ON SOME ASPECTS OF THE BIOLOGY OF *LACTARIUS LACTARIUS* (SCHNEIDER)

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Among the lesser known fishes of India, the big-jawed jumper *Lactarius lactarius* (Schn.) is a prized table fish. Sometimes when there are heavy catches it is also cured. From Madras, Chid mb ram and Venkataraman (1946) and Devaresan and Chidambaram (1953) gave brief notes on the food of this species. Further Chacko (1949), Venkataraman (1960) and Basheeruddin and Nayar (1961) mentioned the items found in the stomach contents of this species from the coastal waters of Gulf of Mannar, Malabar and Madras respectively. The present paper deals with the observations made by the author, on food and feeding habits, size at maturity, maturation and spawning. sex ratio, fecundity, growth and length-weight relationship of this species off Waltair during the period 1959–60.

Material and Methods

Regular collection of material was taken up, in June 1959, and was obtained from three fishing centres, *i.e.*, Bhimilipatnam, Waltair and Pudimadaka. The former centre is 20 km north of Waltair, the second one in Waltair and the third about 50 km south of Waltair. The samples were fixed entire in 5% formalin and brought to the laboratory for detailed studies.

For the studies of food and feeding habits, the stomach contents were analysed qualitatively and quantitatively. The total volume of gut contents was determined by the displacement method. The items were identified upto genera as far as possible and their numbers counted and percentage occurrence estimated. For the determination of ponderal index, the weight length data were analysed for various size groups during different months of the year. The ponderal index (K) was determined by the usual formula $K = 100\ W/L^3$

when W = weight in gms and L = length in centimetres. The values were calculated for individuals and averaged for different size groups and months.

For fecundity studies mature ova from fish in maturity stages IV and above were counted. Two small portions of the ovary from the middle region were taken and weighed. All the mature ova contained in them were counted. Dividing the weight of the ovary by the sample weight and multiplying by the number of eggs in the sample, the number of mature eggs in the ovary was estimated.

For the study of maturation and spawning frequency, the methods described by Clark (1934), Hickling and Rutenberg (1940) and Prabhu (1956) were adopted. The diametres of one thousand ova were measured from each fish with ocular micrometer.

For the length frequency studies, the length frequency data of samples. examined from Waltair over the period from June 1959 to November 1960 was taken into account. The total lengths were grouped into class intervals of 1 cm for each month and the percentage in each length group calculated.

For the study of relationship of body measurements to the total length, the following body measurements were taken of representative specimens of different size groups.

(1) Standard length from the tip of the mouth to the end of hypurals.

(2) Body length from the end of opercle to the end of hypurals.

(3) Length of anal from the tip of the snout to the anterior end of anal fin base.

(4) Depth of the body through pectoral fin base.

(5) Head length from the tip of the snout to the end of opercle.

(6) Depth through orbits.

(7) Least height of caudal peduncle.

The rate of growth of different parts of body in relation to increase in total length was determined by the tangent method (Crozier and Hecht, 1913). The tangent of each curve was calculated by dividing the vertical distance between two points on each line by the horizontal distance.

The relationship between standard length and total length was estimated by the usual method of least squares.

For studying the length-weight relationship, the length measurements were grouped into 1 cm classes and the average weight in each group determined. The average length (the mid-point of the size class) and average weight thus obtained were transformed into logarithms and the relationship estimated, as usual, by the method of least squares.

Food and Feeding Habits

Percentage of empty stomachs.—Of the total number of 1,883 stomachs examined, 493 had empty stomachs. The percentage of empty stomachs ranged from 14·2 in April to 53·0 in February (Fig. 1). It was relatively low from June to September (18–27%) but high from October to March (30–52%). However, during the subsequent months of April and May it was again low (12–20%).

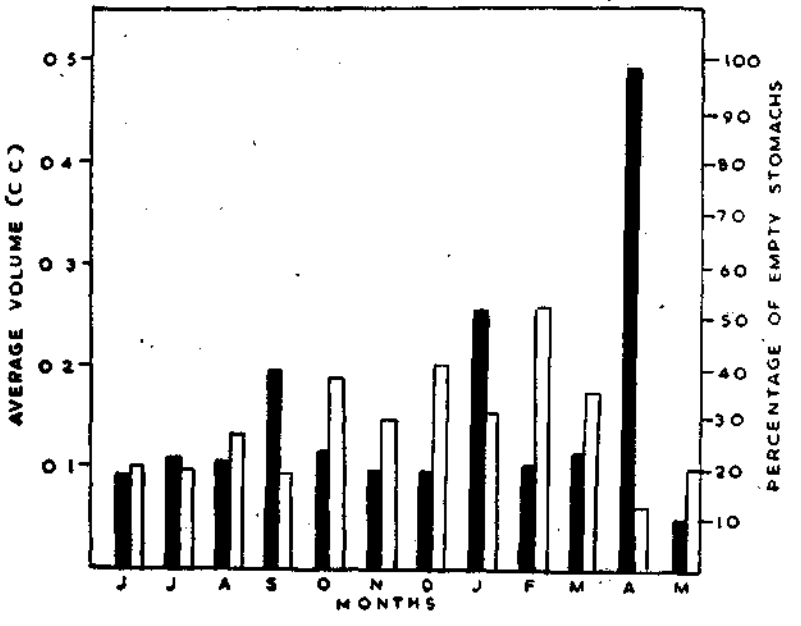

Fig. 1. Average volume per stomach (shaded bars) and percentage of empty stomachs (unshaded bars) during successive months in *Lactarius lactarius* (Schn.).

