STUDIES ON THE BIOLOGY OF COMMERSONI'S GLASSY PERCHLET AMBASSIS COMMERSONI (CUVIER)

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BY

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CERTIFICATE

Mrs. Sushma Bumb has been working under my guidance since 1987. The Ph.D. thesis entitled "Studies on the Biology of Commersoni's Glassy Perchlet Ambassis commersoni (Cuvier)", submitted by her, contains the results of her original investigation on the subject. This is to certify that the thesis has not been the basis for the award of another research degree or diploma of any University.

Research guide

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A C K N O W L E D G E M E N T

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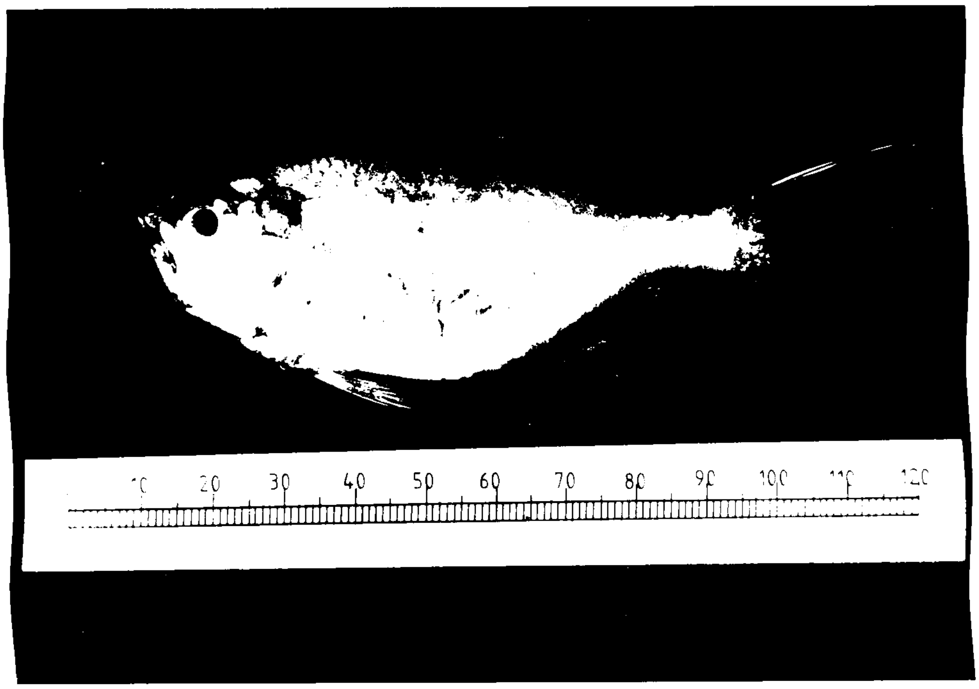


Ambassis commersoni (Cuvier)

INTRODUCTION

Fish as a food is one of main sources of protein. Fish not only gives a wide range of food stuffs, but also can be used as a source of drugs and pharmaceuticals. The size, chemical composition and food value of fish depends on age, sex, physiological state in relation to its surroundings. Towards the proper use of fish as a source of food and further as a renewable and self generating resource, it is necessary to know about its biology and ecology.

In India, as elsewhere, extensive documentation, on biological aspects of numerous species of marine, estuarine and freshwater fishes, is on record. However, few species, like Ambassis commersoni, (Cuvier) still remains to be studied in detail. This common species (A. commersoni) extends from the Red Sea thróugh India to North Australia. In India, it is found in estuarine and nearshore waters along both the west and the east coast. A minor fishery of A. commersoni Fig. 1a, Plate 1 flourishes in the estuaries of Goa (Fig. 1) along the west coast of India.

A. commersoni commonly known as the "commersoni's glassy perchlet" is one of the commonest fish of Goa. It occurs in shoals which can easily be detected in the shallow water due to the silvery outline of the fish. Even though it is caught throughout the year, the main fishing season is from June to September which coincides with the south-west monsoon season.

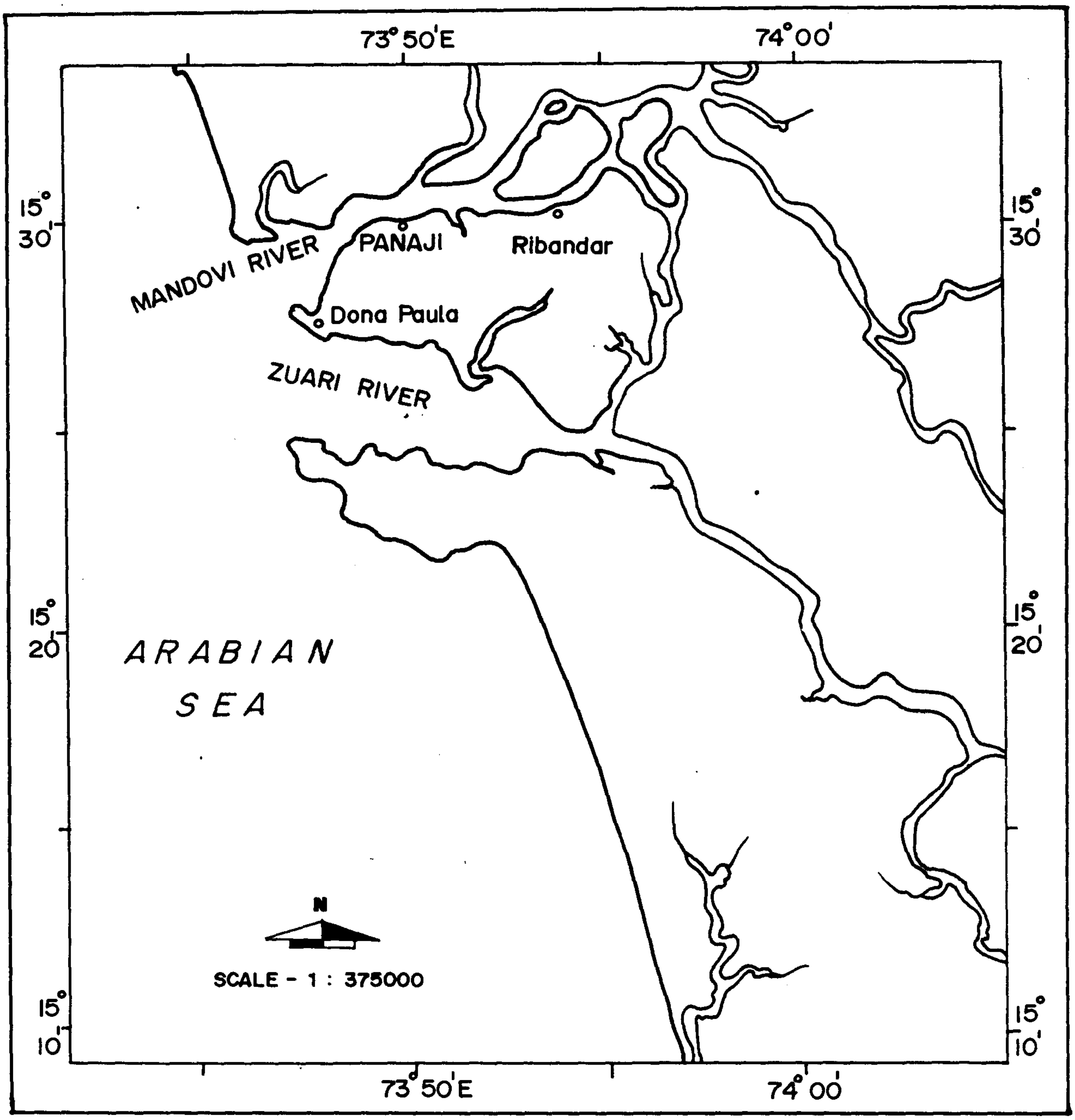


Fig. 1 Map showing the location of stations in Mandovi Estuarine system.

It is generally consumed fresh by poor people especially in monsoon season, when other species of fishes are not readily available.

The biology of the fishes of the family, Ambassidae have not been studied in great detail and earlier reports pertains to food and feeding; maturation and spawning; development of larval stages (Delsman, 1926; Job, 1941; Bapat and Bal, 1952; Nair, 1952; Nair, 1957; Kuthalingam, 1958; Venkataramanujam, 1972; Royan and Venkataramanujam, 1975; Venkataramayan, Ramamoorthi and Rodrigo, 1976) early life history (Laskeer and Shermank, 1981; Venkataramanujam and Ramamoorthi, 1981; Nair et.al, 1983; Mauge LA, 1984; Nair, 1984; Venkataramanujam and Venkataramani 1984); Semple, 1985) and cadmium induced vertebral deformaitries (Pragtheeswara, V., et al. 1987).

In view of the facts noted above, an attempt has been made here to study the biology of A. commersoni which includes maturity and breeding season, spawning periodicity, minimum size at maturity, fecundity estimates, ponderal index as influenced by maturation cycle, food and feeding habits, length frequency distribution, length weight relationship and biochemical analysis of edible parts (muscles) of the fish.

II. SYSTEMATIC POSITION
POSITION OF AMBASSIS COMMERSONI

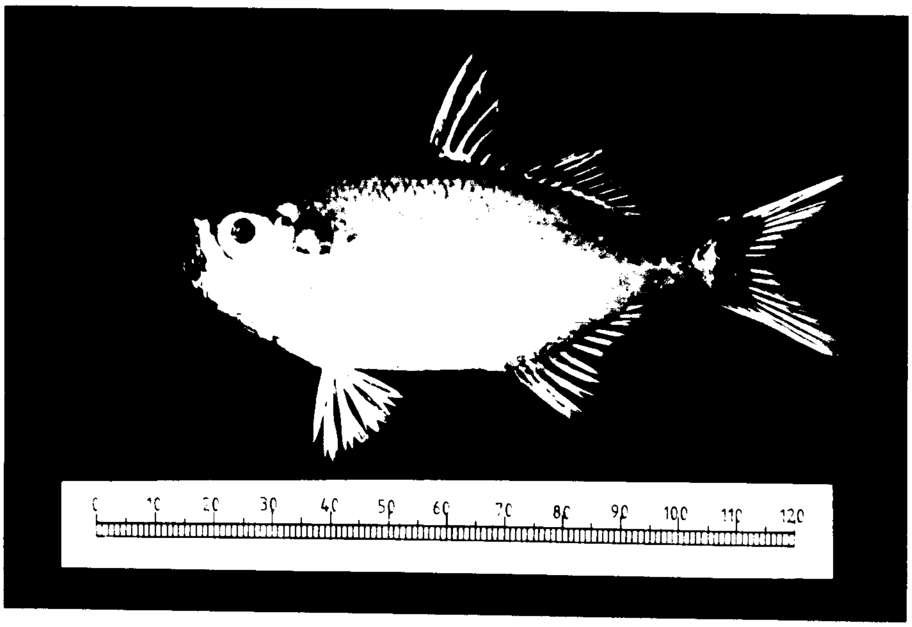


Plate-1 *Ambassis commersoni* (Cuvier)

SYSTEMATIC POSITION OF THE COMMERSON'S GLASSY PERCHLET *AMBASSIS COMMERSONI* CUVIER

Ambassis commersoni, Cuvier is a bony fish belonging to class Teleostomi, order - Perciformes, sub order - Percoidei and Family Ambassidae.

The family Ambassidae is well represented in the coastal waters and estuaries of tropical and sub-tropical areas of Red Sea, East Coast of Africa through the seas of India, Malay Archipèlago to North Australia and even beyond as reported by Day (1889).

Family Ambassidae

Small perch like fishes with compressed body, more or less dimorphous with easily shed cycloid scales moderate or small size frequently deciduous. Oblique mouth with fine villiform teeth on jaws, vomer and palate, sometimes on the tongue, canines rarely present. A forwardly directed recumbent spine in front of the base of dorsal fin. Scaly sheath at the base of dorsal and anal. Operculum with single poorly developed spine. A characteristic feature of the family is the double edge of the preoperculum, so that this bone may be said to have an edge and ridge, the lower edge is nearly always dentate. The hind limb edge is entire in several specimens. Dorsal fin of two continuous parts separated by a notch between the last and penultimate spines. The first dorsal fin with 7 spines and a procumbent spine, and the second dorsal fin with one spine and 9 to 17 soft rays. Anal fin with 3 spines and 9 to 16 soft rays. Pelvic fin with one strong spine and 5 soft rays with an auxiliary scale. Caudal fin forked, lateral line complete, simply interrupted or very distinctly broken.

Fishes of small size (generally under 10 cm.) in the Indo West Pacific Region, enter estuaries and penetrate to freshwater. Usually brilliant or silvery white in colour.

Key to Genus: Ambassis

1. Scales large, 25 to 30 in the longitudinal series; 1 or 2 transverse rows of scales on cheek.
2. Scales relatively small, 40 or more in longitudinal series; 4 or more transverse rows of scales on cheek.

Ambassis, Cuvier 1828

= Chanda Hamilton (ne Buchanan), 1822, fishes Ganges - 370

= Ambassis Cuvier, in Cuvier and Valenciennes, 1828. Hist. nat. Poissons, 2: 175, type species Centropomus Ambassis lacepide, 1801, designated by Bleeker, 1874 = Lutjenus gymnocephalus lacepide, 1801.

= Priopin (Kuhl and Van Hasselt) Valenciennes, Cuvier and Valenciennes, 1830, 6: 503, type species, Priopis argyrozona (k f v.II) Valencieenes, 1830 by monotype.

= Parambassis Bleeker, 1874. Rev. Ambassis, Natuurk. Vehr. Holland maatsch. Wet. 3 Verz. 2: 102, type species

Ambassis apogonoides Bleeker, 1851, by original designation.

= Pseudambassis Bleeker, 1876, Systema percarum revisum, Archs. neerl. Sci. nat. 11(2); 292, type species Pseudambassis lala Bleeker = Chanda lala Hamilton (ne Buchanan), 1822, by original designation.

Distinguishing characters of the Genus - **Ambassis**

Branchiostegals **six** : pseudobranchi well developed. Body compressed, more or less diaphanous. Lower limb of preopercle with a double serrated edge. Opercle without prominent spine. Villiform teeth on jaws, vomer and palate sometimes on the tongue, canines rarely present. Two dorsal fins, the first with seven spines, the anal with three, a forwardly directed recumbent spine in front of the base of the dorsal fin, scales cycloid, of moderate or small size, frequently deciduous. Lateral line complete, interrupted, incomplete or absent. Although this genus consists of little bony fishes, which rarely exceed six inches in length, are generally far less. Buchanan (1822) while observing genus `chanda', which is mostly composed of species of Ambassis, reported that they are very small and of little value, although in many places abundant and used in considerable quantities. Gill rakers well developed 13 or more on lower arm of first arch. Some difficulty exists in ascertaining the species of this genus for the following reasons. The relative length of the second or third spine to that of the body differs in accordance with the size of the specimen, and local variations.

Key to Species :-

1. (a) Supraorbital ridge dentate at least posteriorly; interoperculum entire; preorbital dentate on both edge and ridge.

   (b) Supraorbital ridge smooth, but usually with a single backwardly directed spine posteriorly (rarely two or absent).

2. (a) Posterior edge (i.e vertical limb or preoperculum denticulate) with 6 to 13 small serrae.

   A. dussumieri.

   (b) Posterior edge of preoperculum entire (i.e smooth).

   A. gymnocephalus.

3. (a) Interoperculum smooth.

   4

   (b) Interoperculum denticulate, posteriorly.

   6

4. (a) One transverse row of scales on cheek; lateral line continuous or little interrupted.

   A. commersoni

   (b) Two transverse rows of scales on cheek.

   5

5. (a) Third dorsal spine slightly longer than second dorsal spine; predorsal scales 13 to 16.

A. miops

(b) Third dorsal spine distinctly shorter than second dorsal spine; predorsal scales 17 to 22.

A. macracanthus

6. (a) Posterior margin of preoperculum denticulate.

A. dayis

(b) Posterior margin of preoperculum entire.

.... 7

7. (a) Predorsal scales 8 or 9.

A. kopsii

(b) Predorsal scales 11 to 16.

.... 8

8. (a) Gill-rakers 18 to 22 on lower arm of first arch; lateral line continuous throughout its length.

A. nalua

(b) Gill-rakers 24 to 27 on lower arm of first arch; lateral line well interrupted in middle portion.

A. interruptus

From Indo-Pacific region only two species are known first is A. commersoni and second is A. bleekeri until 1984 as A. gymnocephalus. The two can be distinguished by the following characters.

Difference between A. commersoni and A. gymnocephalus.

	A. Commersoni	A. Gymnocephalus
1.	Lateral line continuous	Lateral line interrupted
2.	3 scales below lateral line	2 scales below lateral line
3.	Head as high as long	Head more longer than high (height)
4.	Interopercular region smooth or with a single or two dentation.	Interopercular region without dentation.
5.	Height 1/3 - 1/3.5 of total length.	Height 1/3.75 to 1/4 of total length.
6.	Second dorsal spine bigger than or equal to length of head.	Second dorsal spine smaller than the length of the head.
7.	Upper jaw ends below the frontal half of the eye.	Upper jaw ends at the frontal half of the eye.

Synopsis of species:-

(1) **Ambassis nama** :- D. 7/ $\frac{1}{18-17}$, A. $\frac{8}{14-17}$ Blunt serrations along horizontal limb of preopercle and on preorbital. Large curved canines in lower jaw. Yellowish olive with a dark shoulder mark. Fresh waters of India, Assam and Burma.

(2) **Ambassis ranga** :- D. 7/ $\frac{1}{18-16}$ A. $\frac{8}{14-10}$. L. r. 60-70. Vertical limb of preopercle serrated or entire. Both edges of its lower limb or preorbital serrated. Golden with vertical bands and black margins to the fins in the young. Fresh water of India and Burma.

(3) **Ambassis baculis** :- $D\ 7\ \frac{1}{15}$ $A.\ \frac{8}{15}$ L. r. 80

Double lower edge of the preopercle serrated. Also the preorbital and upper edge of the orbit. No canines. Yellowish-olive with a golden occipital spot. Fresh waters of Bengal to the Punjab and Orissa.

(4) **Ambassis thomassi** :- $D.\ 7\ \frac{1}{11-12}$ $A.\ \frac{8}{9-10}$. L.1. 35-41. Vertical limb and double lower edge of preopercle and posterior half of interopercle serrated. Preorbital also serrated. Silvery spotted. Malabar Coast in fresh water.

(5) **Ambassis commersoni** :- $D.\ 7\ \frac{1}{10-11}$ $A.\ \frac{8}{9-10}$ L.1. 30-33. Double lower edge of preopercle serrated. Interopercle entire; preorbital also serrated. Silvery, seas of India.

(6) **Ambassis nulua** :- $D.\ 7/\ \frac{1}{10-11}$ $A.\ \frac{8}{9-10}$ L.1. 26-27. Double lower edge of preopercle and posterior half of interopercle serrated; preorbital also serrated. Silvery. Fresh waters of India near the coast.

(7) **Ambassis interrupta** :- $D.\ 7/\ \frac{1}{10-11}$ $A.\ \frac{8}{9-10}$ L.1. 28. Double lower edge of preopercle serrated; interopercle with a few denticulations at its angle; preorbital

serrated. Second dorsal spine high. Lateral line interrupted. A dark band along either caudal lobe. Andamans to the Malay Archipelago.

(8) **Ambassis dayi** :- D. 7/ $\frac{1}{10-11}$ A. $\frac{3}{10}$ L. 1. 30.

Snout pointed. Vertical limb of preopercle minutely serrated; its double lower border more coarsely so, also the posterior half of the interopercle and the preorbital. Malabar.

It appears (therefore) that there are two species in the Indo-Pacific region.

- the first with a continuous lateral line.

Ambassis commersoni Cuvier, 1828

= Ambassis ambassis (Lacepide, 1801) Fowler 1905, 1925, 1928.

= Ambassis safhga (Forskal, 1775) Fowler 1927, Fowler and Bean, 1930.

- the second with a interrupted lateral line.

Ambassis gymnocephalus (not Lacepide, 1801) Bleeker, 1874.

= Ambassis dussumieri Cuvier, 1928.

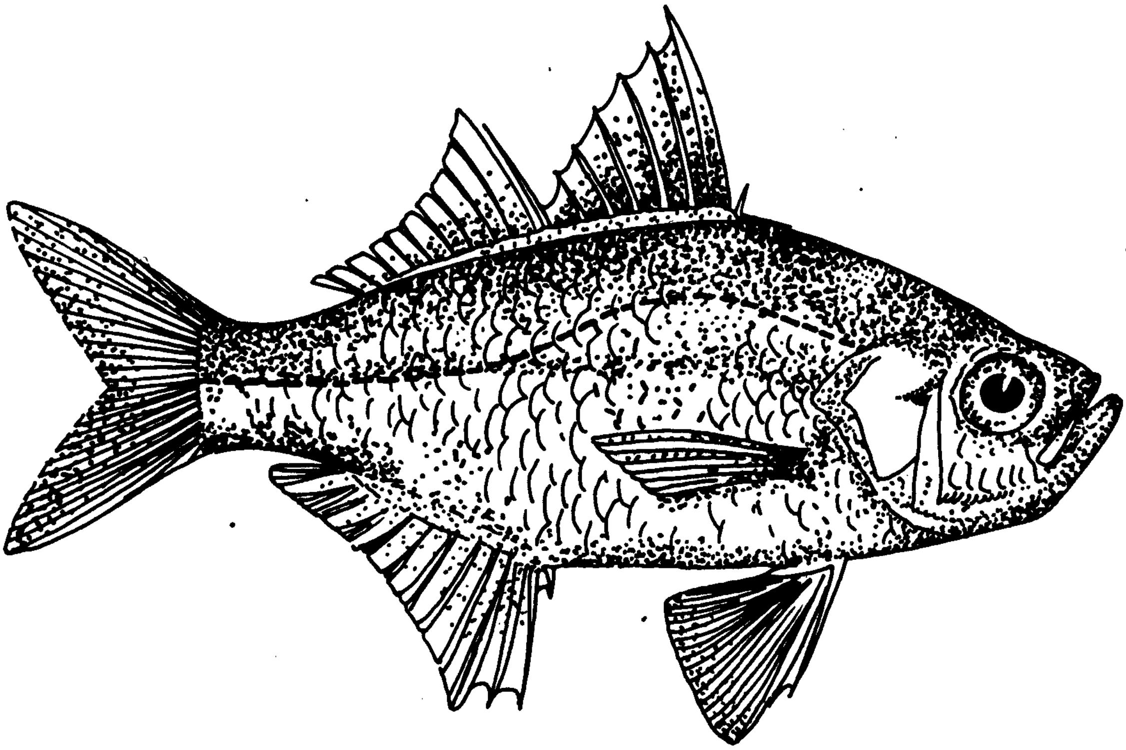


Fig. 1a Body outline of _A_. _commersoni_.

Common Name :-

English	- Commerson's glassy perchlet.
Tamil	- Selanthaan
Marathi	- Kachki
Konkani	- Burryate

Characters :- (Fig. 1 & Plate 1)

B. vi, D 7/6 $\frac{1}{11}$ P 13, V. 1/5, A. 0 $\frac{0}{10}$

C 15, 1, 1, 30.30, L. tr. 4/9 Vert. 9/15

Length of head about 1/4 of caudal 2/9 height of body 3 $\frac{1}{9}$ to 3/7 of the total length.

Eye :- diameter 1/3 to 2/7 of length of head, 1/2 a diameter from end of snout and also apart.

Dorsal and anal : Profiles about equally convex. Lower jaw the longer, its cleft very oblique, so that when closed it forms a portion of the anterior profile. The maxilla reaches to below the first third of the orbit. Preorbital rather strongly serrated, the serratures being directed downwards and slightly backwards. Vertical limb of preopercle entire, its inferior having double edge serrated, two serrated, two or coarser teeth being at the angle; lower margin of interopercle entire. Two or three small and blunt denticulations at the posterior superior angle of the orbit and a line between it and the posterior superior angle of the opercle.

Teeth : Villiform in the jaws, in a single shaped row in the vomer and also present in the palatines.

Tongue : Tongue usually with a narrow band along its centre.

Fins : Dorsal spines strong, transversely lineated, a serrated appearance to the second which is the longest, and equal to the length of the head behind the front margin of the orbit or even slightly longer. The ventral does not extend to the anal. Dorsal fin with 7 spines followed by deep notch, the second part of fin with one spine and 9 to 11 soft rays.

Anal fin :- Anal fin with 3 spines and 9 to 10 soft rays. Anal spine the strongest and nearly as long as the third which almost equals the third of the dorsal.

Caudal fin :- Caudal fin deeply forked, upper lobe usually longer.

Lateral line: Lateral line continuous or little interrupted.

Gill-rakers: Gill rakers 20 - 22 on lower arm of first branchial arch, well developed.

Scales:- Scales relatively small cycloid 40 or more lines in the longitudinal series. 4 or more transverse rows of scales on cheek.

Colour:- Body silvery with purplish reflections and bright silvery lateral band line from eye to caudal fin. Interspinous membrane between the second and third dorsal spine dark.

Geographical distribution:-

This common species extends from the Red Sea through India to North Australia. It ascends rivers and estuaries. Attaining six inches in length. Hamilton (1822) found a fish in the River Ganges. It is also found in Goa, Gulf of Mannar and Palk Bay along the South Eastern Coast in particular and other parts of the coastal belt of India and Java seas.

Uses:- The poorer classes eat them, other classes eat them only in rainy season when other fishes are not caught. Even though it is caught throughout the year, the main fishery season is from June to September. They are extensively consumed by the larger fishes, forming much of their sustenance during the dry months of years. As a food they have little value. Defect is their small size and small bones.

It is mainly and easily sun dried without salt and marketed. It is dried and used as manure also.

Synonym

<u>Ambassis</u> <u>commersoni</u>

1.	1822 -	Chanda Hamilton (chanda is restricted) Formerly Buchanan Type Chanda Ruconius Hamilton.	An account of the fishes found in River Ganges and its branches Edingburg. Francis Hamilton. Page 370. (David & Jordon P. 114).
2.	1828 -	Ambassis safgha Sciena Safgha Forskal	Cuviers Valenciennes Nat. Hist. despo Vol. II. 176. CXXXII and DESC Anim P.53 (David & Jordon P.P. 124).
3.	-	Perea Safgha	Bl Schn P 86
4.	1828 -	Ambassis (commersoni)	Cuvier & Valesciennes II 175: Type centropomus Ambassis lacepede. (Ambassis commersoni Cur & Val) Sciena Safgha Forskal (David Jordon P.P. 124)
5.	1829 -	Ambassis commersoni	Last half of the year second Edition of Regne Animal Vol. II according to Fowler. Page 125.
6.	1830 -	Prio Pis (kuhl & Van Hasselt)	Cuveirs valenciennes VI, 503, Haplotype Priopis argyrozona Kuhl & Van Hasselt. (David & Jordon P.P.174)
7.	1839 -	Hamiltonia swainzon	David & Jordon page 200
8.	1853 -	Bagada bleeker	David & Jordon Page 253 & 275
9.	1859 -	Ambassis commersoni	Gunther catali Page 223
10.	1874 -	Parambassis bleeker	David and Jordon Page 374

11. 1875 -	Ambassis commersoni	Fishes of India: 52, Pl. 15, Fig. 3 Day, 1889 Fauna Br. India, Fishes, 1:488.
12. 1875 -	Ambassis urctrania Bleeker	Day fishes of India 55 Pl 15 Fig. 8 Day 1989 Fauna Br India Fishes 1:489.
13. 1876 -	Pseudambassis Bleeker	System Percarum revisum Arch Neerl Sci. Nat. XI Pars 1, 247-288, Pars II 289-340.
14. 1878 -	Pseudoambassis castenau, 43	David & Jordan pp 393
15. 1878 -	Acanthoperca castelnau, 45	David & Jordan P.P 393
16. 1902 -	Bogoda Blk	Fawler David & Jordon P.P. 172.
18. 1949 -	Ambassis safgha Ambassis commersoni Smith	Fishes, 5th Africa Fig. 635 (Plate 17)
19. 1955 -	Ambassis commersoni	Munro Page 107 Figure 283 Plate 17

III. MATURATION AND SPAWNING

MATURITY AND SPAWNING IN A. COMMERSONI

INTRODUCTION

Since long, studies on maturation and spawning of finfishes have been successfully carried out in many parts of the world. Amongst the notable contributions, mention may be made of Wallace (1903); Hafford (1909); Clark (1934); Hickling and Rutenberg (1936); De Jong (1940); Wade (1950); Bowers (1954); Hanavan and Skud (1954); Bagenal (1957); Mc Gregor (1970); Howard and Landa (1958) and others. The breeding habits of Indian fishes have been studied by John (1939); Job (1940); Hora (1945); Chacko (1946); Nair (1951); Palekar (1952); Pillay (1954); Prabhu (1956); Bal & Joshi (1956); Tampi (1957); Krishnamoorthy (1958); Dharmamba (1960); Tandon (1961); Palekar and Bal (1961) and Parulekar (1964). Qasim (1973) has made an appraisal of maturation and spawning in marine teleoasts from the Indian waters.

