.56	47.60
37	19.6	4.6	384.16	21.16	90.16
38	14.5	3.5	210.25	12.25	50.75
39	12.6	3.5	158.76	12.25	44.10
40	15.0	3.6	225.00	12.96	54.00
41	14.0	3.2	196.00	10.24	44.80
42	12.0	3.0	144.00	9.00	36.00
43	28.5	6.0	812.25	43.56	188.10
44	24.0	5.7	576.00	32.49	136.80
45	24.1	5.5	580.81	30.25	132.55
46	26.4	6.0	696.96	36.00	158.40
47	22.9	5.7	524.41	32.49	130.53
48	23.0	5.4	529.00	29.16	124.20
49	22.1	5.1	488.91	26.01	112.71
50	21.3	5.1	453.69	26.01	108.63
51	2.5	6.0	651.25	36.00	153.00
52	21.6	4.7	466.56	22.09	101.52
53	18.1	4.2	327.61	17.64	76.02
54	17.5	4.2	306.25	17.64	73.50
55	15.5	3.6	240.25	12.96	55.80
56	24.5	5.6	600.25	31.36	137.20
57	22.0	5.0	484.00	25.00	110.00
58	23.1	6.0	533.61	36.00	138.60
59	22.0	5.3	484.00	28.09	116.60
60	21.2	5.1	449.44	26.01	108.12
61	20.5	5.1	420.25	26.01	104.55
62	15.1	3.7	228.01	13.69	55.87

Number of observations	Length of fish up to base of Caudal fin (cm) X	Length upto pectoralis (cm) Y	X ²	Y ²	XY
63	20.5	5.2	420.25	27.04	106.60
64	24.0	5.5	576.00	30.25	132.00
65	26.5	6.0	702.25	36.00	159.00
66	22.5	5.2	506.25	27.04	117.00
67	22.0	5.1	484.00	26.01	112.20
68	26.6	6.1	707.56	37.21	162.26
69	31.5	7.0	992.25	49.00	220.50
70	23.0	5.0	529.00	25.00	115.00
71	24.0	5.5	576.00	30.25	132.00
72	21.2	5.0	449.44	25.00	106.00
73	22.9	5.5	524.41	30.25	129.95
74	18.0	4.2	324.00	17.64	75.60
75	18.6	5.0	345.96	25.00	93.00
76	22.0	5.2	484.00	27.04	114.40
77	22.5	5.4	506.25	29.16	121.50
78	21.2	4.9	449.44	24.01	103.63
79	25.5	5.9	650.25	34.81	150.45
80	19.2	4.1	368.64	16.81	78.72
81	15.9	6.0	670.81	36.00	155.40
82	26.6	6.0	707.56	36.00	159.60
83	29.0	6.5	841.00	42.25	188.50
84	26.1	6.0	681.21	36.00	156.60
85	27.5	6.2	756.25	38.44	170.50
86	23.5	5.5	552.25	30.25	129.25
87	22.6	5.6	510.76	31.36	126.56
88	24.5	5.7	600.25	32.49	139.65
89	20.3	5.1	412.09	26.01	103.53
90	20.5	5.2	420.25	27.04	106.60
91	19.6	4.9	384.16	24.01	96.04
92	19.9	4.6	396.01	21.16	91.54
93	19.0	4.2	361.00	17.64	79.80
94	17.7	4.4	313.29	19.36	77.88

Number of observations	Length of fish up to base of Caudal fin (cm) X	Length upto pectoralis (cm) Y	X ²	Y ²	XY
95	22.0	5.2	484.00	27.04	114.40
96	23.5	5.5	552.25	30.25	129.25
97	22.8	5.5	519.84	30.25	125.40
98	22.1	5.5	488.41	30.25	121.55
99	21.0	4.6	441.00	21.16	96.60
100	18.0	4.1	324.00	16.81	73.80
101	12.6	4.7	158.76	22.09	59.22
102	19.6	5.0	384.16	25.00	98.00
103	19.6	4.1	384.16	16.81	80.36
104	20.1	4.3	404.01	18.49	86.43
105	19.0	4.4	361.00	19.36	83.60
106	19.0	4.6	361.00	21.16	87.40
107	18.1	4.5	327.61	20.25	81.45
108	20.5	5.0	420.25	25.00	102.50
109	24.0	6.0	576.00	36.00	144.00
Total	2289.70	535.20	51024.61	2707.9	11655.01
Mean	21.0064	4.91	468.1157	24.84	106.9267

Coefficient correlationship 'r' = 0.9283

Calculated 't' value = 25.82

Y = 0.4393 + 0.2128 X

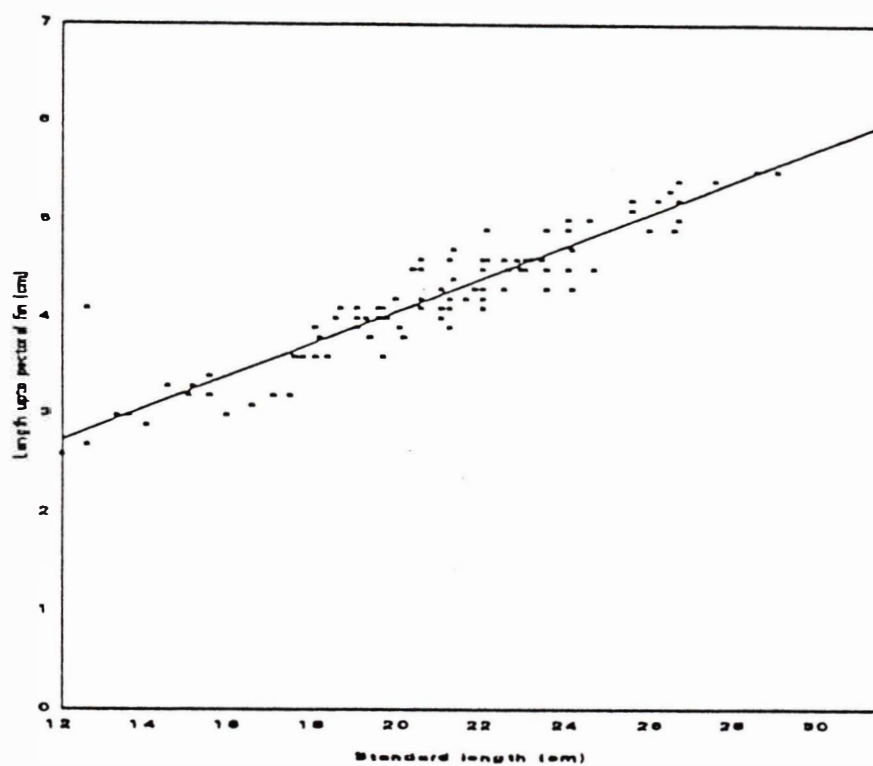


Fig. 6. Relationship between length upto base of caudal fin and length upto pectoral fin of *Notopterus notopterus* (Pallas)

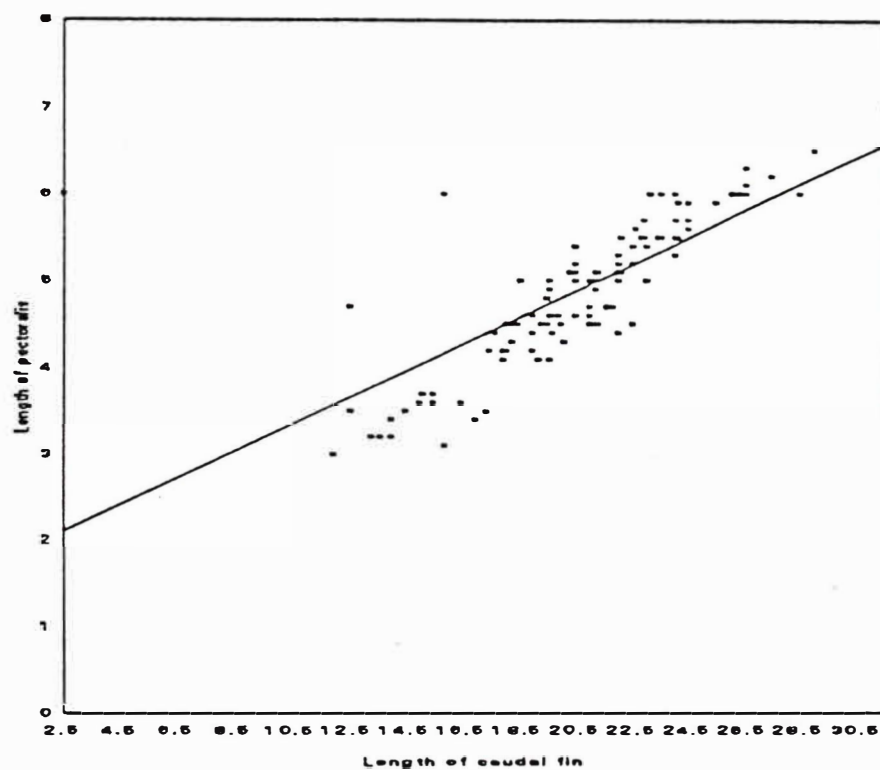


Fig. 7. Relationship between length upto base of caudal fin and length upto pectoralis of *Notopterus notopterus* (Pallas)

4.7 LENGTH FREQUENCY DISTRIBUTION OF *N. NOTOPTERUS* (PALLAS)

The length frequency distribution of female *Notopterus notopterus* has been grouped into three periods consisting of the months. The fish length ranges from 13.0 to 28.9 cm during the month of Sept to November with modes at 14.45, 21.45, 22.45 and 24.45 cm and with maximum number at 24.45. The fish length ranges from 16.0 to 31.9 cm with maximum number at 23.45 cm with modes at 16.45, 22.45, 26.45 30.45 cm in December to February. The fish length group ranges from 16.0 to 34.9 cm during March to August with modes at 19.45, 24.45 with maximum number at 22.45 cm. (Table 7)

Length frequency of female fish throughout the year (Table 8, Fig.8) indicates that maximum number of individual occurred at 22.0 cm to 25.0 cm (about 36.04 %) length group. It is assumed from the observation that when the length increases the number of individuals decreases.

4.8 SEASONAL FLUCTUATIONS IN GONOSOMATIC INDEX OF *N. NOTOPTERUS* (PALLAS)

The rise of gonosomatic index from December to February indicates the preparatory-cum active phase or maturing phase of the fish. (Table 9, Fig. 9). The high gonosomatic index from March to August clearly indicates the vitellogenic period or active cum quiescent period. During this period the gonosomatic index value is 3.05 (Table 10, Fig. 9).

The abrupt fall of GSI from September to November indicates the resting period or quiescent cum preparatory phase of the fish (Table 11: Fig. 9). Correlation of different morphological stages of ovary showed that there is a steady increase in gonosomatic index of ovary up to mature stage V (Table 15, Fig. 10) and recedes in spent (VI) stage ovary (Table 16, Fig. 10). Thus the above data showed that, the GSI increases with the approach of spawning season and recedes at the end of spawning season in *Notopterus notopterus*.

Table 7: Length frequency of female *N. notopterus* (Pallas)

Length group	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
13.0-13.9	-	-	2	-	-	-	-	-	-	-	-	-
14.0-14.9	2	-	1	-	-	-	-	-	-	-	-	-
15.0-15.9	-	-	2	-	-	-	-	-	-	-	-	-
16.0-16.9	-	-	1	-	1	1	-	-	-	-	-	1
17.0-17.9	-	1	-	-	-	-	-	-	-	-	-	1
18.0-18.9	1	-	-	-	1	-	-	-	-	-	-	2
19.0-19.9	-	1	-	-	1	-	-	1	-	2	-	1
20.0-20.9	-	1	-	-	-	-	-	1	1	1	3	2
21.-21.9	3	-	1	-	-	-	-	-	-	3	1	1
22.0-22.9	3	-	-	-	-	2	-	-	-	4	2	4
23.0-23.9	1	-	1	3	1	2	-	3	-	2	-	1
24.0-24.9	3	1	-	1	-	-	2	2	1	1	-	-
25.0-25.9	1	1	-	2	1	-	1	1	2	1	1	-
26.0-26.9	-	1	-	1	1	-	-	1	-	-	-	-
27.0-27.9	-	-	-	1	-	-	-	-	2	-	-	1
28.0-28.9	-	1	-	1	-	-	2	-	1	-	-	-
29.0-29.9	-	-	-	-	-	-	-	-	2	-	-	-
30.0-30.9	-	-	-	2	-	-	-	-	1	-	-	-
34.0-34.9	-	-	-	-	-	-	1	-	-	-	-	-

* Specimens are not available in the length group of 31.0-33.9.

Table 8: Length frequency distribution of female *N. notopterus* (Pallas) throughout the year 1993-94.

Different length groups of female fish (cm).	Number of fish
13.0-16.0	7
16.0-19.0	10
19.0-22.0	24
22.0-25.0	40
25.0-28.0	19
28.0-31.0	10
31.0-34.0	0
34.0-37.0	1
Total	111

Table 9: Gonosomatic index of *N. notopterus* (Pallas) from December to February

No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	230.0	0.635	0.276
2	120.0	0.474	0.395
3	120.0	0.735	0.612
4	150.0	0.599	0.399
5	115.0	0.633	0.550
6	100.0	0.494	0.494
7	95.0	0.426	0.449
8	90.0	0.400	0.445
9	100.0	0.407	0.407
10	85.0	0.439	0.517
11	50.0	0.209	0.419
12	35.0	0.177	0.505
13	30.0	0.079	0.262
14	115.0	0.124	0.108
15	115.0	0.222	0.193
16	80.0	0.905	1.131
17	110.0	0.744	0.677
18	85.0	0.390	0.458
19	75.0	0.429	0.571
20	80.0	0.406	0.508
21	24.0	0.013	0.052
Total	2004.0	8.939	9.428
Mean	95.428	0.426	0.449
	± 43.60	± 0.227	± 0.217

Table 10: Gonosomatic index of *N. notopterus* (Pallas) from March to August

No.of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	80.0	0.173	0.216
2	50.0	0.040	0.078
3	80.0	0.109	0.136
4	100.0	0.329	0.329
5	160.0	0.349	0.218
6	80.0	0.786	0.982
7	70.0	0.155	0.222
8	50.0	0.069	0.138
9	68.0	0.111	0.163
10	65.0	0.464	0.714
11	70.0	0.375	0.535
12	35.0	0.117	0.333
13	70.0	0.292	0.417
14	130.0	10.661	8.201
15	175.0	10.645	6.083
16	100.0	3.342	3.342
17	90.0	0.718	0.798
18	182.0	7.529	4.137
19	300.0	16.517	5.506
20	105.0	4.834	4.603
21	130.0	4.075	3.134
22	84.0	4.439	5.284
23	125.0	12.765	10.212
24	45.0	0.263	0.585
25	50.0	0.446	0.891
26	100.0	0.898	0.898
27	100.0	2.813	2.813
28	80.0	3.623	4.529
29	125.0	1.148	0.919
30	52.0	0.738	1.419

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No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
31	180.0	6.351	3.528
32	210.0	3.160	1.505
33	150.0	2.815	1.877
34	180.0	2.425	1.347
35	110.0	3.699	3.363
36	105.0	2.264	2.156
37	130.0	4.861	3.739
38	75.0	0.584	0.778
39	75.0	2.417	3.222
40	60.0	0.566	0.944
41	65.0	2.235	3.439
42	50.0	0.335	0.670
43	50.0	0.232	0.464
44	120.0	4.561	3.800
45	105.0	5.871	5.591
46	95.0	5.794	6.099
47	105.0	8.545	8.138
48	70.0	3.390	4.843
49	75.0	1.567	2.089
50	45.0	3.919	8.709
51	70.0	5.560	7.943
52	75.0	3.402	4.536
53	70.0	5.210	7.443
54	60.0	4.464	7.440
55	55.0	0.754	1.371
56	70.0	3.044	4.350
57	125.0	9.323	7.458
Total	5531.0	186.164	174.677
Mean	97.03	3.266	3.06
	± 48.23	± 3.514	± 2.78

Table 11: Gonosomatic index of *N. notopterus* (Pallas) from September to November

No.of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	84.0	0.669	0.796
2	100.0	0.322	0.313
3	66.0	0.884	1.340
4	85.0	0.300	0.353
5	85.0	0.708	0.832
6	112.0	0.455	0.406
7	60.0	0.717	1.196
8	110.0	0.356	0.324
9	60.0	0.196	0.327
10	40.0	0.094	0.236
11	85.0	0.349	0.410
12	65.0	0.255	0.392
13	30.0	0.153	0.511
14	110.0	0.391	0.356
15	100.0	0.307	0.307
16	42.0	0.084	0.200
17	167.0	0.592	0.354
18	115.0	0.507	0.441
19	80.0	0.763	0.953
20	20.0	0.016	0.082
21	65.0	0.255	0.393
22	20.0	0.011	0.057
23	20.0	0.061	0.304
24	30.0	0.013	0.043
25	25.0	0.064	0.254
Total	1776.0	8.440	11.18
Mean	71.04	0.338	0.447
	± 36.77	± 0.253	± 0.323

Table 12: Gonosomatic Index of *N. notopterus* (Pallas) of Stage I ovary

No.of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	40.0	0.094	0.236
2	42.0	0.084	0.200
3	20.0	0.016	0.082
4	20.0	0.011	0.057
5	100.00	0.494	0.494
6	50.0	0.209	0.419
7	35.0	0.177	0.505
8	75.0	0.406	0.542
9	24.0	0.013	0.052
Total	406.0	1.505	2.587
Mean	45.11	0.167	0.287
	± 25.33	± 0.166	± 0.192

Table 13: Gonosomatic Index of *N. notopterus* (Pallas) of Stage II ovary

No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	68.0	0.111	0.163
2	60.0	0.196	0.327
3	80.0	0.763	0.953
4	85.0	0.439	0.517
5	35.0	0.177	0.505
6	115.0	0.124	0.108
7	115.0	0.222	0.193
8	80.0	0.905	1.131
9	85.0	0.390	0.458
10	50.0	0.039	0.078
11	50.0	0.069	0.138
12	230.0	0.635	0.276
13	150.00	0.599	0.399
Total	1203.0	4.6681	5.246
Mean	92.54	0.359	0.404
	± 49.79	± 0.275	± 0.309

Table 14: Gonosomatic Index of *N. notopterus* (Pallas) of Stage III and IV ovary

No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	80.0	0.786	0.982
2	70.0	0.155	0.222
3	35.0	0.117	0.333
4	85.0	0.349	0.410
5	30.0	0.153	0.511
6	20.0	0.061	0.304
7	115.0	0.633	0.550
8	90.0	0.400	0.445
9	100.0	0.407	0.407
10	110.0	0.744	0.677
11	65.0	0.464	0.714
12	80.0	0.406	0.508
13	110.0	0.391	0.356
14	120.0	0.735	0.612
15	110.0	0.356	0.324
16	70.0	0.375	0.535
17	70.0	0.292	0.417
18	85.0	0.300	0.353
Total	1480.0	7.125	8.660
Mean	82.22	0.396	0.481
	± 31.89	± 0.208	± 0.177

Table 15: Gonosomatic index of *N. notopterus* (Pallas) of stage V ovary

No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	100.0	0.329	0.329
2	84.0	0.669	0.796
3	66.0	0.884	1.340
4	130.0	10.661	8.201
5	175.0	10.645	6.083
6	100.0	3.342	3.342
7	162.0	7.529	4.137
8	300.0	16.517	5.506
9	105.0	4.834	4.603
10	130.0	4.075	3.134
11	84.0	4.439	5.284
12	125.0	12.765	10.212
13	100.0	2.813	2.313
14	80.0	3.623	4.529
15	180.0	6.351	3.528
16	210.0	3.160	1.505
17	150.0	2.815	1.877
18	110.0	3.699	3.363
19	105.0	2.264	2.156
20	130.0	4.861	3.739
21	75.0	2.417	3.222
22	65.0	2.235	3.439
23	120.0	4.561	3.800
24	105.0	5.871	5.591
25	95.0	5.794	6.099
26	105.0	8.545	8.138
27	70.0	5.560	7.943
28	70.0	5.210	7.443
29	60.0	4.464	7.440
30	70.0	3.044	4.350
31	125.0	9.323	7.458
32	80.0	0.109	0.136
Total	3666.0	163.406	141.036
Mean	114.56	5.106	4.407
	± 49.01	± 3.65	± 2.505

Table 16: Gonosomatic index of *N. notopterus* (Pallas) of stage VI ovary

No. of observations	Weight of fish (g)	Weight of ovary (g)	Gonosomatic index (GSI)
1	80.0	0.173	0.216
2	10.0	0.322	0.313
3	85.0	0.708	0.832
4	112.0	0.455	0.406
5	60.0	0.717	1.196
6	25.0	0.064	0.254
7	120.0	0.474	0.395
8	95.0	0.426	0.449
9	30.0	0.079	0.262
10	160.0	0.349	0.218
11	90.0	0.718	0.798
12	50.0	0.446	0.891
13	45.0	0.263	0.585
14	100.0	0.898	0.898
15	125.0	1.148	0.919
16	52.0	0.738	1.419
17	180.0	2.125	1.347
18	75.0	0.584	0.778
19	60.0	0.566	0.944
20	50.0	0.335	0.670
21	50.0	0.232	0.464
22	70.0	3.390	4.843
23	75.0	1.567	2.089
24	45.0	3.919	8.709
25	75.0	3.402	4.536
26	55.0	0.754	1.371
27	100.0	0.307	0.307
28	115.0	0.507	0.441
29	65.0	0.255	0.393
30	30.0	0.013	0.043
31	167.0	0.592	0.354
Total	2541.0	26.523	37.34
Mean	81.96	0.856	1.204
	± 38.96	± 0.987	± 1.742

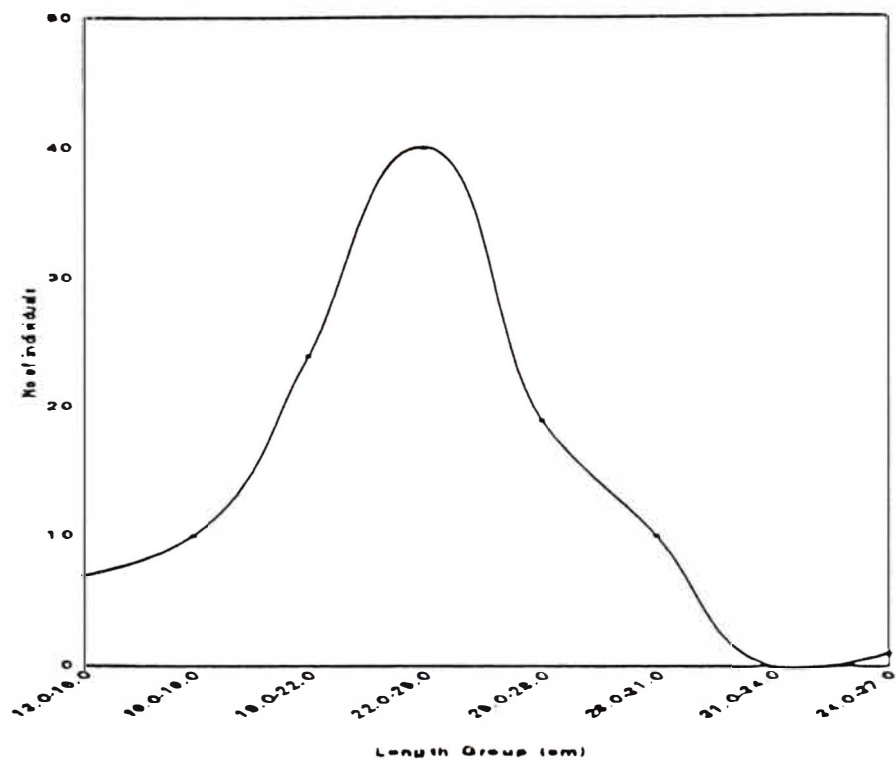


Fig. 8. Length frequency distribution of female *N. nefepterus* (Fallas) throughout the year 1984.

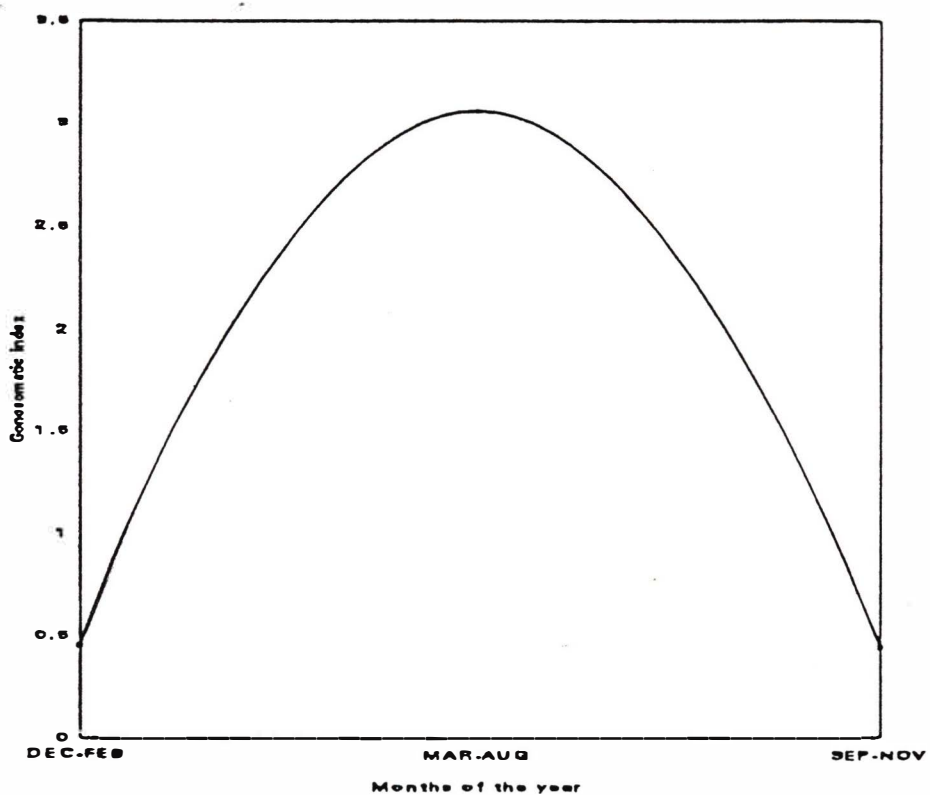


Fig. 9. Gonosomatic index from January to December

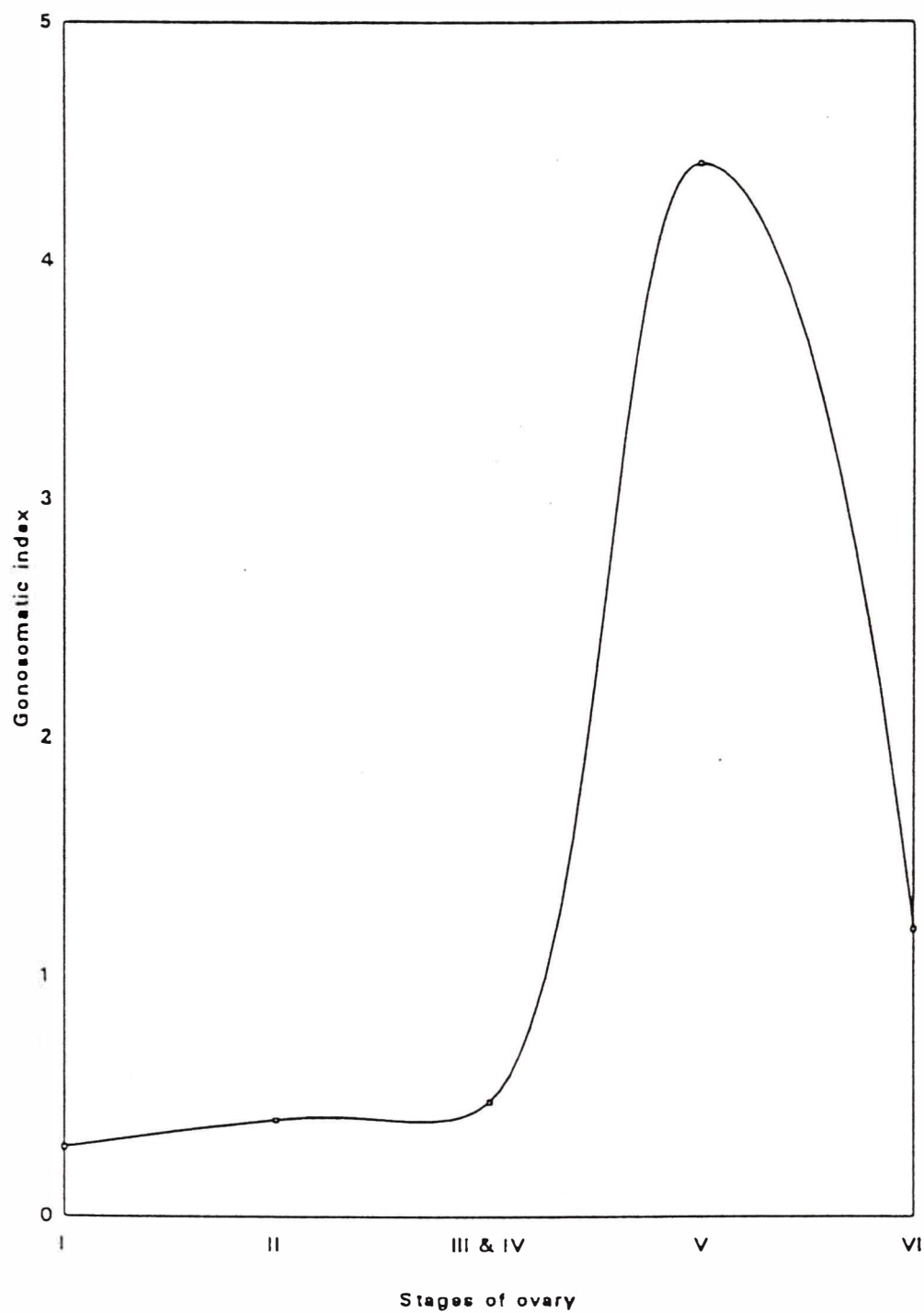


Fig. 10. Gonosomatic index in different stages of ovary of *Notopterus notopterus* (Pallas)

4.9 RELATIVE CONDITION FACTOR OF *N. NOTOPTERUS* (PALLAS)

The relative condition factor (kn) is correlated with the breeding of fish (Rangaswami, 1967). The rise of condition factor (kn) value to 3.940 during December to February (Table 17, Fig. 11) indicates the preparatory cum active phase of *N. notopterus*. The 'kn' value rise to 3.981 from March to August (Table 18, Fig. 11) indicated that the breeding period or vitellogenesis period. This steady rise of 'kn' value coincided with the occurrence of more ripe ovaries. The 'kn' value was found to be 2.94 (Table 19, Fig. 11) from September to November. The drop during this period was due to release of mature eggs indicating the end of spawning season.

4.10 PONDERAL INDEX OF *N. NOTOPTERUS* (PALLAS)

The ponderal index (P.I) from December to February, March to August and September to November are presented (Table 20-22, Fig. 12). The value of ponderal index in the month of December to February is 0.681 which indicates the preparatory cum active phase. The rise of ponderal index upto 0.73 clearly indicates the breeding period or vitellogenesis during March to August. The fall of ponderal index from September to November coincided with the end of spawning season called the quiescent-cum preparatory phase.

The ponderal index at different length groups of female *N. notopterus* is presented (Table 23-29, Fig.13). From this observation of data it is found that there are slight fluctuation of ponderal index value for the length group 13.0-15.9, 19.0-21.9 and 25.0-27.9 cm respectively. Ponderal index increases at length group 16.0-18.9 and also increase at 28.0 cm onwards. From these data it can be assumed that the PI increased coincided with the increased length of the fishes.

Table 17: Relative condition factor of *N. notopterus* (Pallas) from December to February

No. of observations	Observed weight of fish (g)	Calculated weight of fish (g)	Kn = Wo/Wc
1	230.0	28.97	7.94
2	120.0	25.07	4.79
3	120.0	25.07	4.79
4	150.0	26.40	5.68
5	115.0	14.82	4.63
6	100.0	24.06	4.16
7	95.0	23.81	3.99
8	90.0	23.45	3.84
9	140.0	26.00	5.38
10	85.0	23.21	3.66
11	50.0	20.61	2.43
12	35.0	18.98	1.84
13	30.0	18.40	1.63
14	115.0	24.82	4.63
15	80.0	22.85	3.50
16	110.0	24.56	4.48
17	85.0	23.21	3.66
18	75.0	22.62	3.32
19	80.0	22.85	3.50
20	24.0	17.48	1.37
21	81.0	22.97	3.53
Total	2010.0	408.21	82.75
Mean	95.71	22.87	3.940
	± 44.58	± 3.183	± 1.44

Table 18: Relative condition factor of *N. notopterus* (Pallas) from March to August

No.of observations	Observed weight of fish (g)	Calculated weight of fish (g)	$K_n = W_o/W_c$
1	130.0	25.46	5.11
2	175.0	27.23	6.43
3	100.0	24.06	4.16
4	90.0	23.45	3.84
5	182.0	27.51	6.62
6	300.0	30.82	9.74
7	105.0	24.31	4.32
8	130.0	25.46	5.11
9	84.0	23.09	3.64
10	125.0	25.33	4.93
11	45.0	20.09	2.24
12	50.0	20.61	2.43
13	100.0	24.06	4.16
14	100.0	24.06	4.16
15	80.0	22.85	3.50
16	125.0	25.33	4.93
17	52.0	20.82	2.50
18	120.0	25.07	4.79
19	180.0	27.51	6.54
20	210.0	28.38	7.40
21	150.0	26.40	5.68
22	180.0	27.51	6.54
23	110.0	24.56	4.48
24	105.0	24.31	4.32
25	130.0	25.46	5.11
26	75.0	22.62	3.32
27	75.0	22.62	3.32
28	60.0	21.48	2.79
29	65.0	21.81	2.98
30	50.0	20.61	2.43
31	50.0	20.61	2.43

No.of observations	Observed weight of fish (g)	Calculated weight of fish (g)	$Kn = Wo/Wc$
32	120.0	25.07	4.79
33	105.0	24.31	4.32
34	95.0	23.81	3.99
35	105.0	24.31	4.32
36	70.0	22.27	3.14
37	45.0	20.09	2.24
38	75.0	22.62	3.32
39	45.0	20.09	2.24
40	70.0	22.27	3.14
41	75.0	22.62	3.32
42	70.0	22.27	3.14
43	60.0	21.48	2.79
44	55.0	21.04	2.61
45	70.0	22.27	3.14
46	125.0	25.33	4.93
47	100.0	24.06	4.16
48	80.0	22.85	3.50
49	50.0	20.61	2.43
50	80.0	22.85	3.50
51	100.0	24.06	4.16
52	160.0	26.67	6.0
53	80.0	22.85	3.5
54	70.0	22.27	3.14
55	50.0	20.61	2.43
56	68.0	22.04	3.09
57	65.0	21.81	2.98
58	70.0	22.27	3.14
59	35.0	18.98	1.84
60	7.0	22.27	3.14
Total	5796.0	1409.54	238.40
Mean	96.6	23.49	3.97
	± 47.58	± 2.317	± 1.470

Table 19: Relative condition factor of *N. notopterus* (Pallas) from September to November

No. of observations	Observed weight of fish (g)	Calculated weight of fish (g)	$K_n = W_o/W_c$
1	84.0	23.09	3.64
2	100.0	24.06	4.16
3	66.0	21.93	3.01
4	85.0	23.21	3.66
5	17.0	16.17	1.05
6	85.0	23.21	3.66
7	112.0	24.69	4.54
8	100.0	24.06	4.16
9	60.0	21.48	2.79
10	110.0	24.56	4.48
11	15.0	15.76	0.95
12	60.0	21.48	2.79
13	40.0	19.57	2.04
14	85.0	23.21	3.66
15	65.0	21.81	2.987
16	30.0	18.40	1.63
17	110.	24.56	4.48
18	100.0	24.06	4.16
19	42.0	19.78	2.12
20	167.0	26.95	6.20
21	115.0	24.82	4.63
22	80.0	22.85	3.50
23	20.0	16.77	1.19
24	20.0	16.77	1.19
25	30.0	18.40	1.63
26	25.0	17.66	1.42
27	22.0	17.12	1.29
28	65.0	21.81	2.98
29	20.0	16.77	1.19
Total	1930.0	613.03	85.18
Mean	66.55	21.138	2.94
	± 38.29	± 3.236	± 1.37

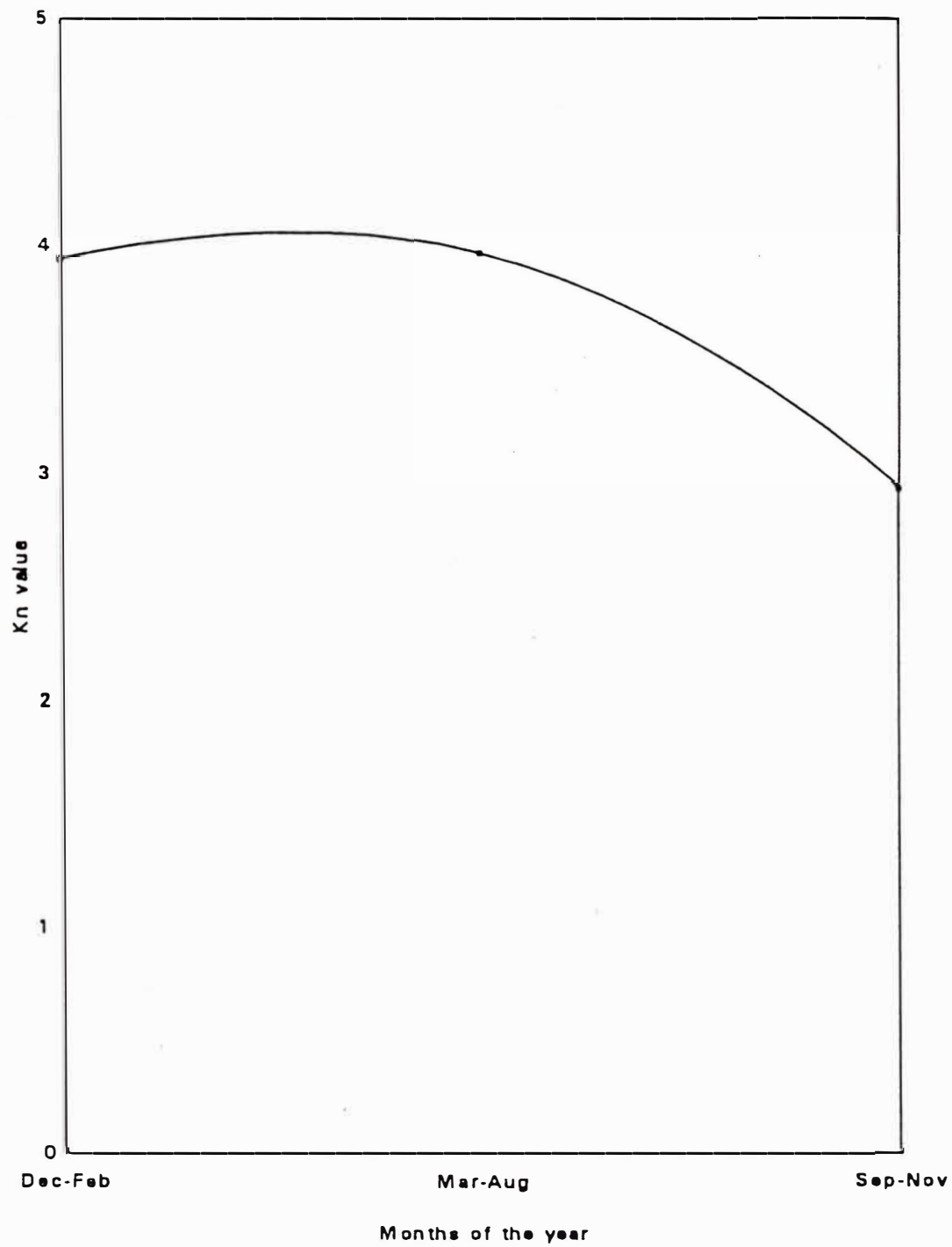


Fig. 11. Relative condition factor (Kn) of *Notopterus notopterus* (Pallas)

Table 20: Ponderal index of *N. notopterus* (Pallas) from December to February

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I. = $W/L^3 \times 100$
1	230.0	30.5	0.81
2	230.0	30.5	0.81
3	120.0	25.6	0.72
4	120.0	26.1	0.67
5	150.0	28.1	0.67
6	115.0	24.6	0.77
7	100.0	25.0	0.64
8	95.0	23.8	0.70
9	90.0	23.3	0.71
10	140.0	27.2	0.70
11	85.0	23.0	0.70
12	50.0	19.6	0.66
13	35.0	18.6	0.54
14	30.0	16.5	0.67
15	115.0	26.1	0.65
16	80.0	23.4	0.62
17	110.0	25.4	0.67
18	85.0	23.4	0.66
19	75.0	23.0	0.62
20	80.0	22.1	0.74
21	24.0	26.5	0.53
22	81.0	22.3	0.73
Total	2240.00	524.6	14.99
Mean	101.81	23.845	0.681
	± 51.76	± 3.671	± 0.068

Table 21: Pondral index of *N. notopterus* (Pallas) from March to August

No. of observations	Weight of fish (g)	Length of fish (cm)	$P.I = W/L^3 \times 100$
1	130.0	25.8	0.76
2	175	28.0	0.80
3	100.0	24.1	0.71
4	90.0	24.3	0.63
5	182.0	28.3	0.80
6	300.0	34.2	0.75
7	105.0	24.3	0.73
8	130.0	26.0	0.48
9	84.0	23.0	0.69
10	125.0	25.0	0.80
11	45.0	19.1	0.65
12	50.0	20.1	0.62
13	100.0	23.5	0.77
14	100.0	24.4	0.69
15	80.0	23.0	0.66
16	125.0	27.0	0.64
17	52.0	20.9	0.57
18	120.0	27.8	0.56
19	180.0	29.5	0.70
20	210.0	30.3	0.75
21	150.0	28.1	0.68
22	180.0	29.5	0.70
23	110.0	25.4	0.67
24	105.0	24.4	0.72
25	130.0	25.7	0.77
26	75.0	22.0	0.70
27	75.0	22.5	0.66
28	60.0	21.0	0.65
29	65.0	21.0	0.70
30	50.0	20.2	0.61
31	50.0	19.8	0.64
32	120.0	22.6	1.64
33	105.0	25.2	0.66