Average volume per stomach.—Except for minor variations, the average volume was approximately the same from June to August, October to December, February and March (0·09 to 0·13 cc) (Fig. 1). But it attained high values in September (0·19 cc), January (0·26 cc) and April (0·49 cc).

Items of diet.—The following items were observed in the stomach contents

TABLE I

Teleosteans	Crustaceans	Other items
Stolephorus sp.	*Acetes indica*	*Salpa* sp.
Thryssa sp.	Mysids	*Ceratium* sp.
Sardinella sp.	*Squilla* sp.	*Nereis* sp.
Leiongathus sp.	Megalopa larvae	Gastropod shells
Pseudosciaena sp.	*Penaeus* sp.	
Saurida sp.	*Metapenaeus* sp.	
Opisthopterus sp.	*Neptunus* sp.	
Dussumeria sp.	*Calanus* sp.	
Harpodon sp.	Alima larvae	
Trichiurus sp.	Euphausii s	
Leptocephalus	*Hippolytes* sp.	
Packets of cycloid scales		

A preliminary analysis of the seasonal variation of gut contents revealed that the fish fed chiefly on crustaceans and teleosts. The other items of food occurred in negligible quantities and were absent in most of the months.

The percentage occurrence of crustaceans and fishes is shown in Fig. 2. Occurrence of crustaceans ranged from 10·6% in January to 77·0% in September and that of fish from 12·0% in May to 44·0% in January. The percentage occurrence of crustacea was high from June to September (59–77%), but dropped to very low levels in December–February (11–12%). On the other hand December–February was the period of high percentage of occurrence of teleosts, it being comparatively low in other periods. The peak occurrence of teleosts was in January. From Fig. 2 it will also be seen that in regard to percentage occurrence, there was an inverse relationship between crustaceans and fishes.

SIZE AT MATURITY

The percentage of females at each centimetre length, which were found to have maturing gonads (stage IV and above), is plotted in Fig. 3. Fish

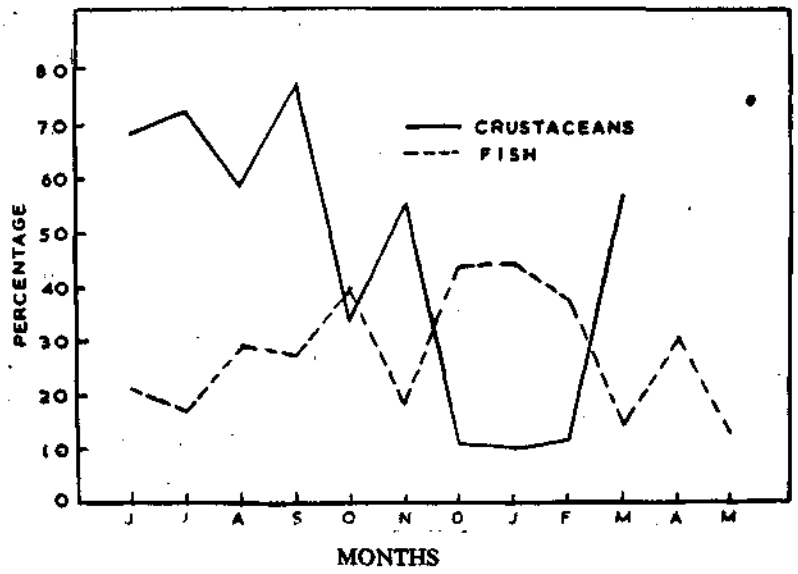

FIG. 2. Frequency of occurrence of the two groups of organisms in *Lactarius lactarius* stomachs during each month, expressed as percentage of total number of stomachs examined.

collected from August to April only were taken into account, since mature fish were obtained only during this period. It is evident that 50% of fish matured at 16·7 cm and above 18·8 cm all were mature.

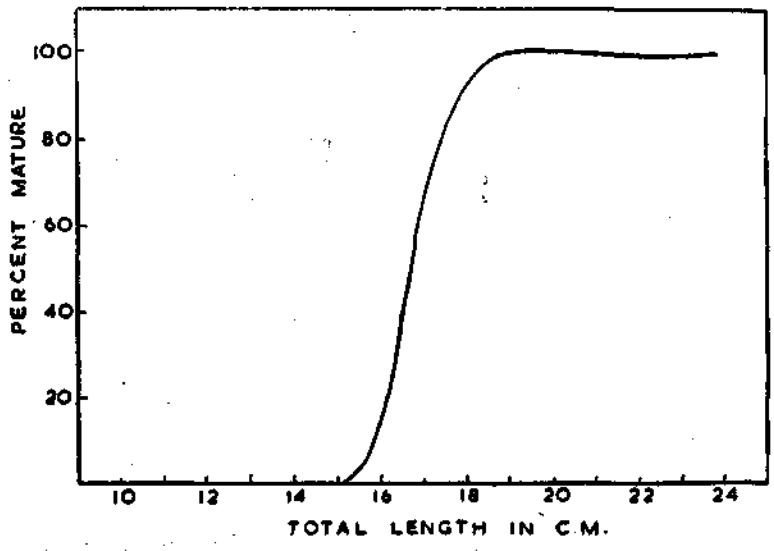

FIG. 3. Size at first maturity of *L. lactarius*.