There is little information available on the maturation and spawning of *A. commersoni* and therefore a detailed investigation was carried out in the present study. Earlier reports on the biology of *A. commersoni* are by Venkataramanjan and Venkataramani (1984) from Porto Novo (Tamil Nadu) and Nair (1984) from Veli and Akulam lakes in Kerala.

MATERIAL AND METHODS

Samples were collected from the fish landing centre at Ribandar, Dona Paula, and Four Pillars, all localities around Panaji, Goa (Fig. 1) during the period December 1987 to March 1989. About 20 fishes per week were examined on each observation day. The percentage occurrence of sex and stage of maturity were assessed and the gonads were preserved in 10% formaline for ova diameter measurements. In the preliminary examination, it was observed that there were no significant differences in number and size of ova between the anterior, posterior and middle portion of right and left lobes of the ovary. Therefore, a piece of ovary was cut and removed from the middle region of left lobe of ovary and after recording the weight, the mature ova were teased out and counted, under magnifying hand lens. The diameter of the ova were measured with an oculometer having each division giving 0.000714 mm. The frequency in diameter of the ova from the ovaries of the same stage of maturity were pooled and plotted. The stages of maturity are comparable to the ICES scale (Wood, 1930; Lovern and Wood, 1937).

Maturity stages were ascertained by gross examination of the gonads of 527 females and 485 males and by ova diameter frequency distribution of 527 ovaries.

The maturity stages were classified based on the macroscopic appearance in fresh condition, microscopic structure and relative ovary weight in females, and macroscopic structure and relative weight of testes in males. The ovaries were examined microscopically for the size of ova and the extent of yolk deposition.

The measurement of ova were restricted to 100 ova for an immature ovary, 200 for maturing, ripe and mature ovary respectively as suggested by Uchid et.al (1958). In order to bring out natural sequence of the finer maturity stage in which ova pass through before becoming fully ripe, the individual ova diameter frequency polygons were classified according to the nature of the size frequency distribution of ova, and the position of the graphic mode of the most mature as well as the maturing group of ova. In studying the growth of ovary from immature to spent stage, ova diameter measurements were taken in different stages of maturity, following the method adopted by Clark (1934).

The ova diameter polygons of several fish of same maturity stage were then pooled and further reduced to the percentage.

Frequency of Spawning:

Frequency of spawning was determined on the basis of the multiplicity of modes in the ova-diameter frequency curves, growth of the successive egg groups and the relative number of eggs in different groups. The frequency of spawning by individual fish was determined from the frequency distribution of the immature, maturing and mature groups of ova following the criteria of Mac Gregor (1970) and from the seasonal occurrence of mature, spawning and spent fishes.

Size at first maturity :

Data collected during 16 months from December 1987 to March 1989 were utilized for this purpose, as fish in advanced stage of maturity commonly occur almost throughout the year. For the purpose of calculating the size at first maturity, fish belonging to maturity stages III, to VII have been considered as mature fish. The data of 16 months were pooled together. The percentage of the mature fish in relation to immature fish in different length groups was computed. A graph showing percentage - frequency distribution of mature female in relation to immature females in different length groups was drawn. The length at which 50% fish mature, is considered as length at first maturity.

Spawning Season :

The percentage occurrence of fish with gonads in different stages of maturity during different months was determined to delineate the spawning season.

Gonado-Somatic Index :

Gonado Somatic Index (GSI) was calculated by using the formula

$$G.S.I. = \frac{\text{Weight of gonad}}{\text{Total weight of fish in gms}} \times 100$$

The GSI was calculated for both females and males. From the individual values, the average GSI value for each month and length group was calculated and the same has been used to describe the maturity condition of the species for each month and length group. Data for this aspect were collected from December 1987 till March 1989.

Ratio of sexes in the commercial catches :

Fish below the minimum size which does not show any sex differentiation was not considered for analysis of sex ratio. In order to minimise any possible error due to either sampling or inadequate number of samples, data were pooled for each month and the sex ratio has been estimated.

Definition of terms :

Different workers have given different interpretations for some familiar terms connected with the maturity stages, of fish. For instance, the term `immature' may refer to a young fish which has never spawned or it may also be applicable to a older fish, which has spawned before, but at the time of examination, it has its ovary in `immature' state. As for this study, the term `immature' is applicable to any fish, which has its ovaries in immature state of maturity, `maturing' to those, with ovaries in maturing or intermediate condition and `mature' to those with mature or ripe ovaries and the `spent' are those with immature or early maturing ova with few mature or ripe ova undergoing reabsorption Hence, the use of these terms is in relation to the condition of the ovaries, irrespective of the fact, whether the fish has spawned once or otherwise. The different stages of maturity has been dealt with more elaborately under the description of ovaries.

RESULTS

The Ovaries Plate 2 : The inner wall of the ovary is lined by germinal epithelium which proliferates the ova. The lumen of the ovary is traversed by a number of vertical laminae, packed with numerous small ova. In the course of development, the ovary undergoes many changes in its internal structure as well as in its external appearance and the size of the ova.

Growth of the Ovary : The growth of the ovary starts in the posterior part of the abdominal cavity just near the vent. The succeeding growth proceeds anteriorly as the ovary undergoes different phases of maturation. This process of

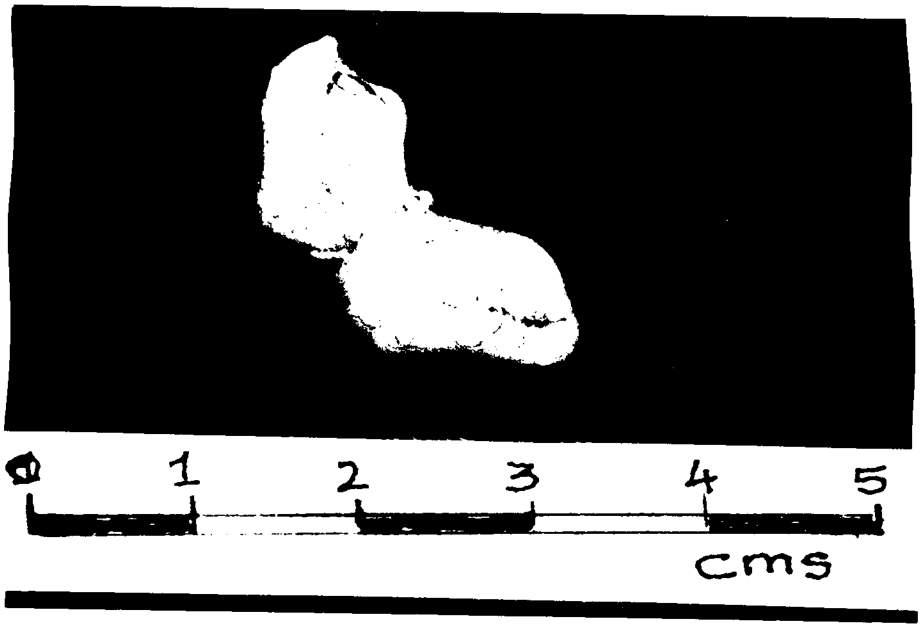


Plate-2 Mature ovary of A. commersoni.

growth, is accompanied by a number of changes in the structure and size of ova at different stages and it results in the increase in size of ova and weight of ovary.

Since millions of ova represent the stage of growth of ovary, the diameter of ova of different sizes were measured for the proper understanding of various stages of maturity. According to the size and the internal structure of ova, the growth stage of ovaries in fishes have been classified into four main categories; namely `immature', `maturing', `mature' and `spent'. The first three categories represent the phase of ovarian growth to complete maturity while last one i.e. spent, denotes the post- spawning condition.

Growth of ova from immature to mature state (Fig.2 & Plate 3):

In the course of the study on the growth of ovary and its condition in the different stages of maturity, four main phases of ovarian growth, namely, immature, maturing, mature and spent were observed. These stages were studied on the basis of ova-diameter measurements, so that the maturation and spawning behaviour of <u>A. commersoni</u> could properly be understood.

The ova-diameter measurement of 527 ovaries in different stages of maturity were grouped into 10 mm (oculometer division), size class. The percentage frequency of ova in each size class was plotted against the

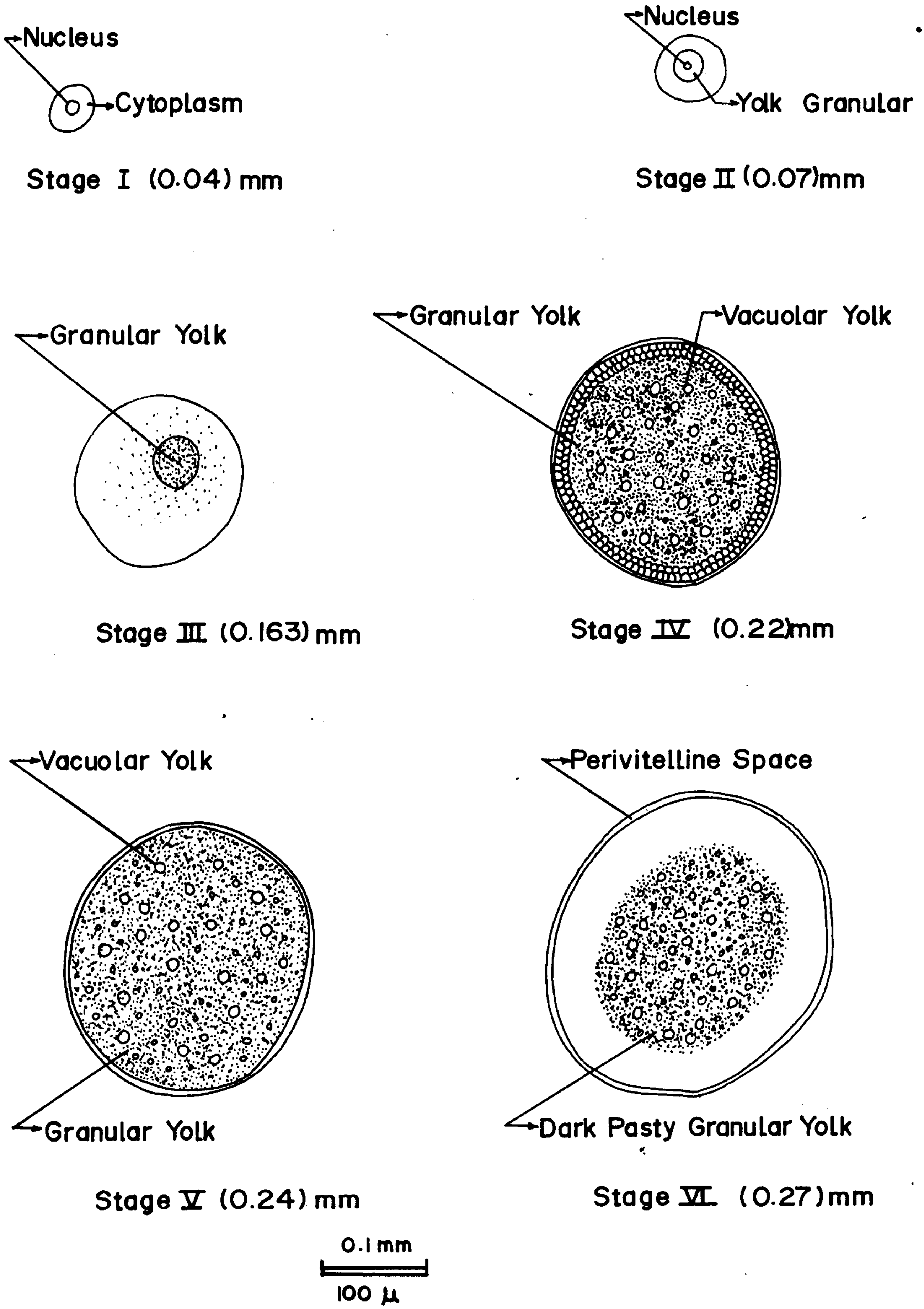
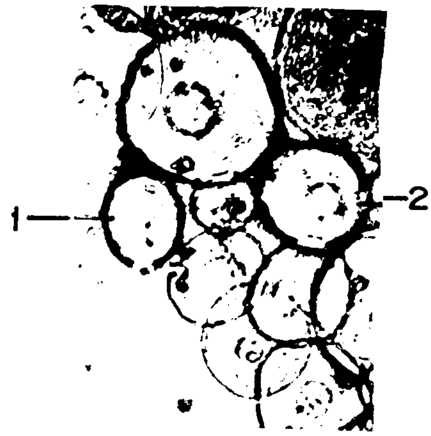
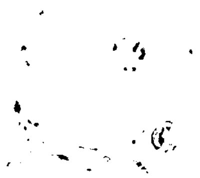


Fig. 2 Growth of ova from immature to ripe stage.





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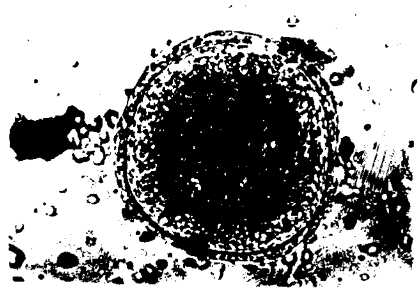

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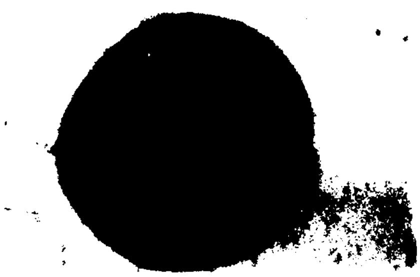

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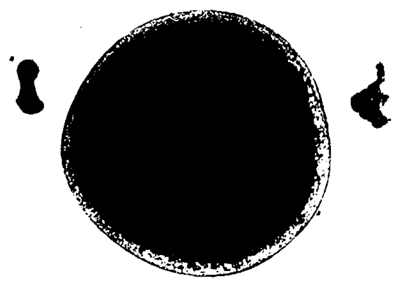

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Plate-3 Developmental stages of ova in A. commersoni defined by the International Council for the Exploration of the Seas, (Wood 1930). Sexes could be distinguished in fishes of 42-50 mm length in both the sexes.

The maturity stages of gonads were classified based on the macroscopic appearance in fresh condition and microscopic structure in preserved female gonads while in male only by visual examination in fresh condition.

Stage I : Immature (Virgin) ovaries appear translucent to pale cream, cylindrical, surface smooth with no distinct blood vessels and with little asymmetry in the length of two lobes. Ovaries are very small. Ova invisible to naked eye, but under microscope they are small yolkless, transparent with nucleus. Majority of ova measure 0.03 to 0.07 mm with maximum size at 0.214 mm. Testes minute pinkish white and translucent.

Stage II: (Developing virgin and adults, spent-resting adults). In developing virgin and adults (Stage II), the ovaries are soft, light yellowish, cylindrical, two lobes asymmetrical occupying 1/3 to 1/2 of the body cavity. Although majority of maturing group of ova are partly opaque due to commencement of yolk deposition, they do not appear as distinct grains to naked respective size class as shown in Fig. 3 and Table 1. The frequency polygons in Fig. 3 show the changes undergone by the ova in different stages of growth of ovary.

From the available data on the diameter of intra ovarian eggs, the following seven arbitrary stages of growth of ova can be derived conveniently.

Maturity

Maturity stages (gross examination)

Ovary :

The ovaries of A. commersoni are oblong bodies lying along the median line ventral to the air-bladder. The anterior ends are broad and rounded while posterior ends are narrow and more tapering. The ovaries are fused together towards the anterior region.

Mature paired yellow ovary is elongated and highly vascular organ attached to the dorsal wall of the body cavity. From the fused region, starts the single oviduct which runs posteriorly and joins the common ureter which opens to the exterior through the urinogenital pore. Right ovary was found to be larger than the left.

Classification of maturity stages :

Seven maturity stages could be delineated (Table 1,Fig. 3). They generally correspond to the maturity stages eye. But a few ova are already fully opaque and they appear to naked eye as distinct grains scattered here and there. The mode of maturing groups of eggs is 0.1 and maximum size at 0.28 mm with yolk formed around the nucleus. Testes white, small short straplike.

Spent-resting gonads (Stage IIb) could be distinguished only in females. Here the ovaries are light, yellowish coloured, with a collapsed and flattened appearance. Tunica thick, surface being not smooth. Clots of blood cells appear as brown masses in between oocytes. Majority of ova transparent, not visible to naked eye and measures .03 to 0.28 mm.

Stage III : Maturing ovaries tinged yellow and granular. Development of blood vessels, perceptible. Usually, there is asymmetrical development in the size of ovaries, the right lobe being longer than the other. This condition persists in the subsequent stages also. Only a single group of maturing opaque ova in the size range of 0.142 to 0.214 mm (Fig. 3) with the maximum size of 0.285 mm, present. They are spherical, opaque and fully yolked. Testes increase in size, become opaque white with two lobes.

Stage IV: **Maturing:** Ovaries yellow, compact and vascular with conspicuous blood vessels on the dorsal side of tunica. Medium sized opaque, spherical, whitish granules, i.e. ova visible to naked eye and not free from the follicular cells. The yolk more at center than at the periphery. Maturing group of ova with diameter from 0.142 to 0.285 mm and maximum size upto 0.321 mm. Testes occupy half of the body cavity, strap like opaque and slight creamy white. Consists of clear two lobes.

Stage V : **Mature:** Ovaries reddish yellow, fully vascular with prominent blood vessels ramifying on the surface. Tunica very thin and tends to burst at slight pressure. Ovaries attain considerable size and occupy 3/4 to 4/5 of body cavity. The disposition of the most mature group of ova present a tightly-packed appearance, with their outline quite distinct. They are spherical and distinctly separated from maturing group of ova in the size frequency distribution and mature ova free from follicle. Most of the mature ova measure around 0.285 to 0.357 mm. A second modal size group appears in this stage within the maturing group. Testes occupy 2/3 of the body cavity, strap like creamy white and opaque. Two lobes become more distinct and clear and increase in length and breadth.

Stage VI: **Stage Ripe**: The ovaries appear like cream coloured cellophane bags filled with boiled sago. They fill entire space of abdominal cavity. The tunica, being very thin, generally bursts when the fish is being handled, with the result that ova are liable to be exuded. The largest ova are transparent, spherical and jelly like with foamy yolk. The egg diameter ranges from 0.321 mm to 0.464 mm. The largest spherical jelly like ova measures about 0.49 mm to 0.57 mm. A single oil globule varying in size group is present. Perivitelline space narrow and measures 0.03 - 0.05 mm. Testes in the form of two opaque distinct lobes and occupy more than 2/3 body cavity and the milt could be exuded easily by slight pressure on the testes or abdominal wall.

Stage VII : **Spent**: Ovaries, blood-shot, flaccid and gelatinous with wrinkles on surface owing to collapsed condition. Tunica leathery. Recently-spent fish have remnants of mature ova that are being resorbed and appear as small distintegrating opaque objects. The blood cells from ruptured capillaries appear as reddish clots. At a later stage a few blood-coloured or brownish masses, representing the distintegrating unspawned ova appear. The largest modal size of ova in this stage correspond with that of the ovaries in Stage II. Overies shrunken and blood shot and wrinkles on surface owing to collapsed condition. Testes dirty white with red tinge, thin leathery in texture.

Stage VIII : Spent: Recovering ovary translucent grey-red. Few eggs can be seen with magnifying glass.

Maturation cycle of <u>A. commersoni</u> (Female) month by month (Table 2 Fig. 4).

The rate of growth of ova in different stages of maturation and their distribution in the ovaries in different months of the year indicates the general trend in the maturation cycle of the fish and also throws light on the spawning behaviour of the species.

In order to study maturation cycle of <u>A. commersoni</u>, the ova-diameter measurement of ovaries, irrespective of maturity stages, in particular month were pooled together and are represented in Table 2 and Fig. 4.

From close scrutiny of Table 2 Fig. 4 it is evident that the female attains maturity in the month of July (21.78% ova in stage V) and it continues upto the month of October. In September and February the mature ova are present in maximum percentage of 31.67 and 22.32

TABLE 1

FREQUENCY DISTRIBUTION OF OVA-DIAMTER OF *A. COMMERSONI* IN DIFFERENT STAGES OF MATURITY

S.No.	Ova-Diameter range in mm.	I NO	I %	II NO	II %	III NO	III %	IV NO	IV %	V NO	V %	VI NO	VI %	VII NO	VII %
1	0.007 - 0.035	1965.	39.18	537.	17.69	181.	5.78	43.	1.73	415.	3.29	383.	3.26	607.	14.30
2	0.035 - 0.071	1701.	33.92	567.	18.68	243.	7.76	169.	6.82	607.	4.82	354.	3.02	475.	11.19
3	0.071 - 0.100	537.	10.71	664.	21.87	201.	6.42	114.	4.60	418.	3.32	238.	2.03	291.	6.86
4	0.100 - 0.142	339.	6.76	572.	18.84	386.	12.32	196.	7.91	672.	5.34	419.	3.57	262.	6.17
5	0.142 - 0.178	185.	3.69	230.	7.58	414.	13.21	202.	8.15	452.	3.59	333.	2.84	221.	5.21
6	0.178 - 0.214	171.	3.40	179.	5.90	730.	23.30	305.	12.30	864.	6.86	392.	3.34	395.	9.31
7	0.214 - 0.249	67.	1.34	119.	3.91	400.	12.77	417.	16.82	919.	7.30	281.	2.40	226.	5.32
8	0.249 - 0.285	35.	.70	130.	4.28	423.	13.50	620.	25.33	4737.	37.62	1572.	13.40	780.	18.36
9	0.285 - 0 321	10.	.20	20.	.66	90.	2.86	208.	8.39	1844.	14.65	1916.	16.33	334.	7.87
10	0.321 - 0.357	5.	.10	15.	.49	45.	1.44	189.	7.62	1515.	12.03	4597.	39.18	494.	11.64
11	0.357 - 0.392	-	-	3.	.10	9.	.29	8.	.32	122.	.97	1021.	8.70	115.	2.71
12	0.392 - 0.428	-	-	-	-	11.	.35	-	-	24.	.19	212.	1.81	42.	.99
13	0.428 - 0.464	-	-	-	-	-	-	-	-	2.	.02	14.	.12	3.	.07

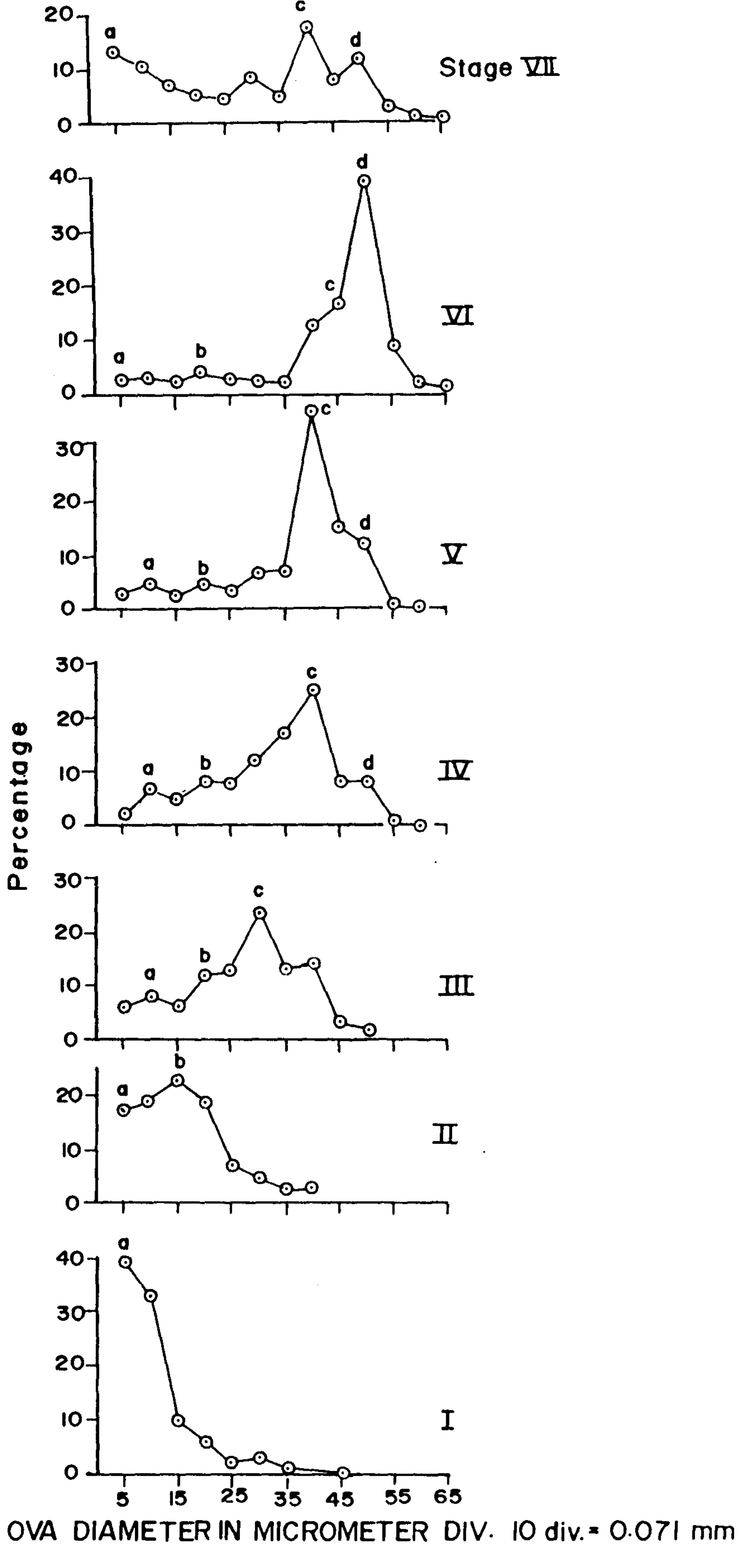


Fig. 3 Frequency distribution of ova diameter of A. commersoni in different stages of maturity.

respectively and this possibly marks the peak of maturation cycle. The study on the average condition of maturity of female in different months shows a close sequence in maturation cycle of A. commersoni. The main features of the maturation cycle are as given :

1. In the month of March, June and December the ovary contains majority of immature ova and hence it is in resting phase.
2. In April, May, and November ova are in state of maturing i.e. in IV stage.
3. In January, February, July, August and September, maximum number of ova in stage V and VI are found in ovary.
4. In October maximum number of ova in stage IV and V are found.

From the Fig. 4 it may be inferred that A. commersoni is a prolonged breeder, having two spawning peaks, once during January-February and another still longer during July-September.