No. of observations	Weight of fish (g)	Length of fish (cm)	$P.I = W/L^3 \times 100$
34	95.0	24.5	0.65
35	105.0	23.6	0.80
36	70.0	23.0	0.58
37	45.0	19.2	0.64
38	75.0	22.1	0.69
39	45.0	21.5	0.45
40	70.0	21.1	0.75
41	75.0	22.2	0.69
42	70.0	20.5	0.81
43	60.0	20.5	0.70
44	55.0	20.0	0.69
45	70.0	22.1	0.65
46	125.0	25.9	0.72
47	100.0	22.0	0.94
48	80.0	28.5	1.26
49	50.0	16.4	1.13
50	80.0	18.5	1.26
51	100.0	23.5	0.77
52	160.0	27.5	0.77
53	80.0	22.1	0.75
54	70.0	20.4	0.82
55	50.0	19.5	0.67
56	68.0	20.1	0.84
57	65.0	22.5	0.57
58	70.0	22.2	0.64
59	35.0	17.0	0.71
60	70.0	21.1	0.75
Total	5796.00	1393.5	44.25
Mean	96.6	23.225	0.737
	± 47.577	± 3.441	± 0.1835

Table 22: Ponderal index of *N. notopterus* (Pallas) from September to November

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I = $W/L^3 \times 100$
1	84.0	22.6	0.73
2	100.0	23.5	0.77
3	66.0	21.8	0.64
4	85.0	21.9	0.81
5	17.0	14.3	0.58
6	85.0	24.0	0.61
7	112.0	25.1	0.71
8	100.0	24.0	0.72
9	60.0	22.5	0.53
10	110.0	24.4	0.76
11	15.0	14.7	0.47
12	60.0	21.0	0.65
13	40.0	18.9	0.59
14	85.0	22.0	0.80
15	65.0	20.8	0.72
16	30.0	17.5	0.56
17	110.0	25.3	0.68
18	100.0	24.9	0.65
19	42.0	19.8	0.54
20	167.0	28.0	0.76
21	115.0	26.1	0.65
22	80.0	23.0	0.66
23	20.0	15.5	0.54
24	65.0	21.6	0.64
25	20.0	25.6	0.53
26	20.0	13.8	0.76
27	30.0	16.4	0.68
28	25.0	14.9	0.76
29	22.0	13.1	0.98
Total	1930.0	596.1	19.48
Mean	66.551	20.555	0.67
	± 38.298	± 4.134	± 0.106

Table 23: Ponderal index of *N. notopterus* (Pallas) at length group 13.0 to 15.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1.	15.0	14.7	0.47
2.	17.0	14.3	0.58
3.	20.0	15.5	0.54
4.	20.0	15.6	0.53
5.	20.0	13.8	0.76
6.	25.0	14.9	0.76
7.	22.0	13.1	0.98
Total	139.0	101.9	4.62
Mean	19.86	14.56	0.66
	± 2.996	± 0.834	± 0.167

Table 24: Ponderal index of *N. notopterus* (Pallas) at length group 16.0 to 18.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1.	80.0	18.5	1.26
2.	50.0	16.4	1.13
3.	80.0	18.5	1.26
4.	35.0	17.0	0.71
5.	40.0	18.9	0.59
6.	30.0	17.7	0.56
7.	30.0	16.4	0.68
8.	35.0	18.6	0.54
9.	30.0	16.5	0.67
10	24.0	16.5	0.53
Total	434.0	174.8	7.93
Mean	43.4	17.48	0.793
	± 19.468	± 0.99	± 0.285

Table 25: Ponderal index of *N. notopterus* (Pallas) at length group 19.0 to 21.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1	70.0	20.4	0.82
2	50.0	19.5	0.67
3	60.0	20.1	0.84
4	66.0	21.8	0.64
5	85.0	21.9	0.81
6	70.0	21.1	0.75
7	60.0	21.0	0.65
8	65.0	20.8	0.72
9	42.0	19.8	0.54
10	65.0	21.6	0.64
11	50.0	19.6	0.66
12	45.0	19.1	0.65
13	50.0	20.1	0.62
14	52.0	20.9	0.57
15	60.0	21.0	0.65
16	65.0	21.0	0.70
17	50.0	20.2	0.61
18	50.0	19.8	0.64
19	45.0	19.2	0.64
20	45.0	21.5	0.45
21	70.0	21.1	0.75
22	70.0	20.5	0.81
23	60.0	20.5	0.70
24	55.0	20.0	0.69
Total	1408.08	472.5	16.22
Mean	58.67	19.69	0.676
	± 10.69	± 4.076	± 0.089

Table 26: Ponderal index of *N. notopterus* (Pallas) at length group 22.0 to 24.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1	100.0	22.0	0.94
2	100.0	23.5	0.77
3	80.0	22.1	0.74
4	65.0	22.5	0.57
5	70.0	22.2	0.64
6	84.0	22.6	0.73
7	100.0	23.5	0.77
8	100.0	24.0	0.72
9	60.0	22.5	0.53
10	110.0	24.4	0.76
11	85.0	22.0	0.80
12	100.0	24.9	0.65
13	80.0	23.0	0.66
14	115.0	24.6	0.77
15	95.0	23.8	0.70
16	90.0	23.3	0.71
17	85.0	23.0	0.70
18	80.0	23.4	0.62
19	85.0	23.4	0.66
20	75.0	23.0	0.62
21	80.0	22.1	0.74
22	81.0	22.3	0.73
23	100.0	24.1	0.71
24	90.0	24.3	0.63
25	105.0	24.3	0.73
26	84.0	23.0	0.69
27	100.0	23.5	0.77

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
28	100.0	24.4	0.69
29	80.0	23.0	0.66
30	105.0	24.4	0.72
31	75.0	22.0	0.70
32	75.0	22.5	0.66
33	120.0	22.6	1.04
34	95.0	24.5	0.65
35	105.0	23.6	0.80
36	70.0	23.0	0.58
37	75.0	22.1	0.69
38	75.0	22.2	0.69
39	70.0	22.1	0.65
40	85.0	24.0	0.61
Total	3539.0	927.7	28.20
Mean	88.47	23.19	0.705
	± 14.11	± 0.875	± 0.090

Table 27: Ponderal index of *N. notopterus* (Pallas) at length group 25.0 to 27.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1	160.0	27.5	0.77
2	112.0	25.1	0.71
3	110.0	25.3	0.68
4	115.0	26.1	0.65
5	120.0	25.6	0.72
6	120.0	26.1	0.67
7	100.0	25.0	0.64
8	140.0	27.2	0.72
9	115.0	26.1	0.65
10	110.0	25.4	0.67
11	130.0	25.8	0.76
12	130.0	26.0	0.48
13	125.0	25.0	0.80
14	125.0	27.0	0.64
15	120.0	27.8	0.56
16	110.0	25.4	0.67
17	130.0	25.7	0.77
18	105.0	25.2	0.66
19	125.0	25.9	0.72
Total	2302.0	493.2	12.92
Mean	121.16	25.96	0.68
	± 13.35	± 0.823	± 0.074

Table 28: Ponderal index of *N. notopterus* (Pallas) at length group 28.0 to 30.9 cm.

No. of observations	Weight of fish (g)	Length of fish (cm)	P.I.
1	167.0	28.0	0.76
2	230.0	30.5	0.81
3	230.0	30.5	0.81
4	150.0	28.1	0.67
5	175.0	28.0	0.80
6	182.0	28.3	0.80
7	180.0	29.5	0.70
8	210.0	30.3	0.75
9	150.0	28.1	0.68
10	180.0	29.5	0.70
Total	1854.0	290.8	7.48
Mean	185.4	29.08	0.748
	± 27.58	± 1.036	± 0.053

Table 29: Ponderal index of *N. notopterus* (Pallas) at length group 32.0 to 34.9 cm.

No. of observation	Weight of fish (g)	Length of fish (cm)	P.I.
1	300.0	34.2	0.69
Total	300.0	34.2	0.69
	$\pm$	$\pm$	$\pm$

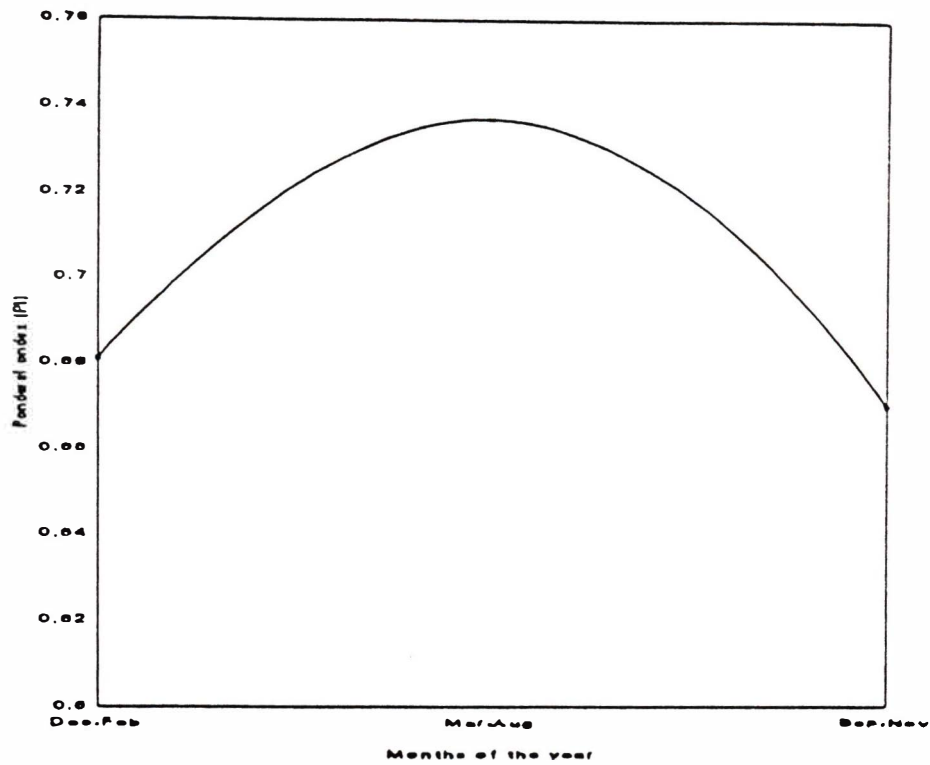


Fig. 12. Ponderal index in different month groups in *Notopterus notopterus* (Pallas)

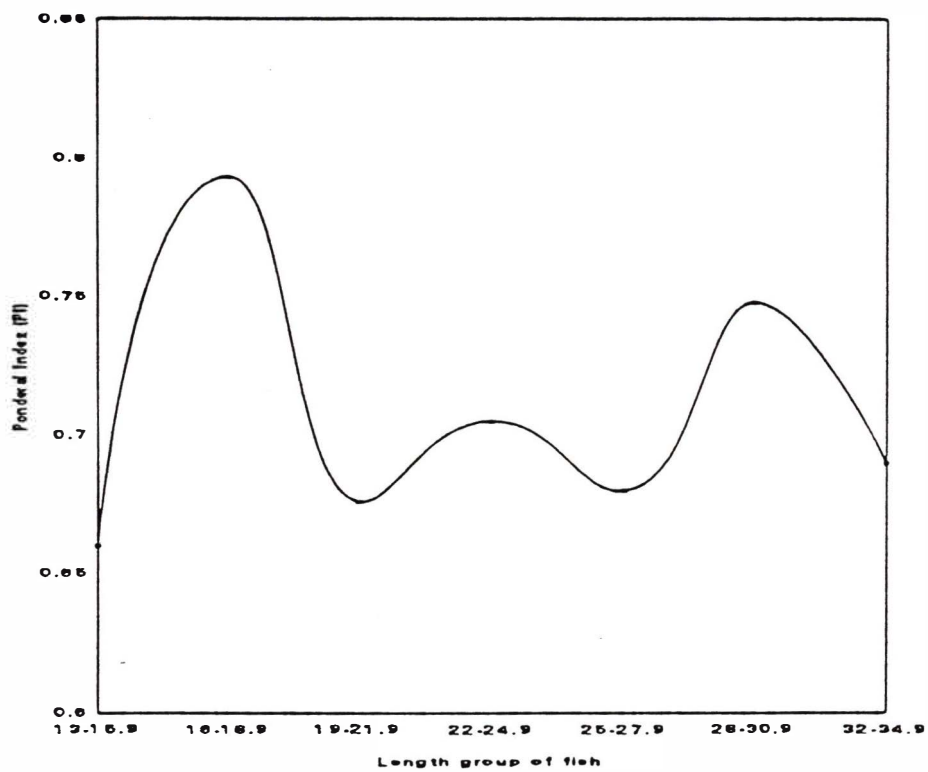


Fig. 13. Ponderal index at different length groups of *Notopterus notopterus* (Pallas)

4.11 SIZE AT FIRST MATURITY IN *N. NOTOPTERUS* (PALLAS)

Observations of one hundred eleven fishes of *N. notopterus* revealed that the fishes in the length range from 13.0 to 16.9 cm were immature (Table 30, Fig. 14). About 15% of mature females were found in the length groups of 17.0 to 20.9 cm. About 42.55% of mature females were found in the length range of 21.0 to 24.9 cm. and 47.82% of maturity was observed in the length group of 25.0 to 28.9 cm. About 60% maturity was observed in fish group with length range from 29.0 to 34.2 cm. These observations indicated that there is a progressive percentage of maturity with increase in length. Thus the size at first maturity is between 17.0 to 20.9 cm (Table 31) and maturity percentage between 40 to 60 lies in the size group of 21.0 to 34.2 cm (Table 32-34), when the value of ponderal index also showed similar coincidence.

Table 30: Percentage of maturity of *N. notopterus* (Pallas) at length group 13.0 to 16.9 cm.

No. of observations	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary
1	13.8	20.0	0.0607	III
2	14.9	25.0	0.0636	VI
3	15.5	20.0	0.0163	I
4	15.6	20.0	0.0113	I
5	16.4	50.0	0.0392	II
6	16.4	30.0	0.0130	VI
7	16.5	30.0	0.0787	VI
8	16.5	24.0	0.0125	I
Total	124.7	219.0	0.2953	
Mean	15.587	27.37	0.037	
	± 1.043	± 9.393	± 0.025	

Table 31: Percentage of maturity of *N. notopterus* (Pallas) at length group 17.0 to 20.9 cm.

No.of obs.	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary	Percentage of maturity
1	17.0	35.0	0.1166	III	15%
2	17.5	30.0	0.1534	III	
3	18.5	80.0	0.1730	VI	
4	18.5	80.0	0.1091	V	
5	18.6	35.0	0.1768	II	
6	18.9	40.0	0.0944	I	
7	19.1	45.0	0.2631	VI	
8	19.5	50.0	0.0688	II	
9	19.6	50.0	0.2093	VI	
10	19.8	52.0	0.0839	I	
11	19.8	50.0	0.2320	VI	
12	20.0	55.0	0.7542	VI	
13	20.1	68.0	0.1111	II	
14	20.1	50.0	0.4456	VI	
15	20.2	50.0	0.3349	VI	
16	20.4	70.0	0.1554	III	
17	20.5	70.0	5.2104	V	
18	20.5	60.0	4.4640	V	
19	20.8	65.0	0.2547	VI	
20	20.9	52.0	0.7377	VI	
Total	390.3	1077.0	14.1485		
Mean	19.55	53.85	0.7074		
	± 1.0413	± 14.1784	± 1.3944		

Table 32: Percentage of maturity of *N. notopterus* (Pallas) at length group 21.0 to 24.9 cm.

No. of obs.	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary	Percentage of maturity
1	21.0	60.0	0.1959	II	
2	21.0	60.0	0.5663	VI	
3	21.0	65.0	2.2354	V	
4	21.1	70.0	0.2917	IV	
5	21.1	70.0	5.5601	V	
6	21.5	45.0	3.0189	VI	
7	21.6	65.0	0.2553	VI	
8	21.8	66.0	0.8841	V	
9	21.9	85.0	0.3001	IV	
10	22.0	85.0	0.3489	III	
11	22.0	75.0	0.5838	VI	
12	22.1	80.0	0.7863	VI	
13	22.1	80.0	0.4063	VI	
14	22.1	75.0	1.5670	VI	
15	22.1	70.0	3.0443	V	
16	22.2	70.0	0.3746	IV	
17	22.2	75.0	3.4021	VI	
18	22.5	60.0	0.7173	VI	
19	22.5	65.0	0.4642	IV	
20	22.5	75.0	2.4166	V	
21	22.6	84.0	0.6685	V	
22	23.0	80.0	0.7627	II	
23	23.6	120.0	4.5605	V	
24	23.0	85.0	0.4393	VI	
25	23.0	75.0	0.4285	I	
26	23.0	70.0	3.3898	VI	
27	23.0	80.0	3.6231	VI	

No.of obs.	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary	Percentage of maturity
28	23.4	80.0	0.9049	II	
29	23.4	85.0	0.3897	II	
30	23.3	90.0	0.4001	III	
31	23.5	100.0	0.3286	V	
32	23.5	100.0	0.3216	VI	
33	23.0	84.0	4.4388	V	42.55%
34	23.5	100.0	0.8979	VI	
35	23.6	105.0	8.5446	V	
36	23.8	95.0	0.4261	VI	
37	24.0	85.0	0.7075	VI	
38	24.1	100.0	3.3420	V	
39	24.3	115.0	0.2216	II	
40	24.3	90.0	0.7181	VI	
41	24.3	105.0	4.8335	V	
42	24.4	100.0	2.8133	V	
43	24.4	105.0	2.2640	V	
44	24.4	110.0	0.3559	IV	
45	24.5	95.0	5.7942	V	
46	24.6	115.0	0.6330	VI	
47	24.9	100.0	0.3066	VI	
Total	1057.70	3959.0	80.7339		
Mean	22.88	84.234	1.7177		
	± 1.099	± 16.70	± 1.901		

Table 33: Percentage of maturity of *N. notopterus* (Pallas) at 25.0 to 28.9 cm.

No. of obs.	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary	Percentage of maturity
1	25.0	100.0	.4942	I	
2	25.0	125.0	12.7654	V	
3	25.1	112.0	0.4547	VI	
4	25.2	105.0	5.8708	V	
5	25.3	110.0	0.3913	IV	
6	25.4	110.0	0.7444	III	
7	25.4	110.0	3.6992	V	
8	25.6	120.0	0.4737	VI	
9	25.7	130.0	4.8609	V	
10	25.8	130.0	10.6608	V	
11	25.9	125.0	9.3228	V	
12	26.0	130.0	4.0746	V	47.82
13	26.1	115.0	0.5068	VI	
14	26.1	120.0	0.7348	III	
15	26.1	115.0	0.1241	VI	
16	27.0	125.0	1.1482	VI	
17	27.2	100.0	0.4072	III	
18	27.5	160.00	0.3486	VI	
19	28.0	167.0	0.5916	VI	
20	28.0	175.00	10.6449	V	
21	28.1	150.00	2.8153	V	
22	28.1	150.00	0.5987	II	
23	28.3	182.00	7.5294	V	
Total	605.9	2966.0	79.2624		
Mean	26.3435	128.956	3.4462		
	± 1.1244	± 23.2631	± 3.9628		

Table 34: Percentage of maturity of *N. notopterus* (Pallas) at 29.0 cm and above

No. of obs.	Length of fish (cm)	Weight of fish (g)	Weight of ovary (g)	Condition of ovary	Percentage of maturity
1	29.5	180.0	6.3506	V	60%
2	29.5	180.0	2.4350	VI	
3	30.3	210.0	3.1599	V	
4	30.5	230.0	0.6353	II	
5	34.2	300.0	16.5167	V	
Total	154.	1100	29.0875		
Mean	30.8	220	5.8175		
	± 1.748	± 44.27	± 5.66		

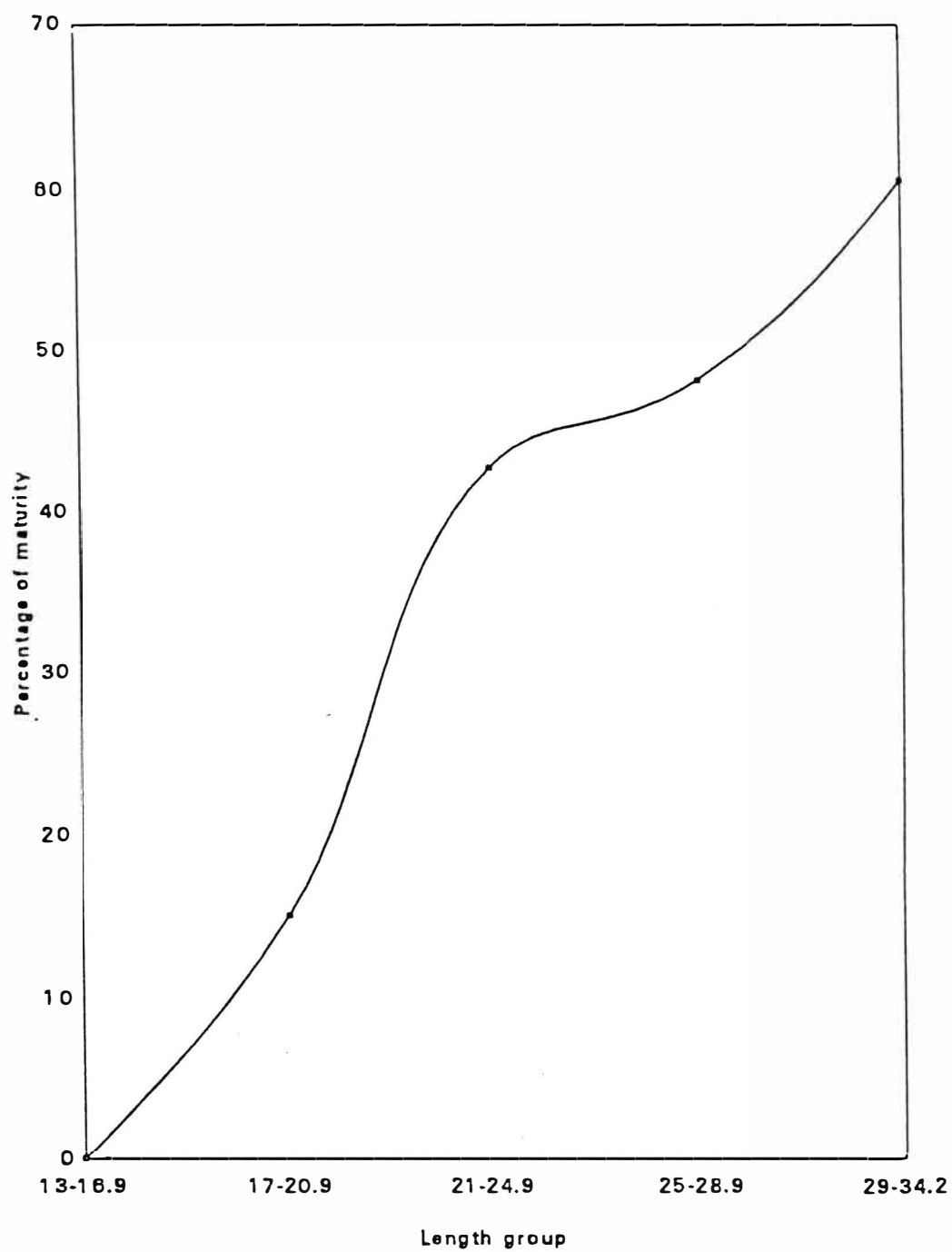


Fig. 14. Percentage of maturity at different length groups of *Notopterus notopterus* (Pallas)

4.12 RELATIONSHIP BETWEEN OVARY AND LIVER OF *N. NOTOPTERUS* (PALLAS)

Relationship between weight of ovary and liver from December to February are presented (Table 35, Fig.15). During the month of December to February immature, maturing and few spent ovaries were observed in *N. notopterus*. The coefficient correlationship (r) between ovary and liver was found to be 0.5420. The calculated 't' value was found to be more than tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence there is a positive relationship between weight of ovary and liver during these months. The statistical formula can be represented as $Y = 0.4910 + 1.3247 X$.

Relationship between weight of ovary and liver of *N. notopterus* from March to August are presented (Table 36, Fig. 16). During these period mature as well as spent ovaries were found. The coefficient correlation(r) value between ovary and liver in these months were found to be 0.4572. The calculated 't' value was found to be 3.812, which is more than the tabulated 't' value at n-2 degree of freedom which shows that there is a interdependent relationship between weight of liver and ovary. The statistical formula can be represented as $Y = 0.6331 + 0.1235 X$.

Relationship between weight of ovary and liver of *N. notopterus* from September to November are depicted (Table 37, Fig.17). In these period immature, maturing oocytes along with a significant proportion of spent ovaries, revealed the quiescent cum-preparatory phase of ovary. The coefficient correlation (r) value between weight of ovary and liver in these month are found to be 0.4955. The calculated 't' value was found to be 2.736 which is more than tabulated 't' value at n-2 degree of freedom at 5% level of population. Hence there is a positive correlation between ovary and liver during these months. The statistical formula for this purpose be represented as $Y = 0.2685 + 0.4423 X$.

Table 35: Relationship between ovary and liver of *N. notopterus* (Pallas) from December to February.

No. of observations	Weight of ovary (g) X	Weight of liver (g) Y	X ²	Y ²	XY
1	0.635	2.471	0.404	6.103	1.570
2	0.473	0.412	0.224	0.170	0.195
3	0.734	1.204	0.540	1.448	0.884
4	0.598	1.556	0.358	2.422	0.932
5	0.633	1.384	0.201	1.917	0.876
6	0.494	1.385	0.244	1.918	0.684
7	0.426	0.814	0.182	0.662	0.347
8	0.400	0.961	0.160	0.923	0.384
9	0.407	1.432	0.166	2.051	0.583
10	0.439	1.256	0.193	1.576	0.552
11	0.209	0.348	0.044	0.121	0.073
12	0.177	0.514	0.031	0.265	0.091
13	0.079	0.403	6.006	0.162	0.032
14	0.124	1.130	0.015	1.277	0.140
15	0.222	0.876	0.049	0.768	0.194
16	0.905	1.203	0.819	1.447	1.089
17	0.744	1.069	0.554	1.144	0.796
18	0.390	2.073	0.152	4.296	0.808
19	0.429	0.787	0.184	0.619	0.337
20	0.406	0.735	0.165	0.541	0.299
21	0.012	0.739	0.0002	0.019	0.002
Total	8.939	22.151	4.891	29.85	10.868
Mean	0.426	1.055	0.233	1.42	0.518

Coefficient correlationship ' r ' = 0.5420

Calculated ' t ' value = 2.811

$Y = 0.4910 + 1.3247 X$

Table 36: Relationship between ovary and liver of *N. notopterus* (Pallas) from March to August.

No. of observations	Weight of ovary (g) X	Weight of liver (g) Y	X ²	Y ²	XY
1	10.6608	3.0039	113.653	9.023	32.024
2	10.6449	3.2619	113.314	10.640	34.723
3	3.3420	0.7719	11.169	0.596	2.580
4	0.7181	0.6087	0.516	0.371	0.437
5	7.5294	2.0706	56.692	4.287	15.594
6	16.5167	2.6598	272.801	7.075	43.931
7	4.8335	1.6541	23.363	2.736	7.995
8	4.0746	1.9691	16.602	3.877	8.023
9	4.4388	1.1556	19.703	1.335	5.129
10	12.7654	1.9456	162.955	3.785	24.836
11	0.2631	0.4421	0.069	0.195	0.116
12	0.4456	0.5422	0.199	0.294	0.242
13	0.8979	1.3715	0.806	1.881	1.231
14	2.8133	1.1718	7.915	1.371	3.294
15	3.6231	0.7930	13.127	0.629	2.873
16	1.1482	0.2546	1.318	0.065	0.292
17	0.7377	0.6871	0.544	0.472	0.507
18	6.3506	1.0841	40.330	1.175	6.885
19	3.1599	1.3383	9.987	1.791	4.229
20	2.8153	1.1504	7.926	1.323	3.239
21	2.4250	1.4797	5.881	2.190	3.588
22	3.6992	0.9562	13.684	0.914	3.537
23	2.2640	1.0431	5.126	1.088	2.362
24	4.8609	1.4784	23.628	2.186	7.186
25	0.5838	0.8619	0.341	0.743	0.503
26	2.4166	0.7015	5.840	0.492	1.695
27	0.5663	0.3089	0.321	0.095	0.175
28	2.2354	0.4126	4.997	0.170	0.922
29	0.3349	0.4697	0.112	0.221	0.157
30	0.2320	0.2608	0.054	0.268	0.061

No. of observations	Weight of ovary (g) X	Weight of liver (g) Y	X ²	Y ²	XY
31	4.5605	1.1210	20.798	1.257	5.112
32	5.8708	1.1846	34.466	1.403	6.155
33	5.7942	0.9072	33.573	0.823	5.256
34	8.5446	1.1452	70.010	1.311	9.785
35	3.3898	0.7215	11.491	0.521	2.446
36	1.5670	0.7886	2.455	0.521	1.204
37	3.9189	0.6512	15.358	0.424	2.552
38	5.5601	0.9092	30.915	0.827	5.055
39	3.4021	0.8902	11.574	0.792	3.029
40	5.2104	0.8512	27.148	0.725	4.435
41	4.4640	0.6080	19.927	0.370	2.714
42	0.7542	0.2562	0.569	0.066	0.193
43	3.0443	0.5242	9.268	0.275	1.596
44	9.3228	0.7727	86.915	0.597	7.204
45	0.1730	0.4109	0.030	0.169	0.071
46	0.0392	0.2940	0.002	0.086	0.012
47	0.1091	0.4736	0.012	0.224	0.052
48	0.3286	0.7420	0.108	0.551	0.244
49	0.3486	6.1937	0.122	38.362	2.159
50	0.7863	0.4852	0.618	0.234	0.382
51	0.1554	0.5031	0.024	0.253	0.078
52	0.0688	0.3123	0.005	0.098	0.021
53	0.1111	0.2316	0.012	0.054	0.026
54	0.4642	0.5020	0.215	0.294	0.252
55	0.3746	0.8907	0.140	0.793	0.334
56	0.1166	0.1528	0.014	0.023	0.018
57	0.2917	0.5715	0.085	0.327	0.167
Total	520.524	87.3084	1311.80	112.538	279.714
Mean	9.132	1.5317	23.014	1.97	4.91

Coefficient correlationship 'r' = 0.4572

Calculated 't' value = 3.812

Y = 0.6331 + 0.1235 X

Table 37: Relationship between ovary and liver of *N. notopterus* (Pallas) from September to November

No. of observations	Weight of ovary (g) X	Weight of liver (g) Y	X ²	Y ²	XY
1	0.6685	0.4216	0.447	0.178	0.282
2	0.3216	0.5140	0.103	0.264	0.165
3	0.8841	0.2385	0.782	0.057	0.211
4	0.3001	0.3745	0.090	0.140	0.112
5	0.7075	0.5136	0.501	0.264	0.363
6	0.4541	0.5484	0.206	0.301	0.249
7	0.7173	0.4133	0.515	0.171	0.296
8	0.3559	0.5302	0.127	0.281	0.189
9	0.1959	0.2825	0.038	0.280	0.055
10	0.0944	0.2249	0.009	0.051	0.201
11	0.3489	0.4655	0.122	0.217	0.162
12	0.2547	0.3055	0.065	0.093	0.078
13	0.1534	0.1288	0.024	0.017	0.020
14	0.3913	0.5877	0.153	0.345	0.230
15	0.3066	0.5258	0.094	0.276	0.161
16	0.0839	0.2084	0.007	0.043	0.017
17	0.5916	1.0254	0.350	1.051	0.607
18	0.5068	0.7854	0.257	0.617	0.398
19	0.7627	0.5968	0.582	0.356	0.055
20	0.0163	0.1002	0.0003	0.010	0.002
21	0.2553	0.6931	0.065	0.480	0.177
22	0.0113	0.2115	0.0001	0.045	0.002
23	0.0607	0.0636	0.004	0.004	0.004
24	0.0130	0.1377	0.0002	0.019	0.002
25	0.0636	0.5826	0.004	0.339	0.037
Total	8.520	10.4795	4.54	5.699	4.296
Mean	0.341	0.419	0.18	0.23	0.172

Coefficient correlationship ' r ' = 0.4955

Calculated ' t ' value = 2.736

$Y = 0.2685 + 0.4423 X$.

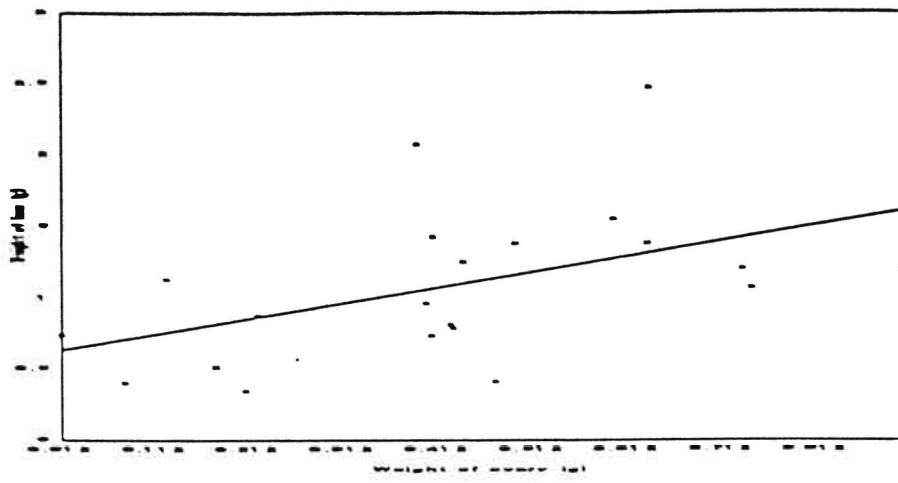


Fig. 15. Relationship between every and liver of *Nereis nereis* (Pallas) from December-February.

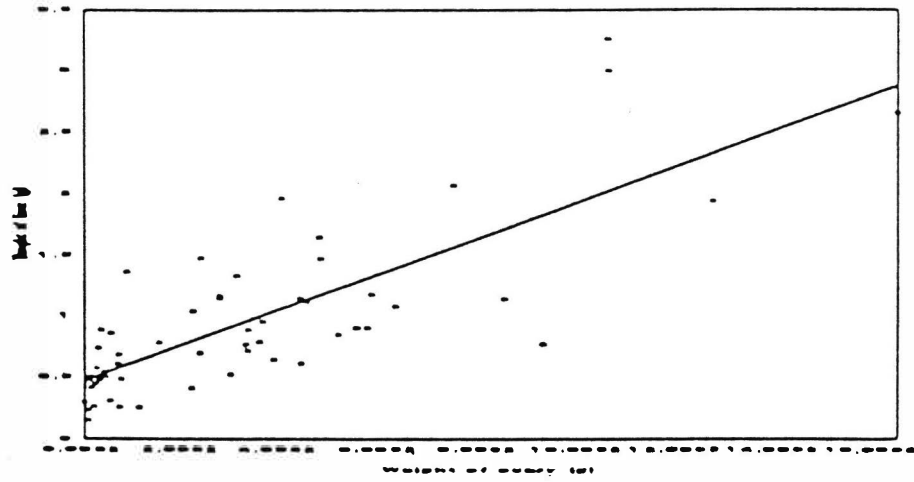


Fig. 16. Relationship between every and liver of *Nereis nereis* (Pallas) from March-August.

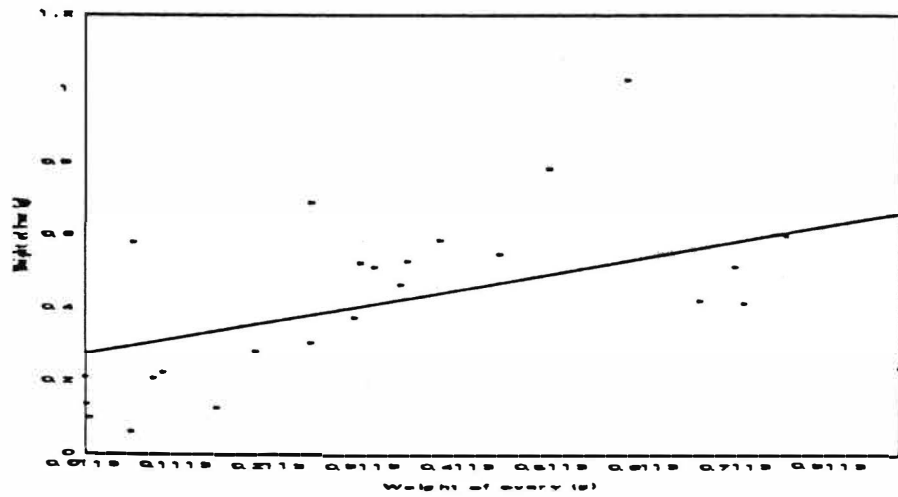


Fig. 17. Relationship between every and liver of *Nereis nereis* (Pallas) from September-November.

4.13 FECUNDITY OF *N. NOTOPTERUS* (PALLAS)

Number of eggs and body weight (Table 38).

The relationship between the number of eggs with the weight of body is expressed by the formula $Y = 1.284309 + 0.697347 W_b$. There is a linear correlation (Fig.18). The exponent value is 0.697347 and the constant value is 1.284309. The minimum number of eggs is 102 and maximum number of eggs is 1646. The minimum weight of the body is 40.0 g and minimum body length is 17.7 cm. The coefficient correlation is positive and significant as its value 'r' is 0.530151.

Number of eggs and body length (Table 38)

The relationship between the number of eggs with the body length is expressed by an equation $Y = -1.044596 + 2.700597 Bl$. The relationship is linear (Fig.19). The exponent value is 2.700597 which is closely relate to 3 thereby indicating that the fecundity in *N. notopterus* is related to the cube of the length. The constant value is -1.044596. When the body length reaches 21.0 cm the number of eggs are 102 (Table 39). Coefficient correlation is positive as the value of 'r' is 0.512386.

There is an increasing trend in weight of body, weight of ovary and average number of eggs, when the length group increases (Table 39). The relationship is highly positive and assumed that when the length of the fish increases, the body weight, ovary weight and average number of eggs also increases proportionately.

Number of eggs and ovary weight (Table 38)

The relationship between the number of eggs with the weight of ovary is expressed by the formula $Y = 2.346319 + 0.059872 W_o$. The relationship is a linear one (Fig.20). The exponent value is 0.059872 and the constant value is 2.346319. The minimum number of eggs is 102 when the weight of ovary is 0.5930 g. The coefficient correlation is positive and significant as its value 'r' is 0.862615.