Ponderal Index in Relation to Size

The average 'K' values at different lengths have been calculated and plotted in Fig. 4. It may be seen from the figure, the 'K' values increased upto 15 cm after which there was a rapid decrease to 17·5 cm. Thereafter a marked increase was seen again.

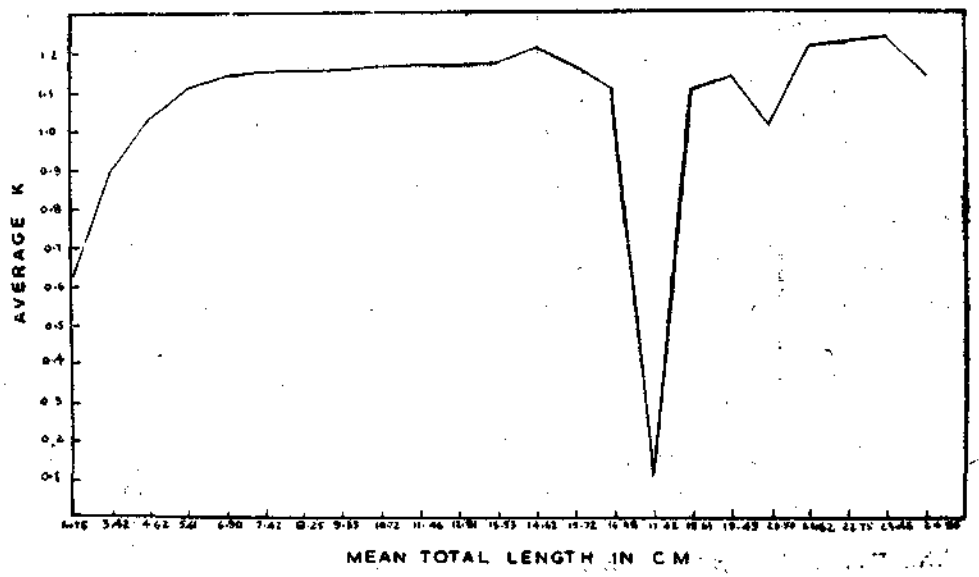

Fig. 4. Average 'K' ponderal index at different lengths of *L. lactarius*.

Seasonal cycle in relative condition.—In Fig. 5, the average 'K' values of specimens of *Lactarius lactarius*, collected during different months, are plotted. The graph shows a steady increase in the values, from August to November, falling thereafter. The values were very low from February to April.

Sex ratio and fecundity.—In all the samples collected males were in larger numbers than females, the ratio being 2·1. It was interesting to note that this ratio was practically constant, in the collections in all months.

Eighteen mature specimens, whose size varied from 15·7 to 22·5 cm, were examined to study the fecundity (Table II). On an average the mature ovary of *Lactarius lactarius*, contained 56,218 eggs.

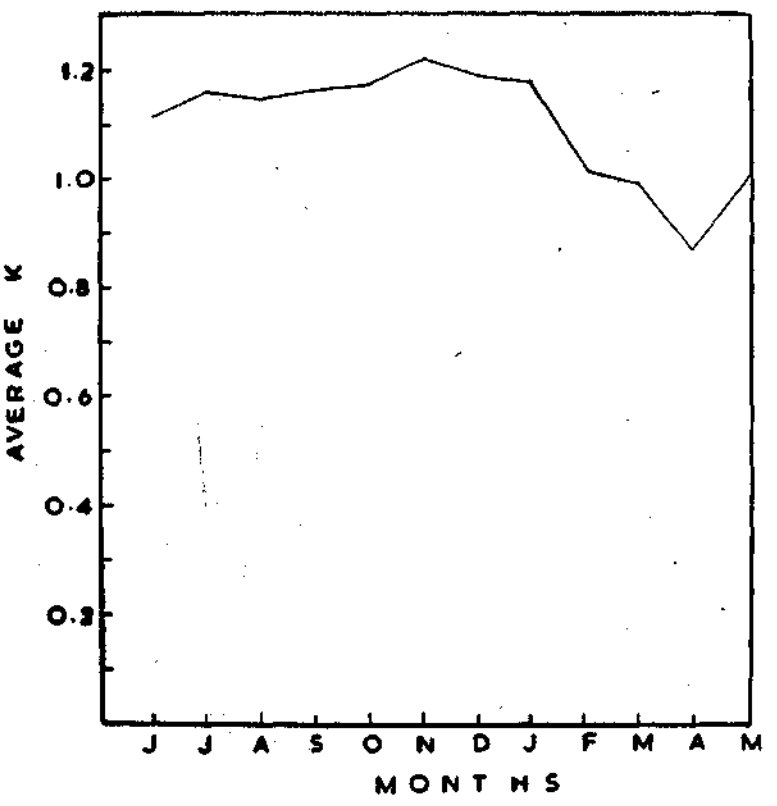

FIG. 5. Average 'K' ponderal index of *L. lactarius* during different months.