Frequency of spawning:

The study of ova-diameter frequencies not only helps in fixing the different stages of maturity but it also serves as an indicator of the frequency and duration of spawning in a species. For determining the duration of spawning

TABLE 2

Frequency distribution of ova-diameter of A. commersoni in different months

S.No.	Ova-Diameter (mm)	1988																								1989					
		January		February		March		April		May		June		July		August		September		October		November		December		January		February		March	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1.	0.007-0.035	874	20.62	422	8.64	382	18.49	192	8.91	146	10.34	293	18.43	296	8.33	281	8.66	206	3.88	77	3.99	67	4.56	116	12.33	75	3.45	174	5.20	260	9.26
2.	0.035-0.071	813	19.18	393	8.05	234	11.33	183	8.49	117	8.29	195	12.26	362	10.19	301	9.27	239	4.50	74	3.84	91	6.19	92	9.77	126	5.79	279	8.35	293	13.99
3.	0.071-0.100	424	10.00	298	6.10	152	7.36	122	5.66	107	7.58	97	6.10	186	5.23	158	4.87	154	2.90	31	1.61	65	4.42	64	6.80	84	3.86	197	5.89	103	3.67
4.	0.100-0.142	365	8.61	317	6.49	245	11.86	124	5.74	136	9.63	165	10.37	192	5.40	146	4.50	149	2.81	45	2.33	146	9.94	110	11.69	116	5.33	248	7.42	186	6.62
5.	0.142-0.178	209	4.93	290	5.94	145	7.02	88	4.08	74	5.24	107	6.73	97	2.73	145	4.47	209	3.94	44	2.28	161	10.96	53	5.63	66	3.03	168	5.03	94	3.35
6.	0.178-0.214	241	5.69	284	5.82	179	8.66	138	6.40	113	8.00	97	6.10	192	5.40	210	6.47	298	5.61	96	4.98	319	21.72	148	15.73	129	5.93	284	8.50	242	8.62
7.	0.214-0.249	156	3.68	196	4.01	200	9.68	186	8.63	92	6.52	61	3.84	183	5.15	140	4.31	214	4.03	64	3.32	175	11.91	129	13.71	156	7.17	245	7.33	188	6.69
8.	0.249-0.285	187	4.41	402	8.23	349	16.87	636	29.50	481	34.06	283	17.80	793	22.31	692	21.31	1045	19.69	795	41.23	353	24.03	215	22.85	539	24.75	840	25.12	672	23.92
9.	0.285-0.321	241	5.69	510	10.44	112	5.42	279	12.94	62	4.39	87	5.47	387	10.89	428	13.19	912	17.18	268	13.90	51	3.47	11	1.17	310	14.23	440	13.16	313	11.14
10.	0.321-0.357	480	11.33	1090	22.32	65	3.15	204	9.46	82	5.81	182	11.45	774	21.78	660	20.33	1681	31.67	413	21.42	41	2.79	3	0.32	388	17.82	441	13.19	347	12.35
11.	0.357-0.392	205	4.84	550	11.26	2	0.10	4	0.19	2	0.14	17	1.07	73	2.05	71	2.19	178	3.35	16	0.83	0	-	0	-	127	5.83	27	0.81	6	0.21
12.	0.392-0.428	41	0.97	117	2.40	1	0.05	0	-	0	-	6	0.38	19	0.53	14	0.43	21	0.40	5	0.26	-	-	0	-	60	2.76	-	-	5	0.18
13.	0.428-0.464	2	0.05	14	0.29	0	-	0	-	0	-	0	-	0	-	0	-	2	0.03	-	-	-	-	-	-	1	0.05	-	-	-	-

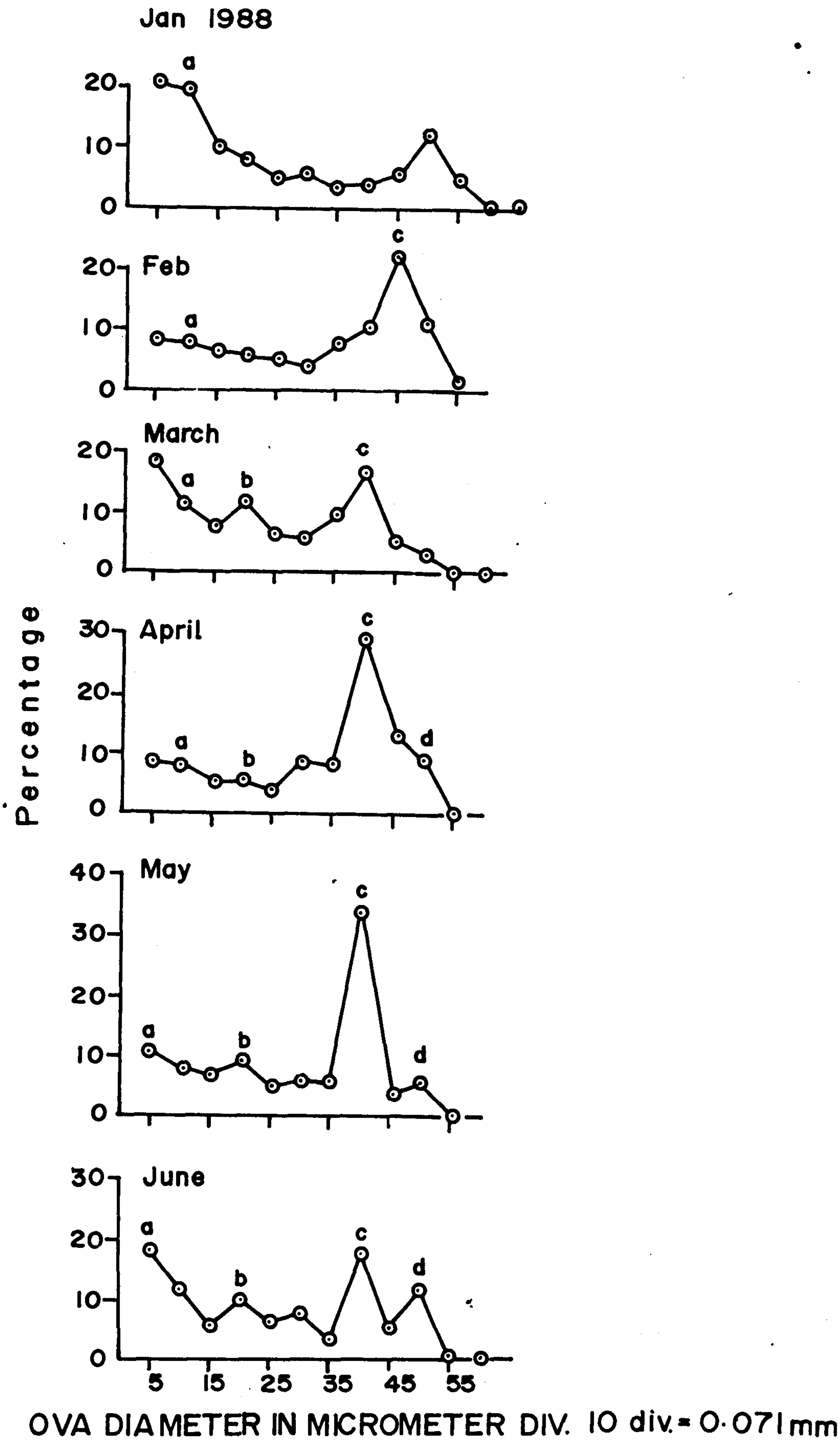


Fig. 4 Frequency distribution of ova-diameter of A. commersoni. in different months.

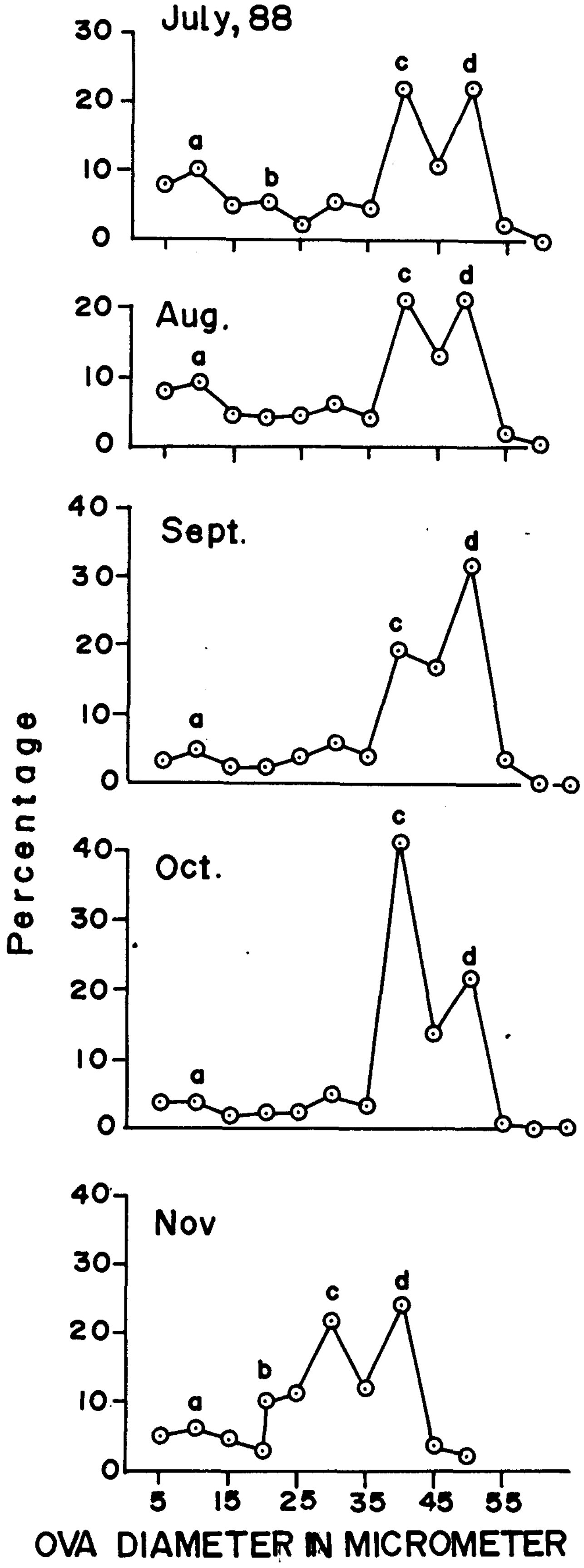


Fig. 4· Frequency distribution of ova-diameter of _A. commersoni_· in different months.

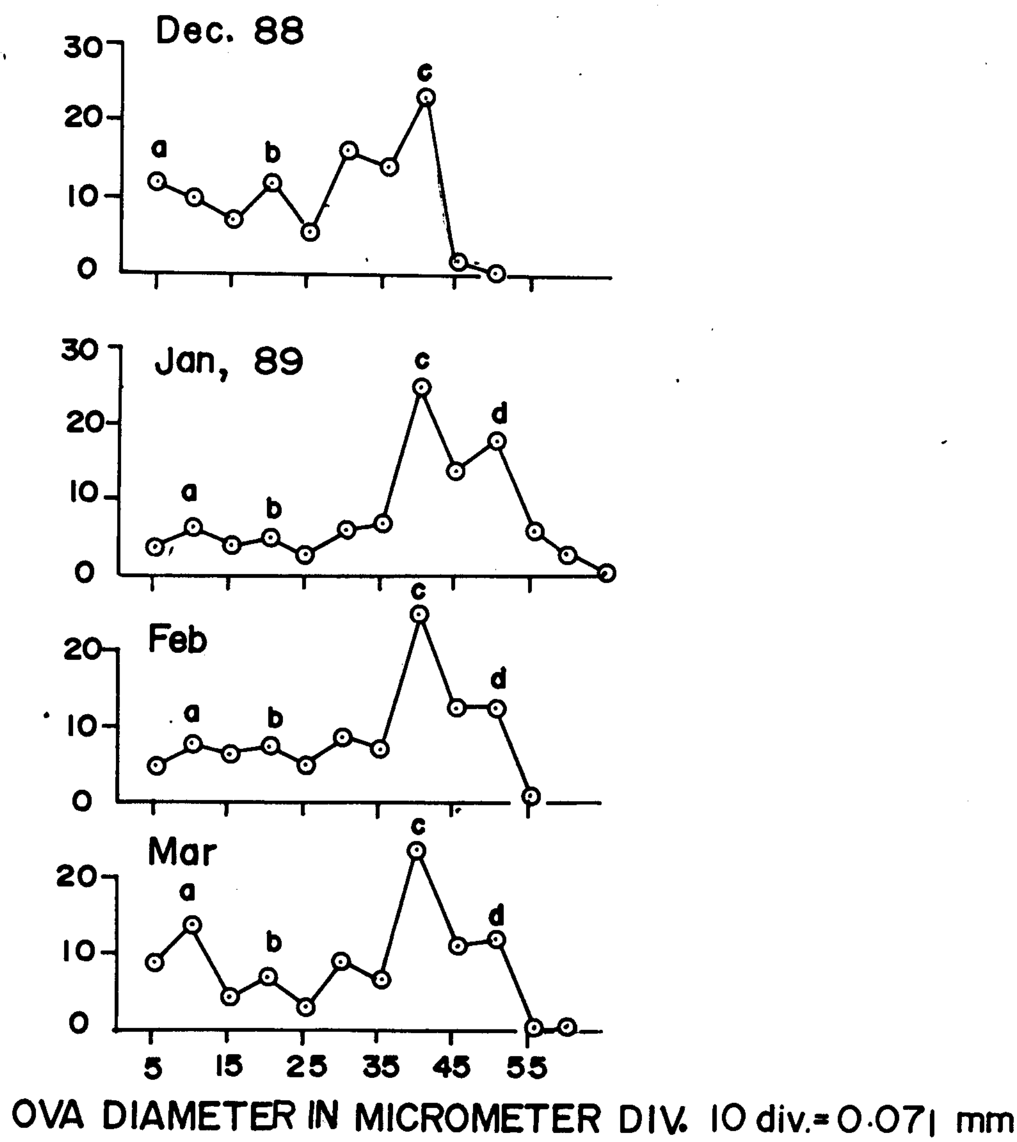


Fig. 4 Frequency distribution of ova-diameter of A. commersoni. in different months.

period, the study of the intra-ovarian ova in ripe ovary was carried out when large number of females were found in stage d. The procedure of Clark (1934) as adopted by Prabhu (1956) was employed.

In the ovary of the adult fish, there is a general egg-stock from which a quota is withdrawn each year to be matured, and spawned and to this egg-stock a fresh batch is added every year by the development of oocytes from germinal epithelium. It is further observed that the measurements of the diameter of eggs in ovaries, well advanced towards spawning may give evidence of the duration of spawning in a fish of which the spawning habits are unknown. In fishes, where spawning period is short and definite, the quota of minute yolkless eggs will be drawn in a single batch. But those fishes who have a long and indefinite spawning period, the withdrawal of egg stock will be a continuous process and there will be no sharp differentiation between the general egg-stock and the mature eggs.

With a view to determine the spawning frequency or periodicity in A. commersoni, mature ovaries in stage V & VI were specially examined for recording the frequency percentage of ova-diamter measurement of intra-ovarian eggs.

Frequency polygons in Fig. 4 & Table 2 show the percentage of ova from ovaries in stage V and VI, in different months. A close examination of the polygons

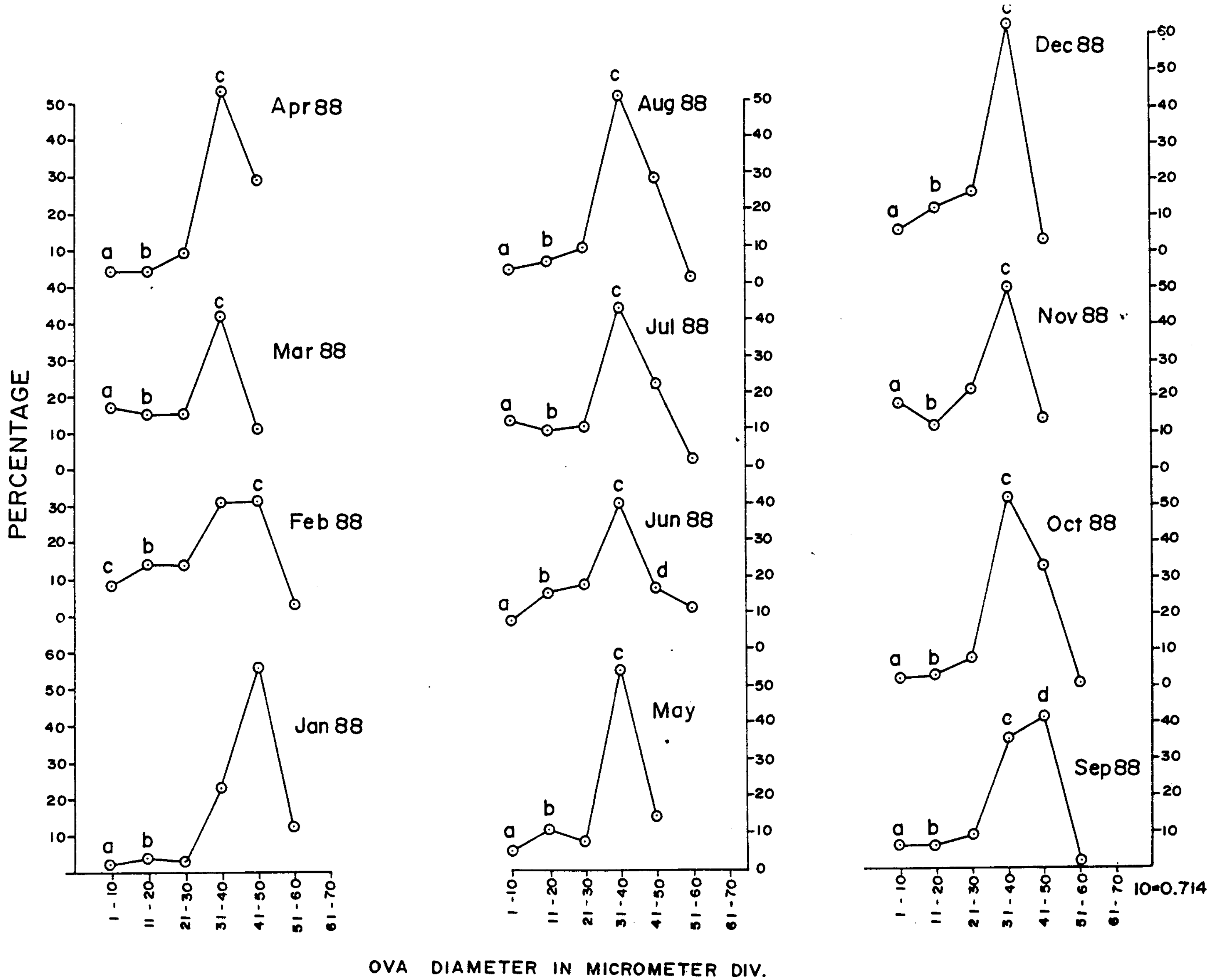


Fig. 5 Frequency distribution of ova in mature female of a <u>A. commersoni</u> in different months.

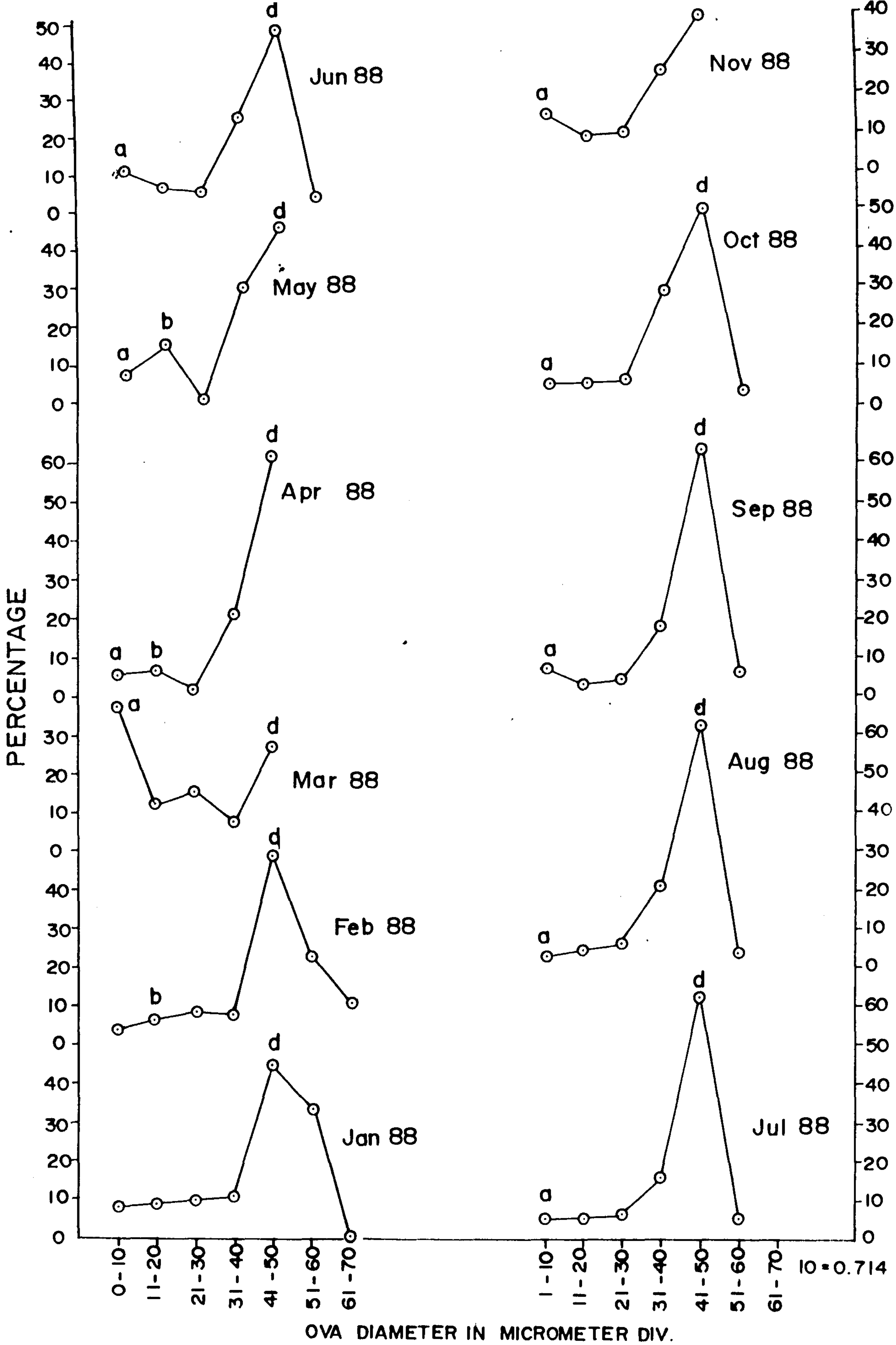


Fig. 6 Frequency distribution of ova in ripe female of *A. commersoni* in different months.

shows that in each ovary, there are three distinct groups of ova, which are represented by separate graphic modes. The first mode `a' which is at 0.007 - 0.071 micrometer division (m.d.), represents the immature group of ova. The mode `b' representing the maturing group is located at 0.07 to 0.142 mm. while the mode `c' and `d' representing the mature group, are spread between 0.285 - 0.321 mm. and 0.321 - 0.392 mm. respectively. The mode `c' stands for ova in stage V where ripe ova in stage VI are represented by the mode `d'. So from Fig. 4 it can be concluded that in the mature ovary of A. commersoni there are three groups of ova, namely immature, maturing and mature and they are distinctly separated from one another.

The total range of distribution of intra ovarian eggs in A. commersoni (Fig. 5 & 6) is 0.007 - 0.464 mm. of which mature ova covers more than half 0.149 - 0.392 mm. Such a wide range in size of mature ova, indicates prolonged breeding behaviour of the species (Prabhu, 1956).

Owing to the fact that the mature ova are clearly differentiated from immature and maturing one, it is evident that there is a definite periodicity in spawning and that the species spawns only once a year. So, enough evidence is at hand to show that A. commersoni does not follow a pattern of periodic spawning but on the other hand an individual might have a series of unrhythmic spawning bursts during the prolonged breeding season.

From Fig. 10 & Table 6, depicting monthwise distribution of females in different stages of maturity, it could be noted that the mature specimens, as a major group, were recorded for the first time, in the month of May and again in January. It was also noted that the percentage of mature specimen goes on increasing in the succeeding months and reaches its maximum in the month of September with a second maximum in February. The persistence of mature specimens for a number of months in a year, indicates that the growth of intra-ovarian eggs is rather on an interrupted basis, especially during June - August period, which incidently coincides with the peak mansoon season, along the coast of Goa.

Hence in light of these observations, it can be said that A. commersoni has a prolonged breeding period with spawning peak twice a year during the month of September and February. Thus, the progression of the ova after winter (February) spawning appears to be faster than summer (September) spawning.

Size at first maturity:

The minimum size at which A. commersoni attains maturity was determined by analysing the data relevant to the condition of -(ovary of) 1012 specimens out of which 527 were females ranging between 48 and 135 m.m. (TL) and 485 males ranging from 42 to 122 mm (T.L).

The specimens were grouped under 10 m.m. size classes and were classified into `immature', `maturing', `mature' and `spent', depending on the condition of the ovary. From Table 3 and Fig. 7 it is seen that the specimens below 45 were immature and it is only in the next size class i.e. 46-55 m.m. the maturing specimens make their appearance. The mature females were first recorded in 66-75 mm size class and thereafter they occur in varying percentage in each length group upto 131-135 mm. In each of the size-class, the mature females constitute a major group with the highest percentage.

To determine minimum size at first maturity, the data of 16 months were pooled together to find out percentage of the mature fishes in relation to immature fishes in different length groups. The percentage of the mature fishes in relation to immature fishes was computed as in Table 4 & 5 and a graph was plotted (Fig. 8). The length at which 50% fishes mature for the first time was observed in females to be at 67.5 mm (TL) and in males at 65 mm (TL). This length was considered as size at which <u>A. commersoni</u> attains first maturity.

TABLE - 3

Distribution, number and percentage of immature, mature, maturing and spent females of <u>A. commersoni</u>.

S.No.	Length gr.	Total No.	Immature	Maturing	Mature	Spent
1	46-55	13	12 (92.30)	1 (7.69)	-	-
2	56-65	99	50 (50.50)	49 (49.49)	-	-
3	66-75	93	28 (30.10)	24 (25.81)	33 (35.48)	8 (8.60)
4	76-85	30	6 (20.00)	6 (20.00)	15 (50.00)	3 (10.00)
5	86-95	59	9 (15.26)	5 (8.47)	33 (55.93)	12 (20.33)
6	96-105	122	9 (7.38)	13 (10.67)	85 (69.67)	15 (12.28)
7	106-115	84	5 (5.95)	9 (10.71)	54 (64.28)	16 (19.05)
8	116-125	23	-	-	21 (91.30)	2 (8.70)
9	126-135	4	-	-	4 (100.00)	-

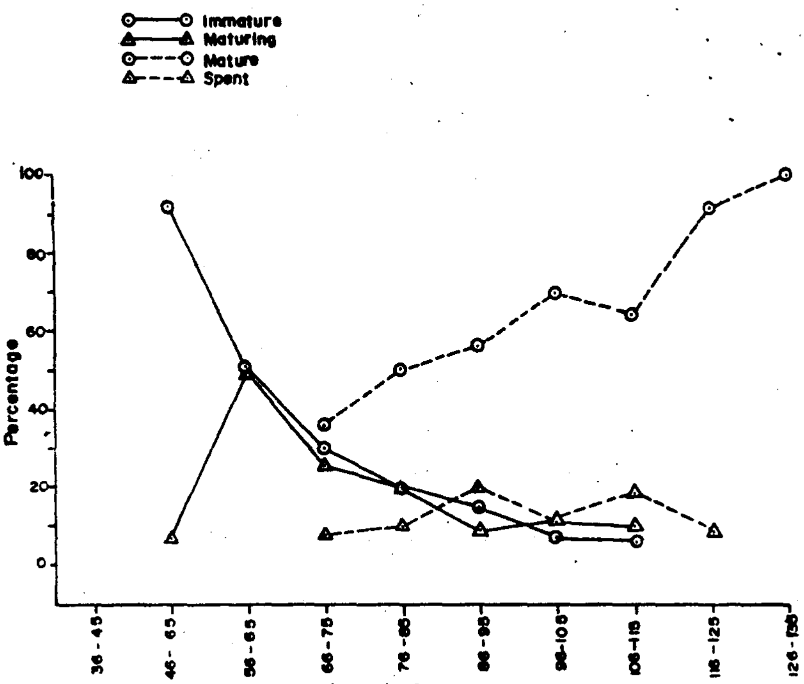
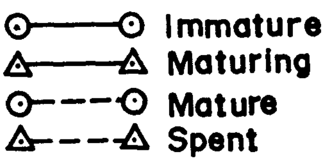


Fig 7 Distribution of immature, mature, maturing and spent females of A. commersoni. in relation to size.