Table 38: Fecundity of *N. notopterus* (Pallas)

Number of observations	Log weight of fish (g)	Log length of fish (cm)	Weight of ovary (g)	Log no. of eggs
1	2.0	1.38	3.342	2.63
2	2.26	1.45	7.529	2.87
3	2.48	1.53	16.517	3.12
4	2.27	1.45	9.505	2.94
5	2.10	1.40	7.055	2.93
6	2.04	1.38	6.119	2.75
7	2.11	1.41	4.075	2.65
8	2.10	1.40	12.765	3.08
9	2.00	1.39	2.813	2.64
10	1.90	1.36	3.623	2.68
11	2.32	1.48	8.097	2.91
12	2.22	1.45	8.967	3.00
13	2.04	1.40	13.502	3.08
14	2.06	1.40	6.565	2.78
15	2.11	1.40	8.505	2.97
16	2.05	1.39	6.870	2.87
17	1.99	1.40	5.735	2.81
18	2.05	1.38	8.396	2.95
19	2.05	1.39	5.074	2.83
20	1.99	1.37	6.928	2.92
21	2.27	1.46	10.555	2.87
22	2.00	1.40	9.795	3.00
23	2.00	1.37	9.175	2.94
24	2.13	1.42	11.583	2.89
25	2.08	1.41	10.268	2.84
26	2.05	1.40	11.269	2.99
27	2.02	1.38	11.576	2.91
28	2.05	1.38	13.808	3.04
29	2.09	1.40	13.552	2.99
30	1.60	1.31	3.797	2.56
31	2.0	1.38	3.359	2.62
32	2.08	1.35	4.561	2.58

Number of observations	Log weight of fish (g)	Log length of fish (cm)	Weight of ovary (g)	Log no. of eggs
33	2.02	1.40	5.871	2.53
34	1.98	1.38	5.794	2.57
35	2.02	1.37	8.545	2.81
36	1.85	1.36	3.390	2.44
37	1.88	1.34	1.567	2.24
38	1.65	1.33	3.919	2.55
39	2.29	1.45	11.535	3.22
40	2.18	1.38	5.820	2.86
41	1.85	1.29	3.340	2.67
42	2.26	1.41	4.604	2.70
43	2.05	1.35	4.815	2.72
44	1.88	1.34	6.905	2.89
45	1.85	1.33	2.680	2.33
46	1.78	1.32	2.653	2.46
47	1.89	1.34	2.665	2.55
48	1.79	1.32	3.009	2.57
49	1.80	1.33	3.193	2.60
50	2.00	1.39	3.353	2.60
51	1.90	1.35	3.654	2.62
52	2.12	1.40	8.605	2.94
53	2.05	1.39	8.079	2.93
54	2.13	1.42	11.523	2.86
55	2.02	1.37	11.503	2.88
56	1.60	1.30	3.003	2.54
57	2.00	1.38	9.173	2.93
58	1.85	1.36	3.378	2.44
59	1.88	1.36	1.503	2.43
60	2.20	1.45	8.367	2.99
61	2.26	1.39	7.521	2.80
62	2.00	1.38	3.004	2.65
63	2.02	1.39	3.926	2.62
64	1.98	1.35	4.910	2.83
65	1.98	1.36	5.370	2.71
66	1.98	1.34	13.249	3.05

Number of observations	Log weight of fish (g)	Log length of fish (cm)	Weight of ovary (g)	Log no. of eggs
67	2.00	1.38	3.004	2.57
68	1.67	1.25	2.101	2.29
69	1.99	1.37	8.182	2.97
70	1.89	1.34	1.590	2.27
71	1.70	1.29	2.560	2.53
72	1.90	1.34	2.5010	2.41
73	2.00	1.37	2.804	2.33
74	1.88	1.35	2.452	2.62
75	1.78	1.32	0.593	2.01
76	2.08	1.35	4.509	2.60
77	2.02	1.37	8.051	3.00
78	1.88	1.35	1.528	2.33
79	1.65	1.33	3.010	2.58
80	2.02	1.39	2.604	2.40
81	2.11	1.41	4.879	2.75
82	2.26	1.47	6.305	2.86
83	2.32	1.48	3.209	2.59
84	2.06	1.42	0.679	2.25
85	2.10	1.44	1.418	2.24
86	2.18	1.45	2.815	2.48
87	2.08	1.35	4.002	2.59
88	2.04	1.41	3.609	2.60
89	1.98	1.36	6.901	2.85
90	2.00	1.39	2.813	2.56
91	1.98	1.34	5.004	2.59
92	1.98	1.35	5.008	2.57
93	1.99	1.37	6.423	2.64
94	1.93	1.35	4.282	2.59
95	2.00	1.37	3.405	2.66

Number of observations	Log weight of fish (g)	Log length of fish (cm)	Weight of ovary (g)	Log no. of eggs
96	2.04	1.41	4.965	2.65
97	2.00	1.38	2.905	2.60
98	1.70	1.30	2.510	2.37
99	1.90	1.36	2.520	2.41
100	1.88	1.36	2.453	2.57
101	1.85	1.32	5.210	2.68
102	1.88	1.35	4.464	2.74
103	1.85	1.31	0.754	2.06
104	1.74	1.30	3.044	2.55
105	1.85	1.30	3.045	2.52
106	2.10	1.41	9.323	2.99
107	2.00	1.38	3.314	2.62
108	1.85	1.34	2.402	2.47
109	1.70	1.30	2.105	2.27
110	2.00	1.37	2.904	2.53
111	1.88	1.34	2.402	2.53
112	2.06	1.41	1.604	2.33
113	1.98	1.38	2.315	2.56
114	1.90	1.35	2.652	2.41
115	2.13	1.41	4.800	2.66
116	1.70	1.30	2.051	2.44
117	2.00	1.36	2.622	2.35
118	2.04	1.39	7.111	2.74
119	2.08	1.38	6.216	2.71
120	2.24	1.46	10.008	2.83

Table 39: Average fecundity counts at various length-weight groups of *N. notopterus* (Pallas)

Length range (cm)	Average length (cm)	Average weight (g)	Average weight of ovaries	Average number of eggs per ovaries	No of ova/g body weight	No of ova/g ovary weight
17.0-18.9	17.7	47.00	2.1014	195.0	4.15	92.86
19.0-20.9	19.94	52.78	2.57	297.33	5.63	115.69
21.0-22.9	21.94	80.5	3.38	367.46	4.56	108.72
23.0-24.9	23.88	102.56	5.77	530.98	5.18	92.02
25.0-26.9	25.66	123.21	6.34	631.47	5.13	99.60
27.0-28.9	28.22	163.14	6.41	652.5	4.00	101.79
29.0-30.9	29.78	196.25	7.04	663.25	3.38	94.21
33.0-34.9	34.2	300.00	16.52	1315	4.38	79.60

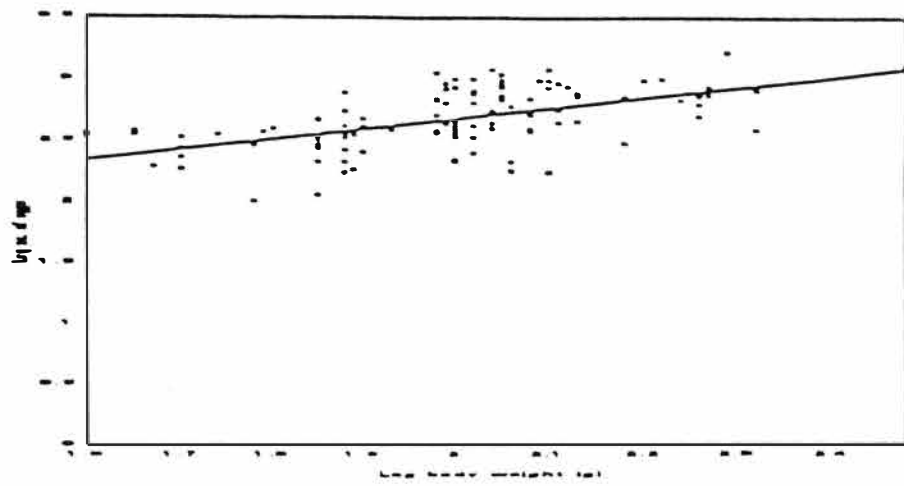


FIG. 18. Relationship between the number of eggs and body weight of *Neotereus nereus* (Fallon).

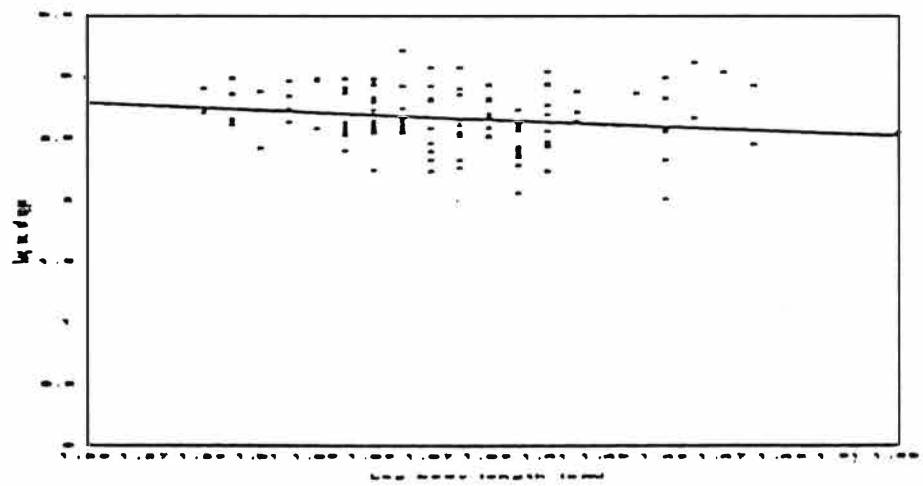


FIG. 19. Relationship between the number of eggs and body length of *Neotereus nereus* (Fallon).

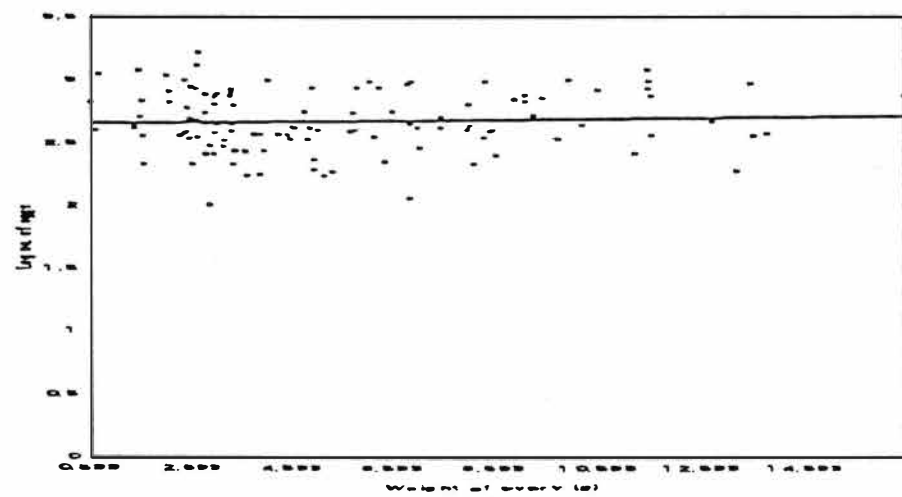


FIG. 20. Relationship between the number of eggs and weight of every of *Neotereus nereus* (Fallon).

DISCUSSION

Results on the biological parameters indicated several important morphometric relationships. In *N. notopterus*, the length-weight relationship with length ranged from 20.0-391.0 mm was found to be curvilinear. When corresponded length-weight values were converted to their logarithmic forms showed a linear, straight line relationship (Parameswaran and Sinha, 1966). Hamza (1980) while working on the biology of *N. notopterus* suggested that it is convenient to plot log weight against log length and calculated the regression line by the least square method. In his observation, the length ranged from 130-135 mm and weight ranged from 14 to 400 g when converted into their respective logarithmic form a linear regression line was obtained and fitted by the method of least squares, in both male and female specimen of *N. notopterus* pooled from Kalyani and Rajbagan of West Bengal. In the present observation the length ranging from log 1.12 to 1.48 cm. with weight ranging from log 1.18 to 2.48g showed a linear relationship indicating that when length increases, the corresponding weight also increases proportionately. Hence, the present study is in agreement with the observations carried out by Parameswaran and Sinha (1966) and Hamza (1980).

A biometric study of *G. chapra* has been described (Banerjee and Venkateswarlu, 1968). Rao and Rao (1972) studied the length-weight relationship in sexually unidentified *L. calbasu* with length range of 100-630 mm and weight range of 10-3712 g from river Godavari. They observed a curvilinear relationship between these variables. The equation expressing the length-weight relationship of *L. calbasu* was closer to the cubic value. Rao (1974) also observed the length-weight relationship of *L. fimbriatus* in the Godavari river which showed curvilinear

relationship. Length-weight ratio of 3 month old scale carp fingerlings from the sodic soil pond at Faizabad area was reported (Pandey and Sharma, 1995). The pooled regression equation that was worked out for the fingerling however, do not follow the cube law.

The work on length-weight relationship for the Deccan Mahseer, *Tor khudree* studied (Ogale, 1993). He indicated that the relationship between length and weight of this fish was highly significant and correlation between standard length and total length was also significant in both male and female as the calculated 't' value found to be higher than the tabulated 't' value. Rao (1990) in *O.bimaculatus* reported that no significant difference in regression coefficient of weight on length was observed for juveniles, males and females and hence a common formula for the pooled data was derived, where the 'b' value is closer to '3'. He was in opinion that there was a change in the preference for food items in *O.bimaculatus* with the growth of fish. The adolescent's stage (51.80.0 mm) was distinctly insectivorous whereas the larger adult's stage (above > 150 mm) was piscivorous. Kaliyamurthy *et al.* (1986) reported the length-weight relationship in juveniles, males and females *G.lucidus* from Pulicat lake by linear regression and plotted the graph as scattered diagram. The slopes of three equations are tested against the hypothetical value of '3'. They were in opinion that no significant difference was found between the hypothetical and observed value which suggest this species follows the cube law.

Rao (1981) found a curvilinear relationship between length and weight in *M. gulio* pooled from Pulicat lake. Similar observation has also been reported in *Hilsa sinensis* (Choudhury *et al.*, 1975). But the study on length-weight relationship in *O.bimaculatus* indicated a deviation from the cube law (Sivakami,

1987), while Gotate (1993) observed that the length and weight relationship of *R. hastate* collected from the river Godavari was found to abide by the cube law theory as profounded by LeCren (1951) in both males and females. The weight increased proportional to the length, showing the normal pattern of growth. Rangaswami (1976) studied the length-weight relationship for the Greymullet *M. cephalus* from the Ennore and Adyar estuaries in order to find out the differences in regression between years and the environments. His analysis indicated that the relationship did not differ significantly between years and environment and regression coefficient found to depart significantly from the cubic value. Similar observations were obtained in *M. corsula* (Fatima *et al.*, 1989). They found that the coefficient of regression of logarithmic of weight on logarithmic of length departs significantly from the cubic value. The 't' value indicated a degree of significance showing that the cubic law $W = CL^3$ does not hold for *M. corsula*.

Allen (1938) has stated that in an ideal fish which exhibits isometric growth the value of regression coefficient is not significantly different from '3'. However, significant deviation from cubic value have been reported by several authors (Mohan and Sankaran, 1988; Fatima *et al.*, 1989). While working on the biological aspects of *E. suratensis*, Jayaprakas *et al.* (1990) observed that the length-weight relationship of juveniles, males and females deviate significantly from the isometric growth pattern. They are in view that a distinct change is observed in the growth pattern of juveniles from that of adults at a length of 59.5 mm (5267.5 mg). He also reported that the student 't' test was used to determine significant differences at 1% level. They classified pooled species in their experiments into three groups, based on the deviation of the regression coefficient from '3' such as:

$b = 3$ (where body form remains constant at different length).

$b > 3$ fish becomes slender as the length increases

$b < 3$ fish grow stouter. However, Jayaprakas *et al.* (1990) observed that

the regression slopes of juveniles was significantly greater than the cubic value whereas the regression coefficient of males and females were lower than 3. A different slope for juveniles and adults have been reported previously by various investigators in many different fishes (cited Jayaprakas *et al.*, 1990).

Abdul Hameed (1994) studied the length-weight relationship of Thread fin Bream (*Nemipterus bipunctatus*) in the length ranged from 9.0-25.0 cm. and weight ranged from 22-350g from the Gulf of Manaar at the latitude 8°.48'N, long. 78°.9' E of India. He expressed the study by linear regression of the log transformed variates and found that the exponent 'b' does not follow the cubic value. The length weight relationship of 26 fish species belonging to 17 families obtained from the Gulf of Thailand was examined (Yanagawa, 1994). He suggested that the cube law ($b = 3$) could be applied to length-weight relationship of most fishes in the Gulf of Thailand with a few exception. Such exceptions are believed to be the impact of location, seasonal and geographic variations of fish samples collected.

The relationship between the length of the body with that of length upto dorsal fin, length upto anal, length upto pectoral, length upto pelvic and length upto pectoralis were found to be linear in *N.notopterus*. Similar observations were reported in *G.chapra* (Banerjee and Venkateswarlu, 1968); in *C.punctata* (Rath, 1980). These linearity indicated that when the length of the body increased the corresponding length on various morphometric parameters cited above also simultaneously increased in *N.notopterus*. Hence, the present study is in agreement with the observation in *G.chapra* and *C.punctata*.

The length frequency distribution of female *N. notopterus* indicated that maximum number of individuals occurred at 22.0-25.0 cm. length group. As 17.0 cm. reported as the size at first maturity, in the present study, the smaller length groups (13.0-16.0 cm.) are immature. The size range group (17.0-25.0 cm.) represents the mature group. The dominance of female in the length group between 22-31 cm. suggested that perhaps the longevity of female may be more. However, it is evident that when the length increased the number of individuals decreased. Similar type of observations have been reported in *N. notopterus* (Parameswaran and Sinha, 1966; Hamza, 1980); in *C. punctata* (Qayyum and, Qasim, 1964; Rath and Hejmadi, 1979). In *N. notopterus* (Parameswaran and Sinha, 1966) reported that the smallest mature female was 19.1 cm. in length and weighed 72g. They are in view that the males mature at 17.0 cm. length and weighed 20 g.

Although in the present study the sex ratio has not taken into account but the sex ratio reported in *N. notopterus* was found to be almost equal (Parameswaran and Sinha, 1966; Hamza, 1980).

Ponderal index is synonymous to condition factor designated 'K' which is employed to indicate the difference related to sex, season or place of fishing. It is also used to compare the condition of fish. Various equations are employed to find out the condition factor, Fulton's condition factor (cited Rath, 1993) follows the equation as $K = \frac{W}{L^3} \times 10^5$. In contrast Hile (1948) employed the equation as $K = \frac{W}{L^3} \times 100$. Similar equations with that of Hile (1948) was also cited (Bal and Rao, 1993).

In the present study the method employed by Hile (1948) is used to determine the condition factor (Ponderal index) of *N.notopterus* in order to assess the condition of fish with that of its maturity at different phases of vitellogenesis. It is observed that the ponderal index was 0.681 during the month of December to February coinciding with preparatory cum active phase. The ponderal index was recorded to be 0.737 during the month of March to August coinciding with active phase. This increase in ponderal index signifies the better maturity condition of the fish. The fall on the value of ponderal index to 0.67 during the month of September to November coincide with quiescent cum preparatory phase of *N.notopterus*. Similar observations on rise of ponderal index was reported during the spawning months, May and June followed by an abrupt fall during July and August when mostly spent fish were encountered. Again the rise in its value from September onwards indicates the subsequent recovery in the condition of *N.notopterus* (Parameswaran and Sinha, 1966). They reported that *N.notopterus* exhibits scanty breeding periods during the month of March, April and August in Orissa State. In the present investigation the peak vitellogenic period otherwise synonymous to active period starts from March to August agreeing with the observation of Parameswaran and Sinha (1966). In contrast, Sahu (1983) although has not correlated the condition factor with that of breeding cycles in *N.notopterus* but he is in opinion that the fish has two distinct vitellogenic period that was June and October considering the value of gonosomatic index and mean oocyte diameter. Hamza (1980) recorded the highest 'K' value (0.911) during the month of May and the lowest value (0.765) during the month of November in female *N.notopterus* suggesting a single breeding period of the fish in West Bengal. He also observed that the males mature in May while female mature in June suggesting males mature earlier than the females. Moreover, Parameswaran and Sinha (1966) observed that

males mature at the size length of 14.0 cm. while females mature at 19.1 cm. in Orissa. Hence, it is accepted that males mature earlier with relatively small size group than that of the females in *N. notopterus*. Similar observation on increase in ponderal index matching with breeding season and its subsequent fall coinciding with non-breeding season was observed in *L. rohita* (Raizada *et al.*, 1986) in scale carp (Pandey and Sharma, 1995); in *H. fossilis* (Bhatt, 1968; 1970); in *C. punctata* (Rath, 1980); in *G. lucidus* (Kaliyamurthy *et al.* 1986); in *O. bimaculatus* (Sivakami, 1987). Yousuf *et al.* (1993) studied the ponderal index of some cyprinid fishes of Kashmir and also agreed with such reports.

In the present observation the ponderal index of *N. notopterus* increased with the length of fish upto 18.9 cm. and then there was a secondary fall in ponderal index value. Earlier workers pointed out that since adolescent fishes have higher (PI) or 'K' value, the increased and decreased in 'K' value is related to the length and that the 'K' value can also be used to determine the size at first maturity. The decline of ponderal index value is attributed due to increased metabolic strain because of spawning in older age groups related to the feeding rate of fish. The rise and fall in 'PI' seems entirely related to the cycle of breeding in the present study. The fall of PI during resting or quiescent cum preparatory phase might be due to increasing metabolic strain during the post spawning period when the fishes engaged in brood care as being reported in *C. punctata* (Qayyum and Qasim, 1964, Rath and Hejmadi, 1979). Thus, the findings of the present study is not only comparable to those of Qayyum and Qasim, 1964; Rath and Hejmadi, 1979; in *C. punctata*, but also with those of Parameswaran and Sinha, 1966; Hamza, 1980; in *N. notopterus*.

The value of 'relative condition factor' (Kn) increased with the approach of spawning and receded at the end of spawning season in *N.notopterus*. Based on the work in *C.punctata* (Rath and Hejmadi, 1979) reported that the rise of 'Kn' value might be due to the occurrence of ripe gonads and dropped due to ovulation making end of spawning season. The current study supports their view.

The month and lengthwise fluctuations in 'Kn' value was reported in *L.calbasu* (Rao and Rao, 1972). Such fluctuations in 'Kn' value was attributed chiefly to breeding only, i.e. increase in weight of gonads and subsequent loss in condition due to spawning activity.

The younger size that showed high 'Kn' value was attributed to the high feeding intensity (Rao and Rao, 1972). Similar observations were reported in *L.fimbriatus* (Rao, 1974). The studies undertaken in *M.gulio* (Rao, 1981) reported that the fluctuation of 'Kn' value of both the sexes during different months can probably be attributed to high feeding intensity of the fish. The high 'Kn' value during July and August in *M.gulio* correspond with the period when the gonads were in fully ripe conditions. He opined that the low 'Kn' value during the month of June might be due to increase metabolic strain during this month which marks the beginning of maturity and spawning. The fall in 'Kn' from August to October indicates the peak breeding activity of the species during these period. Azad (1990) reported the relative condition factor in *A.testudineus* from Manipur. In his studies the high 'Kn' values in mature individuals with size range of 11.0-12.0 cm. during the pre-monsoon month (June) indicated the better condition of ovarian maturity. Based on the work in *M.cephalus*, Rangaswami (1967) reported that the rise of 'Kn' value might be related to ripe ovarian condition and drop in 'Kn' value probably due to spawning.

Moreover, Desai and Shrivastava (1986) suggested the superiority of relative condition factor (K_n) over condition factor (K) on *Rhinomugil corsula* in the size range of 10.5-31.2 cm. collected from Rihand reservoir (U.P.). They were in opinion that, where length-weight formula does not agree to the 'cube law', the condition of fish ascertained by 'K' will be an "underestimation" against the correct assessment made through 'K_n'.

The value of gonosomatic index in the present study increased with the approach of spawning season and receded at the end of spawning season in *N. notopterus* indicating a single active period. Similar observations were also reported in Chaudwar, Cuttack (Parameswaran and Sinha, 1966) and also in Kalyani and Rajbagan area, West Bengal (Hamza, 1980). In contrast, Sahu (1983) has reported two peak gonosomatic index values in the month of June and October in Berhampur area. Hence, the present study agrees with the findings of Parameswaran and Sinha (1966) and Hamza (1980). The gonosomatic index has been studied in many groups of teleosts that include, *C. punctata* (Belsare, 1962; Qayyum and Qasim, 1964; Rath and Hejmadi, 1979); in *C. gachua* (Misra, 1991); in *A. testudineus* (Banerjee and Prasad, 1974); in *A. scandens* (Misra and Verma, 1991); in *G. giuris* (Saksena, 1976), where monophasic ovarian cycle has been reported coinciding mostly with the monsoon. The increased gonosomatic index during spawning activity has also been reported in *M. gulio* (Rao, 1981); in *M. cavasius* (Sharma, 1987), and in *O. bimaculatus* (Rao, 1990).

Sahu (1983) indicated that in female *N. notopterus*, a biphasic ovarian cycle is evident in one annual breeding period. Such biphasic ovarian cycle is also reported in *C. punctata* in the fish population of Southern India (Sunder Raj, 1916)

whereas only once during summer monsoon in Northern and Eastern India (Belsare, 1962; Rath and Hejmadi, 1987). The biphasic ovarian cycle in fish is possibly due to the climatic condition such as photoperiod, temperature and rainfall.

In the present study the coefficient correlationship between weight of the ovary and weight of the liver during the months from December to February was found to be positive which indicated the inter dependence of these two parameters during preparatory cum active phase of *N. notopterus*. Similar observation on ovarian and hepatic biochemical changes has also been observed in *N. notopterus* (Patil and Kulkarni, 1993); in *C. punctata* (Rath, 1980; Mukherjee *et al.*, 1989); in *F. heteroclitus* (Kanungo *et al.*, 1990). There is a negative correlationship during the active phase of ovary in the present study which might be due to transfer of reserved material from liver to ovary for vitellogenesis. Similar results were reported in many other fishes. Patil and Kulkarni (1993) demonstrated a gradual decrease in hepatic biochemical contents during matured phase of ovarian cycle, suggesting inverse relationship between ovarian and hepatic content in *N. notopterus*. The relationship between liver and ovary during the months from September to November i.e. quiescent cum preparatory phase of *N. notopterus* in the present study is positive, suggesting their interdependence.

Study of fecundity can provide information on various aspects of fishery biology such as population dynamics, racial characteristics, recruitment, mortality and stock assessment etc. In recent years fish fecundity has attained an important status in applied Fishery Science and Aquaculture. Due to variation in reproductive habits of fish, various terminologies that are acceptable in all circumstances have not yet been devised. The earlier workers used fecundity for

the number of eggs produced by mouth breeding cichlid and fertility for the number of young produced. However, three definitions with viviparous red fish *Sebastes marinus* as (1) prefertilized fecundity i.e. number of eggs before fertilization in ovary, (2) fertilized fecundity i.e. number of fertilized eggs in ovary (3) larval fecundity i.e. number of larvae after hatching before extrusion were used. In a mouth brooding *Sarotherodon*, one can conveniently categories (1) ovarian fecundity and (2) brooding fecundity. The temperate species which shed eggs in batches, the sum of all ripening eggs during the season can be called as fecundity. Contrast to this, in tropical species fecundity must only include total of ripening eggs shed continuously in one batch only (cited Rath, 1993).

In the present study ovary produces three different generations of eggs, that are similar as per the observations made by Hamza (1980) in *N. notopterus*. For fecundity study the total number of eggs were counted as per the procedure adopted by Hamza (1980).

In the present study the average fecundity of *N. notopterus* varied from 195.0 to 1315.0 with the length range from 17.0-34.9 cm. The studies made by Hamza (1980) showed that the fecundity of above fish varied from 175-1875 with the length ranged from 18.0-34.9 cm. Parameswaran and Sinha (1966) observed the average fecundity in *N. notopterus* varied from 175.0 to 1188 with the length ranged from 19.7 to 29.7 cm. The average number of ova per g weight of ovary varied from 56.05 to 94.90, suggest that with increase in size of the fish, there is a corresponding increase in the number of mature ova per g weight of the ovary. The number of ova per g weight of the body ranged from 3.07 to 5.94 that showed an increasing trend with increased in the size of the fish (Parameswaran and Sinha, 1966).

In the present study, the number of ova per g weight of ovary varied from 79.60 to 115.69 and the number of ova per g body weight varied from 3.38 to 5.63 with the length ranged from 17.0 to 34.9 cm. The peculiarity observed in the present study revealed that the number of ova per g ovary weight increased from the length ranged from 17.0 to 26.9 cm. but declined proportionately thereafter. Such decrease in number of ova per g ovary weight is probably due to higher age group of the fish. Hamza (1980) reported that the age and growth of one year old fish attained 14.5 cm. length and 2nd year old fish became 20.5 cm. length. In the present study, the rate of fecundity decreased, beyond 17.0 to 26.9 cm. length groups, which suggests the negative impact of age on fecundity. The fecundity differences due to variation of eggs necessitates the importance of age specific fecundity for each age group. It is also cited that variation in individual fecundity is so great that the age after eliminating length does not explain the fecundity relations. Thus, many have used age and age length interrelation in their statistical model for estimation of predictive fecundity than length alone (cited Rath, 1993).

In the present study although age has not taken but it is apparent that increased age after attaining certain length negatively act on fecundity. The fecundity of *N. notopterus* was found to be linear with respect to its logarithmic forms of body length, body weight and ovary weight. Similar observations were reported by Parameswaran and Sinha (1966) and Hamza (1980). However, Hamza (1980) plotted the observed fecundity on the (Y) axis and length of fish or weight of fish or ovary weight on the (X) axis, there is a curvilinear tend in the relationship, but are render into linear relationship by logarithmic transformation.

The present study agrees with the findings of Parameswaran and Sinha (1966) and Hamza (1980) in *N. notopterus*. Earlier workers reported the linear relationship in different groups of teleosts such as in *C. punctata* (Rath and Hejmadi, 1976) in *M. gulio* (Rao, 1981); in *M. cavasius* (Sharma, 1987); in *E. suratensis* (Jayaprakas *et al.*, 1990); in *C. gachua* (Misra, 1991); in *L. boggut* (Patil and Kulkarni, 1995). Moreover, the curvilinear relationship of fecundity with that of body length, body weight, ovary length and ovary weight have been reported in *L. calbasu* (Rao and Rao, 1972), in *L. fimbriatus* (rao, 1974), in *C. mrigala* and *L. rohita* (Tripathi 1989a,b), in *L. rohita* (Sehgal and Toor, 1989).

The variation in the fecundity are believed to be not only due to length, weight, age, environment, egg size of the species but also on nutritional diet, running water and influence of vitamins (cited Rath, 1993; Dube, 1993). However, Begenal (1966) attributed the variations in fecundity with reference to size, individual species, geographical location and season in the same locality.

The present observations on fecundity reveals that *N. notopterus* have less fecund. Similar observations are also noticed (Parameswaran and Sinha, 1966; Hamza, 1980). This species can also have relatively more tolerant to sewage pollutants than that of the carp species. This indicates that the fish have tremendous resistance to pollutants. It is possible that lower number of eggs is also correlated with shorter development time and mortality rate of fingerlings which means higher percentage of survival, thus less number of eggs does not prove to be a disadvantage in reproductive potential. However, low fecund fishes can be attributed to exhibit parental care towards their progeny in order to compensate ova paucity.

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* Original not seen.

Section-II

Ovarian Histophysiology

INTRODUCTION

Oocyte growth in the fish ovary is a complex process of development and differentiation involving i) formation of numerous nucleoli, development of lampbrush chromosomes and inclusion bodies in the nucleus, ii) accumulation of various organelles of diverse morphology, RNA and inclusion in the ooplasm and iii) formation of various egg envelopes (cited Guraya, 1986).

All these aspects of oogenesis are characterised by complex morphological, biochemical and molecular transformation that lead to the formation of numerous eggs in the ovary, depending upon the species of fish. Many of the developing oocytes containing in an ovarian follicle passes through the phases of development (multiplication, growth and maturation) and consequently undergoes degeneration forming corpora atretica. The oocyte does not detach itself but rather it involutes and a fibrous or glandular structure of doubtful interpretation appear (Carrato and Fernandez, 1987). According to Bowers and Holliday (1961) in many species of fish, degeneration of the oocytes is accompanied by the proliferation of follicular cells. Febvre (1973) suggests that atresia would have a regulatory function at the gonadal level before and after spawning, eliminating the oocytes which enters the stages of vitellogenesis. Apart from their function in the atretic degeneration of oocytes, the follicular granulosa cells have been reported to produce sex hormones in teleost (Hoar, 1965; Ball, 1960; Bhatti and Javaid, 1973).

It is well known that several metabolic changes occur during the development of gonads and infact all the metabolic activities inside a developing tissue are ultimately under some biochemical control. The metabolic activities are

controlled by the enzymes. It is established that lysosomes are the main organelles where the acid hydrolase like acid phosphatase are localised. The alkaline phosphatase is also much important in animal tissues. Phosphatase in general, play a very important role in phosphate availability in the tissues. Inorganic phosphate is required in the synthesis of several metabolites during the developmental stages of oocytes. On the otherhand, carbohydrate, fats and cholesterol also play a significant physiological role during the developmental stages in gonads.

Several reports have appeared on the biochemical changes that occur during the growth and development in fish. Lal (1963) reported decline in protein contents in the ovaries in *Cirrhina mrigala* during maturation, in contrast Ehlebracht (1973) observed an increase in protein contents during maturation. Wegmann and Goetting (1971) studied a distribution of protein, polysaccharides, nucleic acid and fats in *Xiphophorous helleri*. Cholesterol level in different stages of maturity in fish gonads are reported in *C. punctata* (Siddiqui, 1966); *H. fossilis* (Singh and Singh, 1979); *A. testudineus* (Sen and Bhattacharya, 1981).

Using histochemical techniques, Gopal Dutt (1964, 1966) and Gopal Dutt and Govindan (1967) have studied the chemical substances like nucleic acid, protein and lipids in the oocytes of *A. scandens*. Polysaccharides - SH groups and - SS groups also studied in the same species (Gopal Dutt and Govindan, 1969). Efforts have also been made by some workers on biochemical techniques (Medford and Mackay, 1978; Bohemen *et al.*, 1981) and electron microscope (Droller and Roth, 1966; Anderson, 1968; Beams and Kessel, 1973) to through light on the exo and endogenous pattern of vitellogenesis in certain teleosts. That too, no systematic investigation have been made on the histophysiology of ovarian development, role of protein, carbohydrate, lipid and nucleic acid in the

physiological process of oocyte growth and its maturation. However, few attempts have been made in some species of fish (Verma *et al.*, 1981, 1983, 1985). In conformity with this the seasonal morphohistological studies on ovary, histochemical changes in protein, polysaccharide, lipid and nuclei acid contents in different oocytic developments were studied.

Most of the teleostean fish undergoes regular gonadal cycles. In some species this may be completed in weeks as in the case of *Poecilia reticulata* (Lambert, 1971) while in others it may be completed in a year, as in the majority of the fish groups. Based on the various features such as general appearance, size and weight of the gonads, ova diameter, vitellogenesis, ovulation and sexual cycles have been classified by different workers. Sundararaj (1959) divided the ovarian cycle of *Heteropneustes fossilis* into 4 stages, in contrast Bhatt (1968) defined 5 stages; Bhatti and Javaid (1973) in *Colisa fasciatus* described 5 stages; AL-Daham (1978) in *Barbus luteus* defined 5 stages; combs (1969) in *Brevoortia patronus* suggested 6 stages; Casadevall *et al.* (1993) in *Ophidion barbatum* divided 6 stages; Rath and Hejmadi (1987) in *C. punctata* 6 stages; Braekvelt and McMillan (1967) in *Eucalia inconstans* proposed 8 stages.

Considerable literature exists regarding the morphology of the teleost ovary. It was first Cavolini (1792) who reported the morphology of ovary in teleosts. Several other workers, such as Brock (1878) and Calderwood (1892) confined their study to the general structure of the ovary. Brock described 8 morphological types of teleost ovary based on arrangement of ovarian follicles. A detailed description of the teleost ovary have been given (Bretschneider and Duyvene de Wit, 1947; Cooper, 1952; Bara, 1960). However, seasonal changes in the ovary are studied in *Fundulus* (Matthews, 1938); *Lepomys macrochirus* and

Huro salmonids (James, 1942); *Heteropneustes fossilis* (Ghosh and Kar, 1952); *Gadus* (Gokhale, 1957); *Carassius* (Beach, 1959); *Scomber* (Bara, 1960); *Cirrhinus reba* and *Mystus seenghala* (Sathyanesan, 1958, 1959). *Chanos chanos* (Tampi, 1950); *Hilsa ilisha* (Nair, 1958); *Channa punctata* (Belsare 1962; Verma *et al*; 1981; Rath and Hejmadi, 1987; Srivastava and Singh, 1987). Lehari (1967, 1968) studied the cyclical changes in the gonads of catfish *Clarias batrachus*. General biological principles involved in teleosts reproduction is well reviewed and documented (Rath, 1993).

From these available literatures it is apparent that although some work has been done on air breathing fish groups, but no much literatures are available on the reproductive cycles and ovarian physiology of *N. notopterus* in Eastern region. Therefore, the studies on ovarian histomorphology, annual cyclical changes and the role of cytochemical changes during ovarian activity in the species *Notopterus notopterus* was undertaken.

REVIEW OF LITERATURE

There are several excellent reviews on the reproduction and ovarian cycles of teleosts. It is important at present to have thorough knowledge on biology of fish oogenesis because of its close relationship to the development of fish culture. Several workers (Saxena *et al.*, 1985; Verma *et al.*, 1986; Saxena and Sahai, 1985; Patil and Kulkarni, 1993) have published data on the reproduction and ovarian cycle of Freshwater featherback *Notopterus notopterus*. Guraya (1986) has made a more thorough study of nuclear extrusion in the growing oocytes of several teleosts including *Notopterus notopterus* (Guraya, unpub. observations).

2.1 MORPHOLOGY OF OVARY

Considerable literature exists regarding the morphology of the teleost ovary. Usually the morphological staging of ovary is done on the general appearance, colour and blood vascularisation. Morphology of ovary has been done in *C. punctata* (Chopra, 1958; Belsare, 1962; Qayyum and Qasim, 1964; Malhotra *et al.*, 1978; Verma *et al.*, 1981, 1983; Rath and Hejmadi, 1987), in *Barbus luteus* (AL-Dahm and Bhatti, 1979), in *Heteropneustes fossilis* (Sundararaj, 1959), in *Mystus seenghala* and *Barbus stigma* (Sathyanesan, 1961, 1962), in *Clarias batrachus* (Lehri, 1967, 1968), in *Colisa fasciata* (Bhatti and Javaid, 1973), in *Mystus tengara* (Guraya *et al.*, 1975), in *Glossogobius giuris*, (Saksena, 1976). However morphological staging of ovary (stage I-VII) in *N. notopterus* has been studied (Hamza, 1980).

Gaur (1964) reported on the morphology of the female urinogenital organs of *Notopterus notopterus*, because of a single ovary in this species having great modification in its external morphological structures in accordance with the conspicuous space of the coelomic cavity due to the laterally compressed body of the fish. Munshi and Hughes (1992) cited that several peculiarities are noticed in the gonads of *Notopterus notopterus* and are of the "open" type facing the body wall on the right side only. The gonads are covered by a loose mesovarium or mesorchium (on the left side only), which may slightly project on to the right side also.

2.2 HISTOLOGY OF OVARY

Much of the literature are available on the seasonal changes on the histology and oocyte development in freshwater teleosts. Histological studies on ovary was carried out in *Barbus ticto* and *C. punctata* (Chopra, 1958a,b); in gold fish (Beach, 1959); in *B. stigma* and *M. seenghala* (Sathyanesan, 1961, 1962); in *C. marulius* (Guraya, 1965); in *Brevoortia patronus* (Combs, 1969); in *Glossogobius giuris* (Saksena, 1976); in *Barbus luteus* (AL-Dahm and Bhatti, 1979); in *O. barbatum* (Casadevall *et al.*, 1993). Studies on the nature and origin of corpuscular yolk in the vitellogenic oocytes in air-breathing fish groups, in *C. punctata* (Narain, 1930); in *C. punctata*, *H. fossilis* and *C. batrachus* have been reported by Majumdar and Chatterjee (1974). Bhargava and Saksena (1971) described the yolk nucleus in *G. giuris*. Lot of reports relating to yolk nucleus formation and its function in fish oogenesis were documented (Guraya, 1986; Rath and Thomas, 1992).

Various components of ovarian follicle such as nucleus (or Germinal vesicle), cytoplasm and its organelles and follicular wall show distinct morphological, cytochemical and biochemical changes during pre-vitellogenic and vitellogenic phases of oocyte growth, maturation and ovulation.

2.3 NUCLEUS OR GERMINAL VESICLE

Several workers have studied the morphological changes in the nucleus during the previtellogenesis and vitellogenesis in teleosts. They are in view that such changes are regulated by the presence of similar regulatory mechanisms. It is generally accepted that the nucleus play a vital role in the regulation of various activities in the cell (Wischnitzer, 1973). The significance of polynucleus oocytes in *Puntitus ticto* cited by Guraya (1986) is still fragmentary. Even the nucleoplasm in the growing oocyte is not described in exact terms.

2.3.1 Nuclear envelope

The structural changes in the nuclear envelope ranging from fold, lobated, undulation and evagination are well studied during different phases of oocytic development. Obviously, these structural changes increase the relative surface of the nucleus for nucleocytoplasmic exchanges of molecules during oocyte growth. Guraya (1986) cited that many workers reported double membrane or two parallel membranes in the nuclear envelope, separated by perinuclear space, granular nucleus materials originated from "nucleolar emission" and nuclear pores in oocytes of majority of fish groups. Detailed structure of the annuli in the nuclear envelope of oocyte has been studied for a variety of animal species (Wischnitzer, 1973).

2.3.2 Nucleoli

Among the best studied organelles inside nucleus, nucleoli are studied in great detail during the process of oogenesis. The structural and numerical changes in the nucleoli apparently reflect and amplification of genetic material being cited (Guraya, 1986). The degree of a structural changes from homogenous to heterogenous structure due to development of vacuoles and dense granules with

the process of oocytic development are documented in many species of teleost. (Guraya unpubl. observations).

2.4 CYTOPLASMIC COMPONENTS

There occur conspicuous alteration in the cytoplasm of growing oocytes during oogenesis. The various structure of the follicle during previtellogenesis are believed for the synthesis of cytoplasm and its components namely yolk nucleus substances, free ribosomes (RNA), lipid bodies etc. Some of these ooplasmic components formed a paranuclear complex in the young oocytes called the Balbiani's Vitelline body (Guraya, 1979).

2.4.1 Balbiani's Vitelline body (BVb)

Guraya (1986) cited that the electron microscopic, histochemical and autoradiographic studies were made by many workers about the origin, structure, differentiation, nature and function of BVb in the growing oocytes of different fish species. BVb in the fish oocyte usually forms a paranuclear complex of organelles and inclusions of diverse morphology and chemical nature, which include basophilic yolk nucleus, mitochondria, lipid bodies, Golgi bodies, etc. (Guraya, 1979). BVb has been more extensively studied in the oocytes of teleosts. A granular, basophilic substances gradually accumulates in the form of a crescent or cap adjacent to the nuclear envelope finally form a large juxta nuclear dense mass of hemispherical shape, which is known as yolk nucleus (Guraya, 1963, 1965; Kapoor, 1977; Sobhana and Nair, 1977; Takahashi, 1981). Moreover the studies on the yolk nucleus in *Amphipnous cuchia* (Thomas and Sathyanesan, 1985); in *Mystus gulio* (Rath and Thomas, 1992) were documented.

2.4.2 Cortical alveoli

Very divergent views were expressed in regard to the origin, morphology and chemical composition of cortical alveoli and yolk bodies during fish oogenesis (Saxena, 1985; Guraya, 1986). However, origin of cortical alveoli and yolk formation can be attributed to a variety of factors, but the most important are i) individual interpretations ii) variations of cortical alveoli and yolk formation in different fishes and iii) confusion between Golgi bodies, vacuoles and yolk nucleus and other inclusions (cited Guraya, 1986).

The cortical alveoli have also been described as cortical vacuoles, vacuolar yolk, intravacuolar yolk, intra vesicular yolk, carbohydrate yolk, yolk vesicles, vacuome, etc. (Guraya, 1965, 1982; Shahi *et al.*, 1979). Anderson (1968) using correlative cytochemical and electromicroscopic techniques followed the origin of cortical alveoli in the oocytes of teleosts. viz., pipe fish and Killi fish.

Extensive cytochemical studies on cortical alveoli in the oocytes of different teleosts have been well reviewed and cited (Guraya, 1986). Moreover the cytochemical studies on different types of yolk bodies have been studied in *C. marulius* (Guraya, 1965); in *Anabas scandens* (Gopal Dutt and Govindan, 1969); in *Notopterus notopterus* and *Mystus bleekeri* (Verma *et al.*, 1985, 1986); in *C. punctata* (Rath and Hejmadi, 1989, 1991).

Guraya (1986) cited that recent investigations carried out sophisticatedly suggested three complex pattern with respect of the origin of yolk precursor in fish oogenesis, that are

- i) produced by the oocyte called endogenous vitellogenesis

- ii) outside the oocytes from liver through the process of micropinocytosis called exogenous vitellogenesis and
- iii) yolk precursor have a dual origin as cited above. However, no convincing evidence is yet recorded about the endogenous yolk formations is actually synthesized by the organelles.