TABLE II

Size (in cm)	No. of specimens examined	Fecundity
15·1–16·0	1	19,155
16·1–17·0	1	18,102
17·1–18·0	3	31,726
18·1–19·0	3	34,184
19·1–20·0	4	53,012
20·1–21·0	1	91,037
21·1–22·0	2	104,195
22·1–23·0	3	98,335
Average		56,218

Maturation and spawning.—Figure 6 shows the size distribution of ova in the ovaries of fish in Stages III–VI whose size varied from 16·9 to 18·9 cm. Figure 6 A is based upon the values from an ovary of Stage III of maturity. There is a distinct mode '*a*' formed by the mature ova at 22 micrometer divisions. Besides the maturing ova, which are partially filled with yolk, a large number of immature eggs are also found. In Figs. 6 B and 6 C are shown the frequency polygon of mature ova from the ovaries of Stages IV and V. It was observed that the mode '*a*' at 22 micrometer divisions has shifted to 24 micrometer divisions (Fig. 6 B) and then to 28 micrometer divisions (Fig. 6 C), showing growth in the size of ova from Stages III to V.

In Fig. 6 D the frequency polygons of ripe ova from two ripe individuals (18·7 and 18·9 cm in total length) collected in February and March are presented. It is seen that the fully ripe eggs formed a mode '*a*' at 46 micrometer divisions. Since there is only one mode formed by the mature ova and as they are sharply separated from the rest of the stock of eggs, spawning period in this species could be regarded as not prolonged. Mature specimens of *Lactarius lactarius* occurred in the catches during November–April. Specimens with running ovaries were obtained, in the months of February and March. Thus it appears reasonable to conclude that the period of peak spawning in this fish is February–April. This is supported by the fact that very young fish measuring less than 5 cm are observed in the inshore catches during April–June. The occurrence of fully mature fish in the inshore waters during the spawning period indicates that the fish probably inhabits the inshore waters for spawning purposes.

Length Frequency Studies

The length frequency data are plotted in Fig. 7 in which the modes have been marked. The mode 'A' which was at 9·0 cm in June shifted to 11·0 cm in July and to 18·0 cm in December. The mode 'B' at 9·0 cm in July was represented by the modes at 10·0 cm, 12·0 cm., 16·0 cm, 16·0 cm, and 18·0 cm during August, September, December, January and February respectively. Further the mode 'C' at 8·0 cm in September shifted to 16·0 cm in March 1960. From what is stated above, it could be concluded that a group of fish with a modal size of 8–9 cm would probably attain a modal size of 16–18 cm within 6–8 months. This was further confirmed by the movement of 'D' from 8 cm in June to 15 cm in November 1960. In May 1960, a group of small fish with mode 'E' at 5 cm was recorded. Con-