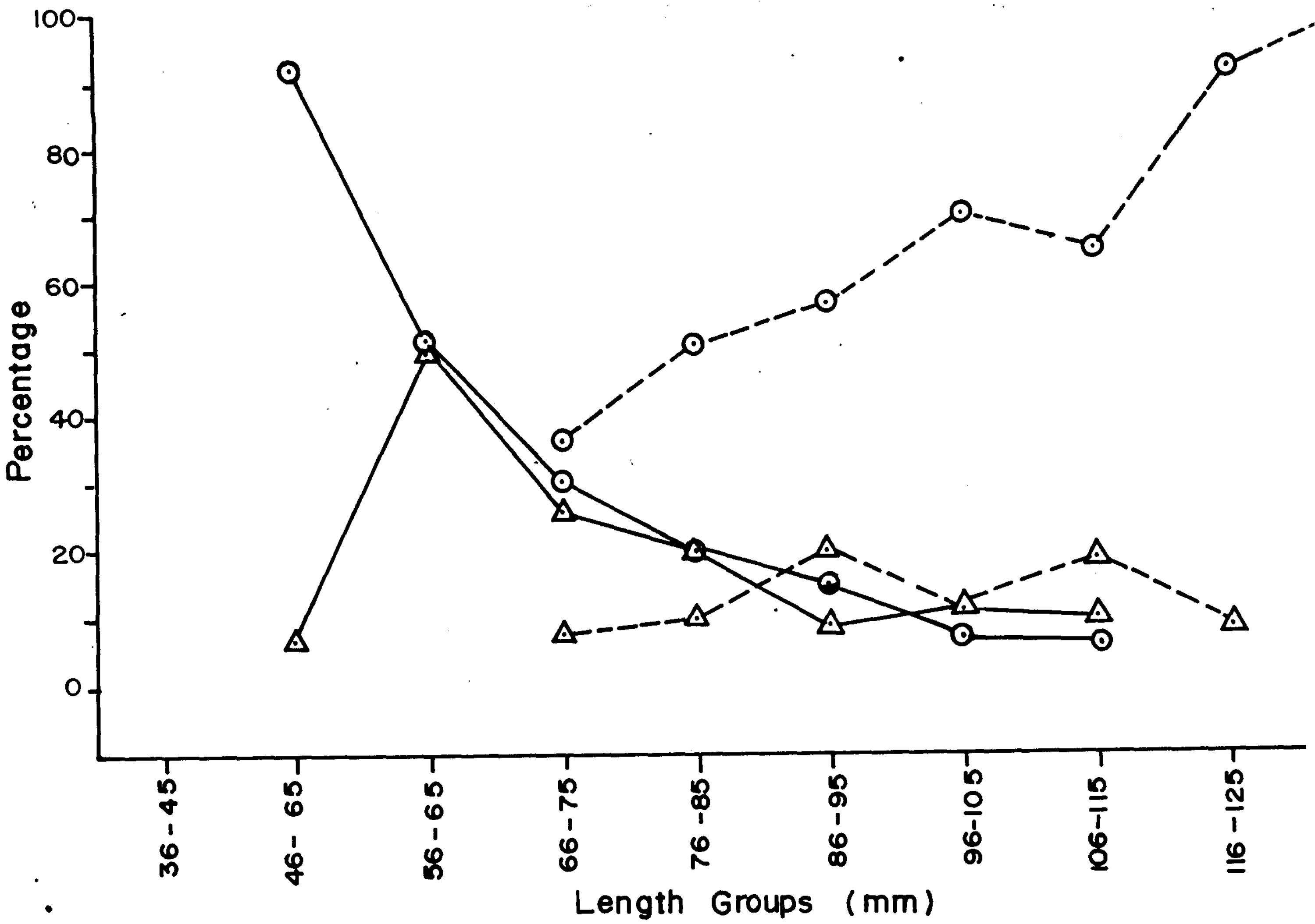


Fig. 7 Distribution of immature, mature, maturing and spent females of A. commersoni. in relation to size.

TABLE 4

Percentage composition of immature, mature and spent female A. commersoni.

Sr. No.	Length group	Total no. of fish	Immature No.	Immature %	Mature & Spent No.	Mature & Spent %
1	46-55	13	12	92.31	1	7.69
2	56-65	99	54	54.55	45	45.45
3	66-75	93	37	39.98	56	60.02
4	76-85	30	6	20.00	24	80.00
5	86-95	59	6	10.17	53	89.83
6	96-105	122	9	7.38	113	92.62
7	106-115	84	5	5.96	79	94.04
8	116-125	23	1	4.35	22	95.65
9	126-135	4	-	-	4	100.00

Length at first maturity in female - 67.5 mm

TABLE 5

Percentage composition of immature, mature and spent, male *A. commersoni*.

S.No.	Length group	Total no. of	Immature No.	Immature %	Mature & Spent No.	Mature & Spent %
1	36-45	1	1	100	-	-
2	46-55	15	13	86.67	2	13.33
3	56-65	126	62	49.21	64	50.79
4	66-75	112	32	28.58	80	71.42
5	76-85	117	16	13.68	101	86.32
6	86-95	73	7	9.59	66	90.41
7	96-105	27	2	7.41	25	92.59
8	106-115	6	-	-	6	100.00
9	116-125	8	-	-	8	100.00

Length at first maturity in male - 65 mm

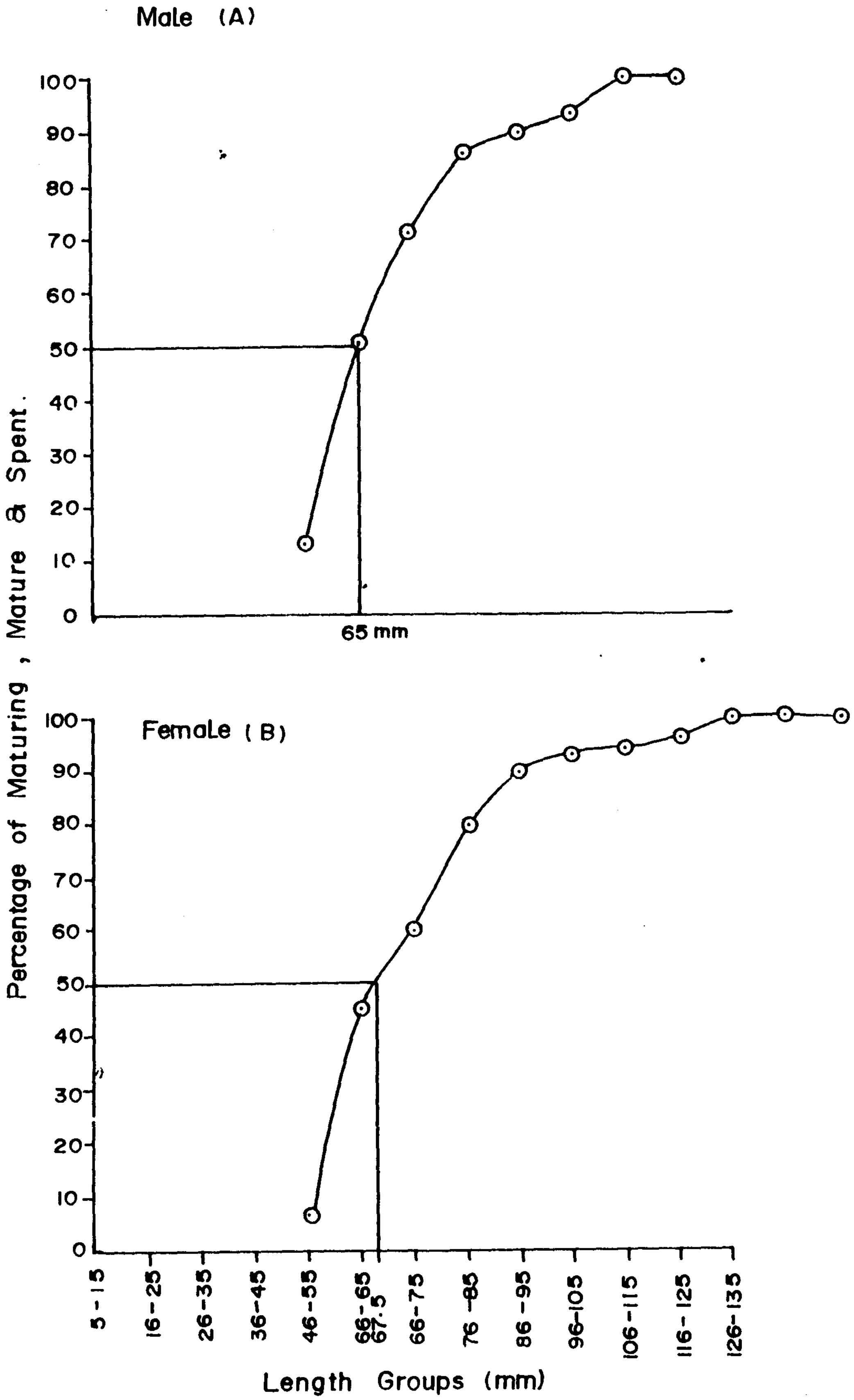


Fig. 8 A) First maturity stage in male, A. commersoni.
B) First maturity stage in female, A. commersoni.

SPAWNING SEASON

In order to determine the spawning period of A. commersoni the data on maturity stage of 527 female specimens were analysed, month by month. The specimens after being brought to the laboratory were cut open and the stages of maturity of ovaries based on the size of intra ovarian ova and deposition of yolk in them, was recorded. Table 6 and Fig. 10 show the number and percentage distribution of females in different maturity stages, monthwise. The fluctuations in the percentage frequency of stages Vth and VIth females, the virtual spawners, in different months are graphically represented in Fig. 9.

It is observed, from Table 6 and fig. 10,that the mature specimens (Stage V) in varying percentages, occur throughout the year. A scrutiny of Table 10 indicates that the occurrence of specimens, in stage V and VI is very high in commercial catches.

The data maturity of A. commersoni were pooled to delineate the breeding cycle and spawning season of the species in Goa waters. It may be seen from Table 6 and Fig. 10, that the `immature', `mature ' and `spent' condition were recorded throughout the year. Over 50% of fish sample were in mature and spent category during August - September and January - February, period.

Spawning and spent fishes were also available almost in all the months of the year. During 1988, spawning and spent fish were available for 11 months out of 12 months, but active spawning was evident only during August - September and January - February, Table 7 (Fig.11) further indicates that maximum number of fishes in stage V and VI were found in 3rd quarter of year, which appears to be first peak of spawning.

A careful examination of Table 6 Fig. 10 of the maturity data relating to the seasonal occurrence of `mature', and `spent' fishes gives an indication of the duration of breeding cycle as 5-7 months. Thus, spawning activity observed in September - October and January - February could have resulted from the same group of individuals. Therefore, the apparent lack of uniformity in the period of peak spawning activity i.e. difference between the first and second spawning peak is only three months, as against six months between second and first burst. This in turn would suggest that an individual takes 6 months to mature for the first time but it takes only three months for successive spawning.

In the present study, the conclusions regarding the spawning season are based on the percentage of specimens in stage VI (Fig. 9) and it is observed that the percentage of female in VI stage of maturity, goes on increasing from

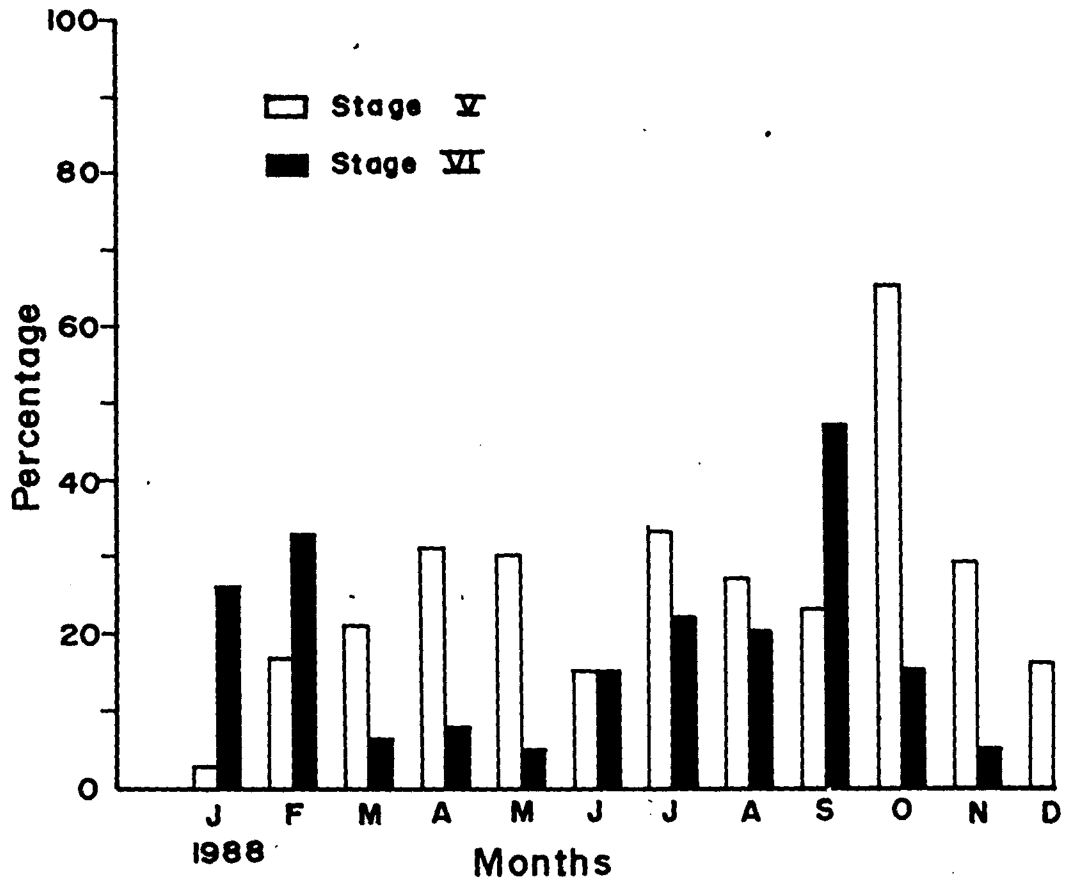


Fig.9 Histogram showing the distribution of stage V and VI in different months in female, A. commersoni.

March to September with highest percentage in September. This is followed by another, increase from October till February with highest percentage in February. The percentage of specimens in stage VI suddenly decreased in November and disappeared in December. The presence of mature fishes in stage VI in all months except in December, supports the view that A. commersoni has a prolonged breeding period with two peaks in September and February.

From a reference to Table 6, it can be seen that spent females were recorded in all months except in December. Their occurrence during the eleven months further confirms that A. commersoni spawns throughout the year, indicating a protracted spawning in the population.

Recruitment :

Since A. commersoni has protected breeding, the recruitment of younger fish to the fishable stock is almost continuous. However, the length frequency distribution of A. commersoni shows the recruitment of juveniles of both male and female into the fishery in May - June and November - December i.e. two peaks of recruitment which follows the two spawning peaks.

TABLE 6

Number of female A. commersoni in each maturity stage in different months

Year & Months	No. of fish	Maturity stages													
		I		II		III		IV		V		VI		VII	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1987															
December	13	6	46.15	2	15.38	4	30.77	-	-	1	7.69	-	-	-	-
1988															
January	32	7	21.87	6	18.73	1	3.13	4	12.51	1	3.13	10	31.25	3	9.38
February	50	8	16.00	2	4.00	1	2.00	5.	10.00	9	18.00	18	36.00	7	14.00
March	28	10	35.71	5	17.86	2	7.14	2	7.14	6	21.43	2	7.14	1	3.57
April	36	5	13.88	6	16.67	5	13.89	4	11.11	10	27.78	2	5.56	4	11.11
May	15	2	13.33	5	33.33	2	13.33	1	6.67	3	20.00	1	6.67	1	6.67
June	24	7	29.16	1	4.17	6	25.00	2.	8.33	4	16.67	2	8.33	2	8.33
July	42	5	11.90	1	2.38	5	11.90	2	4.76	17	40.48	11	26.19	1	2.38
August	53	8	15.09	3	5.66	3	5.66	4	7.55	14	26.41	12	22.64	9	16.98
September	62		-		-	3	4.84	4	6.45	17	27.42	28	45.16	10	16.13
October	26	3	11.54		-	1	3.85		-	17	65.38	4	15.38	1	3.85
November	21		-		-	12	57.14	1	4.76	6	28.57	1	4.76	1	4.76
December	18	8	44.44	2	11.11	6	33.33		-	2	11.11		-		-
1989															
January	27	3	11.11	3	11.11	2	7.41	2	7.41	12	44.44	5	18.52		-
February	46	12	26.08	4	8.70	2	4.35	2	4.35	15	32.61	7	15.23	4	8.67
March	34	7	20.59	1	2.94	6	17.65	1	2.94	10	29.41	5	14.71	4	11.76

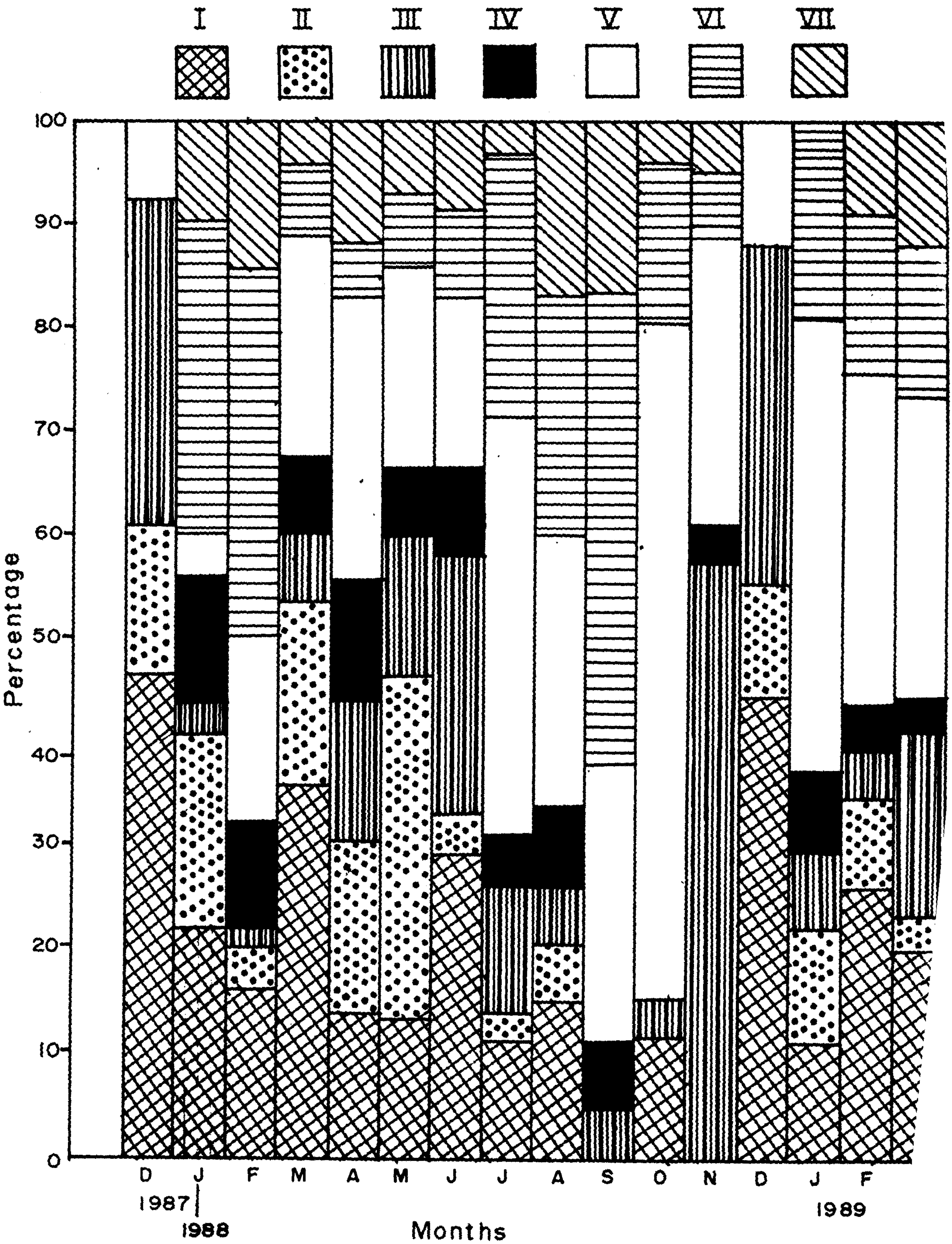


Fig. 10 Monthwise percentage of seven maturity stages in female, A. commersoni.

TABLE 7

Frequency distribution of maturity stages of female <u>A. commersoni</u>
(Only for year 1988 quaterly)

S. No.	Months	Total no. of fishes	I	II	III	IV	V	VI	VII
Ist Quarter	January February March	110	25 (22.72)	13 (11.82)	4 (3.64)	11 (10.00)	16 (14.55)	30 (27.27)	11 (10.00)
IInd Quarter	April May June	75	14 (18.67)	12 (16.00)	13 (17.33)	7 (9.33)	17 (22.67)	5 (6.67)	7 (9.33)
IIIrd Quarter	July August September	157	13 (8.28)	4 (2.55)	11 (7.00)	10 (6.37)	48 (30.57)	51 (32.48)	20 (12.74)
IVth Quarter	October November December	65	11 (16.92)	2 (3.08)	19 (29.23)	1 (1.54)	25 (38.46)	5 (7.69)	2 (3.08)

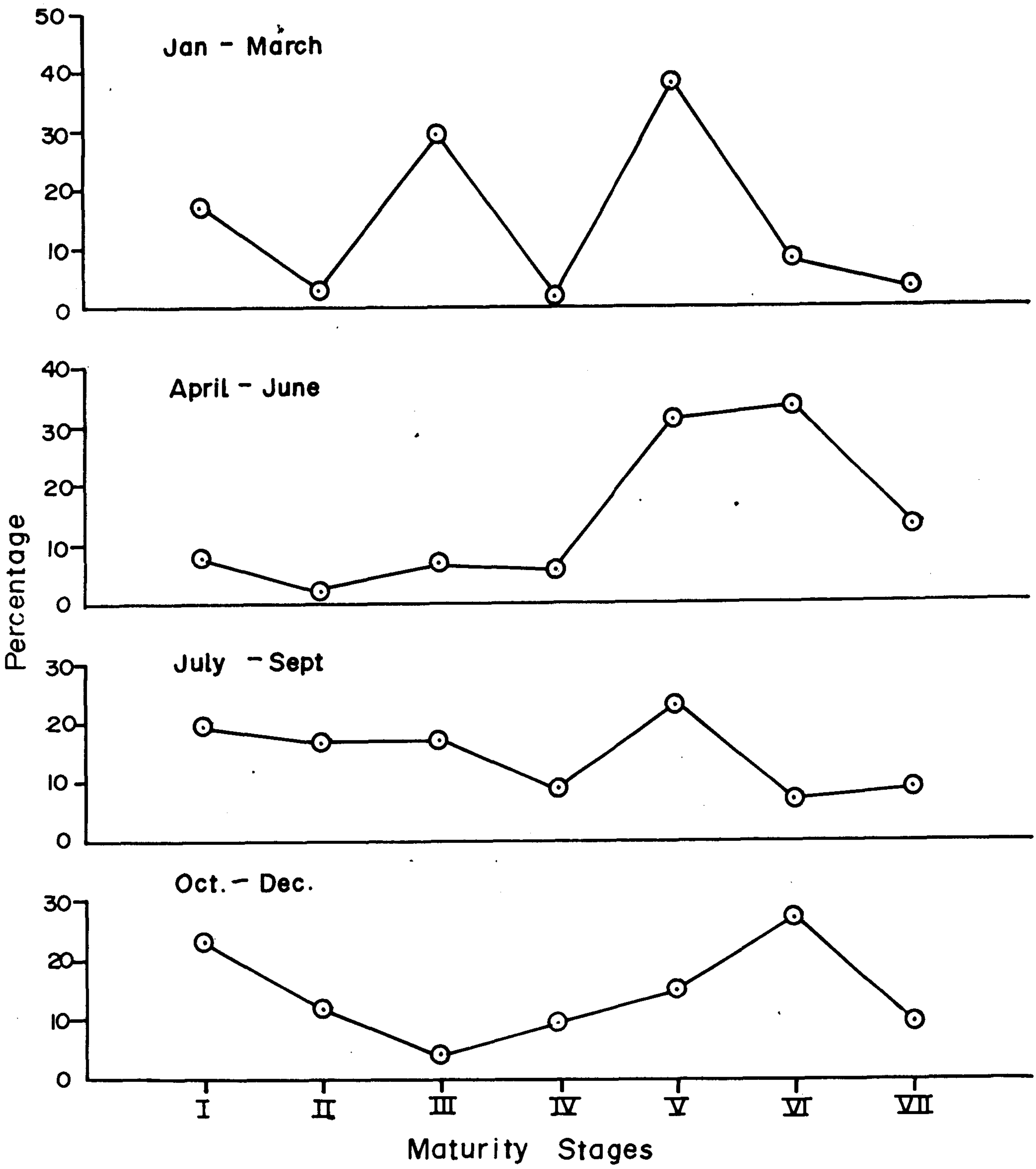


Fig. 11 Quarterly frequency distribution of maturity stages of female, *A. commersoni*.

Gonado-Somatic index :

The gonado-somatic index (GSI) relates to the gonad weight expressed as percent of body weight and has been employed by various workers, to indicate the maturity and periodicity of spawning.

$$GSI = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \times 100$$

1. Gonado-Somatic index (GSI) was calculated in terms of the weight of the fish.

The gonado-somatic index from 527 females and 485 males was calculated during different months, as shown in Fig. 12 and Table 8. From the individual values, the average GSI value for each month was calculated and the same has been used to describe the maturity condition of species for the month. Data for this were collected from December 1987 to March 1989. It is seen from Fig. 12 that, as compared to the ovaries, the testes are underweight. The ovaries are massive organ, showing appreciable variation in their size in different maturity stages.

Gonado-somatic index in different months (Fig. 12 Table 8):

In May and June, there was a slow increase in gonad weight coinciding with the abundance of stage II and III. Continuous increase in GSI during July and September coincided with the abundance of stage V and VI of ovaries.

Maximum weight of gonad was seen in July for female and in September for male. In November, there was a sharp decrease in gonad weight indicating the spawning of the first batch of egg. Again, in January-February, the gonad weight seemed to increase, reaching a second maximum in January. In March, there was a sharp fall in gonad weight of both male and female, suggesting a second spawning peak in the same year. The month of November was the time when most of the spent ovaries recovered and virgins matured. Stage III ovaries were abundant in March and stage IV ovaries in April.

Gonado Somatic Index in relation to **length group** (Fig. 13; Table 9): The lowest gonado somatic index in 46-55 length group indicate that most of the ovaries are in I and II stage of maturity.