2.5 FOLLICULAR WALL

Follicular wall principally consists of theca, basement membrane, follicular epithelium and zona pellucida around the growing oocytes in fish ovary. However, follicular wall in their development, structure and composition show a great diversity in different fish groups, especially in teleosts and elasmobranch (cited Guraya, 1986). Enough of literature are piled up on the morphology, histochemistry and ultrastructural components and their functional role in different yolk bodies, transportation in follicular epithelium, zone pellucida and other structural components of fish eggs. It is an accepted fact that these components give the surface structure of eggs, adopted to environmental condition in which the embryo develops. In free floating buoyant non-adhesive eggs, with that of adhesive eggs of common carp, and *Fundulus heteroclitus* are due to their structural differences in follicular wall. Some are in view that the fibriles on the surface of the eggs along with secondary follicular wall secreted within the ovary of *F. heteroclitus* and common carp are believed to give an adhesive character of these eggs. In contrast, the presence of thin zona pellucida with horizontal lamellae and primary follicular wall develops from its own ooplasm are believed to be the non-adhesive nature of the eggs in most of the cultivated carps (cited Rath, 1993).

2.6 ATRETIC OOCYTES

Follicular atresia is a degenerative process by which oocytes in various stages of their growth and differentiation are lost from the fish ovary (Guraya, 1986). The process of atresia of follicles of Indian fishes have been studied in *M.seenghala* and *Wallago attu* (Dixit, 1956), in *M. seenghala* (Sathyanesan, 1961), in *C. punctata* (Belsare, 1962); in *C. batrachus* (Lehri, 1967), *C. gachua* (Sanwal and Khanna, 1972); in *G. qiuris* (Saksena, 1976), in *N.notopterus* (Saxena, 1979, Saxena and Raizada, 1984; Saxena and Sahai, 1981; Saxena *et al.*, 1984).

MATERIAL AND METHODS

The collected fishes were brought to the laboratory, sexually identified and the ovaries were dissected out, examined and morphologically classified according to the methods of Bhatt (1968). For the histological studies the ovaries were fixed in appropriate fixative. After fixation were over, the tissues dehydrated. cleared embedded in paraffin and cut the section at 4 μ . Different stages of oocytes were identified according to the methods described by Verma *et al.* (1986).

In the present study, ovaries were fixed in Carnoy's fixative for carbohydrate, protein and RNA localisation in different ovarian tissues. Fixation of tissues in the fixative is necessary to prevent subsequent changes (autolysis). When the tissue is dropped in a fixative it is immediately killed and enzymatic digestive processes are inhibited thus preserving the normal structure. Also fixing the tissues is to harden them. Following fixation the tissue blocks are processed in preparation for the paraffin embedding. This gives the tissue the necessary hardness for microtomy. Since paraffin is not miscible or soluble in water, the water must be removed from the specimen to allow the paraffin to infiltrate into the tissue. The four major steps of tissue processing that come under the "paraffin wax technique" are

Dehydration, a process by which water is removed from the tissue. Tissues are thoroughly dehydrated before they are ready for embedding. In this experiment ethanal is used as dehydrant.

Alcohol must be removed (dealcoholization) before the infiltration of paraffin can begin because of not readily miscible with paraffin with the former. This process is known as clearing. Xylene is used as the clearing agent. Also it has the advantage of miscible in both alcohol and paraffin wax. Thus, it helps to replace or clear the alcohol and make room for the paraffin during infiltration and impregnation.

After clearing, tissues are transferred to a bath of molten paraffin wax in an embedding water bath for infiltration and impregnation. During this process, xylene is eliminated from the tissues by diffusion into surrounding melted wax (infiltration) following which the wax diffuses into the tissues to replace the clearing agent (xylene) impregnation. This is carried out in paraffin container (58.0-62.0°C) for 4-5h as per the size of the tissue, infiltrated paraffin, after cooling gives the necessary firmness and support to the cells and intercellular structures to maintain them proper relation to each other when they are cut on the microtome.

After the above processes are over the tissue enters the next step for embedding which is a method of placing the infiltrated-impregnated tissue in warm liquid paraffin that solidifies into a firm block when it cools down to room temperature. This process enables the tissue to be cut on a microtome.

The embedded tissues are now taken for section cutting. This involves the technique of microtomy which yield thin section of tissue for microscopic examination. In the present study the tissue were cut at 4 μ .

3.1 GENERAL STAIN

For studying the general histology, Hematoxylin and Eosin stain was used. Haematoxylin a natural dye which was first used about 1863 is the most

valuable staining reagent used in histologic work. It has polychrome properties which may be brought out with proper differentiation. The active colouring agent, hematein, is formed by the oxidation of hematoxylin.

For staining purpose, the paraffin sections are treated with xylene and then down graded through an alcoholic series to water, kept for 10 minutes in Harris's hematoxylin, rinse in tap water, dehydrated upto 70%, stained with eosin for 5 minutes, dehydrated, cleared in xylene and mounted in DPX. Once the preparation of permanent slide is over, they are examined under the compound microscope where the different oocytes were examined and recorded. The coloration of the nucleoli are blue, while the cytoplasm are pink in colour.

3.2 SPECIAL STAIN

3.2.1 Polysaccharide determination by Periodic Acid Schiffs (PAS) Method

The whole of the modern histochemistry of the polysaccharides, mucopolysaccharides and mucoprotein is bound up with the periodic acid Schiff reaction (PAS), and it is therefore necessary to consider the principle on which this reaction is based. Periodic acid (HIO_4) is an oxidizing agent which was employed by Malaprade (1928,1934) for chemical estimation of glycol ($\text{CH}_2\text{OH-CHOH}$). McManus (1946) was the first to use it in histology for the demonstration of mucin.

The oxidant periodic acid which breaks the C-C bonds in various structures where these are present as 1:2 glycol groups (CHOH-CHOH) converting them into dialdehydes (CHO-CHO) and thus a positive PAS reaction.

The sections were deparaffinized, dehydrated, treated with 0.5% aqueous periodic acid for 45 minutes, rinsed in distilled water for 3 minutes. The

sections were kept in Schiff's solution for 3 and then rinsed for 3 minutes in freshly prepared sulfurous acid, washed in running water and dehydrated them by treating for 3-5 minutes each in ascending grade of alcohol, cleared in xylene and mounted in DPX. The polysaccharide in tissue section was rose to purplish red, nuclei-blue and background-pale green when counterstained with light green.

3.2.2 Protein determination by Mercury Bromophenol blue (HgBPB) Method (after Bonhag)

This staining method was introduced by Durum (1950) for the demonstration of protein on filter paper spots. It was adopted as a general stain for protein (cited Pearse, 1968).

Salts of mercury are much more commonly employed in histological fixatives. Histochemical studies may be called for when no material other than that fixed with mercury is available. It is, therefore, important to consider the effect of salts of this metal on the tissues and particularly on the protein on these. In general, Hg^{++} behaves like other metallic ions in combining with the acid groups of proteins, especially carboxyl and hydroxyl and the phosphoric acid of nucleoprotein. This is in its selective affinity for thiol (SH) groups. If a very small quantity of mercuric salt is added to a protein containing reactive thiol groups, it will reacts with these and stability of the mercury sulphur bond is greater than that between mercury and any other grouping.

For the special purpose of staining, the sections were deparaffinized, hydrated and then treated with mercury bromophenol blue (0.05%) solution for 1 h., treated with 5% acetic acid for 10 minutes, dehydrated in t-butyl alcohol, cleared in xylene and mounted in DPX. The protein in tissue stained deep blue colour.

3.2.3 Protein determination by Ninhydrin Schiff's Method (cited Pearse, 1968).

This is a older method of histochemistry applicable to the study of amines, the best known is the ninhydrin reaction. Ninhydrin reacts with the free NH_2 groups of α amino acid, in acid solution, to give a blue-coloured compound, together with carbondioxide and an aldehyde containing one less carbon atom than the original amino acid.

The sections were deparaffinized and hydrated, treated with 0.5% ninhydrin for 24 h. at 37°C , then washed in running water for 2-5 minutes, kept in Schiff's solution for 30 minutes, again washed in running water, counterstained with haemalum, differentiated in 1% acetic acid, dehydrated, cleared and mounted in DPX. Protein stained tissues pinkish-red to magenta colour.

3.2.4 Ribonucleic Acid (RNA) determination by Methyl green pyronine Method (Kurnick 1955 from Pearse 1968)

The standard method for demonstrating RNA in both nucleus and cytoplasm is the indirect method, which depends on the specific depolymerization of RNA by the enzymes ribonuclease. Pearse (1968) cited that the methyl green mixture was an elective stain for DNA in chromatin, while the pyronine G of this mixture had an elective affinity for RNA in both nucleolus and cytoplasm. Material staining blue with toluidine blue or red with pyronine, and removable by treatment with ribonuclease, is considered to be RNA.

For the purpose of staining, the sections were deparaffinized, hydrated and treated with methyl-green pyronine for 15 minutes. Rinsed in distilled water for 30 seconds, dehydrated for 5 minutes in absolute acetone, rinsed in equal mixture of acetone and xylene, cleared in two changes of xylene and mounted in DPX. RNA was stained red.

3.2.5 Choline type lipid determination (after McManus 1946, from Pearse 1968)

Choline containing lipid can be demonstrated on paper chromatograms by forming insoluble choline-phosphomolybdic acid complexes which are subsequently rendered visible by conversion to molybdenum blue.

For the lipid test, the tissues were fixed in the McManus fixative. Following procedures cited earlier, paraffin sections were cut at 4 μ . The paraffin sections were directly exposed to formalin for 15 minutes and allowed to dry thoroughly and dip in 50/50 acetone-ether for 15 minutes, transferred to 1% phosphomolybdic acid in 50/50 ethanol-chloroform for 20 minutes, rinsed in ethanol-chloroform and dried. The sections were dipped in 1% freshly made aqueous stannous chloride in 3N-HCL washed in water and dried, counterstain with eosin, dehydrated, cleared and mounted in DPX. Choline-containing lipid stain in molybdenum shades blue colour.

RESULTS

4.1 MORPHOLOGY OF OVARY

In *Notopterus notopterus* a single sac type of ovary is found, usually present on the right side of the body only. In this case, the eggs are passed out by the way of a duct, the oviduct, which is an extension of the peritoneal wall of the ovary.

The general shape of the ovary, when fully matured during the breeding season is oval (like a gizzard of a bird) and it is placed in between the lateral sides of the fish in the coelom and is covered over by a peritoneum, by which it remain attached to the coelomic cavity and other organ present in it (Fig. 1). Generally the gonads are of the 'open' type facing the body wall (on the right side) and are covered by a loose mesovarium in female and mesorchium (on the left side) in male which may slightly projected towards the right side. The anterior position of the ovary is broad and rounded, the posterior end is comparatively less rounded. The peritoneal folds of the posterior side of the ovary shows an extension of a hollow tube like structure, the oviduct which runs along by the side of the posterior rounded end of the ovary and ultimately leads to the exterior through the genital aperture near the anal opening (Fig. 2).

The body of the fish itself shows an external morphological structural modification of which several peculiarities are noticeable. These peculiar characteristics are the oval shape of the ovary, laterally compressed structure, lack of coelomic space available, great reduction of the body cavity etc.

The two lateral sides of the ovary shows a great differentiation in its appearance. One of the lateral side of the ovary which is facing the alimentary

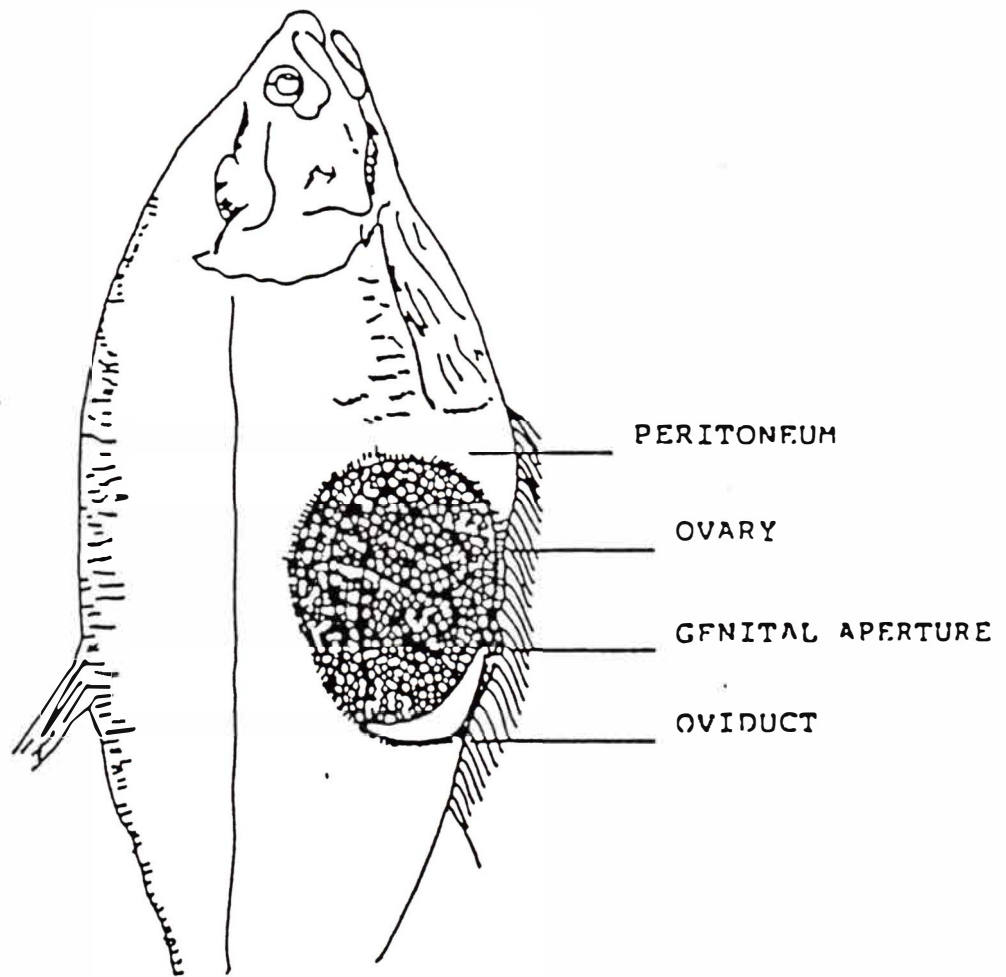


Fig. 1. Reproductive system (Laterally dissected) Notopterus notopterus.

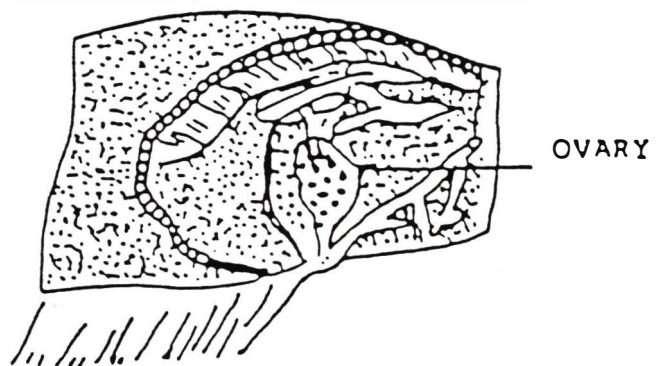


Fig. 2. Female Urinogenital system in Notopterus notopterus.

canal and other viscera present in the coelom shows rounded elevation of mature ova present in it, the other lateral side of the ovary facing the empty space of the coelom with no viscera shows furrows and ridges with elevated structure of mature ova.

The older matured bigger ova are black and present at the posterior side of the ovary, the smaller whitish immature ova are towards the anterior sides of the ovary. On outer general surface of the ovary a great anastomosis of the blood vessels is also being observed. The unpaired ovary is quite big prominent and deep yellowish in colour during the breeding season.

The size shape weight and colour of the ovary changed seasonally according to the degree of maturity, they had attained. The morphological staging of ovary have been done in *H. fossilis* (Bhatt, 1968), in *C. batrachus* (Lehri, 1967, 1968).

In the present work, the study have been carried out on the similar work pattern done by Bhatt (1968) on air-breathing fishes (Table 1). In this study, six different morphological stages of ovary of I to VI were observed and classified according to the colour and blood vascular pattern of the ovary.

The percentage weight of ovary at six different morphological stages in relation to total weight of fishes are presented (Table 2-6).

In stage I, ovary is immature, small single, creamy and jelly like structure, grey white in colour, forms the 0.287% weight of the total body weight (Table 2). Eggs not visible to naked eye. Also blood vessels are not seen on the ovary.

The stage II ovary is also immature but pinkish white in colour. Ovary constitute nearly 0.404% of total body weight of the fish (Table 3). Eggs are not visible, very few blood vascularisation seen on the ovary. Ovary ovally laterally shaped extending $\frac{1}{4}$ to $\frac{1}{2}$ of the body cavity.

The stages III and IV are the maturing stage of the ovary. Ovary become more distinct, prominent and extends nearly 0.481% of the total body weight (Table 4). During these stages, eggs are visible to the naked eye, ovary become pinkish and gradually changes to pink yellow in colour, occupying $\frac{3}{4}$ of the body cavity. Blood vascularisation is well intense.

The stage V ovary is the mature state, as the oocytes are completely oval in shape clearly visible and form like the gizzard of a bird. The colour of the ovary varies from brown to yellow being predominantly deep yellowish in colour. Ovary has a beading appearance due to presence of ripe ova, occupying the whole of the body cavity. Eggs big in size, prominent and blood vascularisation are well developed. The ovary extends upto 4.407% of the body weight of the fish (Table 5).

The stage VI ovary is in the spent state, as the oocytes are at the different states of resorption. During this phase ovary becomes compact, flaccid and shrunken. The colour becomes pale yellowish greyish. Some oocytes are visible from outside of the ovary as minute distinct white spots with less blood vascularisation. Ovary constitute 1.204% of the total body weight (Table 6). The percentage weight of ovary and body weight decreases gradually indicating the spent stage of ovary.

In immature ovary the percentage growth in weight with respect to body weight was found to range from 0.287% to 0.404% respectively (Table 7). Maturing stages constituting of III and IV stages, the percent growth in weight with relation to body weight on an average was found to be 0.481% i.e. 0.194% to 0.077% increase in weight over that of immature ovary (Table 7). The percent weight in mature phase was found to be 4.407% (Table 7). Hence, there was tremendous increase of 3.926% in weight than that of previous stage. In the stage VI ovary which is considered as the spent stage of ovary. The percentage of ovary weight is found to be 1.204 where it declined by 3.203% from the mature stage of ovary, which considered to be the quiescent phase of ovary (Table 7).

Table 1: Comparison of morphological stages of ovary in *N. notopterus* (Pallas)

Stages of gonadal development of air-breathing fishes (Bhatt, 1968)		Present study	
Stage I	Immature virgins Ovaries small; eggs microscopic, translucent.	Stage I	Immature Ovary is small, single creamy and jelly like structure, eggs not visible, grey white in colour. Less blood vascularisation.
Stage II	Maturing virgins and recovered spent Ovaries cylindrical, oblong, occupying 1/4 to 1/2 body cavity, eggs visible to naked eye, reddish to dull green.	Stage II	Immature Ovary single, oval and laterally compressed, occupying 1/4 to 1/2 of the body cavity. Pinkish white in colour. Eggs not visible in this stage, with less blood vascularisation.
Stage III	Ripening Ovaries enlarged, occupying 1/2 to 3/4 body cavity; eggs clearly visible, light green in colour.	Stage III	Maturing Ovary become enlarged, filled 1/2 to 3/4 of the body cavity, pinkish, blood vascularisation moderately intense. Eggs seen in naked eye.
Stage IV	Ripe Ovaries very large, occupying whole of body cavity, eggs large and green.	Stage IV	Maturing Ovary become more prominent occupying 3/4 of the body cavity pinkish in colour with intense blood vascularisation, eggs visible. In some cases ovary is pink yellow in colour.
Stage V	Spent Ovaries shrunken and with some residual dull red eggs.	Stage V	Mature Ovary become very large, occupying whole of the body cavity. Completely oval, prominent yellowish eggs visible, blood vascularisation is well developed.
		Stage VI	Spent Ovary become compact, shrunken and flaccid. Pale yellowish grayish in colour. Distinct white residual spot seen. Less blood vascularisation.

Table 2: Weight of stage 1 ovary in *N. notopterus* (Pallas)

No. of observations	Weight of fish (g)	Weight of ovary (g)	Percentage of body weight
1	40.0	0.0944	0.236
2	42.0	0.0839	0.200
3	20.0	0.0163	0.082
4	20.0	0.0113	0.057
5	100.00	0.4942	0.494
6	50.0	0.2093	0.419
7	35.0	0.1768	0.505
8	75.0	0.4063	0.542
9	24.0	0.0125	0.052
Total	406.0	1.505	2.587
Mean	45.11	0.167	0.287
	± 25.33	± 0.166	

Table 3: Weight of Stage II ovary in *N. notopterus* (Pallas)

No. of observations	Weight of fish (g)	Weight of ovary (g)	Percentage of body weight
1	68.0	0.1111	0.163
2	60.0	0.1959	0.327
3	80.0	0.7627	0.953
4	85.0	0.4393	0.517
5	35.0	0.1768	0.505
6	115.0	0.1241	0.108
7	115.0	0.2216	0.193
8	80.0	0.9049	1.131
9	85.0	0.3897	0.458
10	50.0	0.0392	0.078
11	50.0	0.0688	0.138
12	230.00	0.6353	0.276
13	150.0	0.5987	0.399
Total	1203.0	4.6681	5.246
Mean	92.54	0.359	0.404
	± 49.7	± 0.275	

Table 4: Weight of stage III and IV ovary in *N. notopterus* (Pallas)

No. of observations	Weight of fish (g)	Weight of ovary (g)	Percentage of body weight
1	80.0	0.7863	0.982
2	70.0	0.1554	0.22
3	35.0	0.1166	0.33
4	85.0	0.3489	0.410
5	30.0	0.1534	0.511
6	20.0	0.0607	0.304
7	115.00	0.6330	0.550
8	90.0	0.4001	0.445
9	100.0	0.4072	0.407
10	110.0	0.7444	0.677
11	65.0	0.4642	0.714
12	80.0	0.4063	0.508
13	110.0	0.3913	0.356
14	120.0	0.7348	0.612
15	110.0	0.3559	0.324
16	70.0	0.3746	0.535
17	70.0	0.2917	0.417
18	85.0	0.3001	0.353
Total	1445.0	7.084	8.660
Mean	80.27	0.394	0.481
	± 28.60	± 0.211	

Table 5: Weight of stage V ovary in *N. notopterus* (Pallas)

No. of observations	Weight of fish (g)	Weight of ovary (g)	Percentage of body weight
1	100.0	0.3286	0.329
2	84.0	0.6685	0.796
3	66.0	0.8841	1.340
4	130.0	10.6608	8.201
5	175.0	10.6449	6.083
6	100.00	3.3420	3.342
7	162.00	7.7294	4.137
8	300.0	16.5167	5.706
9	105.0	4.8335	4.603
10	130.0	4.0746	3.134
11	84.0	4.4388	5.284
12	125.0	12.7654	10.212
13	100.0	2.8133	2.313
14	80.0	3.6231	4.529
15	180.0	6.3506	3.528
16	210.0	3.1599	1.505
17	150.0	2.8153	1.877
18	110.0	3.6992	3.363
19	105.0	2.260	2.256
20	130.0	4.8609	3.739
21	75.0	2.9166	3.222
22	65.0	2.2354	3.439
23	120.0	4.5605	3.800
24	105.0	5.8708	5.591
25	95.0	5.7942	6.099
26	105.0	8.5446	8.138
27	70.0	5.5601	7.943
28	70.0	5.2104	7.443
29	60.0	4.4640	7.440
30	70.0	3.0443	4.35
31	125.0	9.3228	7.458
32	80.0	0.1091	0.136
Total	3666.00	163.406	141.036
Mean	114.56	5.106	4.407
	± 49.014	± 3.648	

Table 6: Weight of stage VI ovary in *N. notopterus* (Pallas)

No. of observations	Weight of fish (g)	Weight of ovary (g)	Percentage of body weight
1	80.0	0.1730	0.216
2	100.0	0.3216	0.313
3	85.0	0.7075	0.832
4	112.0	0.4547	0.406
5	60.0	0.7173	0.196
6	25.0	0.0636	0.254
7	120.0	0.4737	0.395
8	95.0	0.4261	0.449
9	30.0	0.6787	0.262
10	160.0	0.3486	0.218
11	90.0	0.7181	0.798
12	50.0	0.4456	0.891
13	45.0	0.2631	0.585
14	100.0	0.8979	0.898
15	125.0	1.1482	0.919
16	52.0	0.7377	1.419
17	180.0	2.1250	1.347
18	75.0	0.5838	0.778
19	60.0	0.5663	0.944
20	50.0	0.3349	0.670
21	50.0	0.2320	0.464
22	70.0	0.3898	4.843
23	75.0	1.5670	2.089
24	45.0	3.9189	8.709
25	75.0	3.4021	4.536
26	55.0	0.7542	1.371
27	100.0	0.3066	0.307
28	115.0	0.5068	0.441
29	65.0	0.2553	0.393
30	30.0	0.0130	0.043
31	167.0	0.5916	0.354
Total	2491.00	26.523	37.34
Mean	80.354	0.856	1.204
	± 41.024	± 0.987	

Table 7: Morphology, percentage of weight, condition and phase of ovary in *N. notopterus* (Pallas)

Stage	Colour of ovary	Condition of Ovary	Phase of ovary	Percentage of body weight	Ovary weight	Condition of oocytes
I	Grey whitish	Immature	Quiescent cum preparatory	0.287	0.167	Previtellogenesis
II	Pinkish white	Immature		0.404	0.359	
III & IV	Pinkish/ Pink yellowish	Maturing	Preparatory cum active	0.481	0.396	Vitellogenesis
V	Deep Yellowish	Mature	Active-cum-quiescent	4.407	5.106	
VI	Pale yellowish	Spent		1.204	0.856	Vitellogenesis

4.2. HISTOLOGY OF OVARY

The ovary consisted of the ovarian wall and the oocytes at different stages of development. Histologically, the ovary consists of an outer wall and inner cavity called the ovocoel. The ovarian wall is unsheathed externally by a thin layer of peritoneum below which lies a layer of tunica albuginea composed of connective tissue, cells and fibres. The blood vessels were also seen along the periphery of the wall as well as within the connective tissue itself. Below the layer of tunica albuginea one may locate a layer of germinal epithelium. These at places, extend into the ovocoel and ultimately form the ovigerous lamellae (Plate 1). Each lamellae was formed of connective tissue fibres, blood capillaries and germinal epithelium. Oocyte differentiate from the germinal epithelial cells and may be seen in different developmental stages. The corresponding histology of ovary at different morphological stages are presented (Plate II to VII).

4.2.1. Oocytic stages

Very few attempts have, however, been made (Verma *et al.*, 1981, 1983, 1986) for the cytochemical analysis of vitellogenesis in freshwater fishes. A very few literature relating to the topic on the freshwater fish *N. notopterus* is available.

Instead of six stages described by Verma *et al.* (1986), the present study clearly defined and demarcated seven stages of oocytes, i.e. stage I to VII (Plate VIII-XI) in *N. notopterus*. For convenience a comparative account of the present classification which relates to that of Verma *et al.* (1986) is given (Table 8).

Based on the shape, size, changes in the nuclear and cytoplasmic components, seven different developmental stages of oocyte has been

distinguished. All the oocytes in the present study have divided into three categories. They are (i) Immature oocyte (ii) Maturing oocyte and (iii) Mature oocyte.

4.2.1.1 IMMATURE OOCYTE

Stage I and stage II are placed under immature oocyte.

(a) Stage I (Plate VIII, Table 8). The average diameter of oocyte was 70-100 μm and that of nucleus was 40-50 μm . Stage I is the first visible stage in the development of an oocyte. Oocyte have a large rounded centrally placed nucleus with a developing nucleoli ranging 2-22 in numbers and found scattered in the chromatin mass of nucleus. Nucleoli took stain in the mesh work of chromatin fibres of the oocyte.

(b) Stage II (Plate VIII, Table 8). At this stage the average diameter of oocyte was 100-130 μm and that of nucleus was 30-50 μm . Nucleoli are arranged in the periphery of the nucleus where number of nucleoli varied from 2 to 12. The nucleus found to be big, rounded and deeply stained.

4.2.1.2 MATURING OOCYTE

Stage III, IV and V are considered to be the maturing oocytes.

(a) Stage III (Plate VIII, Table 8). At this stage oocyte increase in size to about 150-220 μm in diameter. Nucleoli are arranged around the centrally located nucleus and are basophilic. This stage is characterised by the appearance of a number of vesicles preferably one layer around the periphery of the ooplasm. Some granules may be seen in the intravesicular zone as well as peripheral ooplasm. Nucleus rounded sometimes, oval in shape.

- (b) Stage IV (Plate IX, Table 8). At this stage the oocyte measures about 250-400 μm in diameter. In most of the cases nucleus are going to be fused and nucleoli hardly been noticed. This may be due to nucleolar extrusion into cytoplasm. This stage is also characterized by the development of vesicles and yolk globules increases in size and seemingly granular in some cases.
- (c) Stage V (Plate X, Table 8). At this stage, the average diameter of oocyte has further increased to about 450-600 μm in diameter and oocyte nucleus starts migrating. No nucleolus seen. Globular and granular structure of the yolk are seen in this stage. Vesicles are also observed in mid ooplasm as well as in peripheral region of the oocyte.

4.2.1.3 MATURE OOCYTE

Stage VI and VII are placed under the mature oocytes.

- (a) Stage VI (Plate X-XI, Table 8). At this stage the average diameter of oocyte was about 650-750 μm . Oocyte nucleus becomes highly active and also going to be polarised. In some cases nucleoli are also noticed. Numerous minute granules seen in the ooplasm and globular structures are observed in the cortical zone of the mature oocyte.
- (b) Stage VII (Plate XI, Table 8). Oocyte become very large and measures about 750-850 μm in diameter. The oocyte nucleus become active, irregular in shape and seen moving towards the corner of the yolk filled ooplasm as 'migratory nucleus'. In cortical zone of oocyte, intense granules noticed in mature oocyte. No nucleolus is distinctly visible in the oocyte.

Moreover, month wise distribution of different percentage of oocytes are presented (Table 9, Fig. 3).

Table 8: Histological characteristics of different oocytes in *N. notopterus* (Pallas)

Study by Verma <i>et al.</i> (1986)		Present study	
Stage I	Oocyte measures on average about 150 μm in diameter. It has a large nucleus with a number of developing nucleoli. Fine lipid-containing granules appear in the peri and Juxta-nuclear zone of the oocyte.	Stage I	Oocyte measure about a range of 70-100 μm in diameter. Nucleus large, rounded centrally placed with a developing nucleoli ranging 2-22 in numbers and scattered in the nucleus, within the chromatin fibres of the oocyte.
Stage II	Oocyte measures in size to about 225 μm in diameter. Its nucleoli are small in size and appear to be arranged along the nuclear membrane. There develops a number of vesicles with carbohydrate-containing yolk globules. The lipid granules may be seen in the intervacular zone as well as in the peripheral ooplasm. Quantitatively, the lipid granules appear to have reduced to a great extent. Qualitatively also, the lipid granules of this stage are different from those of the earlier stage in as much as while they include neutral lipids (vide infra) during this stage, they are seemingly composed of phospholipid (reacting positively with acid haematein and negatively after pyridine extraction) in the stage I oocyte.	Stage II	Oocyte measuring an average of 100-130 μm in diameter. The diameter of nucleus ranges between 30-50 μm and the nucleoli are found in the peripheral zone of the nucleus with range of 2-12 in numbers. Also nucleus are found to be big, rounded and deeply stained.
Stage III	Oocyte of this stage measures on average about 300 μm in diameter. The nucleoli are arranged along the nuclear membrane and do not appear to have increased in size. The carbohydrate yolk globules, which have in the mean while increased in number and may be seen occupying most of the ooplasm, seemingly degenerate, while staining for protein, one may, however, observe the development of protein containing yolk globules <i>de novo</i> in the central ooplasm. The neutral lipid granules visibly increase in number and accumulate in the peripheral ooplasm.	Stage III	Oocyte increase in size to about 150-220 μm in diameter. Nucleoli are arranged around the centrally located nucleus and are basophilic. There develops a number of vesicles preferably one layer around the periphery of the ooplasm. Some granules may also be seen in the intravascular zone as well as peripheral ooplasm. Rounded nucleus, sometimes oval in shape.
Stage IV	Oocyte has further increased in size to about 450 μm in diameter. Oocyte nucleus is stained deeply and as such no nucleolus can be located. In addition to the intraoocytic protein yolk (while developed in the stage III oocyte). There appear protein containing minute yolk precursor granules in the cortical zone, which apparently coalesce together to give rise to yolk globules. The neutral lipid together to give rise to yolk globules. The neutral lipid granules increase in number enormously in the peripheral ooplasm. Positive coloration for lipid may also be seen in the follicular epithelium. The lipid granules visible together to give rise to globular structure in the peripheral ooplasm.		Oocyte measure about 250-400 μm in diameter. Most of the case nucleus are going to be fused. Nucleoli hardly be seen. The vesicles developed and the globular yolk globules increase in size and seemingly granular in some cases.

Study by Verma <i>et al.</i> (1986)		Present study	
Stage V	Oocyte of this stage measures on average about 675 μm in diameter. Oocyte nucleus appears to be highly active. No nucleoli, as observed in the earlier stages can be seen. However, numerous minute granular ribo nucleoprotein particles develop in the Oocyte nucleus and apparently move to the ooplasm. Besides, a number of larger darkly stained protein-containing globular structures, develop. these globules also Inturn move to the ooplasm to fuse together and /or with other cytoplasmic protein-containing globules to give rise to protein yolk bodies. The lipid yolk bodies increase in number and move towards the central coplasm apparently sandwiched in between the sudanophobic protein yolk bodies.	Stage V	Oocyte has further increased to about 450-600 μm in diameter. In these stages oocyte nucleus start migrating. No nucleolus seen in this stage. The yolk globular and granular structure are seen in this stage. Vesicles also seen in mid ooplasm as well as in peripheral region of the oocyte.
Stage VI	Oocyte becomes ripe and measures on average about 795 μm in diameter. The oocyte nucleus becomes irregular in shape and moves to one corner of the yolk filled ooplasm as 'migratory nucleus'. In the cortical ooplasm there appear minute carbohydrate containing granules. The granules seemingly fuse together and give rise to a layer of carbohydrate yolk (cortical alveoli) in the cortical zone of the mature oocyte.	Stage VI	Oocyte measure about 650-750 μm in diameter. Oocyte nucleus becomes highly active and also going to be polarised. In some cases nucleoli are also observed. Numerous minute granules seen in ooplasm and globular structure are observed in cortical zone of the mature oocyte.
		Stage VII	Oocyte is becoming very large, ripe and measure about 750 to 850 μm diameter. The oocyte nucleolus becomes active, irregular in shape and seen moving towards the corner of the yolk filled ooplasm as 'Migratory nucleus'. In cortical zone of the oocyte, intense granules are observed in mature oocyte.

Table 9: Month wise distribution of different percentage of oocytes in *N. notopterus* (Pallas)

Sl. No.	Month	Stages of oocytes						
		I	II	III	IV	V	VI	VII
1.	Aug.	6.67	20.00	36.00	29.33	5.33	-	2.67
2.	Sept.	48.48	10.10	22.22	18.18	-	1.01	-
3.	Oct.	52.50	40.00	7.50	-	-	-	-
4.	Nov.	56.67	16.67	26.67	-	-	-	-
5.	Dec.	68.66	5.97	19.40	5.98	-	-	-
6.	Jan.	60.96	21.39	8.56	9.09	-	-	-
7.	Feb.	28.85	7.69	23.07	17.31	23.07	-	-
8.	Mar.	-	-	-	-	-	-	100.00
9.	April.	-	-	-	-	-	33.33	66.67
10.	May.	-	-	-	-	-	16.67	83.33
11.	June	-	-	-	-	16.67	16.67	66.67
12.	July	-	25.00	12.5	12.5	10.5	-	37.5

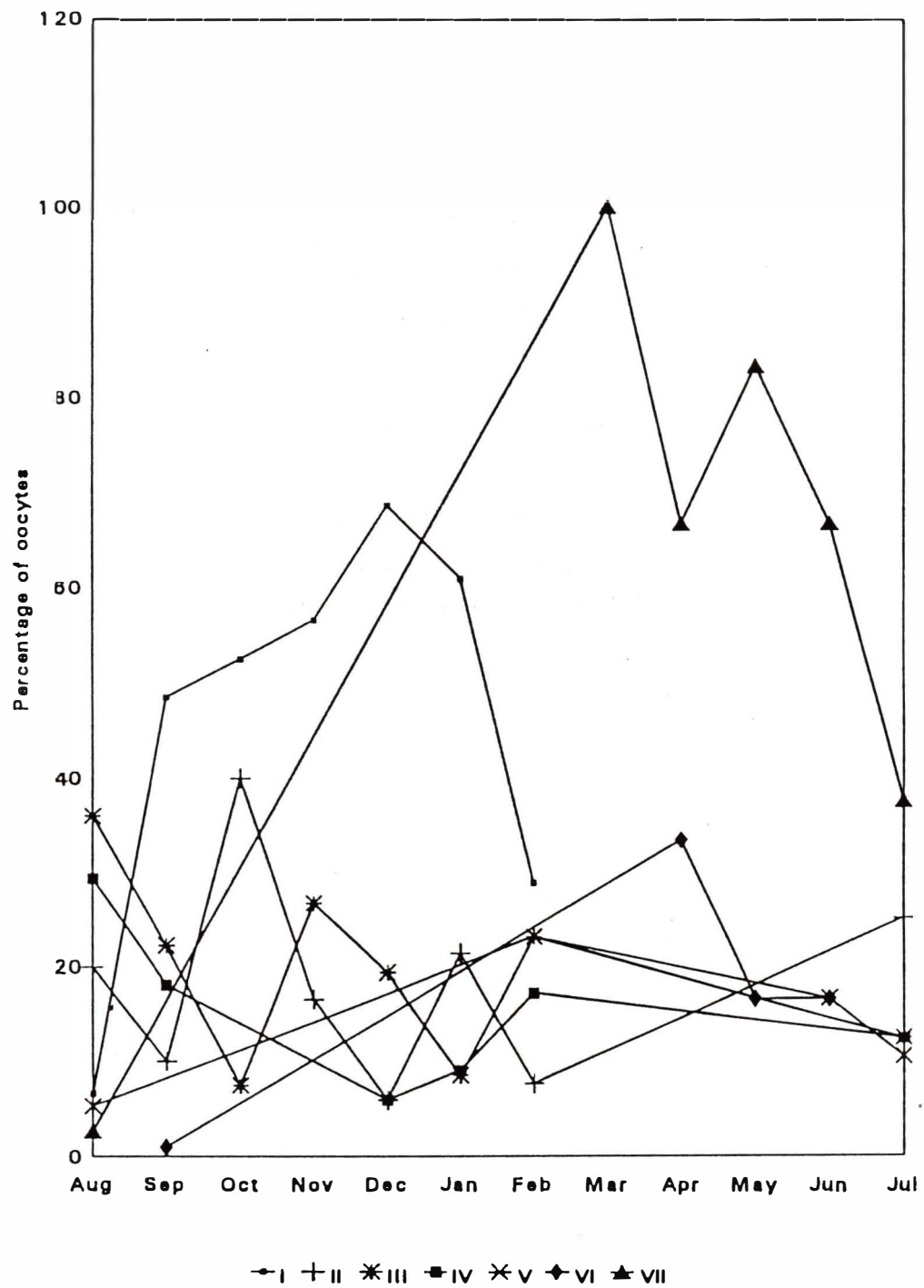


Fig. 3. Monthwise distribution of different % of oocytes in *N. notopterus* (Pallas) during 1993-94.