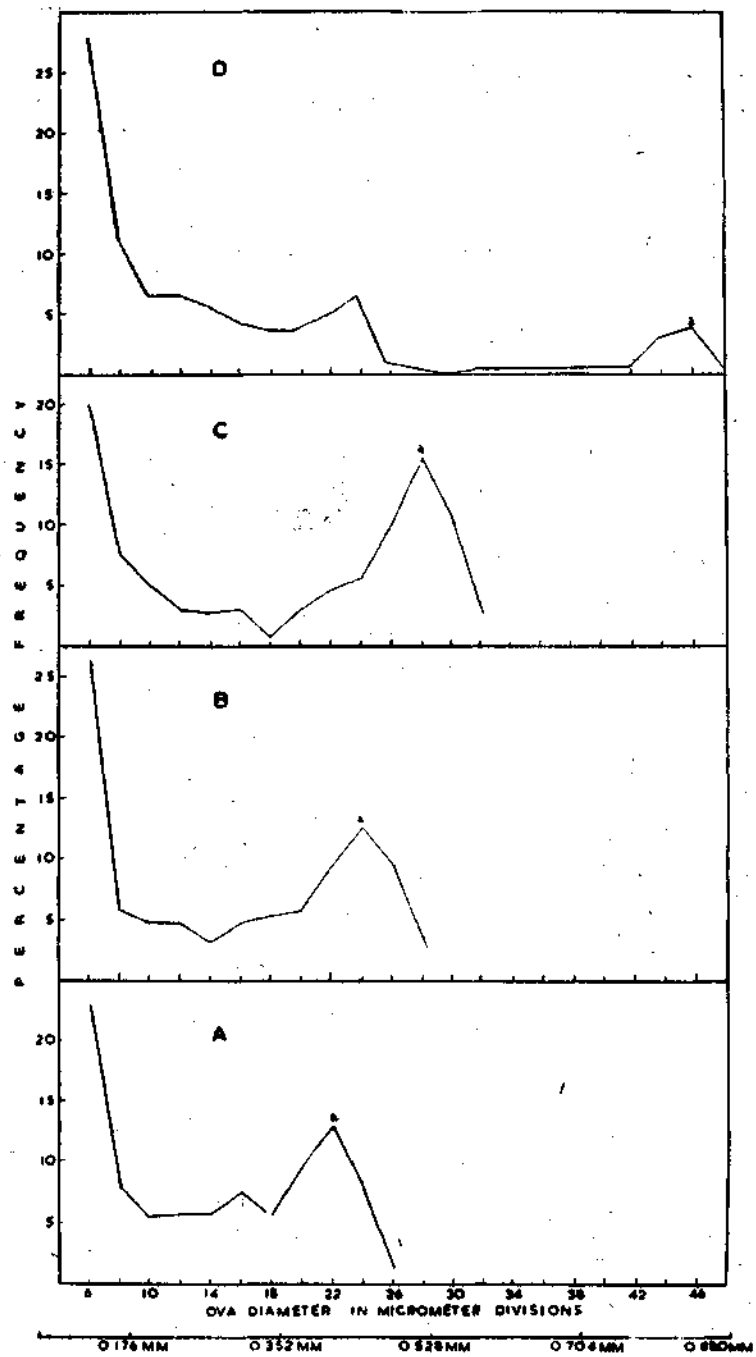

FIG. 6. Frequency polygons of ova diameter in the ovaries of *L. lactarius*.

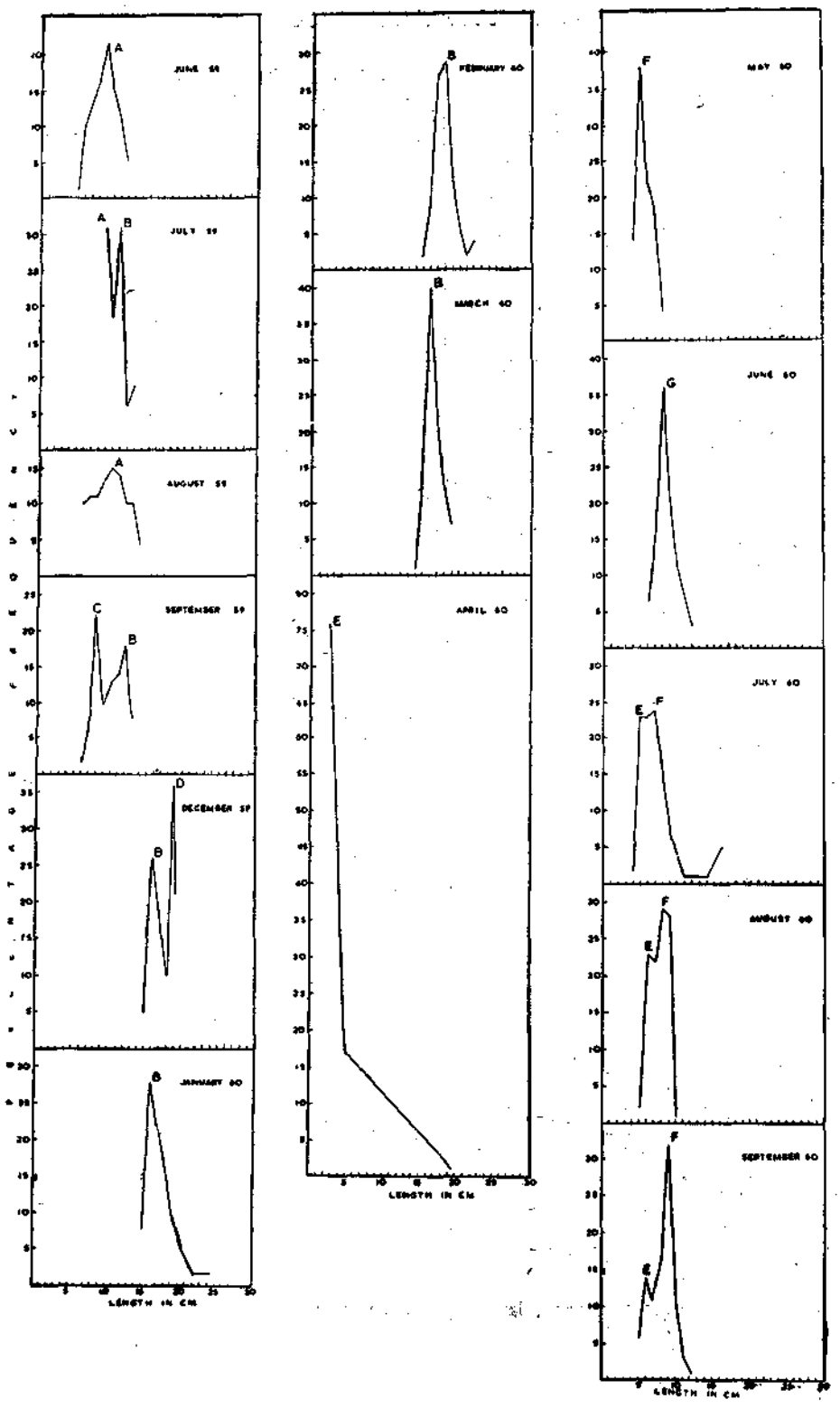

FIG. 7. Length-frequency distribu tions of *L. lactarius*.