After this, in length group 56-65 mm and 66-75 mm gonado somatic index increases to 2.06 and 3.59 indicating that ovaries are in III, IV, V, and VI stages of maturity. It slowly increases and reaches the peak in 96-105 mm size class (6.93) wherein most of the fishes were in V and VI stages of maturity.

In length group of 106-115 mm, 116-125 mm and 126-135 mm the gonado somatic index was 6.42, 6.55 and 8.01 respectively indicating that all fish were mature and spawning takes place simultaneously. Accordingly, GSI was less than in the length group 96-105 mm i.e. 6.93.

TABLE 8

Mean Gonado-Somatic Index, monthwise, in male and female of *A. commersoni*

S.No.	Month	Gonado-Somatic Index (F)	(M)
1988			
1	January	4.6962	1.7700
2	February	5.1525	1.0885
3	March	2.2402	0.8918
4	April	4.7084	0.7897
5	May	2.4729	0.7001
6	June	3.1974	0.8226
7	July	9.1923	1.0100
8	August	5.0434	0.8615
9	September	7.0055	1.4772
10	October	6.3898	0.3713
11	November	2.3212	1.4221
12	December	1.2727	0.6395
1989			
1	January	5.5133	1.5439
2	February	3.2242	0.9316
3	March	3.2755	0.9231

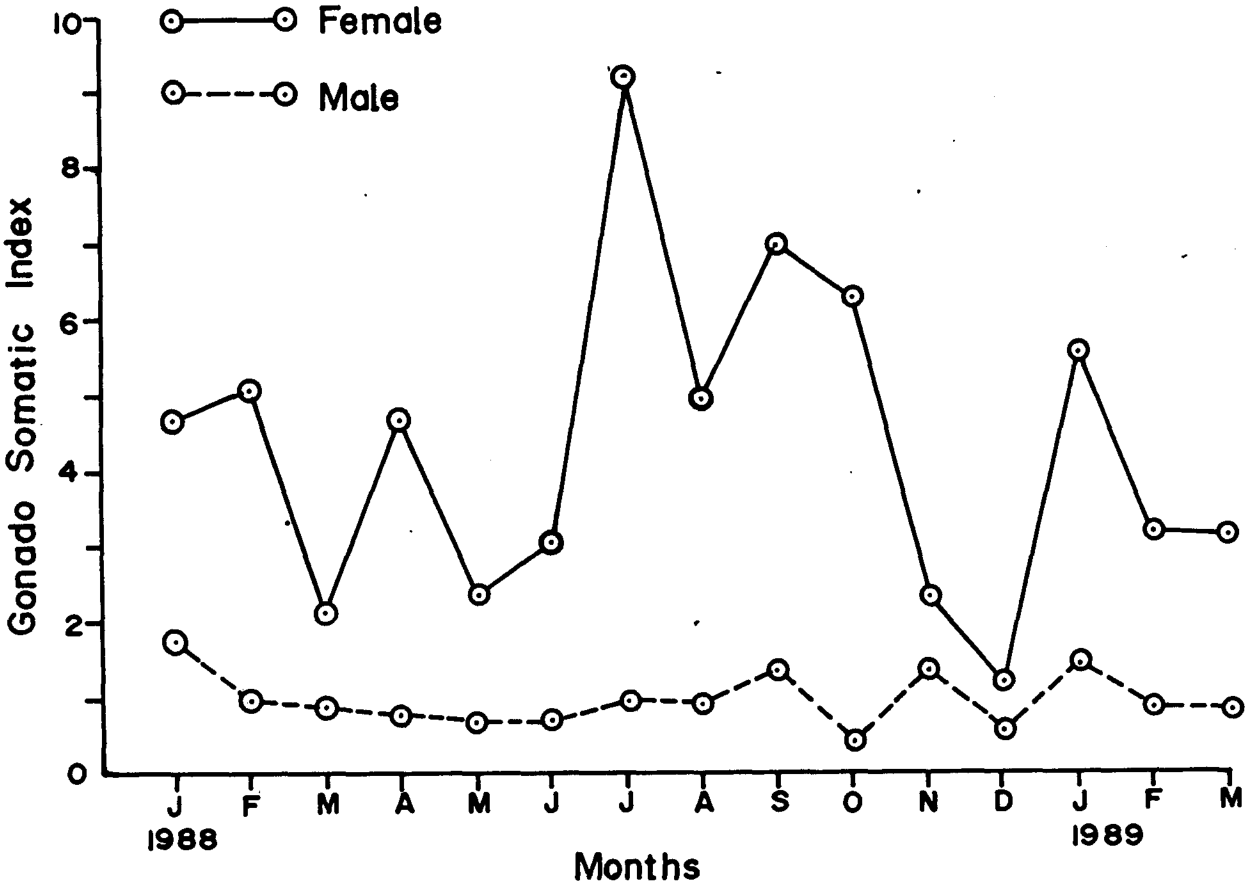


Fig. 12 Mean monthwise gonado-somatic index for male and female, A. commersoni.

TABLE 9

Mean gonado somatic index length groupwise for male and female in *A. commersoni*

S.No.	Length group	Gonado-Somatic Index (F)	(M)
1	46-55	1.2056	0.5969
2	56-65	2.0676	0.8769
3	66-75	3.5906	1.0769
4	76-85	3.3799	1.0678
5	86-95	5.4174	1.0801
6	96-105	6.9350	1.1831
7	106-115	6.4240	1.4952
8	116-125	6.5516	1.8581
9	126-135	8.0168	-

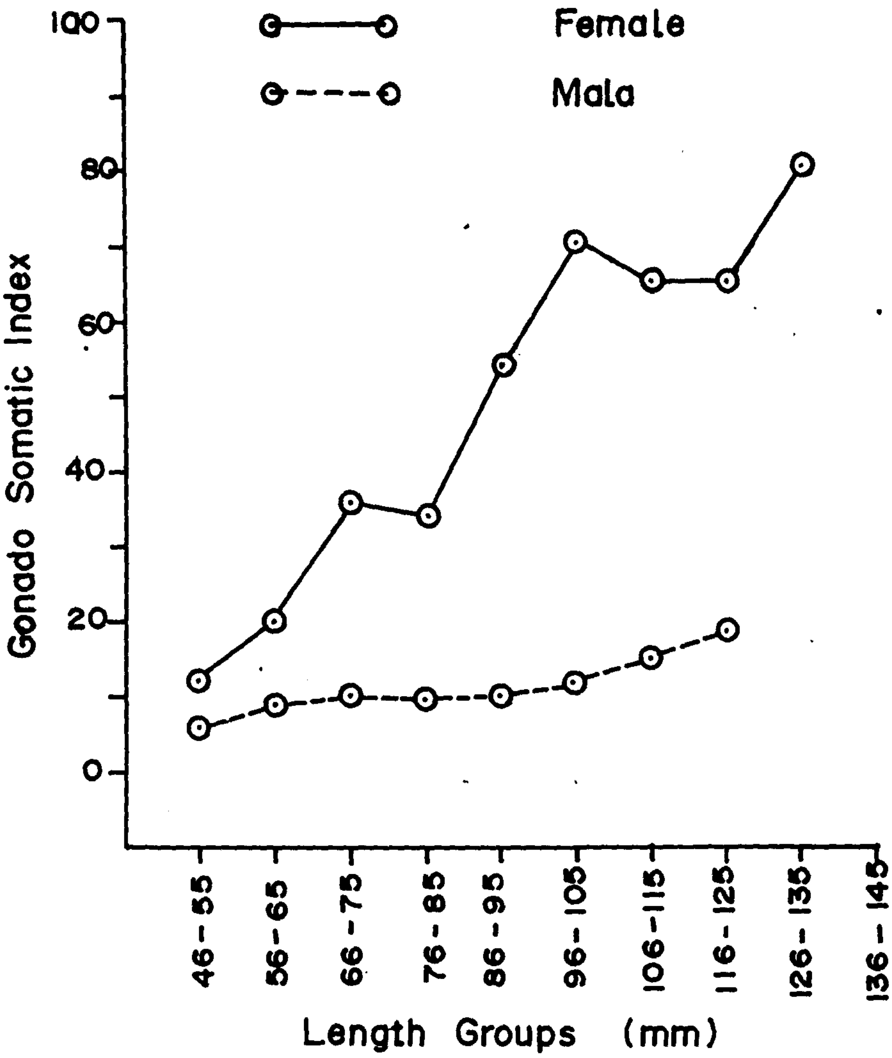


Fig. 13 Mean length groupwise gondo-somatic Index for male and female, A. commersoni.

Sex Ratio in the commercial catches of A. commersoni

The study of sex ratio of fish in commercial catch is important in the context of the participation of the two sexes in the spawning and fertilization of eggs. In A. commersoni, individuals of the two sexes of similar size do not show any sex differentiation from external characters. Ripe females, however, have slightly bulged abdomen.

Sex-ratio in relation to length: (Fig. 14 & Table 10) A total of 1012 fish ranging in length between 42 and 135 mm collected during the 16 months study period, were examined for this study. The largest female measured 135 mm and male 122 mm in length. The sex ratio in different length groups are presented in Table 10 and Fig. 14. The mean sex ratio for the whole period was F-52.12% and M-47.88%. i.e. 1.09:1 respectively.

In length groups from 46-55 mm to 66-75 mm; the incidence of male and female was almost 50.0% which gives a sex ratio of 1:1 but in fish of length group 76-85 mm, male predominated (F-20.41% and M-79.59%) with a ratio of 1:4.

In fish of length group 86-95 mm, the males dominated with a ratio of 1.2:1. From 86-95 mm length onward, however, the number of female fishes increased steeply and the sex ratio in length group 96-105 was 4.5:1 ratio. In all the remaining length groups, females predominated. The sex ratio is reversed in length group 76-85, where males were predominant.

The analysis of the sex ratio in relation to length groups shows an equal representation of sexes upto 46-55 m.m. length and preponderance of males upto 86 mm length followed by the preponderance of females in higher length groups. The change in sex ratio no doubt, be ascribed to a difference in the ratio of growth of malė and female which have passed the juvenile stage.

Sex ratio in relation to season (Fig. 14, Table 11)

The sex ratio in <u>A.</u> <u>commersoni</u> was found generally to be unequal. Females outnumbering males (F-52.12%; M-47.88%.) i.e 1:1.09 respectively.

A total of 1012 fishes were examined for this purpose (527 females and 485 males). Although sexes were found generally to be disproportionate in the commercial catches, females outnumbered males, the latter were found to be dominant only during November-December and May-June.

During July-September, which includes the active spawning period, relative proportion of male (29.21%) was less than the overall mean. During post spawning period (October-December), the proportion of male:female was almost 1:1. but in latter months male predominated and ratio, reversed, (M:F, 53.33:46:67 and 66.04:33.96 in November and December respectively) which coincides with the recovering period of the gonads.

During January, which is second active spawning period, sex ratio was almost 1:1, except in February where female outnumbered male. April - June period which represents the pre-active spawning period, males outnumber females.

Thus, it is seen that the occurrence of sexes is generally unequal throughout the period in the commercial catches. Compared with post-active spawning period, the relative proportion of male however shows a slight improvement during the pre-active spawning period. But the ratio of male decreased during active spawning period.

TABLE 10

Sex ratio in A. commersoni - Lengthwise

S.No.	Len.Gr.	Total No.	Male No.	Male %	Female No.	Female %	Sex ratio Male to Female M:F
1.	36-45	1	1	100	-	-	-
2.	46-55	28	15	53.57	13	46.43	1::0.87
3.	56-65	225	126	56.00	99	44.00	1::0.79
4.	66-75	205	112	54.63	93	45.36	1::83
5.	76-85	147	117	79.59	30	20.41	1::0.26
6.	86-95	132	73	55.30	59	44.69	1::0.81
7.	96-105	149	27	18.12	122	81.88	1::4.52
8.	106-115	90	6	6.67	84	93.33	1::14.0
9.	116-125	31	8	25.81	23	74.19	1::2.88
10.	126-135	4	-	-	4	100	0::4

TABLE 11

Sex ratio in A. commersoni - Monthwise

S. No.	Months	Total No.	Male No.	Male %	Female No.	Female %	Sex ratio Male to Female M F
	1987						
	December	41	28	68.29	13	31.71	1::0.46
	1988						
1.	January	71	39	54.93	32	45.07	1::0.82
2.	February	75	25	33.33	50	66.67	1::2.00
3.	March	74	46	62.16	28	37.84	1::0.61
4.	April	73	37	50.68	36	49.32	1::0.97
5.	May	58	43	74.13	15	25.86	1::0.35
6.	June	69	45	65.22	24	34.78	1::0.53
7.	July	68	26	38.24	42	61.76	1::1.62
8.	August	89	36	40.45	53	59.55	1::1.47
9.	September	68	6	8.82	62	91.18	1::1.33
10.	October	49	23	46.94	26	53.06	1::1.13
11.	November	45	24	53.33	21	46.67	1::0.51
12.	December	53	35	66.04	18	33.96	1::0.51
	1989						
13.	January	54	27	50.00	27	50.00	1::1.00
14.	February	71	25	35.21	46	64.79	1::1.84
15.	March	53	19	35.84	34	64.15	1::1.79

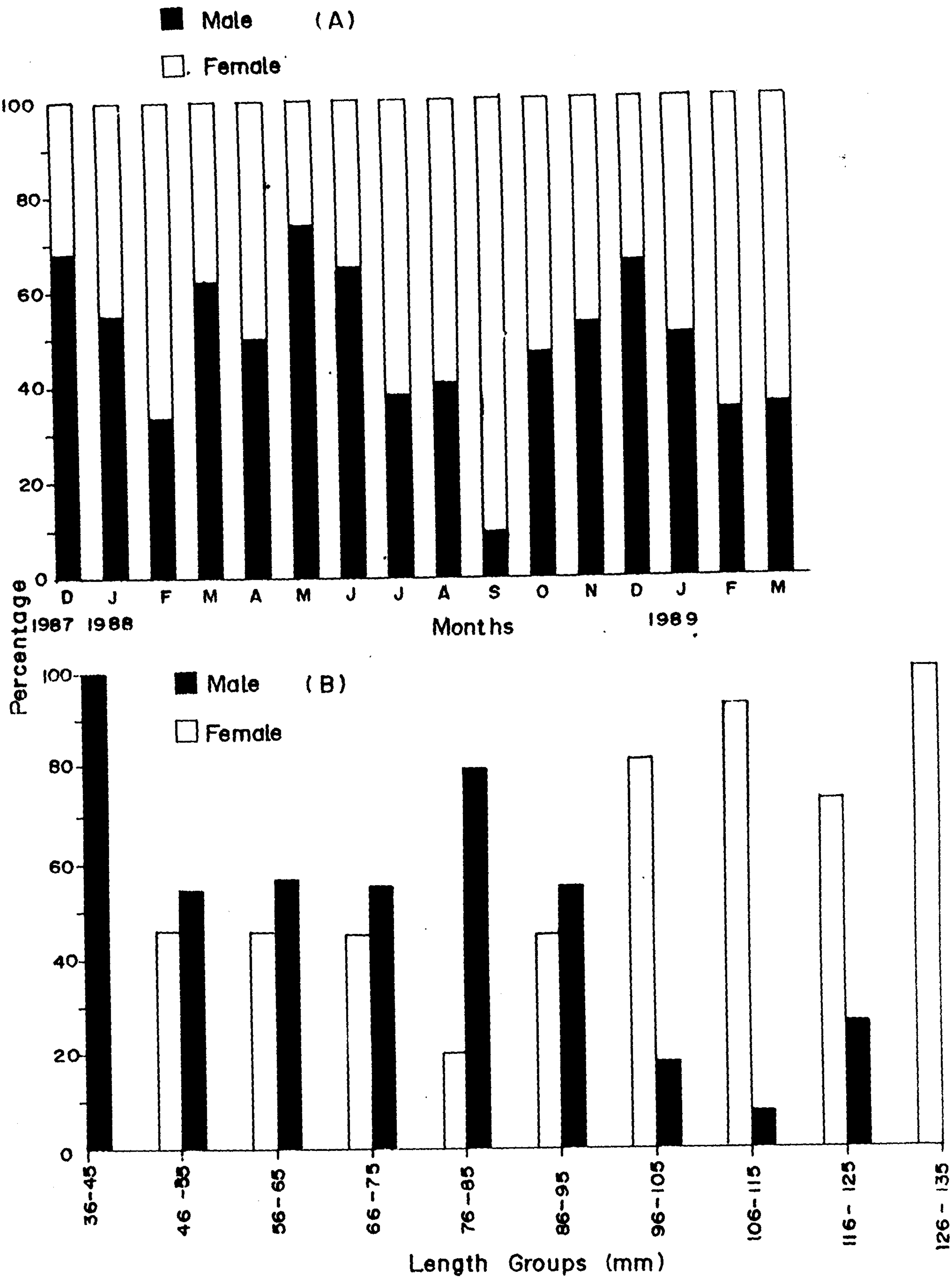


Fig. 14 A) Monthwise sex ratio of male and female in A. commersoni.
B) Length groupwise sex ratio of male and female in A. commersoni.

DISCUSSION

Ovaries have been found to be more reliable for routine macroscopic determination of sexual maturity than testes, as they slowly increase in the length, width and thickness during the different stages of maturation cycle.

The microscopic structure and size of ova were taken in consideration to classify ovary in seven stages of maturity, to study the cycle of gonadal development. In studying the growth of ovary from the immature to spent stage, ova diameter measurement was taken in different stages of maturity, following the method adopted by Clark (1934).

The frequency polygons of monthly progression of ova in seven maturity stages reveals that there are four groups of ova `a', `b', `c', `d', consisting of immature, maturing, matured and ripe ova in *A. commersoni*. The mature ova were distinctly separated from maturing one. The two batches of ova present in ripe ovary, one in very advanced stage and other less developed i.e. bimodal distribution of intra ovarian eggs indicate that the species spawn twice in a year. This is as reported earlier by, Prabhu (1956), Parulekar (1964), Raja (1964), Rao (1967), Girijavallabhan (1982) and Luther (1986) for different species of fish in Indian waters.

Venkataramanujam and Venkataramani (1984) observed that ripe ovary in A. commersoni shows two modes of ova, one `maturing' and other `mature'. Thus indicating that fish spawns twice a year. According to Hickling and Rutenberg (1936) ripe ovary contains an intermediate group of ova which had undergone half maturation process apart from mature group of eggs and it was expected to spawn twice a season. A. commersoni was observed to attain maturity for first time at a total length of 65 mm in male and 67.5 mm in female. According to Royan and Venkaramanujam (1975) A. commersoni attains maturity at 67.0 m.m. length in Porto Novo coast. However, Nair et.al (1984) reported length at first maturity for female 97.5 mm and male 87 mm in A. commersoni from brackish water lakes of Kerala.

The difference in length at maturity between two sexes was clearly seen from combined data of two sexes which show that 50% of male and female attains first maturity at a length of 65 mm and 67.5. mm (total length) respectively. Males attain maturity at smaller length as compared to females.

The annual cycle pattern of the breeding in A. commersoni was characterized by the recurrence of spent and recovering specimens during September - October followed by early maturing in December. The gonadal activity increases rapidly from July onwards, reaching peak in August - September and January - February. The spawning season extends, almost throughout the year with mature, spawning and spent fishes occurring in relatively larger number during two periods in a year, the corresponding months of the two spawning peaks. Venkataramanujam & Venkataramani (1984) reported a prolonged breeding season with two peaks, one in March to May and the other in August to September. Nair, and Nair, (1984) also observed prolonged breeding season in A. commersoni.

Throughout the period of the present investigation, 'mature' gonads were noticed. Similarly, 'spent' individuals were also found in most part of the year. As evident from the frequency distribution of 'mature' and 'maturing' ova and prevalence of ripe ovary in September - October and January - February it can be inferred that it spawns twice a year. Higher value of GSI particularly in female during September - October and January confirmed the occurrence of two spawning peaks.

Similar observations have earlier been reported by Arora (1951), Parulekar (1964), Rao (1967), Luther (1986) and Gowda & Shanbhoque (1988) for other species of marine fishes from Indian waters.

Sex-ratio : The overall sex ratio of the species was unequal, with females having preponderance in the commercial catches. Both the sexes seem to be equally distributed in the small length groups, followed by male dominance in intermediate length groups whereas females out number male in larger size groups. This may be due to reduction in the rate of linear growth which has been found to set in from about the size at first maturity in both sexes. Due to the difference in growth rate, together with the thinning of the numerical strength of the higher age group which is common with the exploited stocks, the female may tend to become more numerous in the larger sizes and male in small size groups even if equal number of them are born and survived. Similar observations have earlier been reported by Begenal (1957) and Luther (1986).

Sex ratio is always between two components deviating significantly from hypothetical distribution of 1:1 in higher length groups. The preponderance of females in larger size groups appears to be due to heavy mortality of males in small size groups. At that stage they are more active thus more liable to be caught by fisherman or more exposed to predators. Males mature earlier than females and also attain maturity at a smaller size. Both these characteristics of males appear to be related to a more active and shorter life. The recovered spent individuals of both sexes mature earlier than the maturing virgin. Nair, and Nair, (1984) reported in <u>A.commersoni</u> average male to female ratio of 1:2.5 which is also different from hypothetical value (1:1).

The monthwise, number of females to male were more in active spawning period i.e. February and September. Post spawning period sex ratio was equal in April and October. While in pre spawning period (May-June) number of male was more than female. Thus, it seems that sexes are generally unequal throughout the period in the commercial catches. The increase of males in the spawning ground particularly so, prior to peak spawning period, suggest that male reaches earlier as well as remain longer on spawning ground.

In A. commersoni, males are smaller in size than females, largest female was 135 mm and male 122 m.m in length. Male being smaller than female is, however, not peculiar to A. commersoni, for according to Nikolsky (1963) males are larger than female only in few species. Qasim (1966), Raja (1972) and Luther (1975) attributed it to the faster growth of females in comparison to male. Studies on A. commersoni also leads to same conclusion.

The dominance of a particular sex in the commercial catch was differently interpreted and reported by Kestevan (1942), Alm (1959), Parulekar (1964), Qasim (1966), James, Gupta and Shanbhogue (1978), James and Gowda and Shanbhogue (1988).

Final analysis shows that sex ratio between male and female do not deviate significantly from hypothetical distribution of 1:1 as it stands as 47.88% male and 52.12% females i.e. 1:1.09.

IV. FECUNDITY

FECUNDITY

INTRODUCTION

The fecundity in fish is defined as number of ripening eggs in females prior to spawning period. The knowledge of the fecundity or reproductive potential of fish, is of great importance, for a number of purposes for example as a part of systematics in racial studies, inconnection with total population estimation or in studies of population dynamics or productivity. The capacity of egg production varies within the individual of a species, depending upon different variables, such as length, body weight, gonad weight, volume of fish etc.

The study of fecundity is also undertaken to determine the index of density dependent factors affecting the population size (Simpson 1951).

Rounsefell (1957) while discussing the fecundity variations in the north American Salmonidae, observed that the fecundity of the same species and that the annual differences in fecundity in the same population, may be caused by differences in size or by differences in age at maturity.

Some of the important contributions on the fecundity estimates of fishes are those of Mitchell (1913) Kisselvitch (1923); Ricker (1932); Raiff (1932), Clark (1934); Farran

(1938); Hickling (1940); Prabhu (1955); Mc Gregor (1957); Sarojini (1957); Hartman and Conkle (1960); Palekar and Bal (1961); Tandon (1961) etc.

MATERIAL AND METHODS

In the present investigation, 43 ovaries of stage V and VI individuals of A. commersoni, were studied to determine the aveiage number of ova produced by the species and to establish the relationship between fecundity and different body variables.

For fecundity estimates, ovaries in stage V and VI were only used. As mature eggs in these ovaries were well separated from immature stock, the number of mature eggs in the two lobes of an ovary were estimated to obtain the fecundity of an individual. A piece of formaline preserved ovary was cut and removed from the middle region of both lobes of ovaries and after recording the weight of the sample piece, the mature ova in it were teased out and counted. Total number of mature ova in each pair of ovaries was estimated by multiplying number of mature ova in the sample by ratio of the ovary weight to sample weight.

$$\text{Fecundity} = \frac{\text{No. of total ova in sample x weight of paired ovary}}{\text{Weight of sample}}$$

The relation between fecundity and the following three variables, were determined:

1. Fecundity and fork length (Total length).

2. Fecundity and total weight of fish (w1).

3. Fecundity and ovary weight (w2).

All the measurements were taken in fresh condition. Fecundity and length of the fish is expressed as -

$$F = aL^b$$

and fecundity and weight as :

$$F = a + bw$$

where F - fecundity in thousand

L - length of fish in mm

W - weight (w1, w2) of fish in grams.

a and b - constants, the value of which is calculated by method of least squares.

The standard error (SE) of estimate of `b', and corelation cofficient were calculated.

RESULTS

(a) Total length and Fecundity Relationship (Fig. 15, Table 13):

It showed the best fit by an exponential equation as :

$$\text{Log } F = -3.6156 + 4.0520 \text{ Log } L$$

where F = Fecundity, L = Total length of fish in mm. From this equation, the calculated value of fecundity were worked out as shown in Table 13. From Fig. 15, it can be said that in *A. commersoni*, the length-fecundity relationship is of linear type and fecundity increased at the rate of 4.0520 times the total length.

(b) **Total weight (w1) and Fecundity Relationship :- (Fig. 16, Table 14)**

As shown in Fig. 16 and Table 14, the rate of increase of fecundity was 1.0328 times of the weight of fish and the regression equation:

$$\text{Log } F = 3.4127 + 1.0328 \text{ Log } W$$

where F = fecundity (in thousands)

W1 = total weight in gms

(c) **Gonad weight (W2) and Fecundity Relationship (Fig. 17 and Table-15:**

Logarithmic values of the fecundity data obtained from 43 fishes have been plotted against logarithmic gonad weight values of fish as seen in Fig. 17 and Table 15. The fecundity increases at the rate of 1.0893 times of the weight of gonads. The regression equation for this relationship is -

$$\text{Log } F = 4.5712 + 1.0893 \text{ Log } W2$$

where F = fecundity in thousands

W2 = weight of gonad in gms

The direct relationship was obtained in between gonad weight and fecundity.

$$\text{Log } F = -3.6156 + 4.0520 \text{ log total length}$$

Log F = 3.4127 + 1.0328 log total weight

Log F = 4. 5712 + 1.0893 log gonad weight

The scatter diagrams show that fecundity of individual fish of same length and weight can vary considerably. Similarly, the relationship between fecundity and gonad weight is also significant.

Thus results show that proportional change in fecundity is about 4 times the proportional change in length of fish and fecundity increases in same proportion of weight (i.e. one time).

Total length/body weight, total length, ovary weight and total length/fecundity relationship:

The relationship between total length/total weight, total length/ovary weight and total length/fecundity were found to be linear (Fig. 18). As the total length increases the three variables also increase, correspondingly. It is represented by following equation.

Log B. W. = -5.9000 + 3.4729 log L

Log O. W. = -8.6482 + 4.2836 Log L

Log F = -3.6156 + 4.0520 Log L

where B.W. = body weight

" O.W. = ovary weight

" F = fecundity

" L = total length

It is clear (Fig. 18) that for each increase in body length there was a corresponding increase in weight of fish and fecundity. The value of b is 3.4729 in body weight, 4.2836 times in ovary weight and 4.0520 times in fecundity. The relationship is linear and the rate of increase of body weight was 3.4729 times of length, whereas rate of increase of ovary weight and fecundity was 4.2836; 4.0520 times of length, respectively.

The co-relation coefficient was 0.94, 0.75, 0.53 in body weight, ovary weight and fecundity respectively, and was highly significant in relevance to body weight.