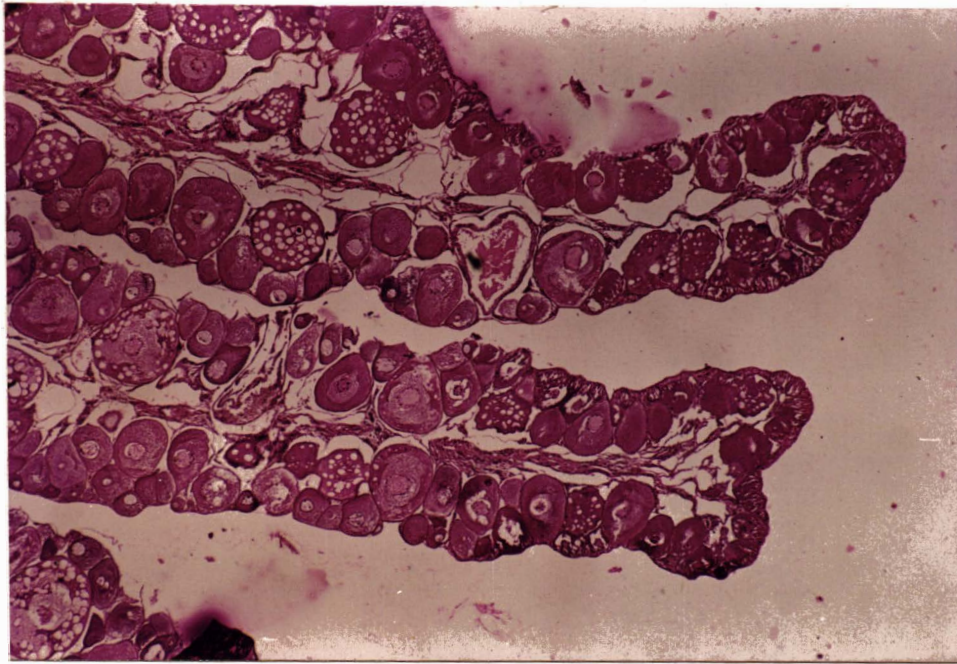


Plate No. I Showing oocytes of different growing stages in ovigerous lamellae. HE x 13.2

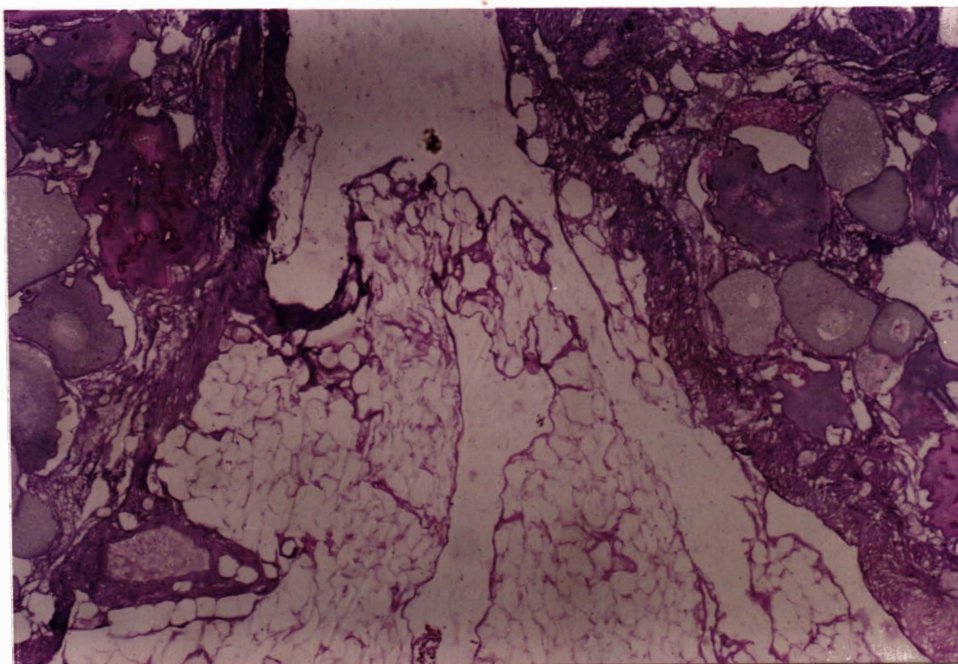


Plate No.II Showing oogonial nest of stage I ovary. x 33

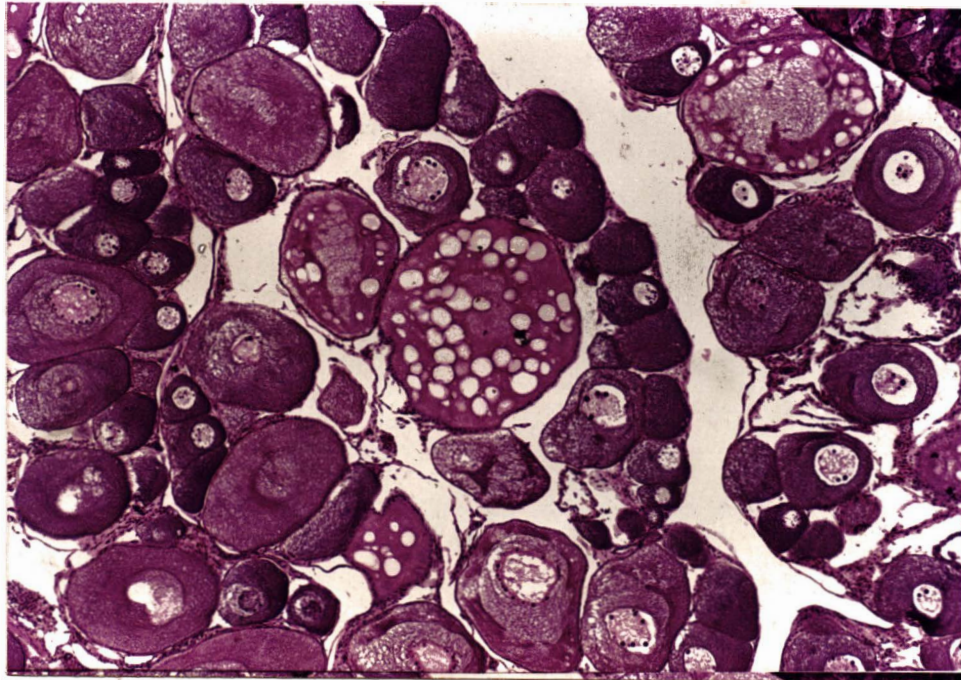


Plate No.III Showing oocytes of different growing stage II ovary.
HE x 33

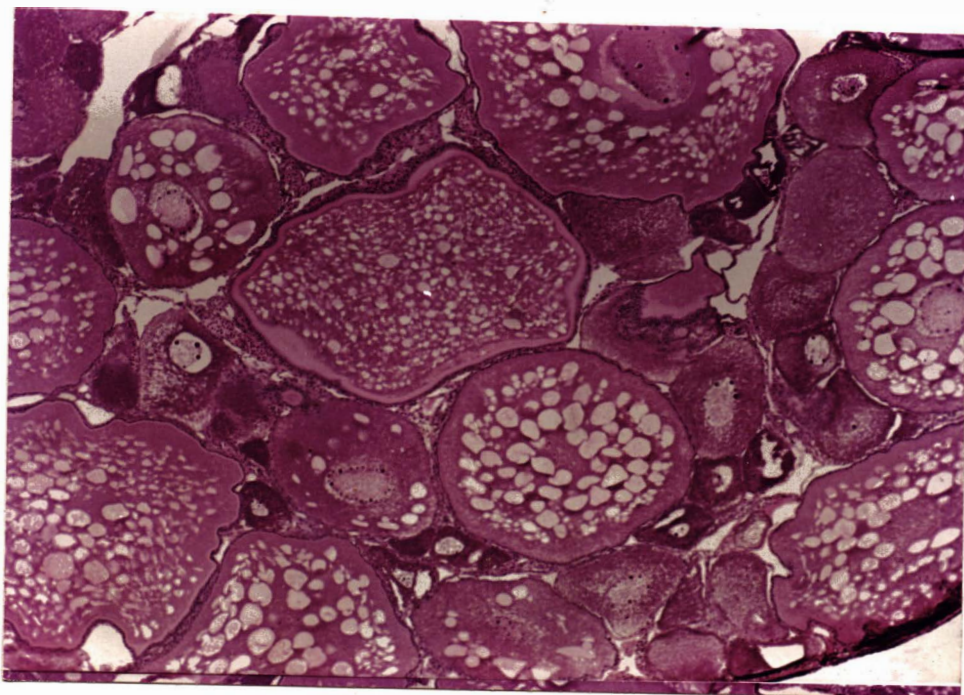


Plate No.IV Showing oocytes of different growing stage III ovary.
HE x 33

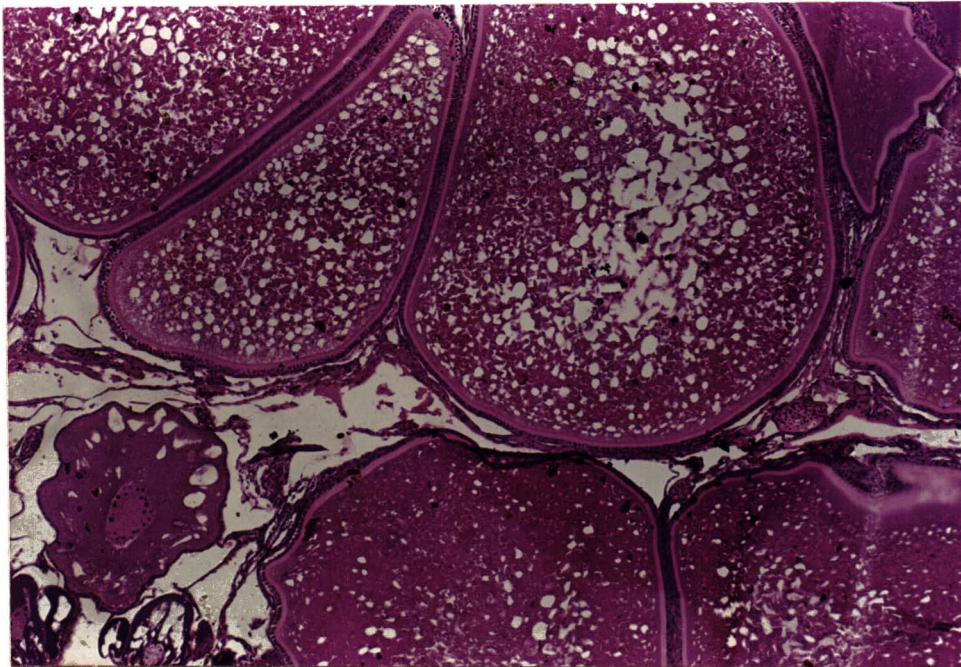


Plate No.V Showing oocytes of different growing stage IV ovary. x 33

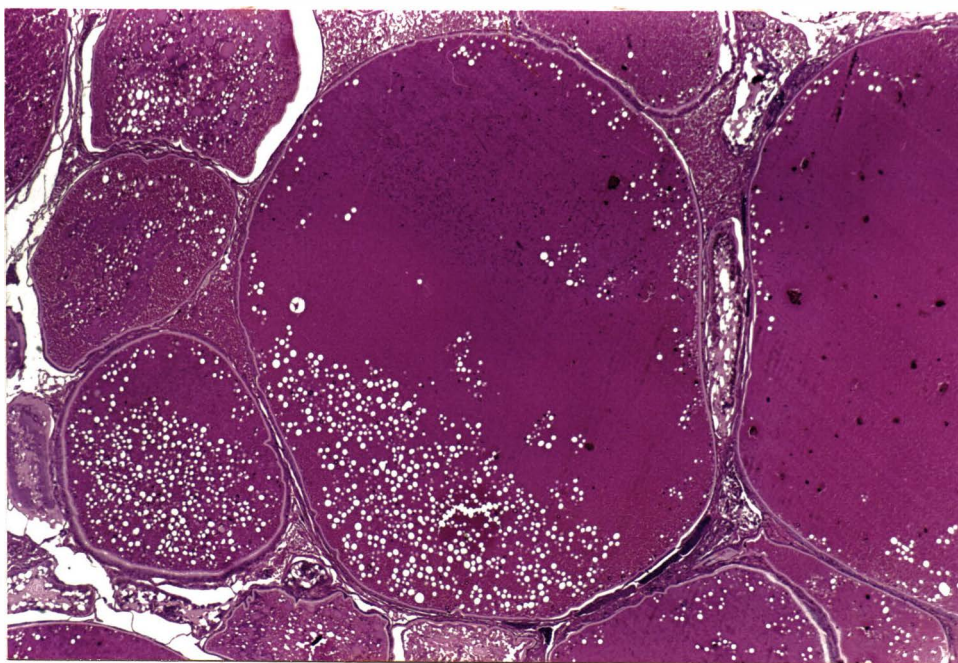


Plate No.VI Showing oocytes of different growing stage V ovary.
HE x 33

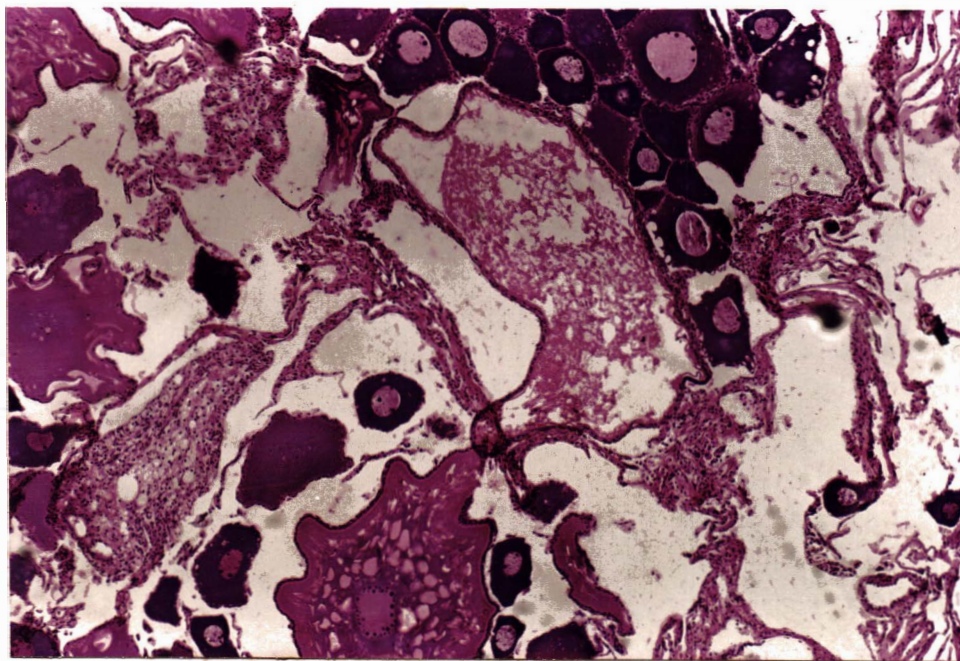


Plate No.VII Showing oocytes of different growing state of resorption or atretics. HE x 33

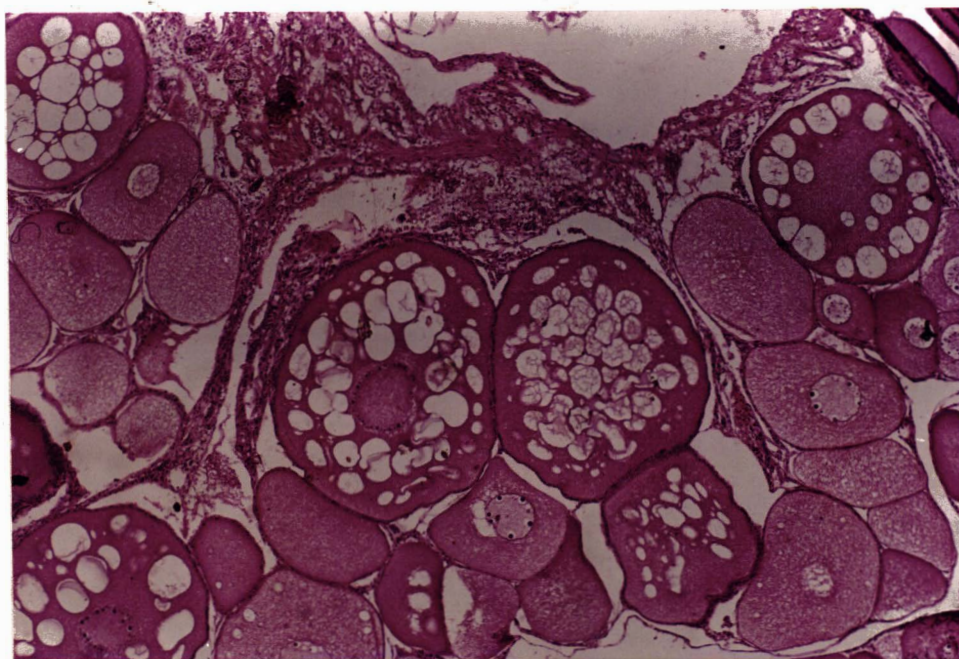


Plate No.VIII Section showing the different growing (I, II, III) oocytes. HE x 33

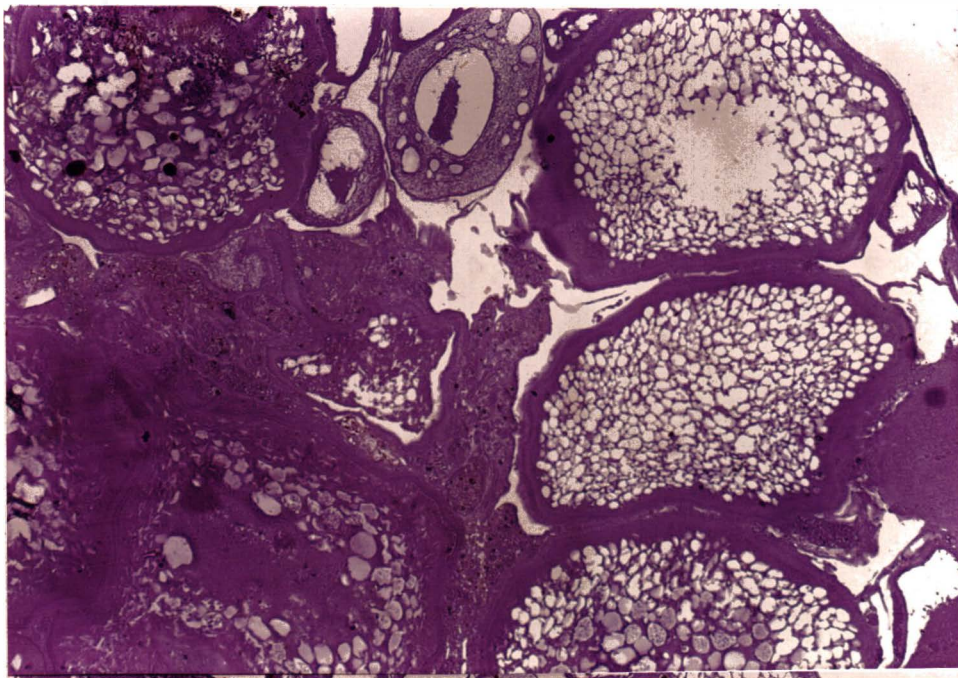


Plate No.IX Section showing the different growing (IV) oocytes.
HE x 33

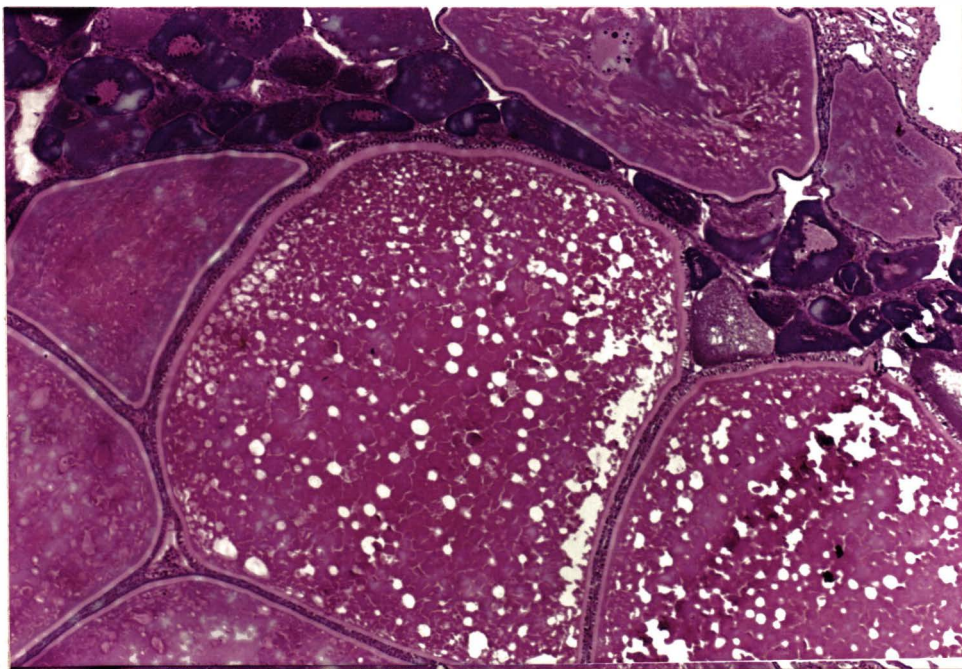


Plate No.X Section showing the different growing (V, VI) oocytes.
HE x 33

4.3 SEASONAL CHANGES OF OVARY IN *N. NOTOPTERUS* (PALLAS)

Month wise variations in the ovary of *N. notopterus* was studied (Table 10 Fig. 4).

4.3.1 January

During this month stage I-III and VI stage of ovary were recorded. The colour of the ovary varied from grey-whitish, pink and pale yellowish. The blood vascularisation is not well developed. Some oocytes are prominent. Histologically immature and maturing oocytes are prominently present. The relative weight of the ovary was 0.47% (Table 11).

4.3.2 February

Three stages of ovary from stage I to III were recorded. The colour of the ovary varied from grey-whitish, pink-white to pinkish. In the stage I and II, blood vascularisation is not distinct, while stage III moderately intense vascularisation noticed. Immature oocytes are prominent in the ovary, while very few maturing oocytes are observed. The relative weight of ovary was 0.397% i.e. 0.074% less than that of previous month (Table 12)

4.3.3 March

Two stages of ovary i.e., V-VI were recorded. The colour of ovary varied from deep yellowish to pale yellowish. The blood vascularisation very intense and mature oocytes were very prominent externally. Histologically, the ovary contained mature and oocyte in different stages of resorption. The relative weight of ovary was 3.790% i.e. 3.393% more than that of the last month (Table 13).

4.3.4 April

Two stages of ovary i.e V-VI were recorded, during the month, The colour of the ovary varied from deep yellowish to pale yellowish. The blood vascularisation well developed. The mature oocytes were prominent externally. Histologically the ovary consists of mature and some oocytes of resorption states. The relative weight of ovary was 2.206% i.e. 1.455% less than that of March (Table 14).

4.3.5 May

Stage V-VI of ovary observed during this month. The colour of ovary were similar to that of the previous month like April and March. Blood vascularisation well intense Complete mature oocytes noticed distinctly from outside of the ovary. Histologically the ovary contained fully mature oocytes and oocytes in different states of resorption. the relative weight of the ovary was 2.206% i.e. 1.455% less than that of the month of April (Table 15).

4.3.6 June

Two stages V and VI were recorded. The colour of the ovary varied from deep yellowish to pale yellowish. The vascularisation was like that of previous month. The oocytes were more distinct. Atretic oocytes are seen more in quantity. Histologically the ovary contained mature oocytes and oocytes at different states of resorption. The relative weight of ovary was 3.753% i.e. 1.55% more than that of previous month (Table 16).

4.3.7 July

Two stages of ovary i.e V and VI were noticed and recorded. The colour of the ovary varied from deep yellowish to pale yellowish. Well developed blood vascularisation. Mature oocytes were prominent and observed clearly from

the outside of the ovary. Histologically, ovary contained fully mature and oocytes at different states of resorption. The relative weight of ovary was 5.79% i.e., a significant gain of 2.039% over that of the last month (Table 17).

4.3.8 August

Five stages of ovary, from stage II to VI were recorded. The colour of the ovary varied from pinkish white, pinkish, pinkish/yellowish, deep yellowish and pale yellowish. The blood vascularisation increased gradually and became well intense in V stage of ovary and reduced to a great extent in spent stage i.e. VI stage. The relative weight of ovary was 0.345% i.e. 5.445% less than the month of July. Histologically, ovary contained immature, maturing, mature oocytes and oocytes at different states of resorption (Table 18).

4.3.9 September

The stage II-IV and VI were recorded. The colour of ovary varied from pinkish white, pinkish, pinkish yellowish and pale yellowish. Blood vascularisation increased progressively. Histologically, immature, maturing and oocytes at different states of resorption were observed. The relative weight of ovary was 0.595% i.e. 0.25% more than that of the previous month (Table 19).

4.3.10 October

In the month of October three stages, I, III and VI were recorded. The colour of ovary varied from grey whitish, pinkish and pale yellowish. the blood vascularisation is not well developed. The ovary in this month very often undergoes resorption. Histologically the ovary contained immature, few maturing and oocytes at different states of resorption. The relative weight of ovary was 0.366% i.e. 0.229% less than that of the September month (Table 20).

4.3.11 November

The stages of ovary I-III and VI were recorded. The colour of ovary varied from grey whitish, pinkish white, pinkish to pale yellowish. Blood vascularisation not well marked. Histologically, ovary contained immature, maturing and oocytes at different states of resorption. The relative weight of the ovary was 0.298% i.e. 0.068% less than that of previous month (Table 21).

4.3.12 December

The stages of ovary I-III and VI were recorded. The colour of the ovary varied from grey whitish, pinkish white, pinkish and pale yellowish. In this month blood vascularisation is less. Comparison to immature oocyte, maturing oocytes are more in numbers. Histologically, ovary contained immature, maturing and few atretic oocytes. The relative weight of the ovary was 0.45% i.e. 0.156% more than the month of November (Table 22).

A study of the ovary during the one year cycle (i.e. Jan-Dec showed that the ovary goes through the following phases.

- 1) Quiescent-cum-preparatory phase (September to November).
- 2) Preparatory-cum-active phase (December to February).
3. Active-cum-quiescent phase (March to August).

4.3.13 Quiescent-cum-preparatory phase

Quiescent-cum-preparatory phase extended from September to the month of November. During this phase, I, II, III, and VI ovarian stages were found (Table 23). The oocytes recorded during this period were in immature, maturing and oocytes at different states of resorption. The relative weight of ovary during this phase was 0.447.

4.3.14 Preparatory-cum-active phase

Once the quiescent-cum-preparatory phase is over, the ovary entered into the next step for its development. This phase extends from December to the month of February. During this period, I, II, III and VI ovarian stages are noticed (Table 23). The relative weight of ovary during this phase was 0.449% which is higher than that of previous phase.

4.3.15 Active phase

This phase extended from March to August. During the phase, V and VI ovarian stages were found except in the month of August, where different stages of ovary (i.e II-VI) were observed (Table 23). The relative weight of ovary during this phase was found to be 2.971 indicating an increase of 2.522 weight than that of the preparatory-cum active phase. The oocytes were mature although few immature and maturing oocytes were not uncommon. Even some oocytes at different states of resorption were also found.

Table 10: Percentage of different stages of ovary in *N. notopterus* (Pallas) during 1993-94

Stage	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
I		14.28	28.57	10.00	14.28	50.0						
II	18.18		14.28	30.00	57.14	25.0						23.08
III	27.27	28.57	14.28	40.00	14.28	25.0						23.08
IV	36.36											15.38
V							83.33	66.66	66.66	46.15	71.43	23.08
VI	18.18	57.14	42.86	20.0	14.28		16.67	33.33	33.33	53.85	28.57	15.38

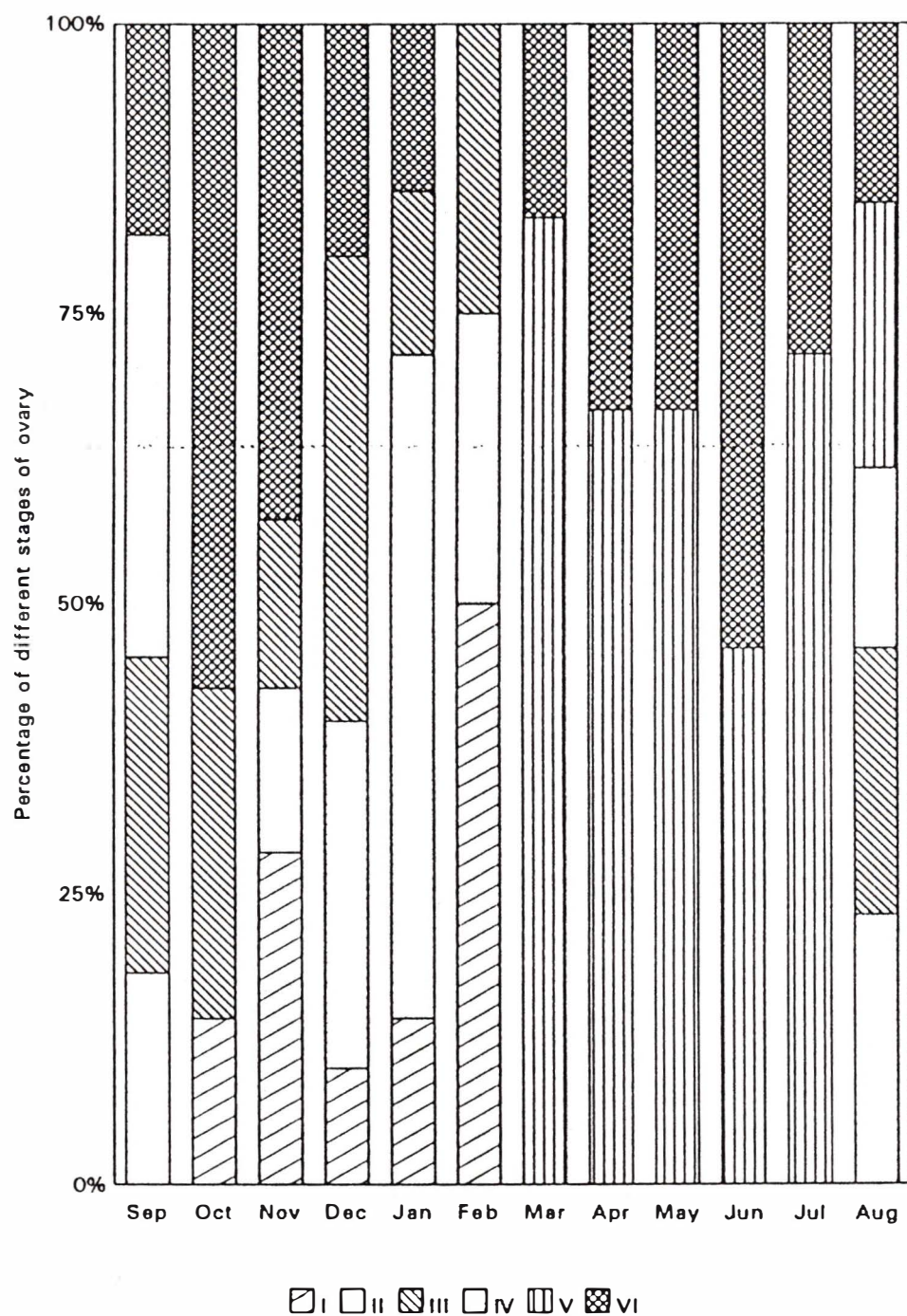


Fig. 4. Percentage of different stages of ovary in *N. notopterus* (Pallas) during 1993-94.

Table 11: Relative weight of ovary in *N. notopterus* (Pallas) in the month of January

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	50.0	0.2093	0.419
2	35.0	0.1768	0.505
3	3.0	0.0787	0.262
4	115.0	0.1241	0.108
5	115.0	0.2216	0.193
6	80.0	0.9049	1.131
7	110.0	0.7444	0.677
Total	535.00	2.459	3.295
Mean	76.429	0.351	0.471
	± 35.225	± 306	

Table 12: Relative weight of ovary in *N. notopterus* (Pallas) in the month of February

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	85.0	0.3897	0.458
2	75.0	0.4285	0.571
3	80.0	0.4063	0.508
4	24.0	0.0125	0.052
Total	264.00	1.237	1.590
Mean	66.00	0.309	0.397
	± 24.505	± 0.172	

Table 13: Relative weight of ovary in *N. notopterus* (Pallas) in the month of March

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	130.0	10.6608	8.201
2	175.0	10.6449	6.083
3	100.0	3.3420	3.342
4	90.0	0.7181	0.798
5	182.0	7.5294	4.137
6	300.0	16.5167	0.182
Total	977.00	49.411	22.743
Mean	162.83	8.235	3.790
	± 70.309	± 5.184	

Table 14: Relative weight of ovary in *N. notopterus* (Pallas) in the month of April

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	105.0	4.8335	4.603
2	130.0	4.0746	3.134
3	84.0	4.4388	5.284
4	125.0	12.7654	10.212
5	45.0	0.2631	0.585
6	50.0	0.4456	0.891
7	100.0	0.8979	0.898
8	100.0	2.8133	2.813
9	80.0	3.6231	4.529
Total	819.00	34.155	32.950
Mean	91.00	3.7957	3.661
	± 27.892	± 3.576	

Table 15: Relative weight of ovary in *N. notopterus* (Pallas) in the month of May

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	125.0	1.1482	0.919
2	52.0	0.7377	1.419
3	130.0	6.3506	3.528
4	210.0	3.1599	1.505
5	150.0	2.8153	1.877
6	100.0	2.4250	1.347
7	110.0	3.6992	3.363
8	105.0	2.2640	2.156
9	130.0	4.8609	3.739
Total	1112.00	27.460	19.852
Mean	123.55	3.051	2.206
	± 40.083	± 1.654	

Table 16: Relative weight of ovary in *N. notopterus* (Pallas) in the month of June

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	75.0	0.5838	0.773
2	75.0	2.4166	3.222
3	60.0	0.5663	0.944
4	65.0	2.2354	3.439
5	50.0	0.3349	0.670
6	50.0	0.2320	0.464
7	120.0	4.5605	3.800
8	105.0	5.870	5.91
9	95.0	5.7942	6.099
10	105.0	8.5446	8.138
11	70.0	3.3898	4.843
12	75.0	1.5670	2.089
13	45.0	3.9189	8.709
Total	990.0	40.015	48.786
Mean	76.153	3.078	3.753
	± 22.715	± 2.475	

Table 17: Relative weight of ovary in *N. notopterus* (Pallas) in the month of July

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	70.0	5.5601	7.943
2	75.0	3.4021	4.536
3	70.0	5.2104	7.443
4	60.0	4.4640	7.443
5	55.0	0.7542	1.371
6	70.0	3.0443	4.349
7	125.0	0.3228	7.458
Total	525.0	22.758	40.541
Mean	75.00	3.251	5.792
	± 21.380	± 1.909	

Table 18: Relative weight of ovary in *N. notopterus* (Pallas) in the month of August

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	80.0	0.1730	0.216
2	50.0	0.0392	0.078
3	80.0	0.1091	0.136
4	100.0	0.3286	0.329
5	160.0	0.3486	0.218
6	80.0	0.7863	0.983
7	70.0	0.1554	0.222
8	50.0	0.0688	0.138
9	68.0	0.1111	0.163
10	65.0	0.4642	0.714
11	70.0	0.3746	0.535
12	35.0	0.1168	0.333
13	70.0	0.2917	0.417
Total	978.00	3.367	4.482
Mean	75.23	0.259	0.345
	± 29.086	± 0.199	

Table 19: Relative weight of ovary in *N. notopterus* (Pallas) in the month of September

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	84.0	0.685	0.796
2	100.0	0.3216	0.322
3	66.0	0.8841	1.340
4	85.0	0.3001	0.353
5	85.0	0.7075	0.832
6	112.0	0.4547	0.406
7	60.0	0.7173	1.196
8	110.0	0.3559	0.324
9	60.0	0.1959	0.327
10	40.0	0.0944	0.236
11	85.0	0.3489	0.410
Total	887.0	5.049	6.542
Mean	80.64	0.459	0.595
	± 21.33	± 0.238	

Table 20: Relative weight of ovary in *N. notopterus* (Pallas) in the month of October

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	65.0	0.2547	0.392
2	30.0	0.1534	0.511
3	110.0	0.3913	0.356
4	100.0	0.3066	0.307
5	42.0	0.0839	0.200
6	167.0	0.5916	0.354
7	115.0	0.5068	0.441
Total	629.0	2.288	2.561
Mean	89.86	0.327	0.366
	± 44.05	± 0.169	

Table 21: Relative weight of ovary in *N. notopterus* (Pallas) in the month of November

No. of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	80.0	0.7627	0.95.3
2	20.0	0.0163	0.082
3	65.0	0.255.3	0.393
4	20.0	0.0113	0.057
5	20.0	0.0607	0.304
6	30.0	0.0130	0.043
7	25.0	0.0636	0.254
Total	260.0	1.180	2.086
Mean	37.143	0.169	0.298
	± 22.968	± 0.255	

Table 22: Relative weight of ovary in *N. notopterus* (Pallas) in the month of December

No.of observations	Weight of fish (g)	Weight of ovary (g)	Relative weight of ovary (%)
1	230.0	0.6353	0.277
2	120.0	0.4737	0.395
3	120.0	0.7348	0.612
4	150.0	0.5987	0.399
5	115.0	0.6330	0.550
6	100.0	0.4942	0.494
7	95.0	0.4261	0.449
8	90.0	0.4001	0.445
9	100.0	0.4072	0.407
10	85.0	0.4393	0.517
Total	1205.00	5.242	4.544
Mean	120.50	0.524	0.454
	± 40.709	± 0.111	

Table 23: Reproductive cycle of female *N. notopterus* (Pallas) for the year 1993-94

Month of the year	Percentage of spent ovary stage(VI)	Other stages of ovary					Phase of growth	Phases
		I	II	III	IV	V		
Dec	20.0	10.0	30.0	40.0	0	0	Previtellogenic	Preparatory cum active phase
Jan	14.28	14.28	57.14	14.28	9	-		
Feb	-	50.00	28.00	25.00	-	-		
Mar	16.67	-	-	-	-	83.33		Active
Apr	33.33	-	-	-	-	66.66	Vitellogenic	
May	33.33	-	-	-	-	66.66		
Jun	53.85	-	-	-	-	46.15		
Jul	28.57	-	-	-	-	71.43		
Aug	15.38	-	23.08	23.08	15.38	23.0		
Sept	18.18	-	18.18	27.27	36.36	-		
Oct	57.14	14.28	-	28.57	-	-	Vitellogenic	Quiescent cum preparatory
Nov	42.36	28.57	14.28	14.28	-	-		

4.4 OVULAR ATRESIA

Atretic follicles are those when the ova failed to attain maturity, or failed to spawn, underwent resorption states. The process of ovular atresia was conspicuous during prespawning and postspawning period of the fish.

Young oocytes of stage I-III of the *Notopterus notopterus* have hardly been observed undergoing atretic processes. Oocytes of stage IV-VII while undergo atretic exhibits marked disorganisation of their ooplasmic and nuclear components (Plate XII). Follicular cells become hyperactive and at places form villi-like structure. The liquefaction of yolk globules is observed first in the peripheral zone and than in the central ooplasm. Zona pellucida undergoes high folding and distinctly separated from the ooplasm due to liquefaction. Follicular cells undergoes hypertrophy during the process of oocyte resorption (Plate XIII).

The last stage of atresia is characterised by the complete resorption and disappearance of the ooplasm and its yolk contents.

4.5 HISTOCHEMISTRY OF OVARY

During the oogenesis, the immature oocytes undergo histochemical changes involving accumulation of materials which can be used during the embryogenesis. The present study revealed that the following materials were accumulated during oogenesis.

4.5.1 Polysaccharides (Plate XIV-XVI, Table 24)

In the present study different stages of oocytes from I to VII are grouped into three states. They are immature, maturing and mature oocytes.

4.5.1.1 IMMATURE OOCYTES

Except nucleus and nucleoli the immature oocytes were completely negative for PAS. Nucleus and nucleoli are weakly stained with PAS.

4.5.1.2 MATURING OOCYTES

The maturing oocytes consists of stage III, IV and V in the present study. In stage III oocytes initially PAS positive yolk globules were restricted to the periphery of the cytoplasm which has been designated as CY1 (Verma *et al.*, 1986) and also called as intravesicular yolk (Gopal Dutt and Govindan, 1969). These yolk globules increase in their size and in numbers, spreading in a centripetal manner in subsequent maturing stages. The nucleoli were stained very weakly and in some cases negatively. The follicular cells were found to be PAS negative (Plate XIV-XV)

4.5.1.3 MATURE OOCYTES

In mature oocytes i.e., (VI and VII) the yolk globules at the cortical regions showed weak PAS positive reaction which has been designated as CY₂ (Verma *et al.*, 1986). The other yolk globules commonly known as extravesicular yolk (Gopal Dutt and Govindan, 1969) being PAS negative. The follicular layer also PAS negative. The vacuolar yolk globules were also positively stained (Plate XVI).