sidering that peak spawning is from February to April this group could probably be regarded as offspring of March spawners. This mode 'E' moved to 9 cm in September, the age at that time could then be estimated as about 6 months. Another mode 'F' was seen at 5 cm in June 1960, which moved to 6 cm in next month, after which it could not be traced. Still another group of young fish was recorded in September 1960, with mode at 6 cm, which shifted to 7 cm in October 1960. The shifting of the modes 'F' and 'G' supported the conclusions on the growth of fish based on the movement of 'E'.

The discussion above indicates that the age of fish having a modal size of 8–9 cm could be regarded as about 6 months and that in another 6–8 months, it would perhaps grow to 16–18 cm. It would appear from this that the size of one year old fish could be regarded as 16-18 cm. Since most of the fish observed in the catches were less than 18 cm in length, the fishery would appear to be supported mainly by the 0-year class.

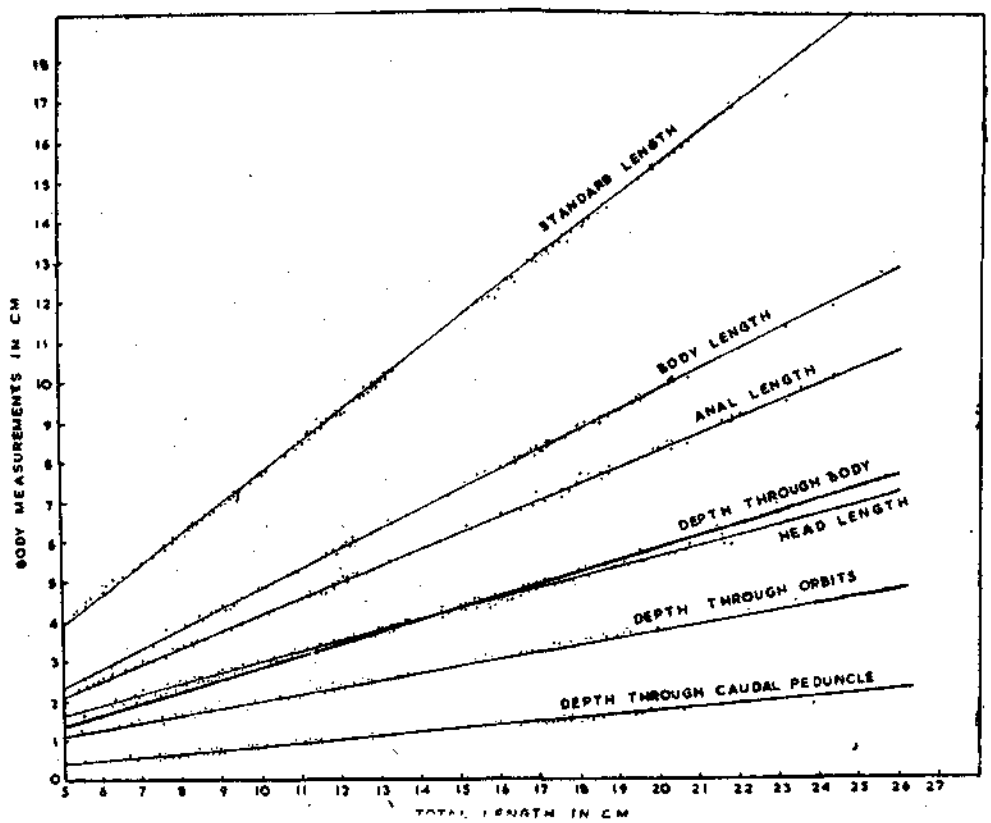

FIG. 8. Graph showing the relationship of body measurements to total length in *L. lactarius*.

Relationship of body measurements to total length (Fig. 8).—500 fish of length range 5–25 cm were examined for the investigation. The rate of growth of the various body parts in relation to total length (expressed by the tangent calculated as mentioned earlier) was:

Standard length	..	0·8000
Body length	..	0·5028
Anal length	..	0·4166
Depth through the body	..	0·2970
Head length	..	0·2576
Depth through orbits	..	0·1742
Least depth of caudal peduncle	..	0·0833

From the above it may be seen that the maximum rate of growth is in the standard length, and the rate of growth in the body length is 5/8 of standard length.