TABLE - 12

Comparison in between three different equations

Sample	Equation	Regression constant	Regression coefficient	Sd. b error (b)+	Correlation coefficient
131	a	3.6156	4.0520	0.5782	0.5251
131	b	3.4127	1.0328	0.1602	0.4931
131	c	4.5712	1.0893	0.0692	0.8109

From these equations, the estimated number of mature ova, for each variable, was calculated as shown in respective tables. After noting down the differences between observed value and the calculated value, the standard error of b was calculated for different variables. This shows that lowest b+ and highest r & b values were found in ovary weight and fecundity relationship which indicates that gonad weight is more suitable than any other parameter for fecundity estimation.

DISCUSSION

There has been some difference of opinion among various authors as to whether square of length or cube of length will give best straight line correlation with fecundity.

Franz (1910 a and b), Kisselvitch (1923) and Clark (1934) held the view that the fecundity of a fish increases with the square of its length. Simpson (1951) pointed out the difficulty of such an assumption in view of the fact that egg production in an ovary is not a surface phenomenon, and that the germinal epithelium is folded to fill the volume of ovary and therefore the fecundity is related to the volume and consequently to the cube of the length.

Parulekar (1964) reported a cube relationship between fecundity and the length. Farran (1938); Prabhu (1955) and Palekar and Bal (1961) have observed that the rate of increase in fecundity was more than fourth power of length. Lehman (1953) and Peterson (1961) have observed a linear relationship between fecundity and length.

The result of this study, however supports the view, that the fecundity of A. commersoni increases at the rate of about 4 times of the total length. Antony Raja, (1972) observed a straight line regression of log fecundity on log length ($r-aL^{b}$) in oil sardine.

The straight line relationship between the fecundity and weight has been reported earlier by Bagenal (1957); Sarojini (1957), Tandon (1961); Peterson (1961); Parulekar (1964). Luther (1967) Parulekar and Bal (1971); Das (1978) and Luther (1986) have reported straight line relationship between weight and fecundity. In *A. commersoni* a similar relationship was observed between total weight and fecundity. However, Venkataramanjam et.al 1984 also reported straight line relationship in between length, fecundity and weight fecundity in *A. commersoni*. Nair et.al (1984) Venkataramanjam et.al (1984) reported fecundity 21,380 to 338,065 eggs and 13072 to 36800 eggs, respectively, in *A. commersoni*.

It may be concluded that fecundity in *A. commersoni* is affected by the ovary weight than any other `parameter' and the maximum number of mature eggs found were 92157 and minimum 5211.

TABLE - 13

Relation between fecundity and total length in *A. commersoni*

Sr. No.	LEN (X)	LOG (X)	FCDTY = Y	LOG Y	COMP Y
1.	116	2.0645	41042	4.6132	4.7497
2.	89	1.9494	40537	4.6079	4.2834
3.	85	1.9294	5481	3.7389	4.2025
4.	111	2.0453	27998	4.4471	4.6722
5.	108	2.0334	50848	4.7963	4.6339
6.	113	2.0531	44957	4.6528	4.7036
7.	104	2.0170	28878	4.4606	4.5575
8.	115	2.0607	75716	4.8792	4.7345
9.	91	1.9590	19472	4.2894	4.3325
10.	114	2.0569	44129	4.6447	4.7191
11.	111	2.0453	64341	4.8085	4.6722
12.	86	1.9345	10788	4.0330	4.2231
13.	107	2.0294	59443	4.7741	4.6076
14.	100	2.0000	66076	4.8200	4.4885
15.	101	2.0043	53721	4.7302	4.5060
16.	103	2.0128	33765	4.5285	4.5405
17.	105	2.0212	23497	4.3710	4.5744
18.	109	2.0374	60549	4.7821	4.6402
19.	102	2.0086	49280	4.6927	4.5234
20.	117	2.0682	79660	4.9012	4.7648
21.	123	2.0899	31908	4.5039	4.8528
22.	135	2.1303	92157	4.9645	5.0166
23.	67	1.8261	9061	3.9572	3.7838
24.	63	1.7993	6906	3.8392	3.6754
25.	129	2.1106	59479	4.7744	4.9366
26.	110	2.0414	36388	4.5610	4.6562
27.	88	1.9445	17679	4.2475	4.2635
28.	99	1.9956	25582	4.4079	4.4708
29.	95	1.9777	39829	4.6002	4.3982
30.	94	1.9731	35202	4.5466	4.3796
31.	93	1.9685	58625	4.7681	4.3608
32.	97	1.9868	20572	4.3133	4.4349
33.	118	2.0719	5211	3.7169	4.7798
34.	122	2.0864	49563	4.6952	4.8384
35.	69	1.8388	189	2.2765	3.8355
36.	98	1.9912	55929	4.7476	4.4530
37.	96	1.9823	17528	4.2437	4.4167
38.	120	2.0792	58655	4.7683	4.8094
39.	112	2.0492	54050	4.7328	4.6879
40.	81	1.9085	11808	4.0722	4.1177
41.	75	1.8751	9859	3.9939	3.9823
42.	72	1.8573	6976	3.8436	3.9104
43.	71	1.8513	11415	4.0575	3.8858

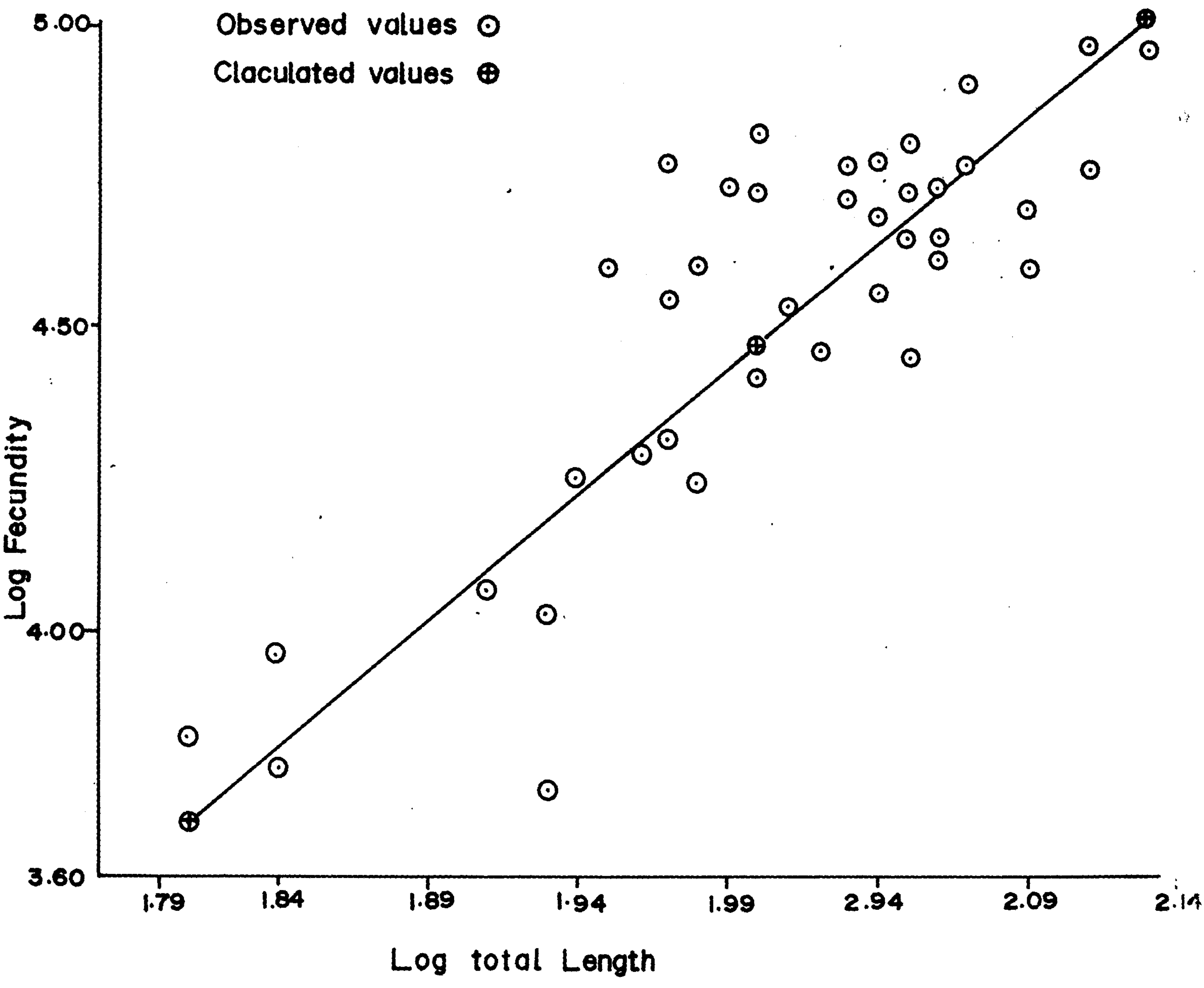


Fig. 15 Fecundity verses total length in *A. commersoni*

TABLE - 14

Relation between fecundity and total weight in A. commersoni

Sr. No.	TL-WT (g)	LOG (TL-WT)	FCTY	LOG (Y)	COMP (Y)
1.	18.33	1.2632	41042	4.6132	4.7172
2.	7.11	.8519	40537	4.6079	4.2925
3.	6.99	.8445	5481	3.7389	4.2848
4.	15.82	1.1992	50848	4.7063	4.6512
5.	16.72	1.2232	44957	4.6528	4.6760
6.	9.07	.9576	27958	4.4465	4.4017
7.	17.96	1.2543	75716	4.8792	4.7081
8.	8.33	.9206	19472	4.2894	4.3635
9.	18.39	1.2646	44129	4.6447	4.7187
10.	15.39	1.1872	64341	4.8085	4.6388
11.	6.73	.8280	10788	4.0330	4.2678
12.	13.25	1.1222	59443	4.7741	4.5717
13.	10.64	1.0269	66076	4.8200	4.4733
14.	12.93	1.1116	53721	4.7302	4.5607
15.	11.49	1.0603	33765	4.5285	4.5077
16.	11.26	1.0515	23497	4.3710	4.4987
17.	15.29	1.1844	60549	4.7821	4.6359
18.	13.70	1.1367	49280	4.6927	4.5867
19.	19.06	1.2801	79660	4.9012	4.7348
20.	23.00	1.3617	31908	4.5039	4.8190
21.	33.82	1.5292	92157	4.9645	4.9920
22.	2.63	.4200	9061	3.9572	3.8464
23.	2.23	.3483	6906	3.8392	3.7724
24.	28.41	1.4535	59479	4.7744	4.9138
25.	14.81	1.1706	36388	4.5610	4.6216
26.	7.00	.8451	17679	4.2475	4.2855
27.	9.00	.9542	25582	4.4079	4.3982
28.	9.00	.9956	39829	4.6002	4.4409
29.	9.28	.9675	35202	4.5466	4.4119
30.	8.36	.9222	58625	4.7681	4.3651
31.	9.00	.9542	20572	4.3133	4.3982
32.	20.00	1.3010	5211	3.7169	4.7563
33.	3.00	.4771	189	2.2765	3.9054
34.	12.00	1.0792	55929	4.7476	4.5272
35.	11.00	1.0414	17528	4.2437	4.4882
36.	30.00	1.4771	58655	4.7683	4.9382
37.	18.00	1.2553	54050	4.7328	4.7091
38.	6.00	.7782	11808	4.0722	4.2163
39.	15.36	1.1864	27998	4.4471	4.6379
40.	11.16	1.0477	28878	4.4606	4.4947
41.	3.48	0.5416	9859	3.9939	3.9720
42.	2.92	0.4654	6976	3.8436	3.8933
43.	2.88	0.4594	11415	4.0575	3.8871

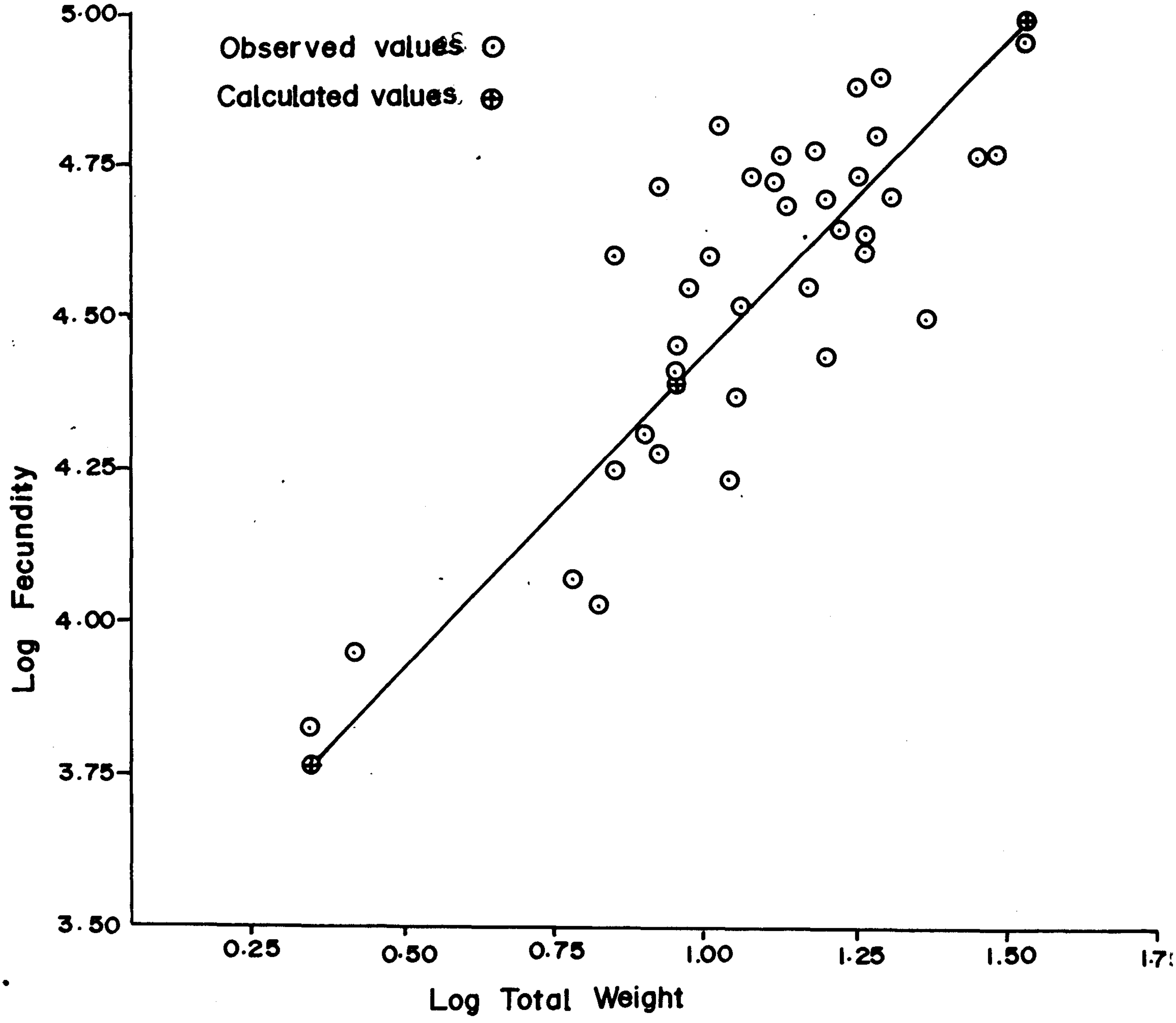


Fig. 16 Fecundity verses total weight in A. commersoni

TABLE - 15

Relation between fecundity and ovary weight in A. Commersoni

Sr. No.	OVRY WT (X) (g)	LOG (X)	FCNDTY (Y)	LOG Y	COMP Y
1.	.7660	- .1158	27998	4.4471	4.4451
2.	2.4942	.3969	75716	4.8792	5.0036
3.	.3532	- .4520	19472	4.2894	4.0788
4.	.9641	- .0159	44129	4.6447	4.5539
5.	1.3389	.1267	64341	4.8085	4.7092
6.	.3041	- .5170	10788	4.0330	4.0080
7.	1.1713	.0687	59443	4.7741	4.6460
8.	.6872	- .1629	66076	4.8200	4.3937
9.	1.0603	.0254	53721	4.7302	4.5989
10.	.6753	- .1705	33765	4.5285	4.3854
11.	.5394	- .2681	23497	4.3710	4.2791
12.	1.7270	.2373	60549	4.7821	4.8297
13.	1.5720	.1965	49280	4.6927	4.7852
14.	1.2461	.0956	31908	4.5039	4.6753
15.	2.3687	.3745	92157	4.9645	4.9791
16.	.2000	- .6990	9061	3.9572	3.8098
17.	.1544	- .8114	6906	3.8392	3.6874
18.	3.5036	.5445	59479	4.7744	5.1643
19.	1.1640	.0660	36388	4.5610	4.6430
20.	1.0926	.0385	25582	4.4079	4.6131
21.	.5608	- .2512	39829	4.6002	4.2975
22.	.8018	- .0959	35202	4.5466	4.4667
23.	.8375	- .0770	58625	4.7681	4.4873
24.	.8095	- .0918	20572	4.3133	4.4712
25.	.3553	- .4494	5211	3.7169	4.0816
26.	2.0978	.3218	49563	4.6952	4.9217
27.	.0185	-1.7328	189	2.2765	2.6836
28.	1.2487	.0965	55929	4.7476	4.6762
29.	.7342	- .1342	17528	4.2437	4.4250
30.	1.6225	.2102	58655	4.7683	4.8001
31.	2.2402	.3503	54050	4.7328	4.9527
32.	.2919	- .5348	11808	4.0722	3.9886
33.	1.3122	.1180	41042	4.6132	4.6997
34.	.7402	- .1307	40537	4.6079	4.4289
35.	.1736	- .7605	5481	3.7389	3.7428
36.	.9115	- .0402	50848	4.7063	4.5273
37.	.9054	- .0432	44957	4.6528	4.5242
38.	.6278	- .2022	28878	4.4606	4.3509
39.	1.5378	.1869	79660	4.9012	4.7748
40.	.2100	- .6778	9859	3.9939	3.8329
41.	.2156	- .6664	6976	3.8436	3.8453
42.	.2673	- .5730	11415	4.0575	3.9470
43.	.6536	- .1847	17679	4.2475	4.3700

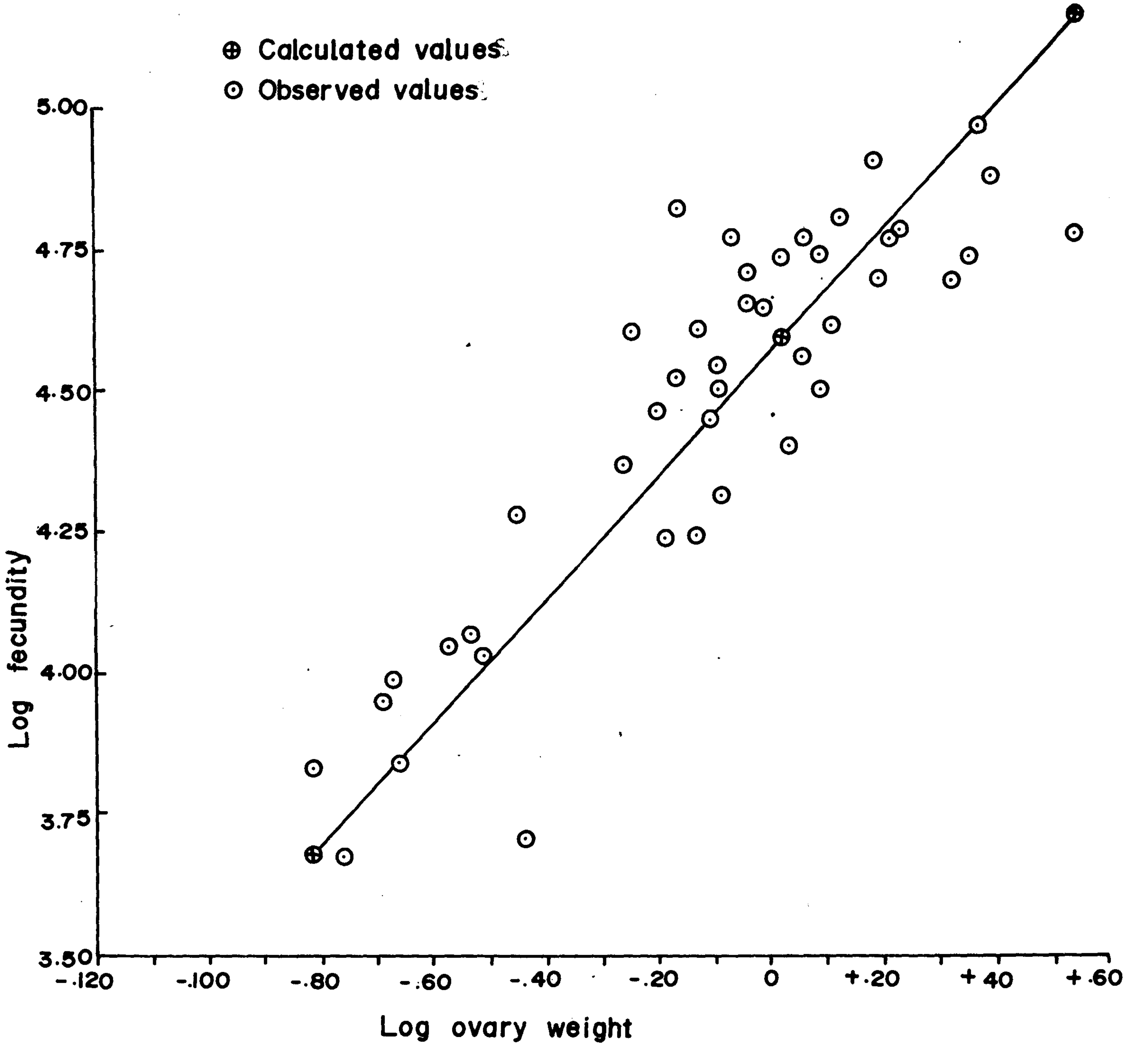


Fig. 17 Fecundity verses gonad weight in A. commersoni

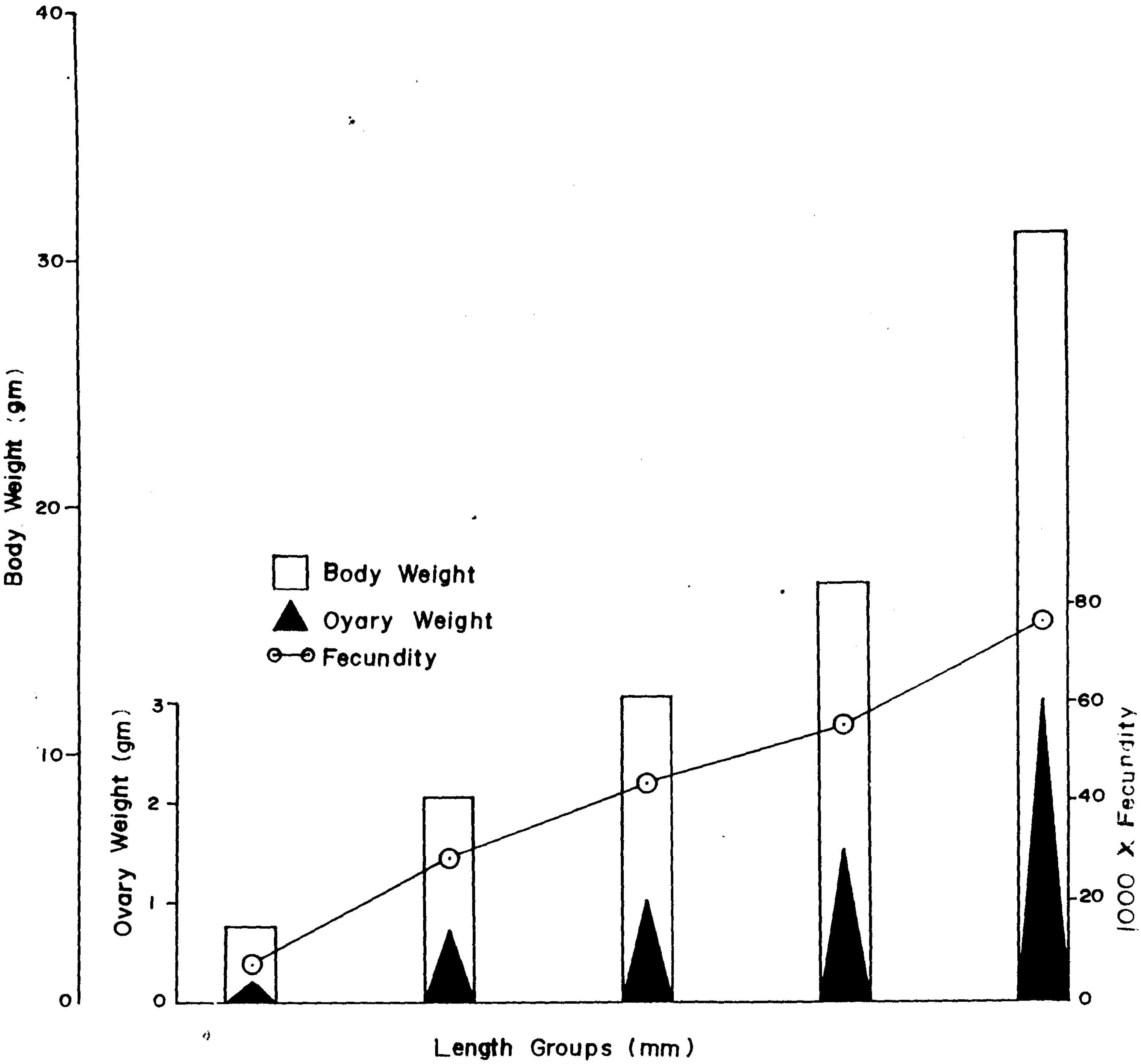


Fig. 18 Comparison between total length / body weight / ovary weight / fecundity relationship.

V. FOOD AND FEEDING HABITS

FOOD AND FEEDING HABITS OF *A. COMMERSONI*

INTRODUCTION

Studies on the food and feeding habits of fishes are important as it gives an insight into the details of food preference at age and maturation of gonads, on feeding in relation to ecology and biology of the fish. Such an important aspect of the biology of *A. commersoni* has not received due attention so far, though the specie is commercially important along the Indian coast.

With a view to obtain the relevant information, a detailed investigation was carried out during 1987-1989 and the results are presented here.

The problem of food of fishes attracted the attention of a few ichthyologists towards the end of last century and since then several investigations on this line have been carried out in many parts of the world. Day (1882) made the beginning of such a study by carrying out observations on the food and feeding habit of Herring. Later Johnstone (1907), Pearse (1915), Lebour (1919b), Scott (1920), Welsh and Breder (1923), Hardy (1924), Stevan (1930), Swynnerton and Worthington (1940), Suyehiro (1942), Frost (1943), Hynes (1950), Kow (1950), and several others have studied the food and feeding habits of different fishes.

A number of workers have studied the various aspects of food and feeding habits of marine fishes of India. In this connection, mention may be made of the contribution of Devanesan (1932), Job (1941), Gopinath (1942), Chidambaran (1944), Mookerjee (1946), Chacko (1949), Pillay (1953), Sarojini (1954), Palekar & Bal (1959), Sreenivasan (1979), Datta and Das (1979) and Tondel Athalye and Gokhale (1986).

MATERIAL AND METHODS

The food and feeding habits of *A. commersoni* were studied by examining the stomach contents of over 1199 specimens both adult and juvenile, in a period of sixteen months from December 1987 till March 1989. The samples in fresh condition were collected from landing centres at Ribandar, four pillar, Dona Paula and Panaji Jetty all places in and around Panaji, Goa and the specimens in the size range of 18-135 mm were collected. The specimens were properly cleaned in the laboratory and the total length, weight, sex, stage of maturity and degree of fullness of stomach was noted down. After this, gut was removed and weighed in electronic balance with an accuracy of 0.0001 gm. The intensity of feeding was determined by the degree of distention of the stomach and also the amount of food it contained. The fullness has been graded as empty, little, 1/4 full, 1/2 full, 3/4 full and gorged. The percentage occurrence of these different categories of stomach was calculated from the total number of fish examined.