Table 24: Localisation of Carbohydrate (polysaccharide) in different stages of oocytes in *N. notopterus* (Pallas)

Name of ovarian components	Immature		Maturing			Mature	
	I	II	III	IV	V	VI	VII
Cytoplasm	-	-	-	-	-	-	-
Intravesicular yolk globules			+++	++	++	+	+
Extravesicular yolk globules				+++	+	-	-
Nucleus (Chromatin fibre)	+	+	-	-	-	-	-
Nucleoli	+	+	-	-	-	-	
Follicular layer	-	-	-	-	-	-	-

- Absent
 + Weak
 ++ Medium
 +++ Strong

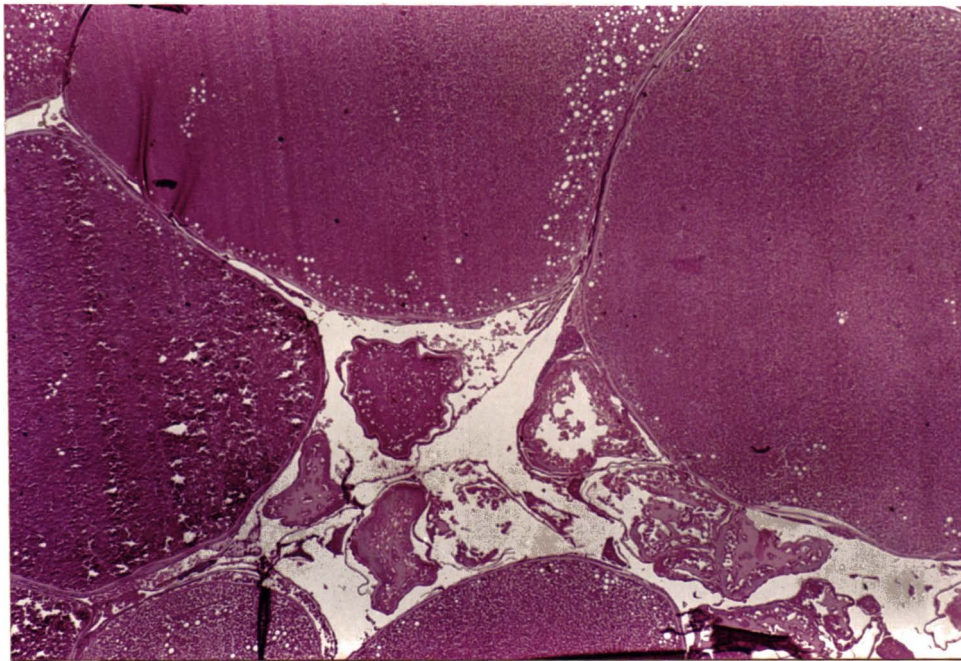


Plate No.XI Section showing the different growing (VI, VII) oocytes.
HE x 13.2

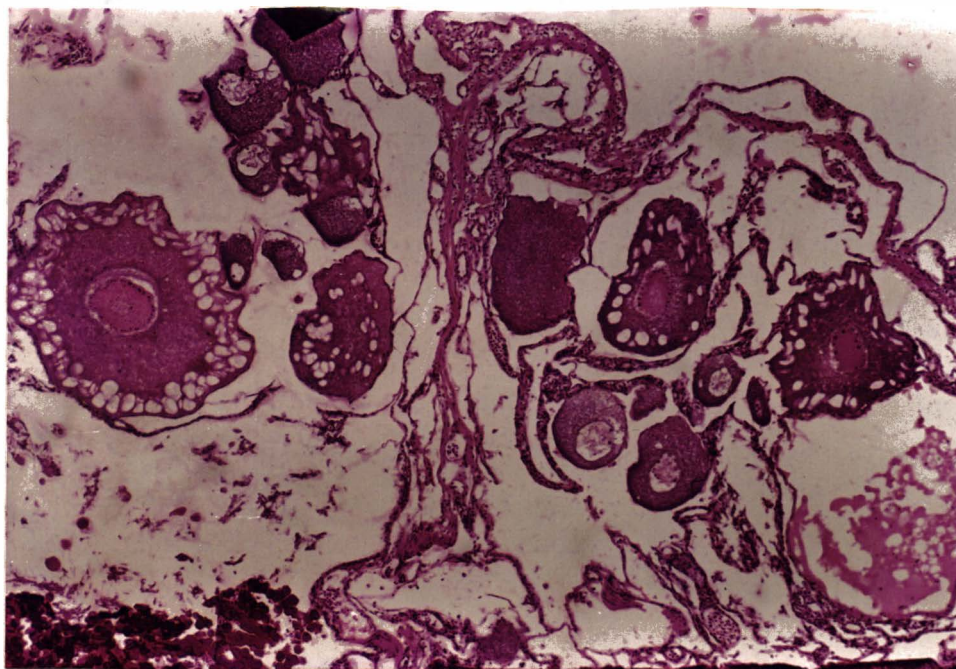


Plate No.XII Section showing the histological changes during resorption
of oocytes. HE x 33

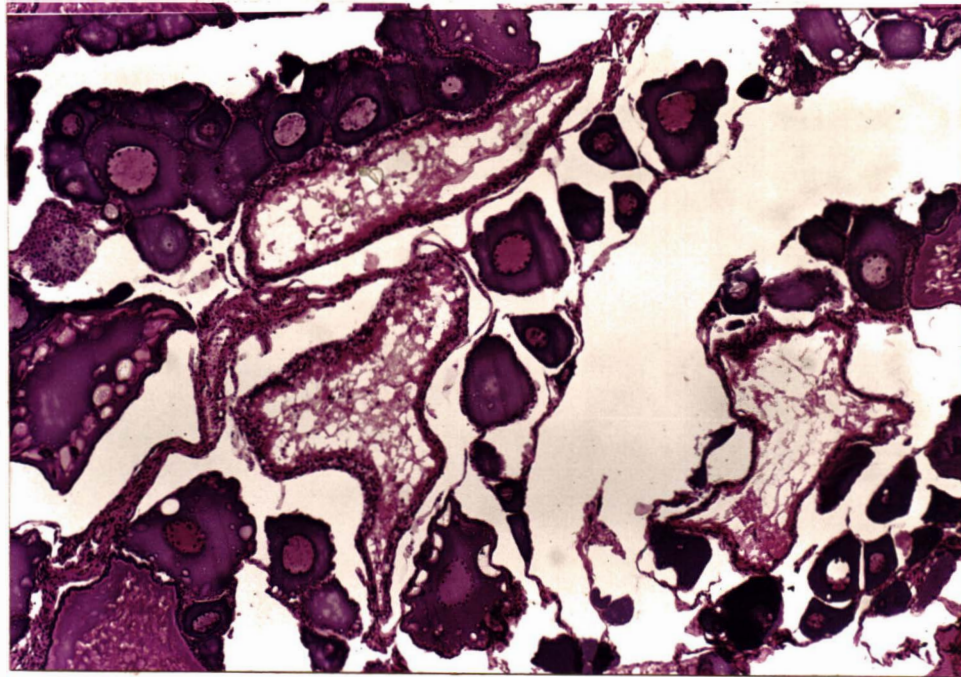


Plate No.XIII Section showing the histological changes during ovular atresia. HE x 33

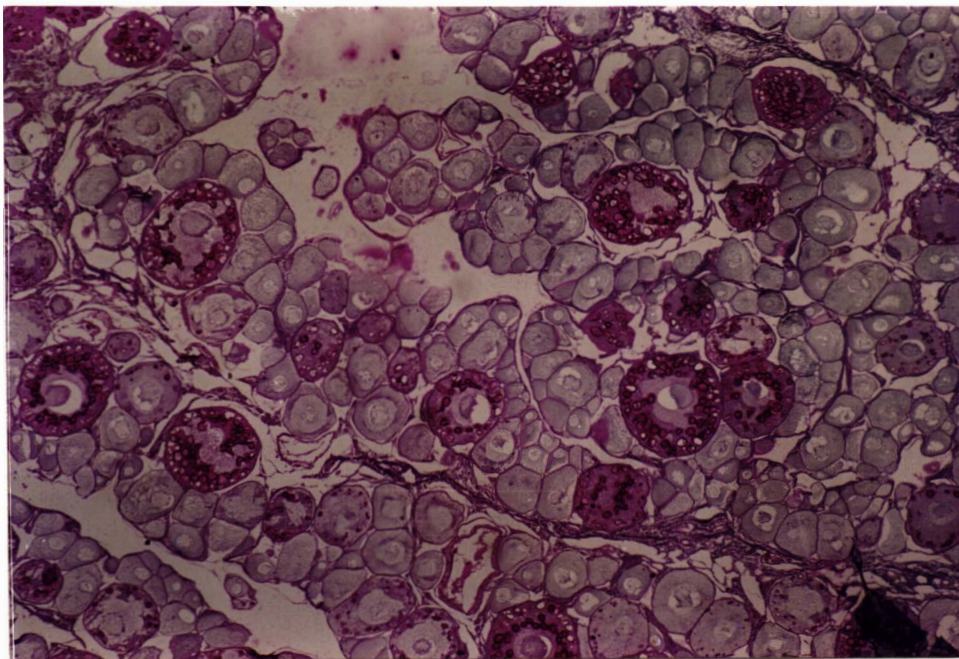


Plate No.XIV Section showing Polysaccharide localisation in maturing stage-III oocytes. PAS x 33

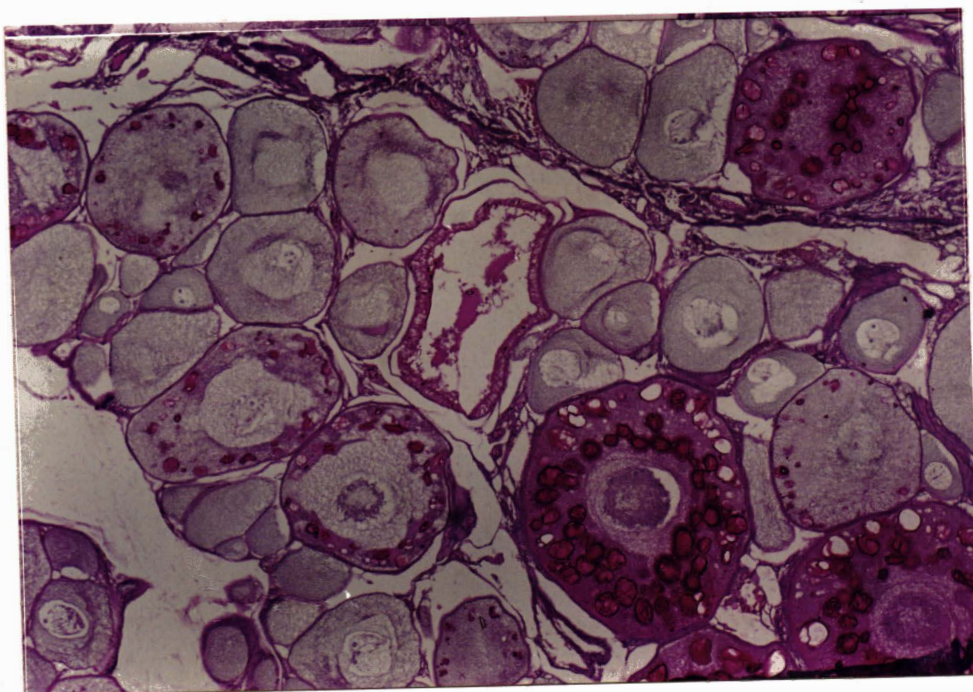


Plate No.XV Section showing Polysaccharide localisation in maturing stage IV, V oocytes. PAS x 33

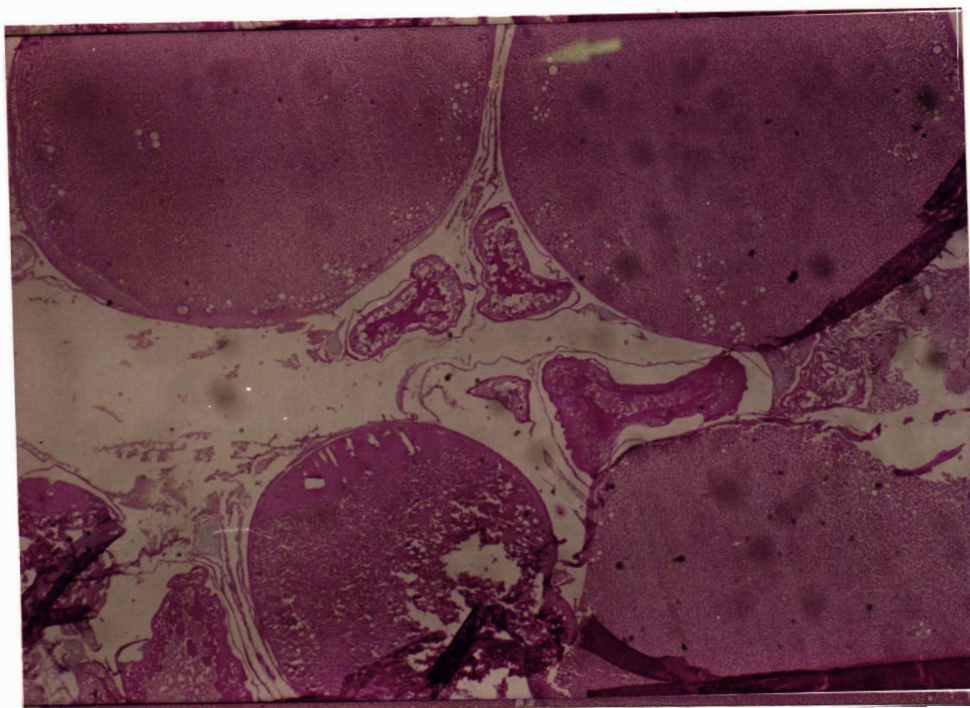


Plate No.XVI Section showing Polysaccharide localisation in mature stage-V, VI, VII oocytes. PAS x 33

4.5.2 Lipids (Plate XVII-XVIII, Table 25)

Lipid was present in the germinal epithelium. The blood vessels which were found in the germinal epithelium were positive for lipid. The ovigerous lamellae had traces of lipid. In connective tissue, traces of choline type lipid was present.

4.5.2.1 IMMATURE OOCYTE

In immature oocytes (i.e., I and II), the cytoplasm took faintly lipid stain. The nucleus and nucleoli were found to be negative for lipid. The follicular layer of immature oocytes were weakly stained (Plate XVII).

4.5.2.2 MATURING OOCYTES

In maturing oocytes (i.e., III, IV and V), the extravesicular yolk globules were positively stained and intravesicular yolk globules in stage V indicated the presence of lipid. In these stages, the lipid were present in the yolk globules but not in the yolk vacuoles. Follicular layer of maturing oocytes also stained (Plate XVII).

4.5.2.3 MATURE OOCYTES

In the mature oocytes (i.e., VI and VII), the cytoplasm were stained moderately. All the extravesicular yolk globules were stained positively with lipid stain. The nucleoli were positive for lipid. The follicular layer also took the stain faintly (Plate XVIII).

Table 25: Localisation of Lipid in different stages of oocyte in *N. notopterus* (Pallas)

Name of ovarian components	Immature		Maturing			Mature	
	I	II	III	IV	V	VI	VII
Cytoplasm	+	+				++	++
Intravesicular yolk globules							
Extravesicular yolk globules			++	++	++	++	++
Nucleus (Chromatin fibre)					+	+	
Nucleoli	-	-				+	+
Follicular layer	+	+	+	+	+	+	+

- Absent

+ Weak

++ Medium

+++ Strong

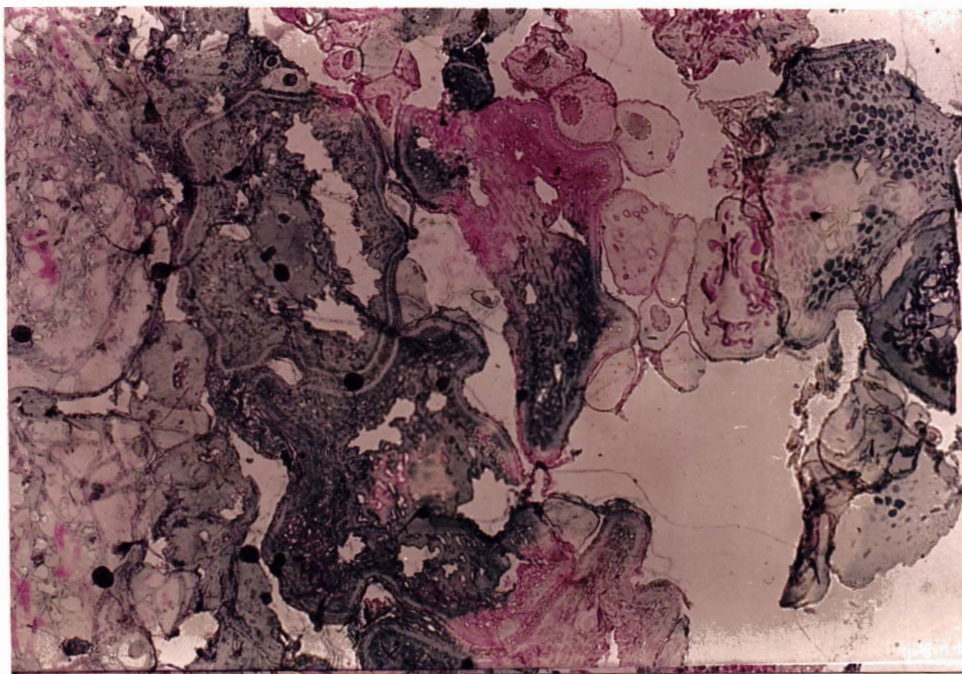


Plate No.XVII Section showing lipid localisation immature stage- I,II and maturing stage III,IV oocytes. Phosphomolybdic x 33

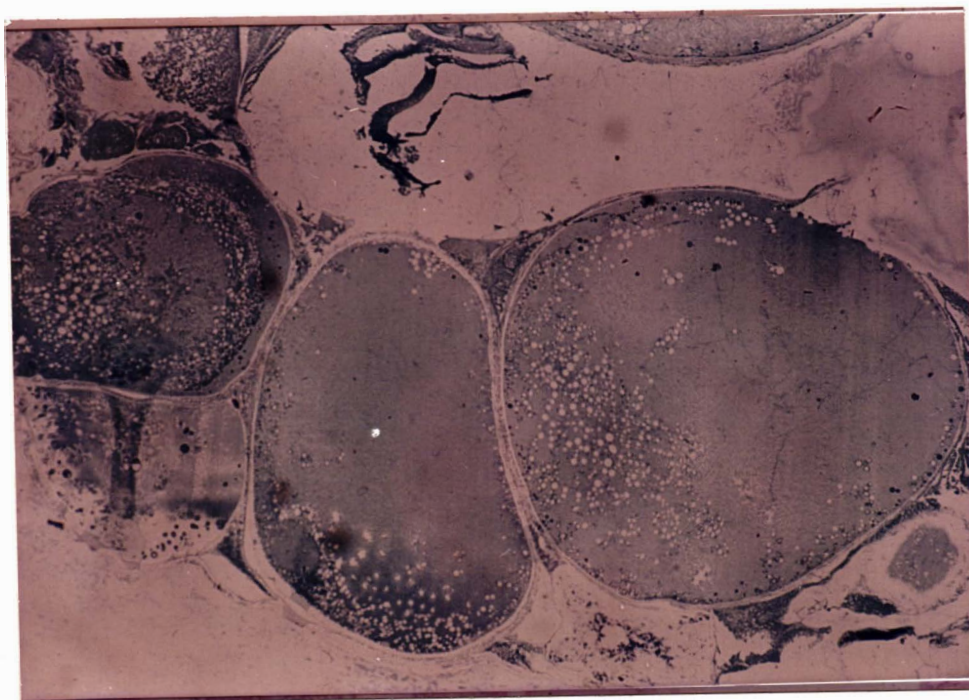


Plate No.XVIII Section showing lipid localisation in mature stage- V,VI,VII oocytes. Phosphomolybdic x 13.2

4.5.3. Ribonucleic acid (Plate XIX, Table 26)

4.5.3.1 IMMATURE OOCYTES

In different stages of immature oocytes the cytoplasm took faint red stain indicating the presence of ribonucleic acid (RNA). The yolk nucleus was more intense indicating the high distribution of RNA. The nucleoli which were at the periphery or in the meshwork of nuclear chromatin, were negative for RNA. The follicular layer along with cortical cytoplasm of oocytes were intensely stained indicating relatively high concentration than that of cytoplasm.

4.5.3.2 MATURING OOCYTES

The cortical cytoplasm of oocytes showed relatively deep stain than that of the rest part of the cytoplasm indicating the presence of RNA. Yolk vacuoles were negative. Nucleoli and follicular layer were also stained.

4.5.3.2 MATURE OOCYTES

In mature oocytes, the cytoplasm in between yolk globule was positively stained. The cortex stained lightly. The yolk globules both intra and extra vesicular were negative indicating the absence of RNA. In mature oocyte, the intensity of staining decreased in the follicular layer.

Table 26: Localisation of Ribonucleic acid in different stages of oocytes in *N. notopterus* (Pallas)

Name of ovarian components	Immature		Maturing			Mature	
	I	II	III	IV	V	VI	VII
Cytoplasm	+	+	+	+	+	+	+
Intravesicular yolk globules			-	-	-	-	-
Extravesicular yolk globules	0	0	-	-	-	-	-
Yolk nucleus	-	+++	-	-	-	-	-
Nucleus (Chromatin fibre)	-	-	-	-	-	-	-
Nucleoli	-	-	+	+	+	-	-
Follicular layer	-	++	++	++	++	+	+

- Absent

+ Weak

++ Medium

+++ Strong

4.5.4 Protein (Plate XX-XXII, Table 27)

4.5.4.1 IMMATURE OOCYTES

In immature oocytes (i.e. stage I and II) the cytoplasm was intense magenta colour indicating the presence of protein. The yolk nucleus was positive. The nuclear membrane and nuclear chromatin fibres were comparatively less stained than the cytoplasm of the oocytes. The nucleoli took intense stain indicating relatively high protein distribution in comparison to nuclear membrane and nuclear chromatin fibres. The follicular cells surrounding the oocytes were also stained. The follicular layer of immature oocytes were stained moderately (Plate XX).

4.5.4.2 MATURING OOCYTES

In the maturing oocytes (i.e. stage III, IV and V) cytoplasm were stained moderately. The nuclear membrane and chromatin were also faintly stained with Ninhydrin Schiff in III and IV stages of oocytes. Intravesicular yolk globules does not take much stain, while extravesicular yolk globules took slight stain. Nucleoli continued to be stained intensely. Follicular layer of the maturing oocytes were more intensely stained than that of the immature oocytes, indicating an increase in the concentration of protein (Plate XXI).

4.5.4.3 MATURE OOCYTES

In the mature oocytes of the stage VI and VII, the cytoplasm were stained. Intravesicular yolk globules stained indicating the accumulation of protein as vitellogenesis progressed. The extravesicular yolk also stained intensely with the growth of the oocytes. A centripetal migration of extravesicular yolk globules and centrifugal migration of intravesicular yolk globules were observed as a result of which they became uniformly distributed in the cytoplasm. The follicular layer of oocyte was stained intensely (Plate XXII).

Table 27: Localisation of Protein in different stages of oocytes in *N. notopterus* (Pallas)

Name of ovarian components	Immature		Maturing			Mature	
	I	II	III	IV	V	VI	VII
Cytoplasm	++	++	++	++	++	++	++
Intravesicular yolk globules						+++	+++
Extravesicular yolk globules				+	+	++	++
Yolk nucleus	+	+	+	+	-	-	-
Nucleus (Chromatin fibre)	+	+	+	+	+	-	-
Nucleoli	++	++	++	++	++	+	+
Follicular layer	++	++	++	+++	+++	+++	+++

- Absent

+ Weak

++ Medium

+++ Strong

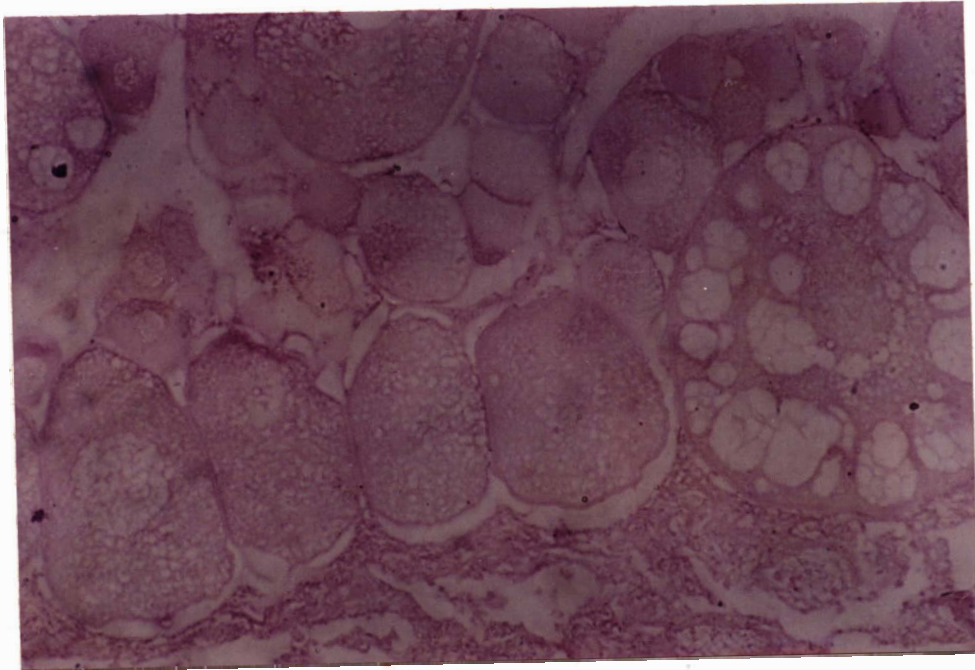


Plate No.XIX Section showing RNA localisation in different oocytes.
Methylgreen pyronin x 66

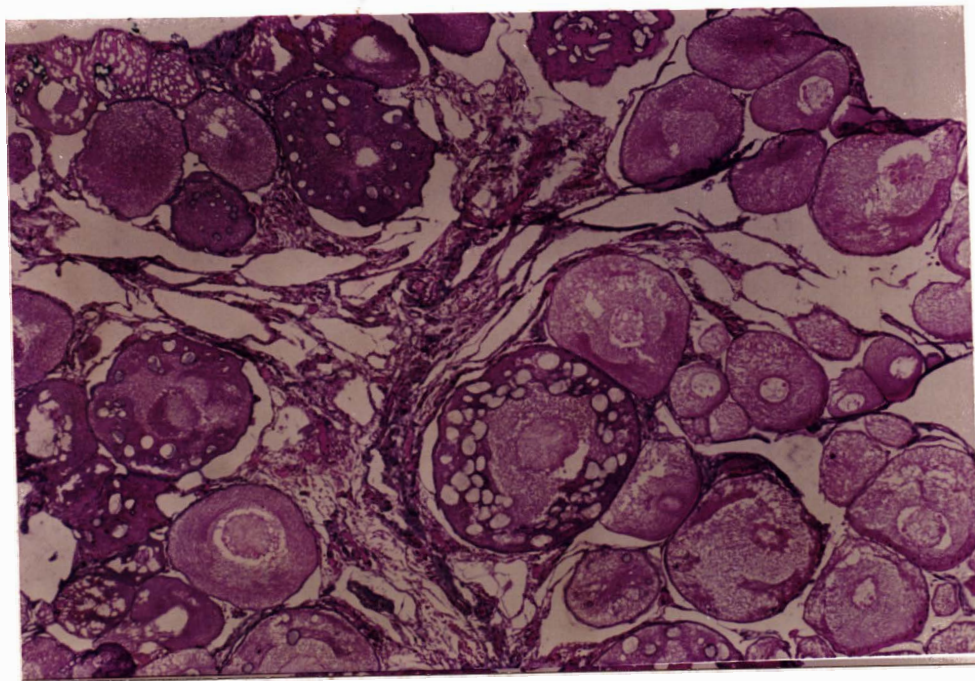


Plate No.XX Section showing protein localisation in immature stage-I,II
oocytes. Ninhydrin Schiffs x 66

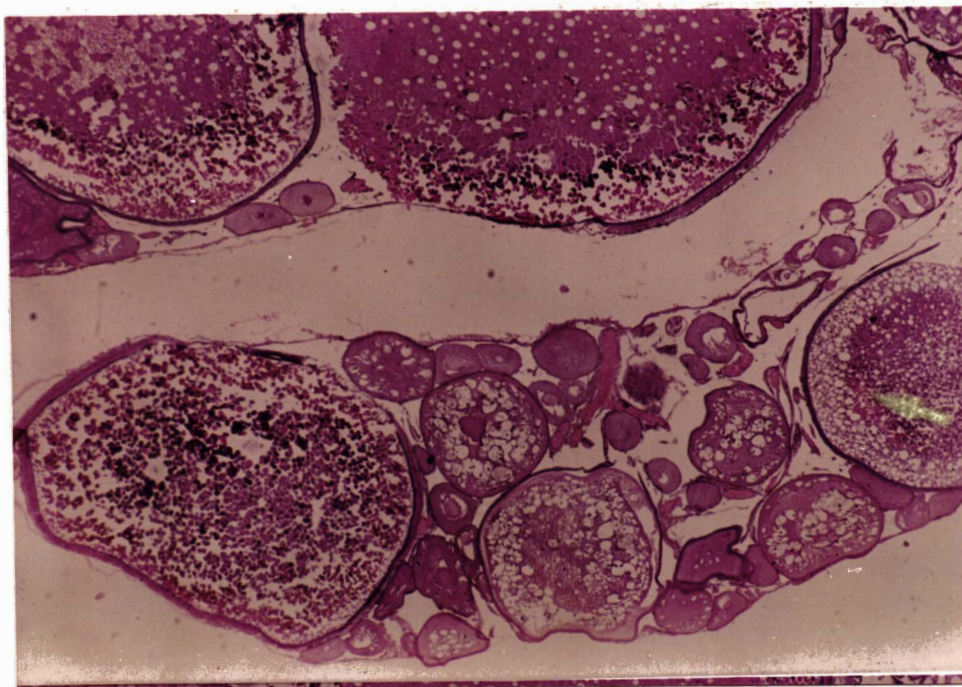


Plate No.XXI Section showing protein localisation in maturing (III,IV,V) oocytes. Ninhydrin Schiff's x 33

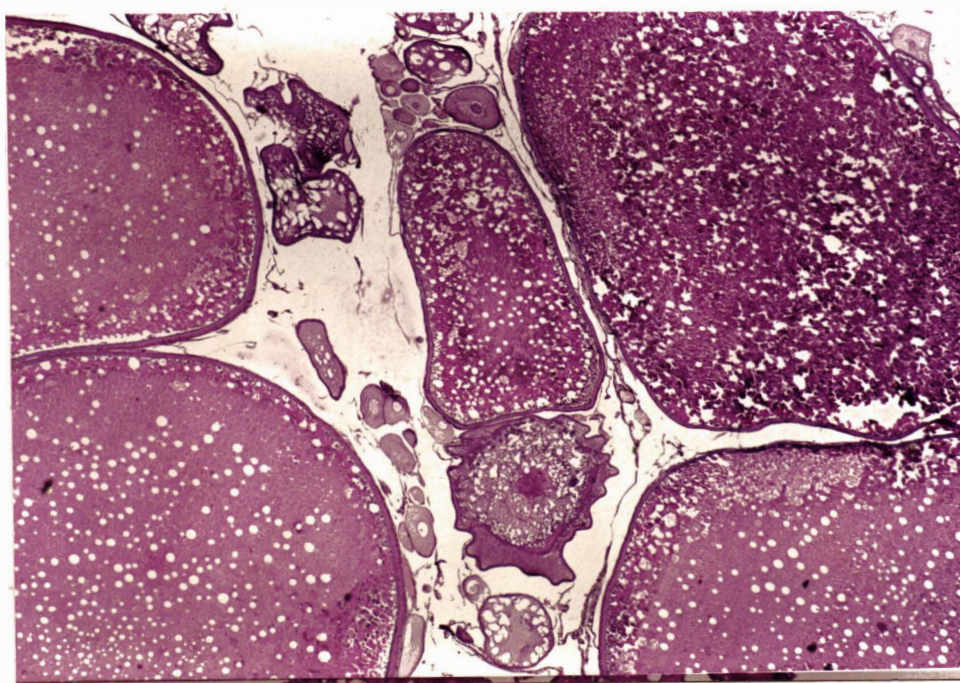


Plate No.XXII Section showing protein localisation in mature (VI,VII) oocytes. Ninhydrin Schiff's x 13.2

DISCUSSION

5.1 REPRODUCTIVE CYCLE

All vertebrates show some degree of periodicity in their reproductive physiology and there is evidence that light and temperature are the external stimuli, most commonly involved in the regulations of reproductive cycle (Dodd, 1972; Akela, 1987; Romanenko, 1991; Asahina and Hanyu, 1991). In the Indian catfish *H. fossilis*, both photoperiod and temperature played an important role in gonadal maturation but temperature found to be comparatively more important factor (Vasal and Sundararaj, 1976; Sundararaj and Vasal, 1976). Young *et al.* (1989) reported that oocyte maturation in Chinese catfish, *Clarias fuscus* was associated principally with temperature than photoperiod. It is generally accepted that these factors are coordinated by the hypothalamus which in turn controls the gonadotropin activity of the hypophysis.

5.2 MORPHOLOGY OF OVARY

In the present study seasonal changes occurred in the ovarian morphology of *Notopterus notopterus* in the populations around Bhubaneswar area. Six morphological stages of ovary were observed. The stage I and II are immature which are synonymous to that of immature virgin, maturing virgin and recovered spent of Bhatt (1968). In the present study the stage I and II are corresponding to that of the studies in *C. punctata* (Rath and Hejmadi, 1984). In contrast, Belsare (1962) identified stage I and II as resting stage and maturing stage in the same species respectively, in *M. Seenghala* (Sathyanesan, 1962) reported stage I as resting condition and stage II as slightly enlarged condition.

In the present experiment the stage III and IV as maturing which are equivalent to that of ripening and ripe stages of Bhatt (1968). However, in *C. punctata* (Rath and Hejmadi, 1984) has identified stage III and IV as early maturing and late maturing phase, while Belsare (1962) reported these as ovaries advanced towards maturity and mature ovaries respectively. In *M. Seenghala*, Sathyanesan (1962) recorded stage III and IV as greatly enlarged condition and spawning and partly spent condition respectively. The present study revealed the stage V and VI as mature and spent phase. However, Bhatt (1968) reported stage V as spent stage. As in the present study in *N. notopterus* similar observations were, made in *C. punctata* (Rath and Hejmadi, 1984). In contrast, Belsare (1962) identified V stage as ripe ovary and VI stage as spent in *C. punctata*. In *M. Seenghala*, Sathyanesan (1962) observed stage V as completely spent condition. Hence, it is very much evident that the morphological staging of ovary in various teleosts varies greatly by different workers. Hence, the morphological staging of ovary is purely arbitrary. Similar reports are also obtained in carps in different countries, such as five morphological stages admitted in India, U.S.A., Japan; six stages are admitted in China while several other countries adopted seven stages (cited Rath, 1993).

5.3 HISTOLOGY OF OVARY

Oogenesis is a process in which oocyte passes through the phases of multiplication, growth and maturation. During these process the oocyte grows as cell and accumulates nutritive reserves (yolk). Several authors have used various terminologies in classifying the oocytic stages on the basis of nuclear and cytoplasmic characteristics in various fish groups. Saksena (1976) classified ten oocytic stages in *Glossogobius giuris* as chromatin nucleolus, early perinucleolus, late perinucleolus, yolk vesicle, primary yolk, secondary yolk, tertiary yolk, prematuration, maturation and matured stage. However, Rath and Hejmadi (1987)

described nine oocytic stages as that of Saxena's classification except maturation stage in *C. punctata*. Although Belsare (1962) has given a classification of oocyte in *C. punctata*, but his classification was not clearly defined. However the classification adopted by Verma *et al.* (1986) in *N. notopterus* as stage I oocyte to stage VI oocyte. The classification adopted by Verma *et al.* (1986) as stage I oocyte which resembles with chromatin nucleolus and early perinucleolus stage, stage II corresponds with that of the late perinucleolus stage, stage III oocyte correspond similar to the yolk vesicle stage and primary yolk stage, stage IV oocyte equivalent to with that of secondary and tertiary yolk stages of Saksena (1976) in *G. giuris* and of Rath and Hejmadi (1987) in *C. punctata*. Stage V oocyte of Verma *et al.* (1986) accepted in *N. notopterus*, resembles with that of the prematuration and maturation stage of Saksena (1976) and prematuration stage of Rath and Hejmadi (1987). Stage VI oocyte which is the final stage of oocytic classification adopted by Verma *et al.* (1986) clearly coincided with that of mature stage as identified in *G. giuris* Saksena, 1976; in *C. punctata* (Rath and Hejmadi, 1987). Moreover in *A. scandens*. Gopal Dutt and Govindan (1969) classified I-VI oocytic stages. The classification on oocytic stages described in *H. fossilis* (Sundararaj and Sehgal, 1970) and in *B. luteus* (Al-Daham and Bhatti, 1979) as immature, maturing and mature ones.

However, in the present study seven oocytic stages in *N. notopterus* ranging from stage I to VII were clearly defined. The stage I oocyte in the present study is corresponding to the early chromatin nucleolus stage which is not cited by Verma *et al.* (1986). However, other stages (i.e. stage II to VII) were corresponded to the oocytic stages (I-VI) adopted by Verma *et al.* (1986) in *N. notopterus*.

Based on the cytochemical studies on the yolk bodies of the growing oocyte the present study clearly distinguished the stage I and II as immature, stage III, IV and V oocyte as maturing and stage VI and VII as mature which is similar to that of classification adopted (Sundararaj and Sehgal, 1970 and Al-Daham and Bhatti, 1979).

5.4 OVARIAN CYCLE

The seasonal changes of ovarian cycle of teleost varies from locality to locality. Belsare (1962) has reported that the spawning season of *C. punctata* varies on different geographical and agroclimatic condition of localities. In Madras where there are two monsoon seasons, this fish breeds twice in a year i.e. during January to February and again in July to August (Sunder Raj, 1916). Khan (1924) suggested a single breeding period in Punjab i.e from mid April to end of July; in Bengal. June to August (Mukherjee, 1946) and in Jammu region from May to September (Malhotra *et al.* 1978). All these periods at different agroclimatic zones coincide with the monsoon. Hence, it is apparent that the breeding season coincide, with the monsoon and vitellogenesis starts with increase in day-length principally during summer in several teleosts including *M. Seenghala* (Sathyanesan, 1962); in *C. marulius* (Guraya, 1965); in *B.luteus* (Al-Daham and Bhatti, 1979). Photoperiod manipulation at ambient temperature condition was associated with earlier oocyte maturation in *C. fuscus* but thermal effects were much more important than photoperiod. Akela(1987). Young *et al.* (1989) and Romanenko (1991) concluded that the temperature of environment water can be suitably manipulated in order to obtain favourable gonadal growth and reproduction in fish. Asahina and Hanyu (1991) reported that low temperature of winter did not seem to influence the gonadal maturation. In *M. seenghala*, Sathyanesan (1962) remarked that a positive correlation exists on gonadal maturation and spawning with that of water temperature.

In *C. gachua*, the spawning phase starts from July to September (Misra 1990), in *A. scandens* from May to July at Berhampur area (Misra and Verma, 1991) coinciding with the rainy season. Sahu (1983) reported that *N. notopterus* breeds from June to October which takes place twice in a year once during June and next during October in Berhampur area. In the present study, seasonal changes of ovarian cycle in *N. notopterus* reveals that the fish has a prolong active period from March to August in Bhubaneswar area.

Regarding the annual ovarian cycle, Sahu (1983) identified six different phases, namely resting (January to February), Maturing (March to April), mature and prespawning (May and Sept.) spawning (June to October), post spawning (July, August and November) and spent phase (December). In contrast, the present study adopted three distinct reproductive phases namely preparatory-cum-active phase (Dec-Feb.); active-cum-quiescent phase (March to Aug.) which is the actual vitellogenic period and quiescent-cum-preparatory phase (Sept. November). From this observation, it is clear that, from September to November i.e. during the onset of winter season, the oocyte in some ovary undergoes liquefaction, oogenial nest formation and subsequent formation of oocyte follicles from the germinal epithelium of the ovarian wall, indicating the quiescent-cum-preparatory phase of the ovarian cycle. From December to February in the late winter and early summer season, the ovary was found to be in stage I-III and VI correspond to the immature, maturing and spent phase. From March onwards there is increase in day length which represents the summer season, the ovary enters into the phase of vitellogenesis. The rainy season starts from mid June and continues upto August in which the ovary enters into vitellogenic and also spent oocytes were seen in some ovary representing the active breeding period of fish. Hence, the breeding period of *N. notopterus* coincide with the rainy season in

Bhubaneswar area. Similar reports were documented in *C. punctata* which breeds in the rainy season and breeding cycle passes through three distinct phases (Rath and Hejmadi 1984) in Bhubaneswar area. The present observation is in agreement with that of Rath and Hejmadi (1984). Thus in addition to temperature and photoperiod, rainfall also has a key role in the breeding of the species *N. notopterus*. The ovary of *N. notopterus* is of 'cystoarian' type because of the lumen of ovary is continuous with the oviduct which is similar to that of *C. punctata* (Belsare, 1962).

Marza (1983) has classified the rhythm of maturation of oocyte into two types, synchronism and asynchronism. Synchronism includes the total maturation of eggs, while asynchronism includes besides mature eggs, immature and maturing oocytes. Prabhu (1956) has studied the spawning periodicity of several teleosts and found variations in the spawning periods of different species. He distinguished four categories of spawning viz. spawning once in a year with a short period, spawning once in a year with longer duration, spawning twice a year and spawning through out the year. On the above basis the spawning periodicity in *G. giuris* (Saksena, 1976); and in *C. punctata* (Rath and Hejmadi, 1984) belongs to group asynchronism of Marza (1983) and second category of Prabhu (1956). In the present study *N. notopterus* belongs to group synchronism of Marza (1983) and second category of Prabhu (1956), as the fish breeds once in a year and has a long active-cum-quiescent phase that extends from mid summer (i.e. March) to rainy season (upto August).

5.5 OOCYTIC COMPONENTS

The development of oocyte in all teleosts are basically the same with slight difference in yolk compositions and yolk deposition, rapidity of growth and

surrounding membranes. In the current study morphological and histochemical observations revealed that three types of yolk and ribonucleic acid are present in the oocyte. Observations reveals a 'stage specific change' in the morphology and accumulation of yolk material. The organelles such as yolk nucleus, follicular cells showed most dramatic changes during oogenesis.

5.5.1 Yolk nucleus

Relatively, Balbiani's vitelline body has been more extensively studied in the oocyte of teleost, which were suppose to be involved in the production of yolk. Many authors have described the similar bodies as pallial substance. Based on the origin, structure, histochemistry and function of yolk nucleus, many authors (Guraya, 1986; Rath and Hejmadi, 1987; Rath and Thomas, 1991) concluded that the yolk nucleus appears in the juxtannuclear cytoplasm adjacent to the nuclear membrane in a form of spherical mass. In the present study the yolk nucleus appeared as a spherical mass in the stage II oocyte and then became diffused and migrated towards the periphery. Then the yolk nucleus ultimately disintegrates while lying in the peripheral cytoplasm of the oocyte.

5.5.2 Nucleus (germinal vesicles)

The role of nucleus along with the nucleoli is well documented in the growing oocytes of teleosts, in *M.seenghala* (Sathyanesan, 1962); in *A.cuchia* (Thomas and Sathyanesan, 1985); in *C. marulius* (Guraya, 1986); in *N. notopterus* (Verma *et al.*, 1986); and in *C. punctata* (Rath and Hejmadi, 1987).

In the present study during previtellogenesis the nucleus grows into a large spherical structure and the number of nucleoli decrease throughout previtellogenesis and early part of vitellogenesis. In contrast, the number of nucleoli

decreases dramatically when the oocyte approach mature stage. Similar observations were recorded in many teleosts. It is generally noted that these nucleoli may possibly pass through the nuclear pores to the cytoplasm (cited Guraya, 1986). The transfer of nuclear material into cytoplasm is an accepted requisite for most theories on nucleo-cytoplasmic interaction. In the present study also reduction in the number of nucleoli in stage V and VI oocyte indicated their extrusion into cytoplasm.

5.5.3 Follicle cells

In the present study the follicular layer could be discerned in the stage II oocyte and become more prominent in the subsequent stages of oocytes. In the stage III, IV and V the vitelline membrane appeared between the ooplasm and the follicular layer. Both these layers increase the thickness during vitellogenesis, however as the oocyte attain stage VI and VII the follicular layer becomes less prominent.

Enough of the literature on the functional role of follicular layer during previtellogenesis, vitellogenesis and transferred of material and enzymatic action in the growing oocyte of different teleost are documented (cited Guraya, 1986).