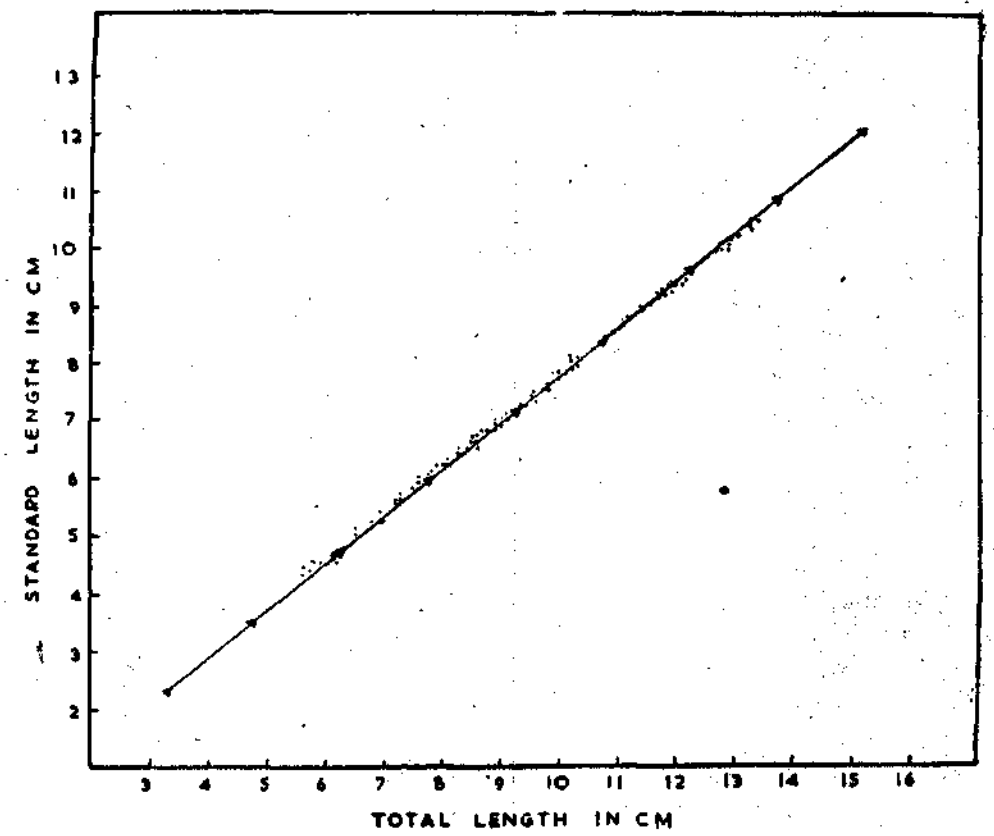

FIG. 9. Relationship of standard length to total length in *L. lactarius*.