The stomach was then separated from the intestine and rectum, after ascertaining that no undigested food particle has passed out. The separated stomach was preserved in 5% sea water formaline for further examination. The amount of gut content was known by weighing gut before and after removing the food present in the gut. Each stomach was cut under binocular microscope, the content observed and counted.

The percentage composition of the various items of the gut content was analyzed by the number method (Hynes, 1950). The different food items were counted (under binocular microscope) and its relative abundance expressed as percentage of the total number of items in the gut content. The prevalence of each item of food among different group was calculated by occurrence method (Hynes 1950). In this method the occurrence of all items was summed in each fish and scaled down to percentage.

From the total number of all food items and the number of each item in each fish, the percentage of each food item was calculated.

The above mentioned procedure was followed in studying the composition of food of both the juvenile and adult in A. commersoni. The specimen below 42 mm in total length were considered to be juveniles and so their food and feeding habit were studied, separately.

In each month as well as in each 10 mm length group, the number of stomach containing a particular item of food was determined and the percentage of prevalence calculated.

RESULTS

Composition of food of A. commersoni: (Table 16, Fig. 19)

Composition of various food items and their relative importance are presented in Table 16. Data on the stomach content of the fish collected from the marine and estuarine environment during the period of present study are presented in Fig. 19 and Table 16. From the qualitative analysis, it is evident that digested food (Chyme), fish, crustaceans and diatoms were the main food items of A. commersoni and remaining food items were present in traces. The decaying organic matter was present in traces which indicates that the species mainly feeds in column rather than on or near the bottom. Only in some cases fine silt was found, which proves that fish is essentially a pelagic feeder, and very rarely it descends to the bottom for feeding. Parasitic helminths which were present in the stomach content, was not the food item of fish.

Phytoplankton: This is one of the main food item, with more prevalence in juveniles than in adults. Only Coscinodiscus was found in stomach content. Highest percentage (26.83%) was found in juvenile and lowest 1.00% in the highest length group. Average percentage was 3.46.

Protozoa: This is not the main bulk of food but found in traces. The specie found was Noctiluca.

Platyhelminthes: Colytogaste with suckers on the anterior and the ventral portion, was found parasitizing the intestine of fish.

Nematehelminth: It consisted of nematod worms with cylindrical body and tapering posterior end. This was also a parasitic form and made upto 3.96%.

Annelid: These were observed in a fewer stomachs and the forms were polychaetes.

Crustaceans: It formed the main bulk of the diet. The average percentage was 59.76% and was represented by crustacean eggs 23.8%, Copepods 6.44%, Acetes 2.72% while others, present in traces, were ostracods, cladocerans, amphipodes, isopodes, lucifers, juvenile prawn, prawn mysis, post larval stage of prawn, Cirriped larvae, Nauplius larvae of copepod, Crab megalop, crab Zoea, prawn Zoea and

Crustacean remains.

Mollusca: This was represented by gastropod larvae and bivalve larvae. Average percentage was 0.31%.

Chaetognaths: Arrow worms were present in traces and represented by Sagitta sp.

Pisces: Fishes form the second important item of the diet and were represented by fish Kowala coval 1.21%; fish egg 3.31%; fish larvae 0.39% and fish remains 6.46%. The percentage of this item was less in juveniles and highest in higher length groups.

Vegetable matter: The average percentage of it was very less in A. commersoni.

Miscellaneous: Number of miscellaneous items in food was very low in comparison to other food items.

Digested food matter: It was found in all specimens in considerable amount. Stomach content analysis indicates that the food mainly consists of zooplankton. Hence from analysis it is concluded that it is a carnivorous pelagic feeder with preference for Zooplankton.

TABLE - 16

Percentage of food composition of *A. commersoni* (1987-89)

Fish	-	19.48
Crustacean	-	73.83
Insecta	-	0.14
Mollusca	-	0.48
Annelida	-	0.22
Phytoplankton	-	5.42
Chetognatha	-	0.42

Food composition of A. commersoni

A. Phytoplankton

1. Diatom-coscinodiscus
2. Vegetable matter

B. Zooplankton

1. Noctulica
2. Cirripedia larvae
3. Nematoda
4. Plalyhelminthes
5. Polycheata
6. Copepoda nauplius
7. Copepoda
8. Cladocera
9. Isopoda
10. Amphipoda
11. Ostracoda

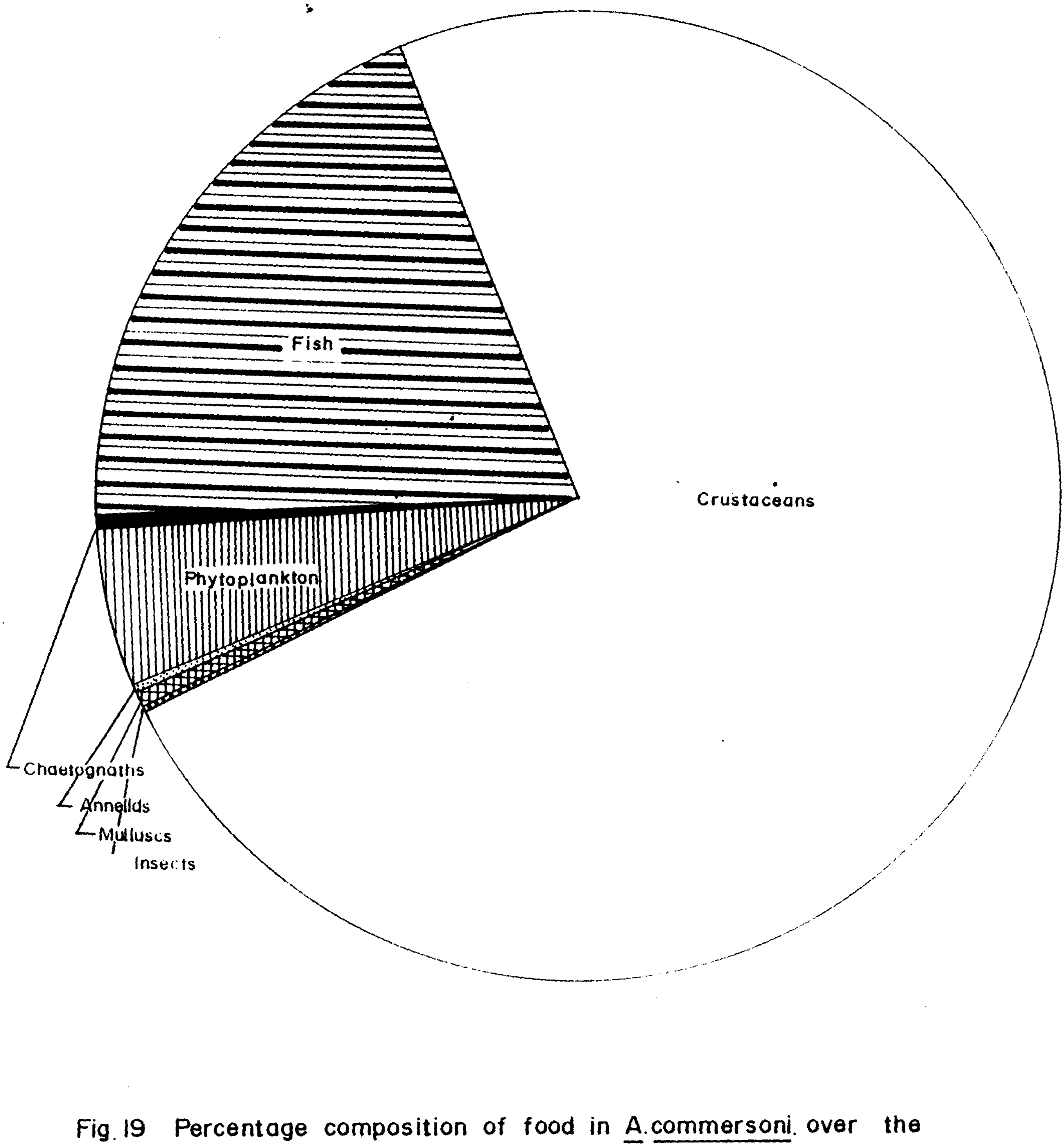


Fig. 19 Percentage composition of food in A. commersoni over the period 1987-89.

12. Lucifer

13. Acetes

14. Crab zoea

15. Crab megalopa

16. Prawn zoea

17. Prawn mysis

18. Prawn post larvae

19. Crustacean eggs

20. Crustacean remains

21. Water insect

22. Chaetognatha

23. Mollusca

24. Salps and Doliolids

25. Fish eggs

26. Fish larvae

27. Fish juveniles

28. Fish remains

29. Digested matter

30. Miscellaneous

Seasonal fluctuations in the composition of food: (Table 17, Fig. 20):

The variation in composition of food in A. commersoni was studied from December 1987 to March 1989. It revealed that percentage composition of different food items, varies in different months according to their availability and preference given to them by the fish (Table 17, Fig. 20).

Crustaceans: It forms the main bulk of diet.

Eggs: The percentage of egg fluctuates between maximum (47.91%) in September 1988 and minimum (8.53%) in February 1988.

Copepoda: Copepod percentage fluctuated between 22.32% in November 1988 and 0.46% in March 1988 and did not occur in July 1988.

Acetes: The percentage of Acetes fluctuated between 1.02% (December) and 5.61% (June).

Ostracoda: Its percentage fluctuated between 4.21% in July 1988 and 3.64% in November 1988. It was absent in January, February, October, December 1988 and January and March 1989.

Lucifer: Percentage of lucifer fluctuated between 8.78% in March 1989 and 0.06% in May 1988. It was present only during months of January, May 1988 and March 1989.

Isopods: They were found in diet of A. commersoni during December 1987 August - September 1988 and February - March 1989. Highest percentage of isopods was 2.74% in August 1988.

Megalop larvae of crab: It was present in diet of A. commersoni in August, September 1988 and March 1989, with percent composition of 2.59%, 0.18% and 2.83% respectively.

Prawn Mysis: It constituted 0.12% in December 1987, 0.25% in September 1988 and 3.65% in March 1989.

Prawn Nauplius: It formed 2.65% in December 1987, 0.19% in August and 2.17% in October 1988.

Prawn Zoea: Found in the months of August (30%), September (1.56%), October (19%), November (1.41%) 1988 and March (0.17), 1989.

Amphipoda : Present in different percentage in December 1987 (1.30%), January (0.28%), November (0.01%) and December 1988 (0.28%).

Cladocera: It was found in the months of December 1987 (1.9%), January (1.52%), February (0.39%), November (5.23%) and again in December 1988 (0.1%).

Crab Zoea: Found only November 1988 (2.52%).

Post larval stage of prawn: Constituted 0.3% in May, 1.38% in June and 0.95% in July 1988.

Cirripedea larvae: Found (3.97%) only in December 1987.

Fish eggs: The percentage of fish egg fluctuated between 18.95% in February 1988 and 0.18% in February 1989. Occurred throughout the year except in January 1989.

Fish: Fluctuated between 3.99% and 0.1%, and found throughout the year except in the month of December 1987 and November 1988.

Fish larvae: Occurred only in February (0.19%), in April (0.28), in May (0.56%), in July (0.046%) and in December (0.88%), 1988.

Fish remains: Found throughout the year with maximum (9.40%) in February and minimum in June 1988 (1.33%).

Phytoplankton: Coscinodiscus sp. was found throughout the year except in March 1989, with percentage fluctuating between 8.60% (August 1988) and 0.31% (December 1988).

Molluscs: Found in all months except February, March, October and December 1988, February and March 1989, with composition fluctuating between 9.38% in May 1988 and 0.30% in August 1988.

Chaetognatha: Observed in traces, in November 1988 (0.72%), in December 1988 (1.94%), and in January 1989 (4.320%).

Annelida: The polychaets were found only in August 1988 with a percentage of 2.30%.

Vegetable matter: Present in little amount (0.67-11.13%) and discontinously.

Digested matter: Accounted for 15.95 to 44.28% and occurred round the year.

From the gut content analysis it appears that crustacea accounted for a major part of the food of A. commersoni and it reflects on the abundance of crustaceans in the feeding grounds of the species, studied. Investigations on the feeding habits of A. commersoni, revealed that the species is plankton feeder with preference for zooplankton.

Fishes and crustaceans dominated the diet during most of the months. This observation, points out that preference is the major factor influencing the food composition yet only when the preferred items are scarce, the fish look for other items of less preference, as evidenced from the presence of fishes alone in majority of months.

Food in relation to size (Pooled data male, female and juvenile) (Table 18 and Fig. 21)

In order to study the variation, if any, in the food of the fish in relation to age (size), the data were analyzed according to size. The fish were grouped into 10 mm size groups and the details are given in Table 18 & Fig. 21. The percentage occurrence of items of food in each size group was calculated, as presented in Table 18.

Remains of acetes, copepod, crustacean, fish crustacean eggs, coscinodiscus and gastropod were recorded from the smallest fish (36 mm) to the larger fish (135 mm). These could be considered as the important food items of A. commersoni. The other items occurred only in a limited way.

26-35 mm length group: In this group, the food component comprised of copepod (66.66%) , phytoplankton (23.33%) and digested matter (10.00%). As the plankton constitute more than 75% of the gut content, this group of fishes are mostly planktivorous.

36-45 mm length group: The food items in the gut comprised of copepods (26.45%), coscinodiscus (26.83%), crustacean parts (11.96%), fish parts (9.93%), crustacean eggs (6.23%), cladocera (2.43%), gastropod (2.48%), platyhelminths (3.15%) and digested matter (10.54%). The composition of food indicates that fish in this stage is plankton feeder because both phytoplankton and zooplankton were present in food content.

46-55 mm length group: In this length group, highest percentage (40.90%) of digested matter was found, followed by crustacean parts (16.32%), copepods (13.62%), and crustacean eggs (9.19%). Contribution of other items, such as fish scales (0.54%), fish (0.63%), fish parts (0.20%), fish larvae (0.25%), fish eggs (0.40%), acetes (0.29%), megalop larvae (0.24%), crab zoea (0.24%), prawn mysis (0.17%), amphipod (0.34%), cladocera (1.37%), lucifer (0.22%), cirripedia (2.18%), gastropod (3.31%), platyhelminthes (3.13%), chetognatha (1.02%), coscinodiscus (2.54%) and vegetable matter (4.02%) was insignificant. As compared to previous group the percentage of phytoplankton decreased and that of zooplankton is increased.

56-65 mm length group: Analysis of gut content reveal the crustacean parts (12.83%), copepods (11.54%), crustacean eggs (10.13%), fish eggs (3.39%), fish (0.63%), fish parts (0.29%), fish larvae (0.15%), acetes (0.70%), megalop (0.08%, ostracod (0.31%), isopod (0.13%), prawn mysis (0.27%), amphipod (0.46%), crab zoea (0.3%), cladocera (0.62%), lucifer (0.018%), cirripedia (0.16%), naupleuos larvae (0.16%), gastropod (0.9%), platyhelminthes (4.86%), chetognatha (0.1%) and polychaetes (0.31%) as the minor items in the gut contents.

In this group also, the highest percentage of digested matter i.e. 37.99% was recorded and contribution by Coscinodiscus was 3.72%.

66-75 mm length group:- Food consisted of crustacean eggs 19.90%, crustacean parts 11.71%, copepod (10.27%), fish (1.22%), fish parts (3.51%), fish scales (0.3%), fish larvae (0.26%), fish egg (1.64%), acetes (2.07%) , megalop larvae (1.59%), prawn zoea (0.98%), ostracod (1.43%), isopod (0.98%), prawn mysis (0.71%), amphipod (0.032%), crab zoea (0.37%), cladocera (1.54%), prawn post larval stage (0.09%), lucifer (0.05%), water insect (0.63%), platyhelminthes (2.90%), chetognatha (0.34%), phytoplankton (6.70%), digested matter (34.05%) and polycheates (0.53%) was rather meagre.

Percentage of acetes, lucifer and fish increased in the gut content. It indicates that the fish prefers larger food items as it grows older and becomes non selective.

76-85 mm length group: The percentage of crustacean parts (14.84%), crustacean eggs (22.99%), fish (1.8%) and acetes (2.65%) increased continuously as the size increased, however percentage of copepods (1.01%), decreased. Fish parts (8.06%), fish scales (0.95%), fish eggs (4.27%), fish larvae (0.12%), megalop (0.03%), ostracods (0.82%), isopodes (0.03%), amphipods (0.13%), cladocera (0.20%), prawn post larvae (0.41%), lucifer (2.52%), naupleuos (0.86%), gastropod (0.24%), water insect (0.54%), platyhelminthes (3.59%) and phytoplankton (0.84%), were found in traces and zoea prawn, prawn mysis, crab zoea and chetognatha were absent.

86-95 mm length group: Percentage of crustacean parts (18.95%), crustacean eggs (24.10%), fish (2.60%), acetes (6.14%) and fish egg (4.55%) increased while percentage of copepod (0.04%) and phytoplankton (1.78%) decreased. Fish parts (4.57%), fish scale (2.80%), fish larvae (0.64%), megalop (0.19%), prawn zoea (0.04%), ostracod (0.03%), prawn mysis (1.42%), lucifer (1.10%), nauplius (0.13%), gastropod (0.73%), platyhelminths (3.50%), digested matter (22.07%), chaetognathes (0.31%) and vegetable matter (0.05%) remained unaltered.

96-105 mm length group: In this group, percentage of smaller species of crustaceans reduced while those of bigger ones increased. Percentage of crustacean eggs (44.33%), acetes (3.71%), crustacean parts (9.96%), fish eggs (6.54%), fish parts (6.24%), fish (1.71%) and fish scales (1.11%), increased. Other food components contributed insignificantly. Disgested matter (13.80%) reduced while other species were absent. Copepods were absent in this length group. Fish slowly changed its food habit from omnivorus to carnivorus.

106-115 mm length group: In this length group, A. commersoni prefers fish, acetes and crustacean eggs. Percentagewise, crustacean egg (32.11%), crustacean parts (9.52%), fish parts (8.66%), fish eggs (6.60%), fish scale (5.85%) and acetes (3.85%) were important items while copepods (0.20%), phytoplankton (2.44%), platyhelminths (2.04%), lucifer (0.04%), prawn post larval stage (0.67%), megalop larvae (0.14%), ostracod (2.32%), isopod (0.16%) and vegetable matter 1.91% were present in low quantity.

116-125 mm length group: Crustacean parts (24.00%), crustacean eggs (20.45%), fish eggs (13.71%), fish parts (7.26%), fish (3.54%), acetes (2.93%), fish scales (2.67%), copepods (0.32%), ostracods (0.06%), isopod (0.32%), gastropod (0.49%), water insect (0.50%), phytoplankton (1.00%, platyhelminths (4.89%) and digested matter (7.53%)

were only present.

126-135 mm length group: Crustacean eggs (32.49%), crustacean remains (30.04%), acetes (22.26%), fish parts (7.74%), megalop larvae (0.44%), platyhelminthes (4.52%) and digested matter (0.47%) was present. In this length group copepods, phytoplankton and other species were totally absent.

Thus, generally the bigger size fishes feed on fish, fish eggs, crustacean egg, acetes, post larval stage of prawn, lucifer, prawn mysis while younger fishes mainly feed on smaller organisms like copepods and phytoplankton. It means that younger fishes are omnivorous but afterwards they become carnivorous.

The length groupwise analysis reveals that as the fish grows percentage of fish larvae, acetes and fish eggs, increases in food content. In case of crustacean eggs, maximum percentage was found in length group 96-105 mm i.e. 44.34% and copepods. Phytoplankton were absent in size groups above 125-135 mm. This indicates that as fish grows in size it feeds on bigger organisms of zooplankton.

Planktonic crustaceans form the total diet in smaller groups and are replaced by fishes in higher size group. Moreover the smaller fishes cannot move so swiftly as to prey upon fast moving organisms and therefore need to rely on the phytoplankton especially during young stages.

Food in male and female length groupwise: (Table 19, 20)

Female: In Table 19 it was observed that percentage of fish, fish remains, fish eggs, crustacean eggs, and Acetes increased as the size of A. commersoni increased, however the intake of copepods and phytoplankton decreased as the size of fish increased (Table 19).

Male (Table 20): The percentage of fish remains, fish eggs crustaceans eggs and acetes increased as the size of fish increased while copepod and phytoplankton decreased after 86-95 mm size group. In large size male, main diet was Acetes.

Monthwise variations in food of female: (Table 21)

Female: Fish, fish eggs and fish remains were observed throughout the year with maximum value in February and July and minimum value in November and December. Crustacean parts, crustacean eggs and Acetes were found in variable percentage throughout. Maximum prevalence of copepods was in May-June and November-December. Remaining organisms were found in traces during post monsoon season. This indicates that fish was the main diet of mature A. commersoni, and copepods of immature fishes, whereas remaining organism did not show any specific pattern of prevalence Phytoplankton was found throughout the year (Table 21).

Food in relation to maturity stages of female, A. commersoni: (Table No. 22):

Significant variations have been observed in dietary composition of A. commersoni during the different maturity stages.

I Stage of maturity: Composition of various food items and their dominance reveals that major constituents were, digested matter (21.06%), crustacean eggs (21.09%), crustacean remains (19.84%), copepods (8.02%) and phytoplankton (5.09%) while others were present in minor quantity i.e. acetes, fish remains, fish eggs, ostracods, isopods, amphipods and fish larvae.

II Stage of maturity: Table No. 22 reveals that prevalence of food items were similar to those observed in I stage but with varying percentage composition viz, crustacean eggs (30.88%), platyhelminths (13.73%), fish remains (6.63%), phytoplankton (5.85%) and fish juveniles (4.99%) as major group of food items. Crustacean parts, molluscs, Acetes, cladocera, ostracod, copepod, salp and water insects also formed a significant part of diet.

III Stage of maturity: Composition of various food items and their relative abundance is present in Table 22. Digested matter (30.17%), copepods (18.28%), crustacean eggs

(15.59%), crustacean parts (14.53%) and phytoplankton (4.31%) formed the major group of food items while juvenile fish, fish parts, Acetes, megalop larvae, prawn zoea, ostracod, amphipods, crab zoea, cladocera, cirriped larvae, mollusca etc. formed the minor group of food items.

IV **Stage of maturity**: The variation in the composition of food of A. commersoni during this stage revealed that digested matter (26.39%), crustacean eggs (26.87%), crustacean remains (11.34%), fish parts (7.36%) and acetes (3.50%) formed the major group of food items. The relative abundance of fish scales, copepods, ostracoda, crab zoea, cladocera, mollusca, platyhelminths and vegetable matter shows that these items form the regular diet of the fish at this stage.

V **Stage of maturity**: The analysis of gut content indicates that percentage of fish parts, fish juveniles and crustacean eggs were increasing with increasing maturity stages and percentage of copepods, phytoplankton and digested matter were decreasing. Crustacean eggs (31.08%), crustacean remains (13.7%), Acetes (3.39%) and lucifer (2.12%) were the major groups of food and remaining food items contributed rather, insignificantly.

VI **Stage of maturity**: Analysis of food indicates that percentage of crustacean eggs (37.51%), crustacean parts

(12.02%), fish eggs (8.59%), fish remains (6.86%) and acetes (3.99%) increased to maximum in this stage while the percentage of copepods, megalop larvae, ostracods, isopods, prawn mysis, cladocera, lucifer, platyhelminths, digested matter and phytoplankton decreased to minimum. In this stage the intake of fish and crustacean eggs had increased.

VII Stage of maturity: The major food items comprising the diet of A. commersoni were crustacean eggs (32.24%), crustacean remains (16.74%), ostracod (7.33%), fish remains (6.56%), copepods (6.04%), and acetes (4.58%) while fish larvae, fish egg, megalop larvae, prawn mysis, lucifer, salp, water insect, platyhelminths, phytoplankton and digested matted were present in small quantity at this stage.

From above study, it may be concluded that as maturation of gonad progresses, A. commersoni, devours more larger zooplankters than phytoplankton and smaller zooplankters, which it relishes in younger stages.

Intensity of feeding: The stage of the stomach in different degree of fullness and average volume of gut content are given in Table 23, 24, and Fig. 22, 23. The variation in intensity of feeding in different months and in different length groups was studied by observing the distention of stomach of 1199 fishes. For the purpose of comparison, the gorged and full stomach were grouped as actively fed, 3/4 full and 1/2 full as moderately fed and 1/4 full and little as poorly fed.

Feeding intensity in different months (Table 23, Fig. 22):

Monthwise occurrence of empty stomachs showed a wide range of fluctuations from 3.77% in November to 37.66% in June The stomachs with little food were represented in varying percentage of 25.64% in July 1988 to 58.49% in November 1988. 1/4 full stomachs were represented in varying percentage of 4.29% in March 1989 to 14.75% in October 1988. Similarly, 1/2 full stomachs were recorded to be 7.79% in June 1988 to 31.43% in March 1989. The range of fluctuation in 3/4 full stomach varied from 1.41% in March 1988 to 15.71% in March 1989. Fishes with full stomach were observed in varying percentage of 2.60 in (June 1988) to 11.42% (March 1989). Full stomachs were not recorded in March, October and November 1988. Gorged stomachs were recorded throughout the year with varying percentage of 1.33% in December 1988 to 14.08% in March 1988.

During premonsoon months of February - April intensity of feeding was moderate while in September, November and December except in October, the intensity of feeding was high, whereas during monsoon season (June-August) intensity of feeding was poor.

A careful examination of food composition and the intensity of feeding suggest that the dominance of fishes as a food item coincides with high intensity of feeding, offering evidence that A. commersoni prefers fish as main food items.

Feeding intensity in relation to length groups :(Table 24 and Fig. 23)

The percentage of empty stomach in all the length groups as shown in Table 24 and Fig. 23 was continuously decreasing with highest value of (100%) in smallest size group of 16-25mm and lowest (5.44%) in 106-115 mm length group. The percentage of empty stomach in 36-45 mm length group was lower than in 46-55 mm length group. This indicates that as the fish grows intensity of feeding also increases.

The percentage of "little" stomach fluctuated from 50.66% as maximum in length group 66-75 mm and minimum of 14.71% in 116-125 mm length group. The percentage of 1/4 full stomach fluctuated between 3.26% in 106-115 mm length group and 17.87% in length group 56-65 mm.

The percentage of 1/2 full stomachs fluctuated from 13.33% in 36-45 mm length group to 66.67% in 126-135 mm length group whereas in length groups 86-95 mm, 96-105 mm and 116-125 mm, it decreased to 17.48%, 18.59% and 17.65% respectively.

The percentage of 3/4 full stomachs fluctuated between 2.63% in 46-55 mm length group and 12.18% in 96-105 mm, followed by decrease with increase in length.

The percentage of full stomach was lowest (1.71%) in 56-65 mm length group and highest (33.33%) in 126-135 mm length group.

The percentage of gorged stomach fluctuated from 1.03%, (56-65 mm) to 38.24%, (116-125), with total absence in 16-25, 26-35, 36-45 and 126-135 length groups.

A study of histogram (Figs. 23) indicates that there is direct relationship between the intensity of feeding and size of fish. The intensity of feeding increased with size of fish.

In relation to sexual cycle: Though the mature fishes were recorded throughout the year, high percentage was noticed only during July-September and again from January to March coinciding with the spawning season. Fishes collected during September 1988 had high feeding activity (Table 23). The high intensity of feeding was noticed again in March 1988, which corresponds to second spawning period of fish, but poor feeding during post spawning period i.e. in October and April.

Active feeding was also observed during November, and December when immature fishes were predominant, but it was low in May-June when immature fishes were dominant. Thus, it is difficult to infer that intensity of feeding was high or low in immature fishes.

The moderate intensity of feeding during January-February and July-August (Table 23) coincided with the dominance of mature fishes. However, active feeding was noticed in mature fishes during September 1988, March 1988 and 1989, which corresponds to spawning period. Hence, it may be concluded that intensity of feeding is high during spawning period.