5.6 CYTOCHEMISTRY OF YOLK BODIES

5.6.1 Lipid bodies

Guraya (1986) cited that previtellogenic oocyte of fish ovary show sudanophile lipid bodies of variable size and shape which consists of phospholipid. In the large oocyte the lipid bodies are dispersed throughout the cytoplasm and show concentric zonation which may be due to manifestation of various lipids, present in different regions of the same liquid droplet or variable physicochemical

state of lipids. Both lipid bodies and multi vesicular bodies in the oocyte of rainbow trout are believed to be of indigenous yolk in response to salmon gonadotropin treatment (Upadhyay *et al.*, 1978). Gopal Dutt and Govindan (1967) demonstrated triglyceride lipids in the ooplasm and nucleus of all oocytic stages in *Anabas*. Moreover Chopra (1958) in *C. punctata* and Saxena and Sahai (1985) in *N. notopterus* reported L₁ and L₂ bodies as phospholipid and triglycerides respectively in the growing oocytes. A general classification of the early lipid inclusion of previtellogenic oocyte as a true yolk is of questionable accuracy as these disappear in some fish species during the exogenous vitellogenesis (cited Guraya, 1986). Such lipid inclusion consisting of phospholipid alone or along with triglycerides in the oocyte of vertebrates and disappeared during the growth of oocyte due to accumulation of ultrascopic organelles. Therefore, these phospholipid bodies play some important role in the development of oocyte. *In vitro* studies of ovarian lipogenesis in rainbow trout although revealed the polar lipid functions of ovaries in early stages of recurrence but it needs to understand whether the polar lipid functions are identical to phospholipid oocytes (cited Guraya, 1986).

Verma *et al.* (1986) described the lipid histochemistry of the growing oocyte of *Notopterus*. Their study revealed the presence of phospholipid in the granules lying in the peri and juxtannuclear zone of stage I oocyte. These tends to spread over the entire ooplasm and in stage II oocyte gradually disappears. There appear some neutral lipid containing granules in the peripheral ooplasm and also in the intravesicular zone of stage II oocyte. The positive reaction in the follicular epithelium and accumulation of large number of neutral lipid containing granules in the peripheral zone of stage IV oocyte, indicates the possibility of their extraneous origin. These exogenous lipid element fuse together to give rise to globular lipid yolk.

In the present study the choline type of lipid was detected in the cytoplasm of immature oocyte. although nucleus and nucleoli were found to be negative. In maturing oocyte (i.e. III, IV and V) the extra and intravesicular lipid yolk globules were found indicating the presence of lipid contents in the growing oocyte. In the mature (i.e. stage VI and VII) oocyte besides lipid containing extravesicular yolk globules, the follicular layer were also stained indicating the possibilities of extraneous source of lipid origin in the growing oocyte. Therefore, the present study is in the agreement with Verma *et al.* (1986).

In the present study choline type of lipid (hydroxy ethyl trimethyl ammonium hydroxide) a saturated amino alcohol compound which occurs in lecithin was detected. Similar type of lecithin containing phospholipid in fatty yolk bodies was observed in *N. notopterus* (Verma *et al.*, 1986).

5.6.2 Carbohydrate yolk bodies

Guraya (1986) cited the cortical alveoli have also been described as extravacuolar yolk, intravesicular yolk and carbohydrate yolk. Extensive cytochemical studies have been made on the cortical alveoli in the oocyte of different teleosts, in *C. striatus* (Venugopalan, 1962); in *C. marulius* (Guraya, 1965); in *A. scandens* (Gopal Dutt and Govindan, 1969); in *N. notopterus* (Saxena and Sahai, Majumdar and Chatterjee, 1974; Rath and Hejmadi, 1989).

In the present study the immature oocyte were completely negative for PAS indicating the absence of carbohydrate. With the growth of oocyte (stage III), the small vesicles which appeared at the peripheral ooplasm contains minute PAS positive granules. These are designated as intra vesicular yolk. Further, the oocyte grow big in their size in addition to PAS positive globules increasing in

number and spreading in a centripetal manner. Intense reaction with PAS indicated higher accumulation of polysaccharide in extra and intravesicular yolk bodies as oocyte grow in size. In the mature oocyte of stage VI and VII, polysaccharide were restricted to intra vesicular yolk bodies at the cortex. The probable explanations to such may be that the carbohydrate for the extravesicular yolk bodies was either utilised or transferred to cortical alveoli as designated as intravesicular yolk bodies. Verma *et al.* (1986) represented CY₁ bodies in the stage II oocyte at the cortex region which correspond to that of intravesicular yolk bodies in the present study. They also observed CY₂ bodies in the growing oocyte which correspond to that of extravesicular yolk. Therefore, the present study confirms the presence of two types of carbohydrate yolk bodies in the growing oocyte of *N. notopterus*. The studies made in *C. striata* (Venugopalan, 1962); in *C. marulius* (Guraya, 1965); in *A. scandens* (Gopal Dutta and Govindan, 1969); in *C. punctata* (Chopra, 1958; Majumdar and Chatterjee, 1974; Rath and Hejmadi, 1989) also demonstrated similar observations with that of the present study.

However, Gopal Dutt and Govindan (1969) reported that the cytoplasm of immature oocyte of *A. scandens* is negative to Bauer's Feugen indicating the absence of glycogen. These trend in increase of glycogen content during yolk formation has also been recorded in many teleosts. The greater abundance of glycogen in older oocyte appears first and utilized latter when remarkable morphological changes occur in the oocyte, during oocyte growth. Regarding the origin and nature of cortical PAS positive granules, many are in view about the functional role of Golgi bodies. Guraya (1986) cited that the cortical granules are identical to the peripheral dense fragments of yolk nucleus.

Most of these worker on the oogenesis of fish and amphibians believe that carbohydrate yolk elements are first formed at the peripheral cytoplasm from where they spread towards the inner cytoplasm and finally concentrated in the cortical cytoplasm. The present investigation confirms this observation since the carbohydrate yolk globules were first formed in the cortex and spread centripetally and then became restricted to the cortex as the oocytes matured. In the present study even the oocyte undergoes resorption have showed PAS positive stain at the central liquifying granular mass indicating the source of energy being utilized for complete resorption of oocyte in *N. notopterus*.

5.6.3 Ribonucleic acid (RNA)

Ribonucleic acid (RNA) has been reported in many previous studies on fish and amphibian oogenesis (cited Rath 1980; Guraya, 1986). It can be stated that during various stages of previtellogenesis and vitellogenesis, a large amount of RNA is synthesized to contribute to the different types of autosynthetic protein which are necessary during oogenesis. Some of this RNA also utilized during embryogenesis.

Guraya (1965) has demonstrated RNA in all the cytoplasm during the various stages of previtellogenesis and specially in the yolk nucleus in *C. marulius*. He observed that diffuse RNA occurs throughout the cytoplasm of previtellogenesis and accumulation of RNA and protein is very rapid in mid vitellogenic oocyte (cited Guraya, 1986). Similar observations in the present study in *N. notopterus* coincide with the previous study.

In the present study, the cytoplasm of all the three phases of oocyte uniformly stained. Also RNA was localised in the nucleoli of vitellogenic (maturing)

oocytes while immature and mature oocyte shows negative stain. Intense stain of yolk nucleus showed the accumulation of RNA in this area. The presence of moderate concentration of RNA in follicle cells of maturing oocyte which decreased as the oocyte matured indicated that perhaps some RNA is utilized during the early stage of embryogenesis. Moreover most of the RNA synthesized late in oogenesis is stored within the nucleus for embryonic protein synthesis.

5.6.4 Protein Yolk Bodies

Protein yolk was localized in the cytoplasm of the oocyte throughout the oogenesis. The yolk nucleus and extravesicular yolk globules took intense stain indicating concentration of protein. The proteid yolk granules first originate in the cortical region of the oocyte and then filled the entire ooplasm. In their size and morphology, the proteid yolk bodies may vary different region of the eggs. Protein was localized in the nucleus throughout the oogenesis. The nucleoli are more intensely stain than the nucleoplasm. The follicular layer also had moderate amount of protein in the immature and maturing oocyte but gradually its intensity increases till the oocyte reaches at its VII stage. Chopra (1958) had observed in *C. punctata* that lipid granules appeared first during vitellogenesis and latter vacuolar yolk and protein rich yolk spheres appeared in the periphery. These proteinaceous granules increase in size and number and filled up the entire cytoplasm. He concluded that proteid yolk bodies chiefly consisted of protein and some lipids. Guraya (1965) observed in *C. marulius* that these first arised in association with the yolk nucleus. These proteid yolk bodies have some carbohydrate also. Latter these yolk bodies extends towards the periphery, grew in size and reacted positively for lipoprotein. Comparatively, the animal pole and peripheral zone of stage VI and VII oocytes had mainly smaller proteid yolk bodies, while the central zone of vegetal pole had large yolk elements in the present study. Similar observations were obtained in *C. punctata* (Rath and Hejmadi, 1991).

Various modes for the formation of endogenous proteid yolk have been described in fish (a) the yolk is formed in the cytoplasm without any relationship with formed elements, (b) in some cases a direct transformation of nuclear emission into proteid yolk granules, (c) proteid yolk granules arises either among the mitochondria or directly from the mitochondria (d) the yolk globules arise in close contact with the mitochondria and yolk nucleus substances (cited Guraya, 1986). Although various modes of proteid yolk formations was described by different workers in different teleost groups, but it is an accepted fact that the proteid yolk formation is by *de novo* synthesis or autotynthesis in association with ergastoplasmic cisternae within the Golgi elements in the pre existing vacuoles or in the mitochondria. Secondly by accumulation from outside the ovary or heterosynthesis by pinocytosis. Various morphological (including ultrastructural), autoradiographic and biochemical studies have shown that the female-specific protein (vitellogenin) is synthesized and secreted by the liver under the stimulation of oestrogen either of ovarian origin during breeding season or exogenously administered (cited Guraya, 1986).

The autoradiographic study demonstrated that exogenous protein sources are synthesised in the liver. Electron microscopic investigation confirm the pinocytic uptake of blood protein in the extravesicular yolk. Such accumulation of serum protein synthesis by liver during vitellogenesis has been convincingly demonstrated in Amphibian and teleost, *Fundulus heteroclitus* (Kanungo *et al.*, 1990). Sahu (1983) demonstrated three types of proteid yolk as PY₁, PY₂ and PY₃ in *N. notopterus*. In the present experiment the proteid yolk chiefly consisted of glycoprotein, lipoprotein and protein conforming the similar pattern of proteid yolk in *N. notopterus*.

The cytochemical technique employed in the present study demonstrated the formation of protein yolk is possibly from the cytoplasm in association with cytoplasmic organelles in stage III and IV oocytes and through nuclear emission in subsequent stage of oocytes in *N. notopterus*. This confirm the autosynthesis of proteid yolk in this species. Although the direct technique for confirming heterosynthesis, proteid yolk formation has yet been carried out but the sequence of localisation and further accumulation in the cortical region indicates heterosynthetic protein yolk formation in this species. Similar observations were also obtained by Verma *et al.* (1986).

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Section-III

Effect of Hormones on Ovary

INTRODUCTION

A primary requisite for adopting advance techniques in fish culture is to ensure adequate production of fish seed under controlled conditions. Procurement of quality fish seed in large scale is the most crucial input in the aquaculture enterprise and its timely availability is an essential prelude to any ambitious plans to complete the aquaculture development project. Hence, with a view to augment the fish seed production, attempts were made to induce the difficult to spawn carps by the use of pituitary hormones, since 1957. The administration of fish pituitary extract to induce breed the fish has become a common standard practice in aquaculture all over the country and elsewhere where the much known indigenous major carps and exotic carps are farmed. Recently, hormones of mammalian origin and various synthetic preparation have been tried to breed commercially important species and their effects studied thereof. In the context of this, reproductive endocrinology of teleost has drawn the numerous attention of many researchers and considerable success has been achieved in this regard.

Environmental conditions in freshwater are characteristically variable and the cultured fish experience a rhythm of changing diurnal and seasonal conditions. Their successful living demands a continual adjustment or regulation of internal media, metabolism and activity in relation to these cycles of environmental changes.

The influence of environmental factors on gametogenesis of fish is mediated through the hypothalamo pituitary-gonadal and/or pituitary interrenal-

ovarian axis. The hormones involved in the process are mainly gonadotropin releasing hormones, gonadotropin and steroids. In captive conditions, the progressive development of gonad remains in general, uninhibited upto the final stage of gamete maturation and it is only at the point of gamete release that the sequence is arrested. Both the gonadal maturation and spawning behaviour have long been known in responses to environmental stimuli. This has been accomplished through the techniques of induced breeding by hormonal manipulation, for which the Indian Scientists achieved a timely major breakthrough in intervening, where needed environmental cues are lacking and push the process to an artificial completion. But the precocious maturation (literally means developed maturity at an earlier age than usual) is one kind of technique in which the maturation process is accelerated through hormonal or environmental manipulation.

Recent studies have demonstrated that the gonado tropinreleasing hormone (GnRH) and dopamine, acting as a gonadotropin release inhibitory factor, (Peter *et al.*, 1988) regulate the gonadotropin secretion in teleost. The spermiation in male and oocyte maturation and ovulation in female fishes are initiated by a surge in gonadotropin (GtH) secretion (Crim *et al.*, 1975) which some how lacks in fish in confined water. Therefore, in artificial breeding environment, the surge of gonadotropin (GtH) is made by supplementing GtH exogenously like pituitary gland or use of exogenous hormones of mammalian origin like Human Chorionic gonadotropin (HCG), resembling luteinizing hormone in its action is secreted by the chorio tissue of the placenta during pregnancy and its excreted through urine and Synahorin mainly a preparation of HCG and mammalianpituitary extract (Weil *et al.*, 1978) and/or by using some dopamine antagonistic factor.

Through pituitary still form a major dependable source of inducing agent for breeding various species of fish, many of the bottleneck problems like scarcity of gland, tedious process involves in its preservation and preparation of dosages. therefore, it is imperative to find an effective substitutes which will have less problem of storage and high rate of success (Halder *et al.*, 1991). In this direction. considerable progress has been achieved in the last decade in the use of a new substance, Luteinizing hormone releasing hormone (LH-RH) and its analogues (D-Ala, Des-Gly-NH₂)-LH-RH-ethylamide, which is nanopeptide synthesized in 1973. It has been found to be several times more effective in induced spawning of grass carp, silver carp, bighead and black carp than that of the synthetic decapeptide or natural releasing hormone. The first report of Breton *et al.* (1972) based on an *in vitro* study on the possibility of using LH-RH for stimulation of gonadotropin release from carp pituitary led to a number of valuable investigations.

The first successful claim in using (D-Ala⁰, Pro⁹, NEt) Luteinizing hormone releasing hormone analogue (LH-RHA) for induction of ovulation and spawning of cultivable carps came from researches in China (Co-operative Team for Hormonal Application in Pisciculture, 1977; Fukien-Kiangsu-Chekian-Shanghai co-operative group, 1977; Fish Reproductive Physiology Research Group and Peptide Hormone Group, 1978).

This success immediately gained international attention and LH-RHA has been successfully used for maturation and spawning of various fish including Coho-Salmon, *Oncorhynchus kisutch* (Van Der Kraak *et al.*, 1983), bighead carp (Fermin, 1991). Atlantic salmon (Crim and Glebe, 1984), sea bass and rabbit fish (Harvey *et al.*, 1985) and milkfish (Marte *et al.*, 1988). Besides, many other reports

have already appeared in the literature suggesting that gonadotropin releasing hormones and some commercially available agnostic analogues of LH-RH, can be used to accelerate the breeding cycle of fishes (Crim *et al.*, 1983; Weil and Crim, 1983; Billard *et al.*, 1983; Sokolowska *et al.*, 1984; Rao *et al.*, 1991).

The biological effectiveness of the synthetic form of LH-RH promises maximization of its utilization in fish reproduction. Although the vast majority of studies with LH-RH and its analogues have been used for induction of egg and sperm productions at the final stage of gamete maturation, the precocious sexual maturation is also relevant to aquaculture to ensure steady and early production of fish seed.

Although the LH-RH analogues are receiving great attention as a potential agent for controlled reproduction of fishes and proved to be useful, still there are number of problem arises while adopting this technique at farmers' level, like careful calculation of dosage, preparation of suspension to get the desired dosage level etc. Use of Ovaprim, a ready to use drug in solution form, manufactured by Syndel Laboratory in Canada, removed these problems. The drug contains calibrated amount of salmon gonadotropin releasing hormone analogue (sGnRHA) and domperidone dissolved in an organic solvent. Also the drug does not require refrigerated storage and single injection is sufficient to breed the fish and thereby reducing the strain of second injection (Nandeeshha *et al.*, 1990a).

The bionomic and breeding of the genus *Notopterus* have been tried by the use of both homoplastic and heteroplastic pituitary glands (Hamza, 1980) but much information on the use of synthetic hormones on ovulation have not yet been available in this species.

Hence, the present study was undertaken with a view to understand the effects of exogenous hormones such as LH-RHA and Ovaprim on the ovary and their role in inducing precocious maturation, so as to envisage the seed production possibilities of *Notopterus notopterus* for utilizing numerous derelict water bodies in the country.

REVIEW OF LITERATURE

Hormonal and environmental manipulations are accomplished the induced spawning of fish. The strategic role of vertebrates hypothalamus in mediating endocrine response and adjustments to that manipulation is now a universally accepted concept. Like any other vertebrates, the nervous and endocrine systems in fish act in concert to co-ordinate reproductive events. Major link in these chain of events occur through brain-hypothalamo-hypophysial gonadal axis. There have been several excellent reviews available on the various aspects of endocrine control of reproduction in fishes (VanOrdt, 1968; Lofts, 1968; Dodd and Weibe, 1968; Barr, 1968; Jorgensen, 1968; Hoar, 1969; Fontaine, 1969; Ball and Baker, 1979; Dodd, 1972, 1975; Donaldson, 1973; Peter, 1973, 1982; Sundararaj, 1981; Hoar *et al.*, 1983; and Scott, 1986).

Since the present study specifically deals with the effects of LH-RHA and Ovaprim on the precocious maturation of ovary in freshwater featherback *Notopterus notopterus*, only the very pertinent literature is covered in the present review.

2.1 NEUROENDOCRINE MECHANISM OF REPRODUCTION IN TELEOST

The receptions of environmental stimuli is mediated by nervous system and involves the passage of information from sensory receptor to brain. This neural information, upon reaching the hypothalamus determines the activity of hypophysis by way of chemical messengers, termed releasing hormone (RH). This inturn stimulate the hypophysis to release , into general circulation, hormone where target organ is gonad. This hormone is gonadotropin (GtH). The function of

gonadotropin is to stimulate production of sex steroids in the gonad and interrenal gland. Sex steroids are responsible for maturation of gametes (Hoar *et al.*, 1983).

In brain, the transition from neural information to hormonal control takes place at interface between hypothalamus and hypophysis (Hoar *et al.*, 1983). The chemical factor (releasing hormone), that is released at the junction of neuro and adenohypophysis to regulate the activity of pituitary gonadotropin in teleost, is a decapeptide, similar in its basis, structure and biological action to mammalian LH-RH (Sherwood *et al.*, 1983). This hormone is popularly known as gonadotropin hormone releasing hormone (GnRH) or also called as luteinizing hormone releasing hormone (LH-RH) in fish. In teleost, there is a variation in responsiveness of pituitary and the gonadotropin released from pituitary is under the stimulatory control of hypothalamus (Weil *et al.*, 1978).

2.2 LUTEINIZING HORMONE RELEASING HORMONE (LH-RH) AND ITS ANALOGUE (LH-RHA)

2.2.1 Trial with LH-RH

The first report of Breton *et al.* (1972) based on an *in vitro* study on the possibility of using LH-RH for stimulation of gonadotropin release from carp pituitary led to a number of valuable investigations. After isolation and characterisation of LH-RH, several attempts were made to use it as inducing agent in teleost. However, injection of native form of LH-RH is not very effective in elevating the plasma concentration of gonadotropin (Crim *et al.*, 1988) or inducing spawning; this is probably due to rapid break down of the peptide in body.

A study in goldfish on the disappearance of LH-RH administered by intraperitoneal injection showed that the concentration of LH-RH in the blood peaks by 4 minutes after injection, 50% of the peak amount is gone by 20 minutes and about 90% by 45 minutes after injection (Sherwood and Harvey, 1986).

To prolong the life of LH-RH in blood stream without frequent administration, a number of LH-RH analogues have been synthesized. Over 2000 analogues have been made (Struthers *et al.*, 1985). Synthetic hormones have been found to be more stable and several time more potent than the natural form. One of the analogues that is relatively more effective in stimulating events related to reproduction in both fish and mammals is (D-Ala⁶, Pro⁹-ethylamide) mammalian LH-RHA. The residence period of this analogue is about 9 times more than that of natural LH-RH (Crim *et al.*, 1988). In fish this analogue stimulates an increase in circulating level of gonadotropin and/or induce ovulation and spawning in various teleost species.

Another significant finding of the last decade is the isolation and characterisation of releasing hormone from salmon (Sherwood *et al.*, 1983). Among the various analogues of salmon releasing hormone, D-Arg⁶, Trp⁷, Leu⁸, Pro⁹ Ethylamide have found to be 17 times more potent than the most effective mammalian LH-RHA (D-Ala⁶, Pro⁹, NEt).

2.2.2 LH-RHA in teleost reproduction

After finding, LH-RHA has been successfully used for the induce ovulation of goldfish at 12°C (Lam *et al.*, 1975) and in combination with fish pituitary in grass carp, silver carp, big head and black carp (Conference on Application of hormone to Economic fish, 1975). LH-RH caused germinal migration and GVBD in common carp, but not ovulation (Sokolowska *et al.*, 1978). The effect of LH-RHA on plasma gonadotropin levels in mature male goldfish investigated Peter (1980). The results of the investigation done by Peter lead the following assumption. (1) Excessive dosage may be detrimental due to self suppression of response (2) a series of injections of low dosage may be necessary because of self potentiation of response and (3) The superactive analogues effective for fairly longer period than LH-RH.

Chinese were the first to claim on successful use of mammalian origin LH-RH analogues (D-Ala⁶, Pro⁹-Eth) for breeding carps (Co-operative team for hormonal Application in pisciculture, 1977). 78% overall spawning success achieved with this injected hormone of chinese carps as against 75% with the fish pituitary extract. Peter *et al.* (1988) indicated that in practice, Chinese farmers always use LH-RHA in combination with the pituitary or HCG.

Donaldson *et al.* (1981) demonstrated the LH-RH and two of its superactive analogues, D-Ala⁶ des gly¹⁰ LH-RH (1-9) ethylamide and D/soc (But)⁶ - LH-RH (1-9) ethylamide in combination with SG-100 (Salmon gonadotropin) have found to be effective agents for the induction of ovulation in coho salmon (*Onchorhynchus kisutch*).

Weil and Crim (1983) have observed that, administration of LH-RHA to prespawning landlocked salmon, (*Salmo salar*) effectively, accelerates the onset of spermiation and increases the volume of milt. Billard *et al.* (1983) have also succeeded in inducing spermiation in Common carp (*Cyprinus carpio*) with LH-RH and its superactive analogue.

A number of studies conducted in breeding various species of cultured fish in China with LH-RHA led to the development of "Linpe method" (Peter *et al.*, 1988) wherein the releasing hormone analogue is combined with dopamine antagonist, Pimozide or Domperidone for successful spawning.

2.2.3 Trials with LH-RHA in India

Kaul and Rishi (1986) reported successful spawning of *Cirrhinus mrigala* with LH-RHA (des-Gly¹⁰-(D-Ala⁶) LHRH-Eth) at 10 mg/kg body weight. Their

trials with pimozide at 10 mg/kg body weight also resulted cent percent ovulation. In contrary to this Sahu and Biswal (1988) were unable to induce spawning in all the three Indian major carp when LH-RHA, 10 μ g/kg body weight was combined with 10 mg/kg pimozide. Parameswaran *et al.* (1988) achieved successful spawning of *Cirrhinus mrigala* with LH-RHA, buserelin acetate (D-ser (But)⁶-des-Gly¹⁰) LH-RH-ethylamide at a dose of 150-200 μ g/kg in combination with 100 μ g progesterone. Successful spawning of *Lebeo bata* achieved with LH-RHA at a dose of 10 μ g/kg (Das and Das, 1989). Similar result has also been obtained by Jose *et al.* (1989) with LH-RHA (des-Gly¹⁰-Ala⁶) at a dose of 80 μ g/kg in *Cirrhinus mrigala*. LH-RHA at a dose of 15 μ g/kg is found to be unsuccessful in inducing spawning in silver carp, *Hypophthalmichthys molitrix*. But the same species responded when the above dose was combined with 5 mg/kg pituitary (CPE) or HCG.

A series of trial conducted by the Asian Fisheries society, Indian Branch in various states, on the use of LH-RHA either alone or in combination with dopamine antagonist. Initial trial on catla and rohu with LH-RHA (10-20 μ g/kg) indicated that though ovulation could be induced, spawning success was very poor. But LH-RHA (20-30 μ g/kg) when combined with pimozide (10-20 mg/kg) or domperidone (5-10 mg/kg) induced high rate of spawning in both fishes. Interestingly, combination of LH-RHA with pituitary resulted in successful spawning (Nandeeshia *et al.*, 1990 b).

Rath and Das (1993) investigated the effect of LH-RHA on the induction of precocious ovarian maturation in the Asian catfish *Clarias batrachus* during the prespawning period of the fish (April-May). Administration of LH-RHA at the dose level of 40 μ g/kg on alternate day and 5 days interval have significant effect in inducing precocious ovarian maturation in *C. batrachus*. The hormone

therapy resulted in higher gonosomatic index (GSI) and increase in ova diameter. Ovulatory response of Indian major carps with LH-RHA alone and in combination with PIM and DOM was investigated in commercial fish seed farm of Orissa (Rath and Das, 1993). Nayak and Singh (1995) investigated the effects of single intraperitoneal injection of LH-RHA and pimozone (PIM) alone or in combination on oocyte maturation, ovulation and spawning in Asian catfish, *Heteropneustes fossilis*. Both the drug, LH-RHA or PIM when tested alone, failed to evoke any ovulation response, although both the drugs resulted the advancement of oocyte maturation in catfish. LH-RHA is more potent in advancing oocyte maturation as compared to that of pimozone.

Several literatures are available on hormone implantation in various ways viz. Pellet-implantation, Osmotic pump etc, using LH-RHA as inducing agent with varied degree of success (Lee *et al.*, 1986; Marte *et al.*, 1988; Rao *et al.*, 1991). These result may prove advantageous for maximising the effect of LH-RHA application.

2.3 TRIALS WITH OVAPRIM

Realising the problems of fish breeding and to make it more simplified in term of easy handling, storage of potency, single dose of administration, M/S. Syndel Laboratories Ltd., Canada developed a drug known as Ovaprim a soluble form, essentially based on the "Linpe Method". Peter *et al.* (1988) reported that Ovaprim is 17 times more potent than the mammalian LH-RHA, (D-Ala⁶, Pro⁹-Ethylamide). This increased effectiveness of SGN RHA is predicted to be due to its higher affinity for the binding site on pituitary (Habibi *et al.*, 1989).

Trials conducted with Ovaprim on a number of species of carp administering in a single dose to both male and female brooders simultaneously

yield encouraging results in inducing complete spawning. Most of the carps tested generally spawned within 10-14 h. (Nandeeshha *et al.*, 1990b).

Sharma *et al.* (1993) reported that dose rate of Ovaprim as recommended by the earlier workers, did not cause spawning in carps under different agroclimatic conditions. The effective dose rate was found considerably low for grass carp (0.30 ml/kg), silver carp (0.30 to 0.40 ml/kg), catla (0.35 ml/kg) and rohu (0.25 - 0.30 ml/kg) but very high in case of mrigala (0.50 ml/kg) at one of the centres.

Spawning was achieved in catla, rohu and mrigala by injecting Ovaprim. Spawning as observed in 8-10 h. after Ovaprim injections. Fertilization rate was more than 90-95% in most Ovaprim induced cases (Singh and Singh, 1993). Similar observations were also reported in Ovaprim induce fishes (Rath and Das, 1993).

MATERIAL AND METHODS

Fishes were collected as described earlier. Once the collection of live fish is over, they are immediately taken to the laboratory and treated with KMnO_4 so as to heal up any injury thereof. Then, the fishes were kept in aquaria and maintained their health status for a period of 15 days, so as to acclimatize them in confined condition prior to hormonal experiment. During the period of acclimation and also the time for keeping with hormonal treatment, the fishes were fed with live earthworm, notonecta, small shrimps everyday at 5% of their body weight. The water in the aquaria were changed daily along with the excreta and faecal matter. After acclimatization of these fishes in the aquaria, they were subjected to hormonal treatment which were injected during the afternoon between 16 to 18.00 h, in order to avoid differences arising from circadian rhythms.

Two types of inducing agents *viz* LH-RHA and Ovaprim were used in the hormonal experiment for the precocious maturation of ovary.

The source of LH-RHA is M/S. Ningbo Laboratories Limited, China, having a molecular formula as $\text{C}_{58}\text{H}_{78}\text{N}_{16}\text{O}_{12}$. The chemical structure of this hormone is (Pyro) Glu-His-Trp-Ser-Tyr-Ala-Leu-Arg-Pro-Ethylamide (D-Ala⁵, Pro⁹-NEt). Basically the hormone looks amorphous white in appearance (Mannite is used as filler) that is 10 times as much as its weight as a water soluble base.

The Ovaprim used in the experiment was manufactured by Syndel Laboratories limited, Canada. marketed by Aggravate farm care, a sister concerned of Glaxo India Limited. The vial used were having Product No. 13430, Plot No. 4055A and Vial No.1/6.

The product Ovaprim is essentially based on the 'Linpe Method' consisting of the mixture of SGN RHA with dopamine antagonist 'DOM' dissolved in a nontoxic calibrated amount of organic solvent. The basic structure of SGNRH is Glu-His-Trp-Ser-Trp-Gly-Trp-Leu-Pro-Gly-NH₂. Various analogues have been prepared from this SGNRH. Among the various analogues of salmon releasing hormone, D-Arg⁶, Trp⁷, Leu⁸, Pro⁹-Ethylamide has found to be highly effective and this particular analogue is used in Ovaprim.

At the time of injection of selected female fish for the hormonal experiment the required quantity of hormone is taken out. Teleost saline (5.5g NaCl + 0.14g KCl + 0.12g CaCl₂/1 litre D.W) was used as a vehicle medium for administration of LH-RHA. LH-RHA was first dissolved in teleost saline by injecting a small amount into vial containing 1 mg LH-RHA. The final volume of 5 ml was adjusted with the medium to prepare the stock solution (200 µg LH-RHA/ml). From the stock solution the final suspension was made by taking 1 ml stock solution and adding 2 and 4 ml of teleost saline to get 20 and 40 µg/ml concentration. The volume of inducing agents injected was calculated depending on the weight of the recipient fish.

Based on preliminary experiment, fishes were given LH-RHA at a rate of 20 µg/kg of body weight. Similarly, fishes were injected LH-RHA 40 µg/kg body weight and Ovaprim at a rate of 0.1 ml to the individual, irrespective of their body weight. The fishes were injected with respective hormones intramuscularly. Intramuscular injection of hormone is administered using 2 ml hypodermic syringe (with B.D. needle No.24) at the caudal peduncle of the fish. In the same way, the control group of fishes were injected with teleost saline and maintain for comparison with LH-RHA treated groups. The other control group of fishes were

not injected with teleost saline and kept in aquaria for comparison with Ovaprim treated group.

Each group had five female fishes. The volume of the injection did not exceed 1.0 ml. Fishes treated with hormone and untreated ones were kept in aquaria separately. These were maintained for a period of 30 days from the date of injection, after that they were sacrificed the next day. The LH-RHA at the rate of $20 \mu\text{g}/\text{kg}$ body weight was injected during the month of December and $40 \mu\text{g}/\text{kg}$ body weight during the month of January, when ovary was in preparatory-cum active phase. In order to induce ovulation the other set of fishes were injected with Ovaprim during the month of March, when the ovary enters into the active phase.

After length and weight of the fishes were recorded and the ovaries were dissected out and measured in a single pan balance and recorded. All the ovaries were fixed in appropriate fixative, embedded in paraffin, sectioned at $4 \mu\text{m}$ and stained with hematoxylin and eosin and examined under the microscope for further study. The gonosomatic index, average ova diameter and ponderal index along with standard error were calculated. The percentage of different stages of oocytes were calculated from the slides observed under the microscope.

RESULTS

4.1 EFFECT OF LH-RHA (20 μ g) (Table 1-2, Fig.1-2, Plate I-II)

In the control group, the mean relative weight of ovary was $0.283\text{g} \pm 0.093$. The mean gonosomatic index, mean ponderal index and average ova diameter were, 0.283 ± 0.093 , 0.787 ± 0.051 and $147.5\mu \pm 38.81$ respectively. The ovary had reached the stage IV. The ovary consists of immature, maturing and oocytes at different state of resorption.

In the case of LH-RHA treated group, the mean relative weight of ovary was $0.563\text{g} \pm 0.156$ i.e. 0.28g more than that of the control group. The mean GSI, mean ponderal index and ova diameter were 0.563 ± 0.156 , 1.007 ± 0.051 and $305\mu \pm 90.87$ respectively. The ovary had reached up to IV stage. In LH-RHA (20 μ g) treated fish groups, the immature oocytes were very few and maturing oocytes were clearly observed. From these observations it can be assumed that treatment of LH-RHA (20 μ g) had enhanced the growth of these oocytes to their next progressive stages. Moreover 48.54% more oocytes were at IV stage in treated group in comparison to the control. Maturing oocytes were also 68.97% more in number than the control (Table 1, Fig.1) suggesting enhancement of ovarian growth and oogenesis under the influence of LH-RHA. The atretic oocytes were also seen more than that of control, indicating that LH-RHA had also promoted the resorption of eggs. The values in LH-RHA (20 μ g) treated group were significant than that of the control group.

Table 1: Effect of LH-RHA (20 μ g) on ovary in *N. notopterus* (Pallas)

	Body weight (g)	Body Length (cm)	Ovary weight (g)	Individual OSI	Mean OSI	Av. ova dia.	Individual PI	Mean PI	Stage of ovary
Control	120.0	24.1	0.1936	0.161			0.867		VI
	130.0	27.0	0.2979	0.229			0.660		II
	86.0	23.0	0.2108	0.248	0.283	147.6	0.899	0.787	III
	116.0	24.6	0.7444	0.677	± 0.093	± 38.81	0.782	± 0.061	IV
	100.0	22.0	0.1296	0.130			0.839		I
LH-RHA	100.0	21.6	0.9360	0.936			0.006		IV
	110.0	23.6	0.6986	0.931			0.846		III
	100.0	20.6	0.2160	0.216	0.683	306	0.161	1.007	II
	90.0	21.0	0.1644	0.183	± 0.166	± 90.87	0.872	± 0.061	I
	100.0	21.2	0.8493	0.849			1.060		IV

Table 2: Percentage of different oocytes of treated and untreated groups in *N. notopterus* (Pallas)

Experiment	Oocytic stages						
	Stage I	II	III	IV	V	VI	VII
Control	58.62	10.34	10.34	20.69	-	-	-
LH-RHA (20 μ g)	-	-	15.38	69.23	15.38	-	-
Control	65.22	13.04	13.04	8.70	-	-	-
LH-RHA (40 μ g)	14.28	28.57	35.71	14.28	7.14	-	-
Control	-	-	-	42.86	14.29	28.57	14.29
Ovaprim	-	-	-	-	-	50.00	50.00

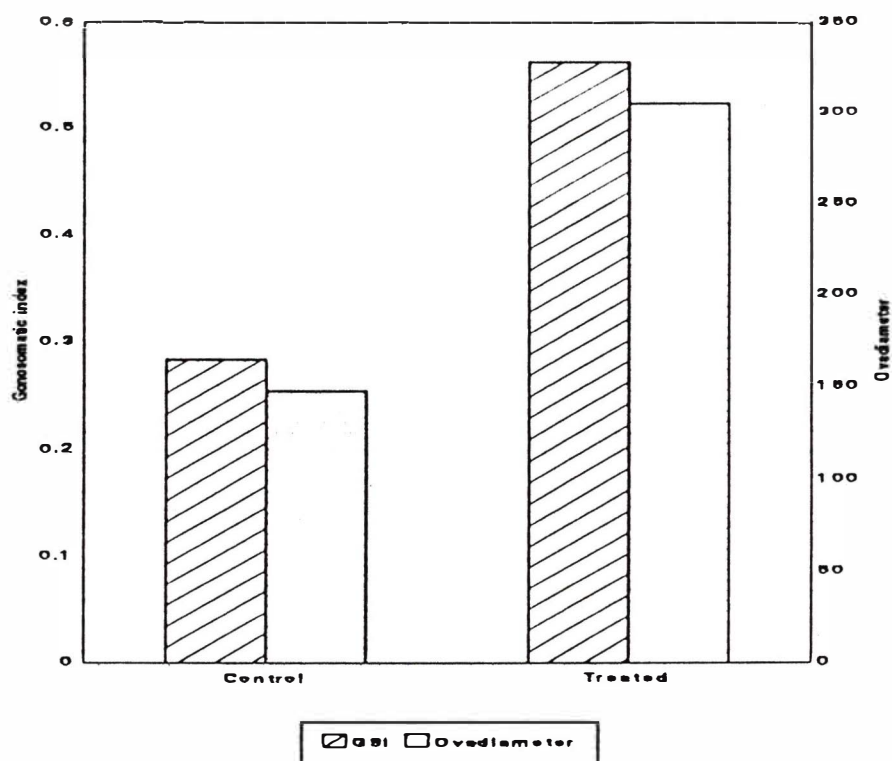


Fig. 1. Effect of LH-RHA (20 g) on gonosomatic index and ovidiameter in *N. notopterus*.

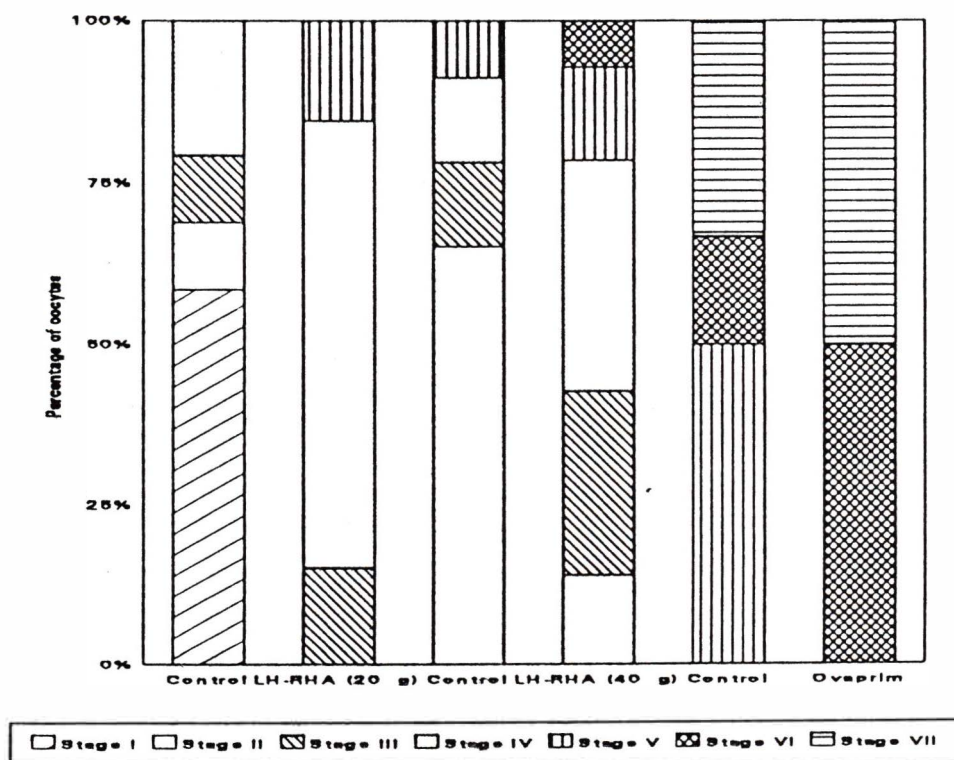


Fig. 2. Percentage of different oocyte of control and hormone treated groups in *N. notopterus*.