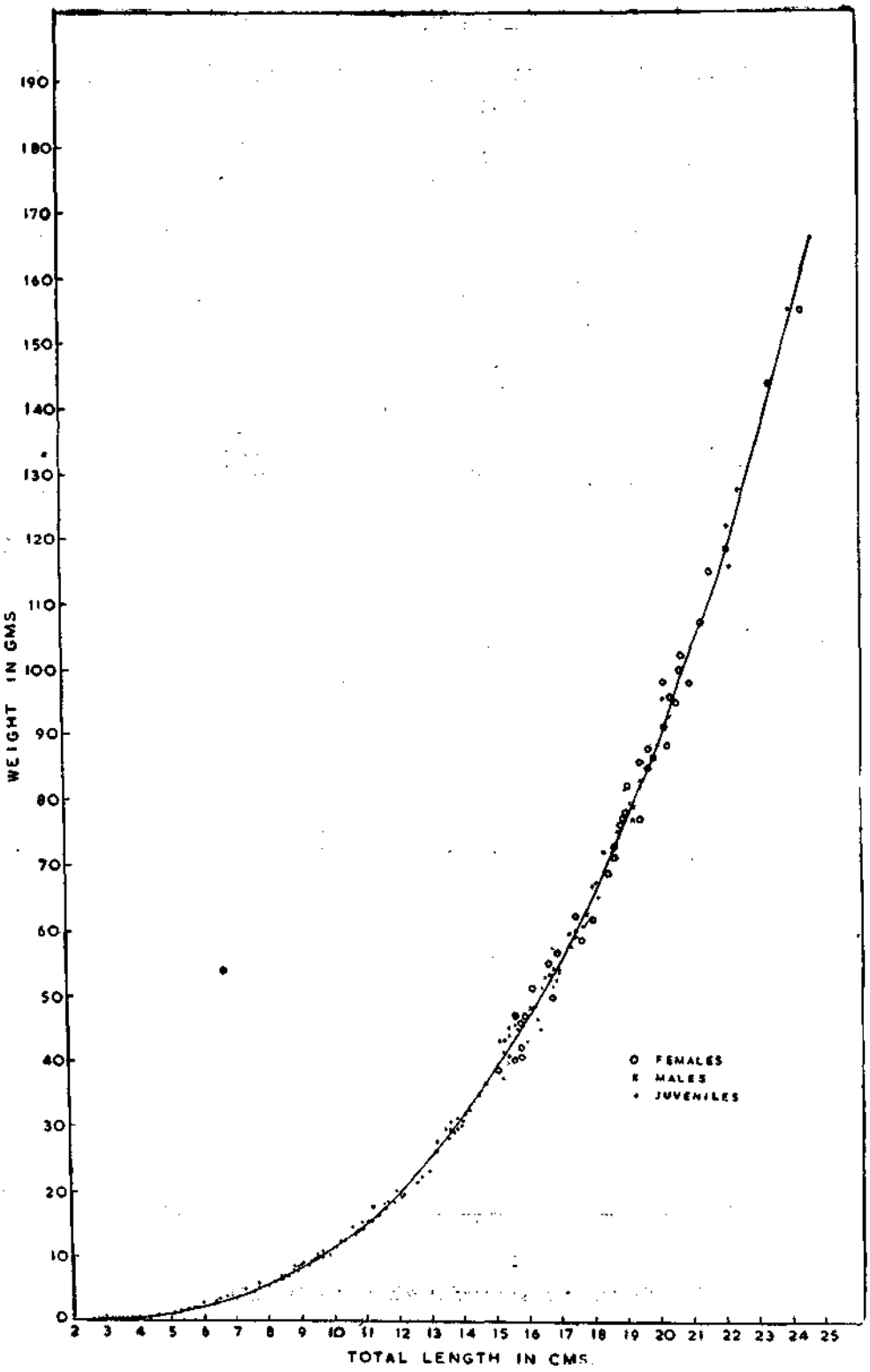

FIG. 10. Length-weight relationship in *L. lactarius*.

Relationship between total length and standard length (Fig. 9).—The estimated regression was $Y = 0{\cdot}81X - 0{\cdot}36$ when Y = standard length X = Total length. The correlation coefficient was 0·8879.

Length-weight relationship.—Although a primary division was first made into juveniles, males and females, it was seen that the same formula fitted the relationship for all the groups (Fig. 10). The estimated logarithmic relationship was

$$\text{Log } W = 2{\cdot}86186 + \text{Log } L - 1{\cdot}793602$$

and the parabolic equation

$$W = 0{\cdot}01608\ L^{2.86186}$$

Discussion

The study of stomach contents shows that from December to February fishes are more important than crustaceans as items of the diet of *Lactarius lactarius*. The probable reason for this becomes apparent when the size of the fish is taken into account. It may be seen from Fig. 7 that from December to February *Lactarius lactarius* caught in the inshore waters were above 15 cm in total length, whereas during the other periods, they were less than 15 cm. During this investigation the younger fish were seen to take more of crustaceans than fishes as diet. The seasonal change in the items of diet is therefore partly the result of seasonal changes in the size of *L. lactarius* inhabiting the inshore waters. Basheeruddin and Nayar (1961) also have observed that off Madras *Lactarius lactarius* less than 9 cm fed mainly on *Acetes* sp. and *Lucifer* sp.

The present study shows that *Lactarius lactarius* is a carnivore. Chidambaram and Venkataraman (1946), Chacko (1950), Devanesan and Chidambaram (1953) and Venkataraman (1960) had also come to the same conclusion. Chidambaram and Venkataraman (1946) recorded *Coscinodiscus* and *Rhizosolenia* in the gut contents of this fish. But the present author did not observe any diatoms in the stomach contents of this species.

Feeding activity was low in February–March when spawning activity was intense. During this period a fall in the ponderal index was also seen. From October to January also feeding activity was low compared to earlier months but there was no fall in the ponderal index. The fish at this time were in immature and maturing stages. This appears to indicate that spawning activity has stronger influence on ponderal index than feeding activity.

That there was no close correlation between spawning activity and feeding activity would also be evident from the present study.

It is seen that the drop in ponderal index commences at 15 cm. The size at 50% maturity is about 16·7 cm. The present observations to a large extent confirm those of Hart (1946) and Menon (1950) on the relation between ponderal index and maturation in fishes. That the fall in the monthly values of 'K' takes place only from February to April is also significant, since it lends further support to the conclusion arrived at from ova diameter frequency studies that spawning takes place only during a short period in a year.

Summary

1. Analysis of stomach contents showed that crustaceans and teleosts are the chief constituents of food. *Acetes indica* was the most important item among the crustaceans and *Stolephorus* sp. among fishes.

2. The average 'K' values at different lengths show that there is a decrease in the 'K' values between 16 and 18 cm. From the observations made it is seen that 50% of the fish mature at the size of 16·7 cm and at 18·8 cm all are mature.

3. By the study of the frequency distribution of intra-ovarian eggs, it is inferred that the spawning period extended from February to April.

4. There is a decrease in the average 'K' values from February to April; this is also the spawning period as determined from the study of mature gonads.

5. The male to female ratio was 2:1.

6. Length frequency distribution studies show that the fish attains a size of 16–18 cm at the end of the first year of life. The commercial catches mainly consist of 0-year group.

7. The study of various body proportions of the fish in relation to total length has shown that the standard length and least depth of caudal peduncle have the maximum and minimum rates of growth respectively.

8. The relation between total length and standard length is found to be $Y = 0 \cdot 81X = 0 \cdot 36$ where Y is the standard length and X is the total length.

9. The length-weight relationship is expressed by the formula: $W = 0{\cdot}01608\ L^{2.86186}$ where W = weight in grams, L = length in cm.

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