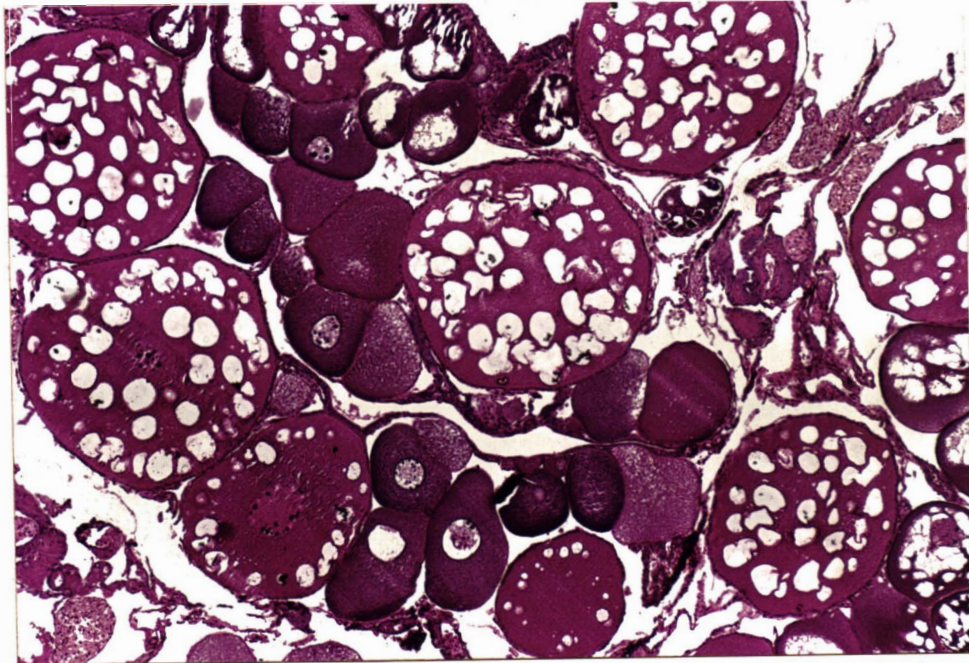


Plate No.I Transverse section through ovary of control group.
HE x 33

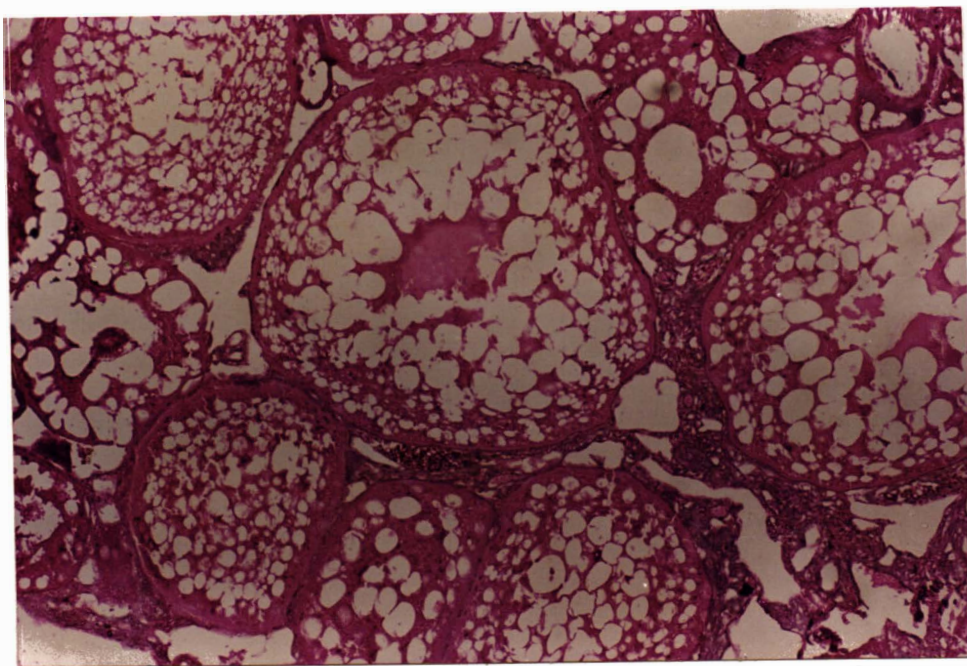


Plate No.II Transverse section through ovary of LH-RHA (20 µg)
treated group. HE x 33

4.2 EFFECT OF LH-RHA 40 μ g (Table 3, Fig.3, Plate III-IV)

In the control group, the mean relative weight of ovary was $0.754\text{g} \pm 0.099$. The mean gonosomatic index, mean ponderal index and average ova diameter were found to be $0.754\text{g} \pm 0.099$, 0.785 ± 0.024 and $148.75\mu \pm 41.15$ respectively. The ovary had reached up to IV stage. The immature oocytes were more common. The ovarian wall was thick, supplied with blood vessels. A group of immature oocytes were enclosed by oolemma in several pockets. Some maturing oocytes were seen along with different oocytes at resorption state.

In LH-RHA (40 μ g) treated group the mean relative weight of ovary was $0.909\text{g} \pm 0.153$ i.e. 0.155g more than the control. The mean gonosomatic index, mean ponderal index and average ova diameter were found to be 0.909 ± 0.153 , 0.798 ± 0.018 and $209.4\mu \pm 68.09$ respectively. The ovary had reached upto IV stage. In this treated group, both immature and maturing oocytes were seen although maturing oocytes were very common. The ovarian wall was thick and supplied with blood vessels. The values in LH-RHA (40 μ g) treated group was found to be significant than that of the control group.

Table 3: Effect of LH-RHA (40 μ g) on ovary in *N. notopterus* (Pallas)

	Body weight (g)	Body Length (cm)	Ovary weight (g)	Individual OSI	Mean OSI	Av. ova dia.	Individual PI	Mean PI	Stage of ovary
Control	180.0	22.1	0.4063	0.508			0.741		I
	100.0	23.0	0.6982	0.698	0.764	148.75	0.822	0.786	II
	85.0	22.5	0.6258	0.971	$\pm .099$	± 41.15	0.746	± 0.024	IV
	115.0	24.0	0.9664	0.840			0.832		IV
	85.0	22.5	1.1835	1.392			0.746		IV
LH-RHA	110.0	23.6	1.0065	0.915			0.837		IV
	85.0	22.0	1.5986	0.704	0.909	209.40	0.798	0.798	II
	90.0	22.1	1.1930	1.326	± 0.153	± 68.09	0.834	± 0.018	IV
	130.0	26.0	0.6817	0.524			0.740		III
	115.0	24.0	0.6790	0.590			0.832		IV

4.3 EFFECT OF OVAPRIM (Table 4, Fig.4, Plate V-VI)

The mean relative weight of ovary was $1.943\text{g} \pm 0.625$ in the control group. The mean gonosomatic index (GSI), ponderal index (PI) and ova diameter were found to be 1.943 ± 0.625 , 0.698 ± 0.027 and $592.5\mu \pm 109.63$ respectively. The ovary had reached upto IV stage. The immature oocytes were not seen at all.

In Ovaprim treated groups, mean relative weight of ovary was $2.219\text{g} \pm 0.399$ i.e. 0.275g more than the control group. The mean gonosomatic index, ponderal index and average ova diameter were found to be 2.219 ± 0.399 , 0.772 ± 0.034 and $740\mu \pm 85.0$ respectively. The ovary had reached upto V stage and also had fully mature oocytes. The values in Ovaprim treated group were found to be significantly higher than the control group. Based on these above observations, it is assumed that Ovaprim was very effective in enhancing the maturation of oocytes.

Table 4: Effect of Ovaprim on ovary in *N. notopterus* (Pallas)

	Body weight (g)	Body Length (cm)	Ovary weight (g)	Individual OSI	Mean OSI	Av. ova dia.	Individual PI	Mean PI	Stage of ovary
Control	115.0	24.9	3.8992	3.217			0.745		IV
	95.0	23.5	0.8979	0.945	1.943	592.5	0.732	0.698	IV
	100.0	24.4	2.8137	2.813	± 0.625	± 109.63	0.682	± 0.027	IV
	90.0	24.3	0.7181	0.798			0.627		III
Ovaprim	215.0	29.2	6.3506	2.954			0.864		V
	185.0	28.6	3.1599	1.708			0.791		V
	150.0	27.8	2.8153	1.877	2.219	740.0	0.698	0.772	V
	200.0	29.0	2.4250	1.213	± 0.399	± 85.0	0.820	± 0.034	V
	100.0	24.4	3.3420	3.342			0.688		V

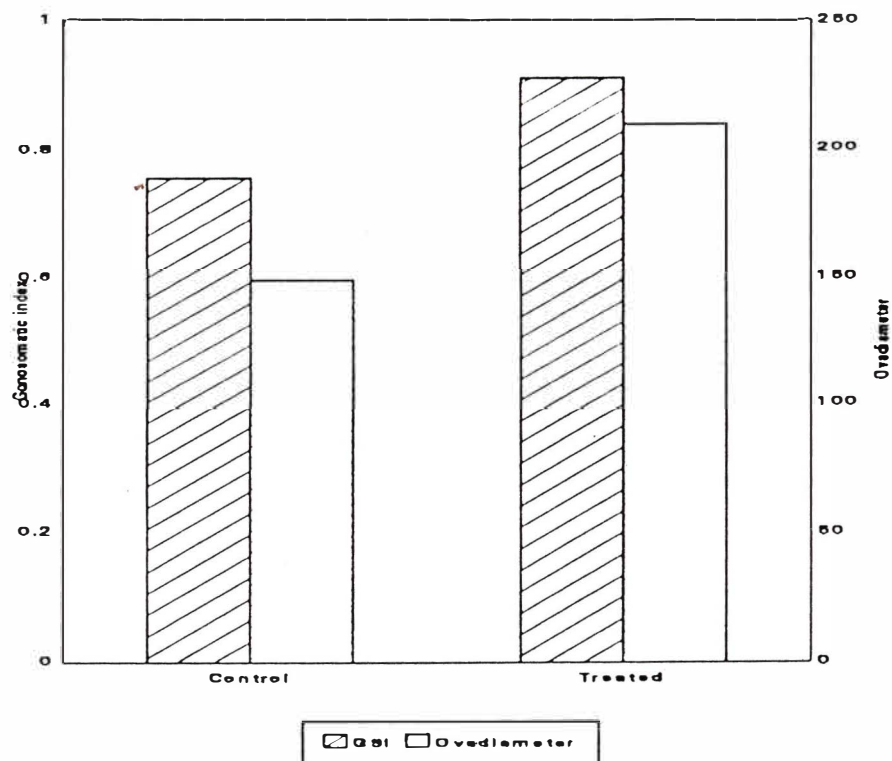


Fig. 3. Effect of LH-RHA (40 µg) on gonosomatic index and ovidiameter in *N. notopterus*.

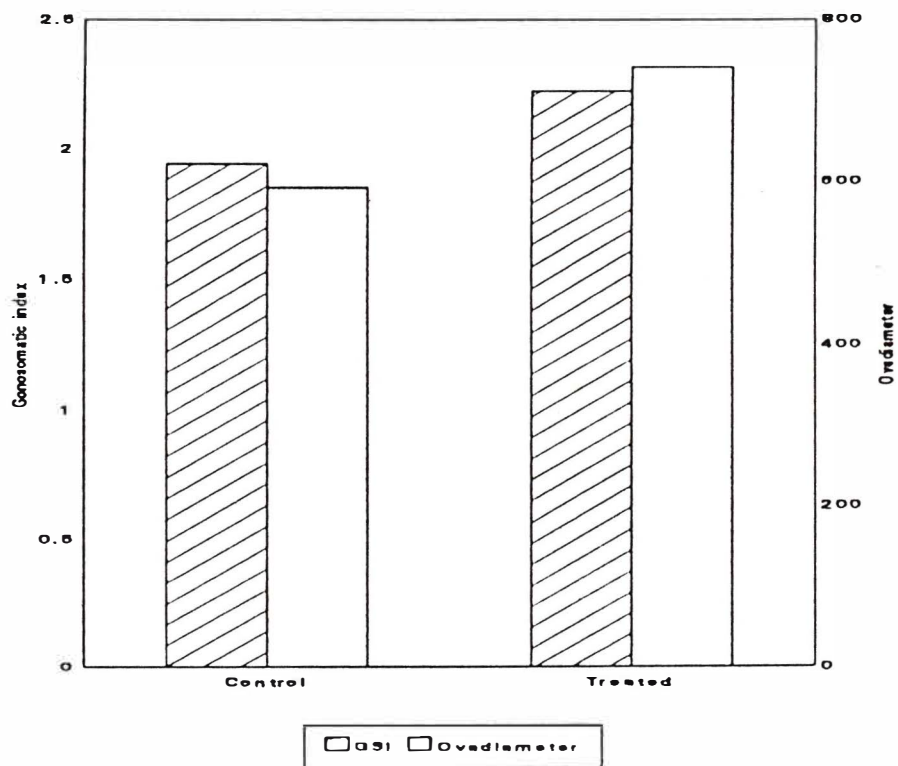


Fig. 4: Effect of Oviprim on gonosomatic index and ovidiameter in *N. notopterus*.

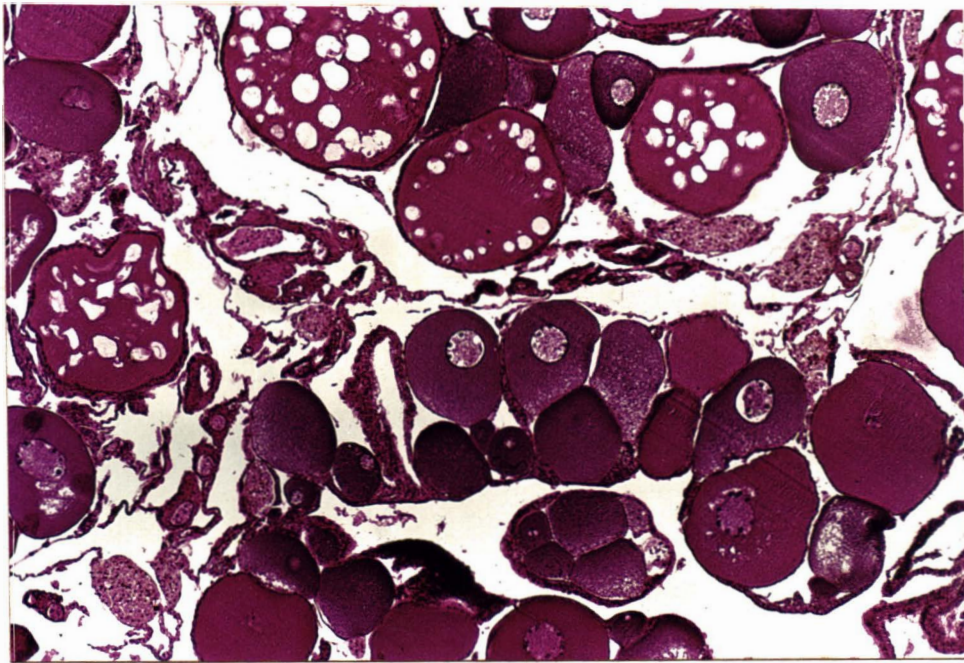


Plate No.III Transverse section through ovary of control group. HE x 33

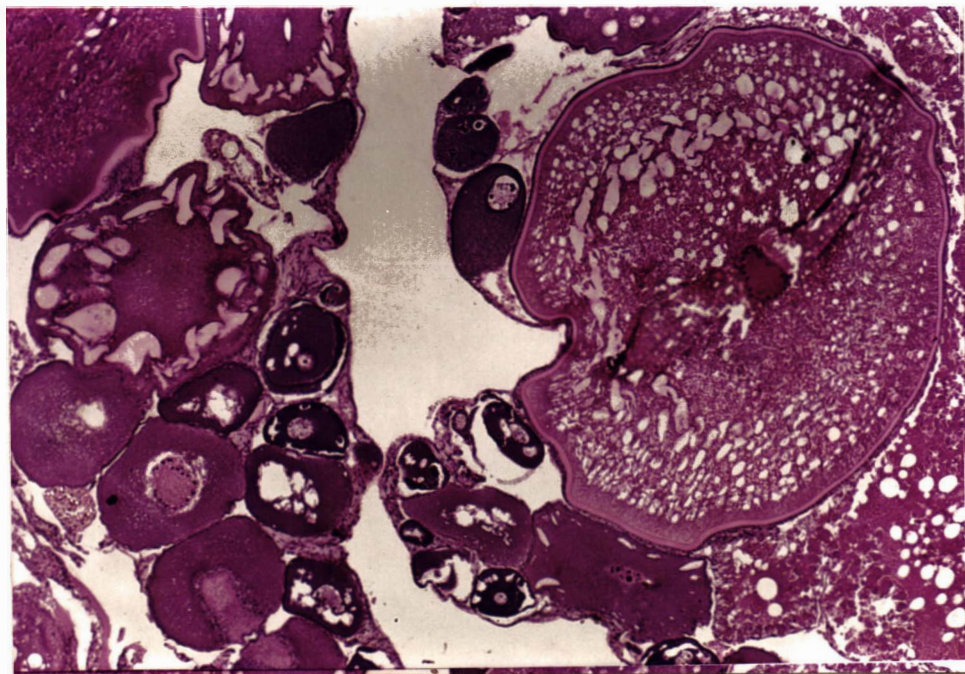


Plate No.IV Transverse section through ovary of LH-RHA (40 µg) treated group. HE x 33

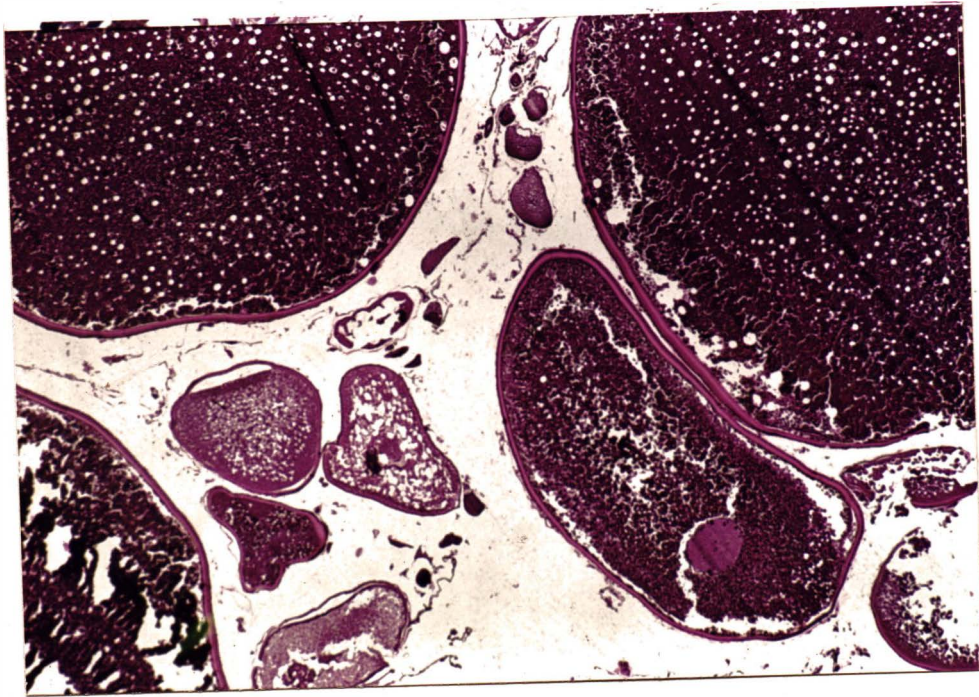


Plate No.V Transverse section through ovary of control group.
HE x 13.2

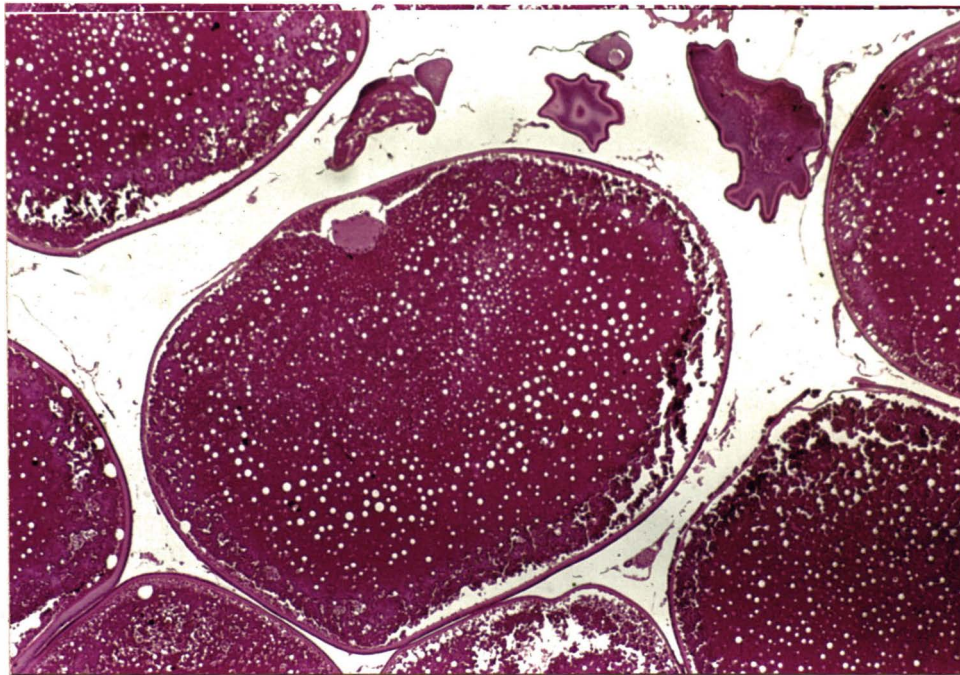


Plate No.VI Transverse section through ovary of Ovaprim treated
group. HE x 13.2

DISCUSSION

In the present study long term therapy of LH-RHA and Ovaprim stimulated oogenesis of the freshwater featherback *Notopterus notopterus*, in previtellogenic and vitellogenic period, indicating its stimulatory action on secretion and release of gonadotropin from pituitary. Similar observation have also been reported by many researchers suggesting that gonadotropin releasing hormone and some commercially available agnostics analogues of LH-RH, can be used to accelerate the breeding cycle of salmonides (Crim *et al.*, 1983; Weil and Crim, 1983; Billard *et al.*, 1983). Ramos (1986) have observed precocious ovulation in common sole (*Solea solia*) following LH-RHA treatment.

In the 20 μ g and 40 μ g/kg body weight LH-RHA treated fish, the gonosomatic index (GSI), ova diameter and ponderal index (PI) in the present experiment showed a significant increase from that of all the control groups. In the LH-RHA 20 μ g treated group, the mean relative weight of ovary was $0.563\text{g} \pm 0.156$, i.e. 0.28g more than that of the control group. The mean GSI and mean PI in this group were recorded to be 0.563 ± 0.156 and 1.007 ± 0.051 respectively which is highly significant than the control. The mean ova diameter of treated and control were found to be $305\mu \pm 90.87$ and $147.5 \mu \pm 38.81$ respectively, which was 157.5μ more than the control, indicating the positive effect of hormone on oocytic development. Similar observations were recorded in *Clarias batrachus* (Rath and Das, 1993).

In the LH-RHA 20 μ g treated fish, the oocytic stages reached the 5th stage while in control it reached the IV stage only. Moreover, the maturing oocytes

(III, IV, and V) were accounted 70% more than the control. However, maximum percentage of stage IV oocytes (69%) was encountered in this treated group, which around 40% more than the control. In control group immature oocytes (I and II) accounted 30% which is 70% less than that of treated group. When the 20 μ g LH-RHA treated group was compared with control group, the GSI, PI and ova diameter were found higher and significant at 5% level of population.

These observations revealed that 20 μ g LH-RHA has positive effect on oogenesis and the oocytes have developed progressively to next successive stage of development.

In the LH-RHA 40 μ g treated group, the mean relative weight of ovary was 0.909 ± 0.153 , i.e. 0.155g more than that of the control. The mean GSI and mean PI in this group were recorded to be 0.909 ± 0.153 and 0.798 ± 0.018 respectively, which is significantly higher than the control. The mean ova diameter of LH-RHA treated and control group were found to be $209.40 \mu \pm 68.09$ and $148.75 \mu \pm 41.15$ respectively, which was 60.65μ more in the treated group than the control, indicating the positive effect of hormone on oocytic maturation and development.

In the LH-RHA (40 μ g/kg) treated fish, the oocytic stages reached the V stage while in control it reached the IV stage. In case of LH-RHA treated group, both immature and maturing oocytes were observed but maturing (III, IV and V) oocytes were 35% more than the control. In LH-RHA treated group around 58% represents the maturing oocytes while only 21% maturing oocytes were observed in the control group. In control group immature (I and II) oocytes alone contributes around 78% which was 36% more compared with treated group showing the positive effect of hormone on oocytic development. When the 40 μ g LH-RHA

treated group was compared with control group, the GSI, PI and ova diameter were found to be higher and significant.

In the Ovaprim treated group, the mean relative weight of ovary was $2.219\text{g} \pm 0.399$, i.e. 0.28 g more than that of control. The mean GSI and mean PI in this group were recorded to be 2.219 ± 0.399 and 0.772 ± 0.034 respectively, which is highly significant than that of control. The mean ova diameter of Ovaprim treated and control group were found to be $740\mu \pm 85.00$ and $592.5\mu \pm 109.63$ respectively which is 147.5μ more in treated ones than the control, indicating the positive sign on its effect.

In the Ovaprim treated fish, the oocytic stages reached the fully mature stage (i.e. VII stage) while in control both the maturing and mature oocytes were observed. In treated groups cent percent mature (VI and VII) oocytes were recorded while in control around 57% oocytes contributes maturing (IV and V) stage, which clearly indicates that Ovaprim is found to be highly effective on the oogenesis. The immature oocytes were not seen at all probably because of the peak vitellogenic period of fish while taking up the hormonal experiment.

Ngamvongchon *et al.* (1988) found that one injection of LH-RHA ($20\mu\text{g/kg}$ body weight) induced Gunther's walking catfish, *Clarias macrocephalus* Gunter, to ovulate within 16-18h after injection. But in the present study the dose of LH-RHA administered to freshwater featherback *Notopterus notopterus* was by single injection. The single dose of injection at the rate of $20\mu\text{g/kg}$ body weight caused the positive effect on oogenesis but ovulation was not encountered. Similar result was reported for induced final maturation and ovulation in female Pasu (*Piaractus mesopotamicus*) by Carolsfeld *et al.* (1988). They reported that $50\mu\text{g/kg}$

total dose applied as two split equal dose of injections at the rate of 25 $\mu\text{g/kg}$ was significantly more effective than a single injection of 50 $\mu\text{g/kg}$ in inducing ovulation. The present experiment revealed that LH-RHA 20 $\mu\text{g/kg}$ was found to be more effective than the 40 $\mu\text{g/kg}$ LH-RHA treated group while comparing percentage of different oocytes.

Gonosomatic index (GSI) and ova diameter of LH-RHA 20 μg and 40 $\mu\text{g/kg}$ treated fish showed that 20 $\mu\text{g/kg}$ have relatively more effective on ovarian maturation. However, 40 $\mu\text{g/kg}$ injected fish group showed an adverse effect of stress on ovarian development. The histological picture of ovaries of 20 μg treated LH-RHA revealed the positive effect on oogenesis, mostly maturing (III, IV and V) oocytes were found in this group with less atretics. However, 40 μg LH-RHA treated group exhibited relatively higher atretic follicles than 20 μg treated group showing the adverse effect of stress on ovaries due to comparatively higher dose of LH-RHA. Similar observations were reported by many workers (Catt *et al.*, 1979; Peter, 1980). They suggested that, administration of excessive dosage of LH-RHA and its superactive analogues would be detrimental due to self suppression response. But repetitive injection caused atresia and even death in species sensitive to stress as reported by Lam (1982). However, in the present study no death was encountered in the treated groups.

Experiment on *Cirrhina mrigala* by administering LH-RHA at the rate of 10 $\mu\text{g/kg}$ in a single injection, has been found to be very effective in causing spawning (Kaul and Rishi, 1986). The effect of LH-RH analogue treatment on egg maturation of brood stock females of Lake trout (*Salvelinus namaycush*) studied by Erdahl and McClain (1987) confirmed that either 10 or 20 $\mu\text{g/kg}$ LH-RHA was sufficient to induce ovulation. He opined that an overdose of LH-RHA has not resulted any adverse effects.

The present study revealed that LH-RHA promoted vitellogenesis in *Notopterus notopterus*. In other words, such exogenous LH-RHA treatment appear to mimic the required stimulus for induction of oogenesis and maturation.

In the treated groups of *Notopterus notopterus* induction of ovulatory response was not observed by LH-RHA at a dose level of 20 μ g and 40 μ g/kg, body weight. Similar result was also observed in *Gobio gobio* (Kestemont, 1988), in *Clarias batrachus* (Manickam and Joy, 1989). However, Manickam and Joy (1989) reported that simultaneous injection of LH-RHA and pimozide induced the maturation and ovulation in *C. batrachus* for which the combination can be used as a simple and efficient method.

Halder *et al.* (1991) found that treatment with CGnRH-Pimozide- Ca^{2+} combination resulted in significant increase in oocyte diameter and GVBD occurred both in catfish (*Clarias batrachus*) and perch (*Anabas testudineus*). Complete maturation of catfish and perch under captivity by CGnRH- Pimozide plus Ca^{2+} will indeed be an effective tool to manipulate the maturation and spawning in an artificial culture system. This would be highly advantageous for the fish, that can be easily raised in captive condition, as they are air-breathers and have high economic importance. Administration of testosterone in combination with LH-RHA is very effective as inducing maturation of trout (Crim *et al.*, 1988) and milkfish (Marte *et al.*, 1988). Similar study conducted by Fermin (1991) confirmed that hydration response of oocytes in bighead (*Aristichthys nobilis*) injected with HCG + LH-RHA and LH-RHA + DOM caused significant increase in oocyte diameter. According to De Vlaming (1974) oocyte enlargement due to hydration occurs in concomitance with maturation, the mechanism of which is said to be hormonally stimulated.

In the present experiment treatment with 20 µg/kg and 40 µg/kg LH-RHA alone administered intramuscularly appears to be very effective in air-breathing fish *Notopterus notopterus* since there is rapid increase of oocyte diameter by 157.5 µ and 60.65 µ more respectively when compared with that of the control. With the help of LH-RHA administered exogenously there appears to have enough possibilities to induce the precocious maturation and ovulation in a captive condition.

Experiment carried out by LH-RHA pellete implantation to *C. batrachus* weighing 150 g and above individual at a dose of 100 µg resulted in spawning (Rao *et al.*, 1991). Although in the present experiment such pellete implantation has not taken up, but the present observation revealed a positive action of LH-RHA for maturation in *N. notopterus*. The use of exogenous hormone in Indian major carps especially gonadotropin has resulted positive action on oogenesis (Vardia, 1993). Similar observations were reported in *Channa punctata* (Rath, 1980); in *C. batrachus* (Rath and Das, 1993); in *Heteropneustes fossilis* (Nayak and Singh, 1995); in *Oreochromis mossambicus* (Personal communication).

At present, much of the literatures are available up on spawning of Indian major carps and exotic carps by use of Ovaprim (Nandeeshha *et al.*, 1990 b, Rath and Das, 1993). However, Literature on the precocious maturation by use of Ovaprim in carp and other commercially airbreathing fish groups are not available. Therefore, in the present study, Ovaprim was used to ascertain its effectiveness on precocious maturation of freshwater featherback *N. notopterus*.

Nandeeshha *et al.* (1990 b) in their preliminary trials used Ovaprim at 0.5 ml/kg for inducing successful spawning in catla. They reported that even a lower dose of 0.4 ml/kg is effective in causing spawning.

The trial conducted by a group of scientists sponsored by the Asian Fisheries Society in different states of India revealed the excellently uniform spawning response of rohu to Ovaprim administration. The dose generally varied from 0.25-0.4 ml/kg. Ovaprim as inducing agent to mrigala in various states conducted by group of Scientists showed positive results. The dose beyond 0.3 ml/kg. resulted in plugging, believed to be due to overdose of hormone or over handling of brooders resulting in clumping of eggs which blocked the oviduct (Nandeeshha *et al.*, 1990c). Sharma *et al.* (1993) studied the breeding of Indian major carps and Chinese carps with Ovaprim in different agro-climatic conditions of U.P and reported that dose rate as recommended by earlier worker did not cause spawning in carps under different agroclimatic conditions. In the present study the experiment was undertaken during the vitellogenic period of the fish, but still there arises a steady increase in GSI (0.28) and PI (0.074) more than that of control.

In the present study, the freshwater featherback *Notopterus notopterus*, consistently revealed the bigger size of eggs, completely matured, deep yellowish coloured with less atretics than that of control group. The histological picture of the ovaries undergoes various changes. The oocytic diameter of the ova in treated group was 147.5μ more than the control. Moreover, fully matured oocytic stages of VI and VII were observed. In contrast, few mature and maturing oocytes were found in the control. This may be attributed to the fact that Ovaprim has caused complete development of eggs in the ovary probably due to the endogenous gonadotropin action.

SUMMARY

The investigation on some aspects of biology, ovarian histophysiology and effect of hormones on ovarian maturation in *N. notopterus* was carried out in the P.G.Dept of Aquaculture, which revealed the following important observations.

1. The biological parameters in the present study indicated several important morphometric relationships. The length ranging from log. 1.12 to log 1.48 cm with weight ranging from log 1.18 to log 2.48 g showed a linear relationship indicating that when length increases, the corresponding weight also increases proportionately.
2. The relationship between length of the body with that of length upto dorsal fin, length upto anal, length upto pectoral, length upto pelvic and length upto pectoralis were also found to be linear in *N. notopterus*.
3. In the present study the specimens of length group (13.0 to 16.0 cm) are immature and the size range group (17.0 to 25.0 cm) are the mature ones.
4. The dominance of the female in the length group between 22.0 to 31.0 cm suggested that perhaps the longevity of female may be more. However it is observed that when the length increased, number of individuals decreased.
5. It is observed that the ponderal index was 0.681 during the month of Dec.-Feb. coinciding with preparatory cum active phase of the ovarian cycle. The ponderal index was recorded to be 0.737 during the month of March to August coinciding with active phase. This increase in ponderal index signifies the better maturity condition of the fish. The fall in the values of ponderal index to 0.67 during the month of Sept.-Nov. coincide with quiescent cum preparatory phase of ovarian cycle in *N. notopterus*.

6. In the present study the ponderal index of *N. notopterus* increased with the length of fish upto 18.9 cm and then there was a secondary fall. This increased or decreased in 'K' value is related to length and that the 'K' value can also be used to determine the size at first maturity. The decline of the PI value is attributed due to increased metabolic strain because of spawning in older age groups related to the feeding rate of the fish. The rise and fall of PI is entirely related to the cycle of breeding.
7. It is accepted that, usually males mature earlier with relatively small size group (14.0 cm), than that of the female. Usually females mature in the length group of 17.0 cm.
8. The value of relative condition factor (Kn) in the present study increased with the approach of spawning and receded at the end of spawning season.
9. The value of gonosomatic index increased with the approach of spawning season and receded at the end of spawning season indicating a single active period in the present investigation.
10. The correlationship between weight of ovary and weight of liver during the month from Dec.-Feb. and from Sept.-Nov. were positive, indicating their interdependance. However, there is a negative correlationship during the active phase of ovary which might be due to transfer of reserve material from liver to ovary for vitellogenesis.
11. The average number of fecundity in *N. notopterus* varied from 195.0-1315.0 with the length range from 17.0-34.9 cm. The average number of ova per g weight of ovary varied from 79.60-115.69 and the number of ova per g body weight varied from 3.38 to 5.63 with the length ranged from 17.0-34.9 cm. The peculiarities observed in the present study revealed that the number of ova per g ovary weight increased from the length ranged from 17.0-26.9 cm but decline thereafter. Such decreased in number of ova

per g ovary weight is probably due to higher age group of the fish. This suggests the negative impact of age on fecundity. The fecundity of *N. notopterus* was found to be linear with respect to its logarithmic forms of body length, body weight and ovary weight.

As mentioned earlier the lower number of eggs does not prove to be disadvantage in reproductive potential. However, low fecund fish can be attributed to exhibit parental care towards their progeny in order to compensate ova paucity.

12. The present study revealed seasonal changes in the ovarian morphology of *N. notopterus* in the populations around Bhubaneswar area. Six morphological stages of ovary were identified of which stage I-II are immature, III, IV are maturing, V is mature and VI is the spent stage.
13. Histologically the process of oogenesis passes through the phases of multiplication, growth and maturation during which the oocyte grows as cell and accumulates nutritive reserve (yolk).
14. In the present experiment seven oocytic stages were clearly defined in *N. notopterus* on the basis of nuclear and cytoplasmic characteristics of which stage I and II are immature, III, IV and V are maturing and VI, VII are mature ones.
15. The seasonal changes of ovarian cycle was found to vary on different geographical and agroclimatic conditions of localities. The seasonal changes of ovarian cycle in *N. notopterus* passed through three distinct reproductive phases namely
 Preparatory cum active (Dec.-Feb.)
 Active cum quiescent (Mar.-Aug.)
 Quiescent cum preparatory (Sept.-Nov.).

16. The breeding period of the species mostly coincide with rainy season in Bhubaneswar area. In the present study *N.notopterus* belongs to group asynchronism and has a long active phase that extends from midsummer (i.e. March) to rainy season (up to August) indicating monophasic breeding cycle of the fish.
17. Observation reveals a 'stage specific change' in the morphology and accumulation of yolk materials. The oocytic components such as yolk nucleus, nucleus (germinal vesicle), follicle cells showed most dramatic changes during oogenesis.
18. In the current study histochemical observations revealed that three types of yolk and ribonucleic acid (RNA) are present in the oocytes.
19. In the present study the choline type of lipid (hydroxy ethyl trimethyl ammonium hydroxide) a saturated amino alcohol compound which occurs in lecithin was detected in maturing oocytes (i.e. III, IV and V). Moreover the extra and intravesicular lipid yolk globules were found in the growing oocytes. In the mature (i.e.VI, VII) oocytes besides extravesicular yolk globules, the follicular layer were also stained indicating the possibilities of extraneous source of lipid origin in the growing oocytes.
20. The immature oocytes were completely negative for PAS, indicating the absence of carbohydrate. With the growth of oocytes (stage III), small vesicles appear with minute PAS positive granules at the peripheral ooplasm. Further the oocytes grow large in their size with increasing PAS positive globules which spread centripetally. The extra and intravesicular yolk bodies were found to be PAS positive. However, in stage VI and VII oocytes, polysaccharides were restricted to intravesicular yolk bodies at the cortex. This indicates probably that the carbohydrate in the extravesicular yolk bodies was either utilised or transferred to cortical alveoli.

21. It can be stated that during various stages of pre-vitellogenesis and vitellogenesis, a large amount of RNA is synthesised to contribute different types of autosynthetic protein during oogenesis and also utilized during embryogenesis.
22. Protein yolk was localised in the cytoplasm of oocytes throughout oogenesis. Yolk nucleus and extravesicular yolk globules were stained indicating concentration of protein. The proteid yolk granules first appeared in the cortical region of the oocytes and then filled the entire ooplasm.
23. In the present experiment three types of proteid yolk were observed. They are glycoprotein, lipoprotein and protein.
24. The cytochemical techniques employed in the present study demonstrated the formation of protein yolk possibly from the cytoplasm in association with cytoplasmic organelles in stage III and IV oocytes and through nuclear emission in subsequent stage of oocytes in *N. notopterus*. This confirm autosynthesis of protein yolk in this species. However the sequence of localisation and further accumulation in the cortical region indicates heterosynthetic protein yolk formation in this species.
25. The long term therapy of LH-RHA and Ovaprim stimulated oogenesis in *N. notopterus* during previtellogenic and vitellogenic period indicating its stimulatory action on secretion and release of gonadotropin from pituitary.
26. In the 20 μ g and 40 μ g per. kg body weight LH-RHA treated fish, the mean GSI, mean PI and average ova diameter showed a significant increase from that of all the control groups.
27. In the LH-RHA 20 μ g treated fish upto V oocytic stages were encountered while in control, it reached the IV stage only. Moreover, the maturing oocytes (III,IV,V) were accounted 70% more than the control. However,

maximum percentage of stage IV oocytes (69%) was encountered in the treated groups which was 40% more than the control. The value of mean GSI, mean PI and average ova diameter were found to be higher and significant at 5% level of population when compared with that of control.

28. In LH-RHA 40 μ g treated group the values of mean GSI, mean PI and average ova diameter were found to be higher than that of control, indicating the positive effect of hormone on oocytic maturation. Moreover, the present experiment revealed that LH-RHA 20 μ g per kg was found to be more effective than the 40 μ g per kg LH-RHA treated group, while comparing the percentage of different oocytes. However, 40 μ g per kg injected fish group showed an adverse effect of stress on ovarian development which is due to excessive doses of LH-RHA administered. This would probably be attributed due to self suppression response in *N. notopterus*.
29. In Ovaprim treated group the mean GSI, mean PI and the average ova diameter were found to be higher than that of the control, indicating the positive sign on its effect. In the Ovaprim treated fish the oocytic stages reached cent percent mature (i.e. VI and VII) while in control around 57% oocytes contributes maturing (i.e. IV and V) stage which clearly indicates that Ovaprim is highly effective. Comparing the efficacy of LH-RHA with that of Ovaprim, it is apparent from the values of mean GSI, mean PI and average ova diameter that, Ovaprim is superior than that of LH-RHA in its action, probably due to presence of dopamine antagonist that inhibits the gonadotropin releasing inhibiting factor in the hypothalamus.
30. Thus such exogenous LH-RHA and Ovaprim treatment appear to mimic the required stimulus for induction of oogenesis and maturation in *N. notopterus*.

CONCLUSION

Out of the several biological parameters studied during the , of investigation, reveals a linear relationship between log length and log weight of the species. The other biometrical relationship viz., length of the body with respect to length upto dorsal, anal fin etc. are also found to be linear suggesting when length increases the corresponding parameters also increases proportionately. Length frequency study also reveals that the longevity of female is more but the number of individual decreases with increase in length. The males usually mature earlier than that of females in *N. notopterus*.

Study on ponderal index indicates the ovarian cycle of the fish which passes through distinct phases. The PI value increase during the active phase while its value recedes during the prespawning and postspawning periods. The value of gonosomatic index and condition factor also follows the same pattern of ovarian cycle with that of ponderal index.

A negative correlationship exists between the weight of ovary and liver during the active phase of the ovarian cycle. This negative correlationship between ovary and liver can be attributed due to transfer of reserve material (yolk) from liver to ovary during vitellogenesis. However, positive correlationship exists during the prespawning and postspawning periods which indicates their interdependance.

A negative impact of age on fecundity of the species was observed. Although the fecundity in this species was found to be low but such low fecundity does not prove to be detrimental in reproductive potential. Inturn the low fecund fishes exhibits parental care to compensate ova paucity.

The species exhibits distinct seasonal changes on morphology and histology during ovarian cycle. Six distinct morphological stages of ovary and seven oocytic stages were clearly identified based on different characteristics. The ovarian cycle passes through preparatory cum active (Dec.-Feb.), active cum quiescent (Mar.-Aug.) and quiescent cum preparatory (sept.-Nov.) phases. The species showed monophasic ovarian cycle with single spawning period mainly coinciding with the monsoon in Bhubaneswar area.

Cytochemical studies revealed three types of yolk bodies and ribonucleic acid (RNI) in the growing oocytes during oogenesis. The ribonucleic acid is utilised for protein synthesis in growing oocytes. However, three yolk bodies chiefly consist of lipoprotein, glycoprotein and protein. The appearance of proteid yolk first in the cortical region and subsequently filled the entire ooplasm confirmed autosynthesis of proteid yolk in this species. However, the sequence localization and further accumulation in the cortical region indicates heterosynthetic protein yolk formation.

Long term therapy of LH-RHA and Ovaprim at different doses were studied to ascertain their effects on ovarian maturation. The study reveals that administration of 20 μ g LH-RHA per kg body weight of the fish was found to be more effective than that of 40 μ g LH-RHA per kg body weight in enhancing ovarian maturation. The group of fishes treated with 40 μ g per kg body weight showed an adverse effect of stress on ovarian development. The group of fishes treated with Ovaprim showed positive response in ovarian maturation. When the effects of LH-RHA was compared with Ovaprim it was observed that the efficacy of Ovaprim was found to be better. The probable reason for better efficacy of Ovaprim may be due to the presence of dopamine antagonist which inhibits the gonadotropin releasing inhibiting factors in the hypothalamus.

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