To understand more clearly the relationship between feeding activity and spawning all the fishes were sorted out in two arbitrary groups, immature and mature, and the results are shown in Fig. 24. It can be seen that variations in the intensity of feeding between two groups showed a uniform pattern wherein an active feeding was noticed in mature fishes during September and March 1988 and 1989 (spawning period). It is further confirmed that intensity of feeding was high during the spawning period, but poor in post spawning period.

Weight of food in the gut of A. commersoni:

In relation to months (Table 25 and Fig. 25): Percentage of average weight of food in September, March 1988, and 1989 was high comparison to other months of the year except in

February and July (Table 25 Fig. 25). This indicates that intensity of feeding was high during these months which corresponds to active spawning phase. Weight of food in February and July was also high which suggests that mature fishes prefer fish in place of crustacean in higher size groups. As fishes are heavier than crustacean hence weight of food is also more.

In relation to size: (Table 26 Fig. 26) Percentage of average of food indicates that as size of fish increase, intake of food also increases (Table 26, Fig. 26). It fluctuated between 0.20% and 46.16% but was low in length group 126-135 mm which may be due to post spawning strain.

Gastro-somatic index of A. commersoni: Gastro-somatic index for different months indicates variability in feeding intensity.

In relation to months: Highest gastro-somatic index was in July, February and November 1988 (Fig. 25, Table 27) which corresponds to pre spawning period of the fish. During this period the number of mature fishes were more.

Second highest GSI was in September and march 1988 and March 1989 (Table 27) which suggest high intensity of feeding with lowest value in Oct. and Aug. The value of GSI in November suggest high intensity of feeding which corresponds with the low percentage of empty stomachs.

During spawning period though the gonads occupy large part of the abdomen, the feeding intensity was more during spawning period as evident from the presence of large amount of food in gut and correspondingly the high gastro-somatic index observed during March, September 1988 and March 1989 (Table 27).

In relation to length: (Table 28, Fig. 26) Gastro-somatic index increased as the length of fish increased, and varied between 1.56 (26-35 mm) and 4.35, (116-125 mm) except in 96-105 mm where it was low.

DISCUSSION

Analysis of food content of 1199 fishes revealed that juvenile in the length 16-45 mm mainly feed on copepods, phytoplankton and crustacean eggs.

In higher length group upto 96-105 mm, food mainly consists of acetes, megalop larvae, zoea larvae, ostracods, isopods, mysis, lucifer, amphipods, crab zoea, cladocera, cirriped naupli, gastropod, chetognatha and fish eggs. After 96-105 length group, main food of fish consists of mysis, lucifer, isopod, ostracod, megalop larvae, prawn larvae and rarely the phytoplankton.

In length group above 105 mm, acetes and crustacean eggs, megalop larvae and fish remains occurred. As the percentage of fish and acetes increases in larger fishes, the percentage of copepods and phytoplankton decreased.

Thus, a marked change in feeding habits with the size of _A. commersoni_ was observed. The percentage of copepods decrease and that of bigger organisms like, prawn, fish larvae and amphipods increased as the fish grow bigger.

Such differences in the feeding habits of juvenile and adult were noticed by Bapat and Bal (1952) in _T. hamiltoni_ and _A. commersoni_, by Venkataraman (1956) in _T. mystax_, by Marichamy (1972) in Anchovy _Thrissina baelama_ and by Venkataramanujam (1972) in _A. commersoni_.

Bapat and Bal (1952) examined the food of larvae of _A. commersoni_ in size group of 25-50 mm and 59-75 mm and found that they feed on polycheats and prawn larvae. But Venkaramanujam (1972) examined 75 pro larvae and post larvae out of which polycheats were not found in the guts in any of these larvae at any stage. Nair (1952) in his studies reported that post larvae feed mainly on copepods.

Present study reveals that polycheats were found only in August 1988 in the guts of two specimens in length groups of 56-65 mm and 66-75 mm. This indicates that feeding is influenced by polychaets.

Venkataramanujam (1972) examined 15 specimens and only in two specimens the stomach were filled with 200, and 290 eggs of Amphiprion percula. During present investigation also, some guts full of small elongated eggs were recorded but it was not possible to identify them.

Observations on the food and feeding habits of Ambassis commersoni revealed that the species is a plankton feeder. It begins to feed on phytoplankton organisms during the pro larval and post larval stages and as they grow older feed mainly on a wide range of zooplanktonic and occasionally on nektonic organisms. A. gymnocephalus is reported to feed on mullet eggs in Chilka Lake. (Natarajan, and Patnaik 1957). Similarly, A. commersoni may be descending to the bottom for feeding on bottom organisms and therefore, it is difficult to decide between selective and indiscriminate feeding.

Variation in food and feeding habits among the different species of the same family is not uncommon. Venkataraman (1960) noticed the varied feeding habits among the inshore anchovies of the Malabar Coast. He observed that T. malabaricus, T. setriostris, T. purava and A. commersoni prefer zooplankton, chiefly copepods and prawns while in T. dussmieri and Amchviellatri sp., the diet is supplemented by diatoms, mostly Coscinodiscus sp. Carnivorus feeding habit in the allied species of anchovy has also been reported by Jones and Menon (1942), Venkataraman (1956), Basheeruddin and Nayer (1962) and Srinivas Rao (1964).

Martin et.al (1983) reported that Ambassis along South African Coast feeds mainly on zooplankton, insects and fish fry. Nair and Nair (1984) reported that major food items of A. commersoni (quantitative and occurrence-wise) were crustaceans, polychaets and insects in the estuaries of south followed by west coast of India. They further stated that the fish feeds at all layers of water column utilizing the surface, water column and benthic niches of the ecosystem, as is observed in the present study. Therefore, the occurrence of fish and acetes in the stomach of A. commersoni is justified.

TABLE - 17

Food composition monthwise (Pooled data)

S.No.	Months	Crust	Fish	Mollusca	Echinodum	Helminths	Phyto-plankton	Veg. matter	Miscella-neous	Digested matter
	1987									
1.	December	48.31	10.72	0.17	-	11.10	8.39	-	0.15	21.16
	1988									
2.	January	61.30	8.94	0.41	-	5.93	3.93	-	0.01	19.48
3.	February	35.00	33.67	-	-	3.43	1.52	6.19	-	20.18
4.	March	35.79	4.67	-	-	3.55	5.85	11.13	-	39.01
5.	April	34.57	11.85	1.38	-	3.02	0.79	4.11	-	44.28
6.	May	35.33	7.57	9.38	-	2.66	1.64	8.71	0.04	34.66
7.	June	63.89	5.52	0.65	-	7.11	1.17	-	0.17	21.49
8.	July	42.99	12.86	0.48	-	2.95	6.20	-	0.01	34.51
9.	August	46.34	8.08	0.03	0.03	2.81	8.60	8.80	2.32	22.99
10.	September	64.23	9.28	0.14	-	3.78	4.16	2.38	0.08	15.95
11.	October	69.53	10.37	-	-	1.21	0.48	-	0.04	18.36
12.	November	63.93	11.84	1.79	-	2.21	4.52	1.96	0.04	13.71
13.	December	41.45	13.50	-	-	3.07	0.31	4.58	0.01	37.08
	1989									
14.	January	55.16	3.76	0.25	-	4.99	3.24	-	-	32.60
15.	February	52.72	6.77	-	-	5.19	3.07	1.10	0.01	31.14
16.	March	68.96	6.73	-	-	0.76	-	0.67	-	22.88

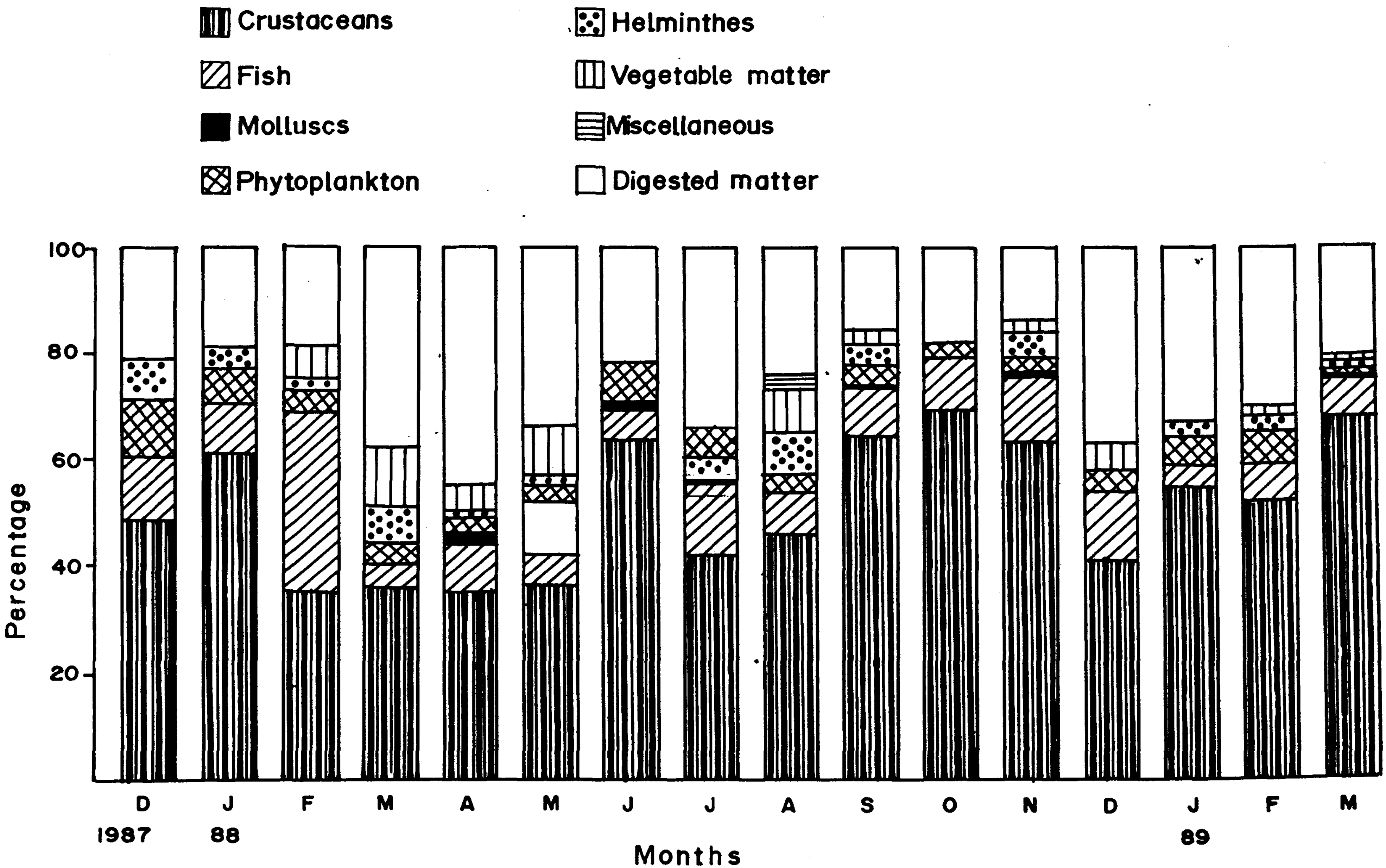


Fig. 20 Monthwise food composition in *A. commersoni*

TABLE 18

Food of *A. commersoni* in relation to length groupwise (Pooled data)

Sr. No.	Length gr.	Crustaceans	Fish	Mollusca	Phytoplankton	Helminths	Veg. matter	Miscellaneous	Digested matter
1.	26-35	66.66	-	-	23.33	-	-	-	10.00
2.	36-45	47.07	9.93	2.48	26.83	3.15	-	-	10.54
3.	46-55	44.06	2.03	3.31	2.54	3.13	4.02	0.01	40.90
4.	56-65	43.89	5.75	0.90	3.72	4.86	2.45	0.34	37.99
5.	66-75	44.96	6.92	0.67	6.70	2.90	3.27	0.53	34.05
6.	76-85	46-49	15.20	0.25	0.84	3.59	5.53	0.01	28.09
7.	86-95	52.50	15.18	0.74	1.78	3.50	4.18	0.05	22.07
8.	96-105	59.78	15.62	0.74	2.47	4.52	2.90	0.44	13.80
9.	106-115	48.52	23.07	1.88	2.44	2.04	1.91	0.03	20.11
10.	116-125	48.09	27.19	0.49	1.00	4.89	10.70	0.01	7.53
11.	126-135	85.94	7.74	-	-	4.52	1.32	-	0.47

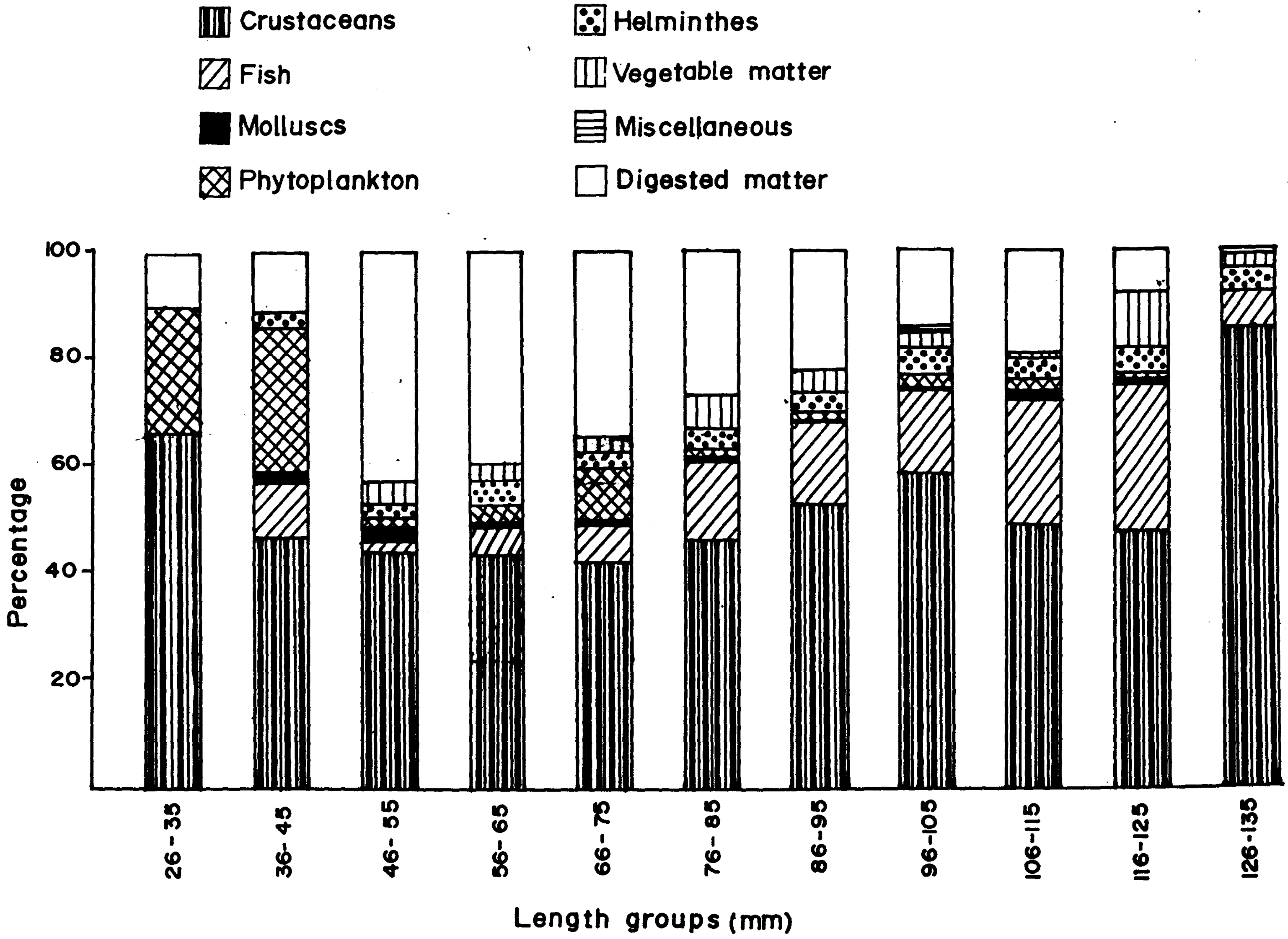


Fig. 21 Length groupwise food composition in A. commersoni.

TABLE - 19

Food of female A. commersoni length groupwise

S. No.	Food Item	46-55	56-65	66-75	76-85	86-95	96-105	106-115	116-125	126-135
A.	Phytoplankton									
1.	Diatom coscinodiscus	-	3.48	9.15	0.38	2.15	2.77	2.57	1.10	-
2.	Vegetable matter	8.22	4.82	1.65	-	2.05	2.16	1.50	11.76	1.32
B.	Zooplankton									
1.	Cirripedia larvae	-	-	0.31	-	-	-	-	-	-
2.	Nematoda	-	-	-	-	-	-	-	-	-
3.	Platyhelminthes	4.81	1.80	3.64	7.25	6.00	3.87	2.25	2.53	4.52
4.	Polycheats	-	.31	0.53	-	-	-	-	-	-
5.	Copepoda nauplius	-	0.23	-	-	-	-	-	-	-
6.	Copepoda	9.82	9.45	11.96	5.12	0.02	-	0.21	0.36	-
7.	Cladocera	-	1.08	1.57	1.02	-	-	-	-	-
8.	Isopoda	-	-	1.53	-	-	1.11	0.17	0.36	-
9.	Amphipoda	-	0.49	0.07	0.67	-	-	-	-	-
10.	Ostracoda	-	0.28	1.59	1.59	0.06	0.47	2.66	0.06	-
11.	Lucifer	-	-	-	-	2.03	0.82	0.05	-	-
12.	Acetes	1.19	0.72	0.71	1.61	7.09	4.15	3.39	3.23	22.96
13.	Crab zoea	-	0.80	0.76	-	-	-	-	-	-
14.	Crab megalop	0.98	0.15	0.82	-	0.07	0.30	0.14	-	0.44
15.	Prawn zoea	0.49	-	1.34	-	0.07	0.20	-	-	-
16.	Prawn mysis	-	0.06	0.15	-	1.11	0.02	-	-	-
17.	Prawn post larvae	-	-	0.02	2.07	-	0.06	0.71	-	-
18.	Crustacean eggs	5.39	18.55	20.12	35.90	29.84	47.45	35.87	22.49	32.49
19.	Crustacean remains	9.42	10.77	10.04	6.06	20.99	8.86	9.37	21.70	30.05
20.	Water insect	-	-	0.06	-	-	0.67	-	0.55	-
21.	Chaetognatha	-	-	-	-	-	-	-	-	-
22.	Mollusca	1.40	1.05	-	0.60	0.52	1.99	0.48	0.53	-
23.	Salps and doliodids	-	-	0.40	-	-	-	-	-	-
24.	Fish	-	4.35	8.71	7.72	8.79	16.26	22.36	26.97	7.74
25.	Digested matter	58.28	41.59	24.86	30.00	19.20	8.79	10.24	8.35	0.47
26.	Miscellaneous	-	0.02	0.01	0.01	0.01	0.05	0.03	0.01	-

TABLE - 20

Food of male A. commersoni length groupwise

S. No.	Food items	36-45	46-55	56-65	66-75	76-85	86-95	96-105	106-115	116-125
A.	Phytoplankton									
1.	Diatom coscinodiscus	-	0.23	5.45	5.09	1.00	1.44	-	-	-
2.	Vegetable matter	-	-	0.66	5.55	7.21	6.60	8.97	-	-
B.	Zooplankton									
1.	Cirripedia larvae	-	7.62	0.11	-	-	-	-	-	-
2.	Nematoda	-	-	-	-	-	-	-	-	-
3.	Platyhelminthes	-	6.03	8.02	1.91	2.42	1.08	9.91	-	28.44
4.	Polychaets	-	-	-	-	-	-	-	-	-
5.	Copepoda nauplius	-	-	0.59	-	1.12	0.30	-	-	-
6.	Copepoda	79.43	24.91	12.51	7.56	-	0.90	-	-	-
7.	Cladocera	-	4.78	0.54	1.76	-	-	-	-	-
8.	Isopoda	-	-	-	0.11	0.04	-	-	-	-
9.	Amphipoda	-	1.18	0.58	-	-	-	-	-	-
10.	Ostracoda	-	-	0.43	1.26	0.66	-	-	-	-
11.	Lucifer	-	-	-	0.11	3.28	-	-	-	-
12.	Acetes	-	-	0.09	2.35	2.99	5.20	-	12.29	-
13.	Crab zoea	-	4.78	0.54	1.76	-	-	-	-	-
14.	Crab megalop	-	-	-	2.53	0.04	0.35	-	-	-
15.	Prawn zoea	-	-	-	0.73	-	-	-	-	-
16.	Prawn mysis	-	-	-	-	-	1.92	-	-	-
17.	Prawn post larvae	-	-	-	-	-	-	-	-	-
18.	Crustacean egg	-	16.45	16.53	20.33	20.69	17.36	18.42	-	-
19.	Crustacean remains	20.57	5.85	12.95	13.59	17.77	16.59	19.07	12.30	46.41
20.	Water insect	-	-	-	-	0.07	-	-	-	-
21.	Chaetognatha	-	3.57	0.23	0.77	-	0.71	-	-	-
22.	Mollusca	-	-	0.16	-	0.10	-	-	-	-
23.	Salps and doliolids	-	-	-	-	-	-	-	-	-
24.	Fish	-	2.09	7.65	5.07	16.57	16.49	-	-	-
25.	Digested matter	-	22.49	32.92	29.44	26.03	30.97	43.62	75.41	25.15
26.	Miscellaneous	-	0.02	0.04	0.08	0.01	0.09	-	-	-

TABLE - 21

Food of female A. commersoni monthwise

S. No.	Food Items	1987 December	1988 January	February	March	April	May	June	July	August	September	October	November	December	1989 January	February	March
A.	Phytoplankton																
1.	Diatom coscinodiscus	7.92	0.13	2.28	7.19	0.47	3.40	3.06	7.15	12.84	2.43	-	1.90	1.23	-	4.45	-
2.	Vegetable matter	-	-	5.60	11.18	6.29	-	-	-	6.73	1.73	-	3.82	1.04	-	1.35	0.13
B.	Zooplankton																
1.	Cirripedia larvae	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.	Nematoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.	Platyhelminthes	8.60	1.71	2.96	4.78	3.09	1.79	5.54	3.84	4.32	3.59	2.05	2.90	1.23	5.60	6.14	0.49
4.	Polycheats	-	-	-	-	-	-	-	-	-	2.30	-	-	-	-	-	-
5.	Copepoda nauplius	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.	Copepoda	5.51	3.17	3.56	1.06	-	11.06	17.53	-	3.05	1.96	4.58	29.07	1.63	1.58	4.09	2.85
7.	Cladocera	3.68	1.07	0.12	-	-	-	-	-	-	-	-	7.80	0.39	-	-	-
8.	Isopoda	-	-	-	-	-	-	-	-	3.05	0.50	-	-	-	-	0.34	0.59
9.	Amphipoda	2.39	-	-	-	-	-	-	-	-	-	-	1.49	-	-	-	-
10.	Ostracoda	-	-	-	0.05	0.11	-	1.33	5.84	0.21	1.27	-	5.61	-	-	-	-
11.	Lucifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.43
12.	Acetes	1.80	1.44	2.06	2.21	6.66	0.20	9.38	1.57	4.02	1.74	0.86	1.58	1.36	1.21	3.48	7.69
13.	Crab zoea	-	-	-	-	-	-	-	-	-	-	-	6.18	-	-	-	-
14.	Crab megalop	-	-	-	-	-	-	-	-	1.38	0.21	-	1.14	-	-	-	1.52
15.	Prawn zoea	-	-	-	-	-	-	-	-	0.49	1.79	-	1.11	-	-	-	0.32
16.	Prawn mysis	0.36	-	-	-	-	-	-	-	-	0.29	-	-	-	-	-	2.01
17.	Prawn post larvae	-	-	-	-	-	1.17	3.61	1.32	-	-	-	-	-	-	-	-
18.	Crustacean eggs	20.19	61.12	15.08	16.10	17.41	9.12	6.80	12.70	24.07	49.56	35.12	21.27	28.83	53.12	43.02	25.20
19.	Crustacean remains	1.45	4.97	8.80	18.25	9.98	12.52	24.46	23.51	9.40	7.29	2.54	2.99	17.39	7.82	14.13	18.11
20.	Water insect	-	-	-	-	-	-	-	-	2.01	-	-	-	-	-	-	-
21.	Chaetognatha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.	Mollusca	-	-	-	0.40	11.06	17.53	-	3.05	1.96	4.58	29.07	1.63	-	-	-	-
23.	Salps and doliolids	-	-	-	-	-	-	2.06	-	-	-	-	-	-	-	-	-
24.	Fish	10.81	10.07	39.14	6.69	14.03	19.02	9.28	18.09	7.39	4.48	9.58	1.83	9.2	-	4.38	2.23
25.	Digested matter	33.67	14.33	20.40	32.08	30.90	24.02	16.72	22.91	16.74	14.57	16.20	9.68	37.69	29.88	10.6	32.43
26.	Miscelleneous	0.20	0.01	-	0.01	-	0.17	0.23	0.01	0.04	0.01	-	-	-	-	0.02	-

TABLE - 22

Food in different maturity stages of A. commersoni

Sr.No.	Food items	I	II	III	IV	V	VI	VII
A.	Phytoplankton							
1.	Diatom coscinodiscus	5.09	5.85	4.31	8.85	4.07	2.20	1.15
2.	Vegetable matter	2.99	13.80	2.71	2.63	4.07	2.18	-
B.	Zooplankton							
1.	Cirripedia larvae	-	-	0.31	-	0.79	-	-
2.	Nematoda	-	-	-	-	-	-	-
3.	Platyhelminthes	4.89	13.73	2.67	2.07	2.21	4.95	5.09
4.	Copepoda Nauplius	0.94	0.30	-	-	-	-	-
5.	Copepoda	8.02	1.39	18.28	3.08	5.49	4.41	6.04
6.	Cladocera	0.12	2.07	0.42	3.14	1.17	-	-
7.	Isopoda	2.30	-	-	-	0.27	0.10	-
8.	Amphipoda	0.30	-	-	-	0.28	0.22	-
9.	Ostracoda	0.30	0.6	0.08	1.36	1.28	0.46	7.33
10.	Lucifer	1.78	-	-	-	2.12	0.15	0.98
11.	Acetes	1.08	1.99	2.58	3.50	3.39	3.99	4.58
12.	Crab zoea	-	-	0.46	0.52	0.40	3.43	-
13.	Crab megalop	0.92	-	0.34	-	0.14	0.12	1.69
14.	Prawn zoea	-	-	2.82	-	0.32	-	-
15.	Prawn mysis	0.92	-	0.45	-	0.39	0.01	0.25
16.	Prawn post larvae	-	-	-	-	-	-	-
17.	Crustacean eggs	21.09	30.88	15.59	26.87	31.08	37.51	32.24
18.	Crustacean remains	19.84	6.23	14.53	11.34	13.71	12.02	16.74
19.	Water insect	-	1.38	-	-	0.29	-	0.83
20.	Chaetognatha	-	-	-	-	-	-	-
21.	Mollusca	0.74	7.33	0.34	0.37	2.22	-	-
22.	Salps and doliolids	2.95	1.18	-	-	-	-	1.65
23.	Fish	4.66	12.85	3.86	9.88	10.8	16.06	15.72
24.	Digested matter	21.06	0.16	30.17	26.39	15.37	12.10	5.71
25.	Miscellaneous	0.01	0.26	0.08	-	0.04	0.01	-

TABLE - 23

Intensity of feeding in A. commersoni (monthwise)

Months	Gorged		Full		3/4 Full		1/2 Full		1/4 Full		Little		Empty		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
1987															
Dec.	-	-	3	6.52	3	6.52	11	23.91	2	4.35	13	28.26	14	30.43	46
1988															
Jan.	3	3.57	3	3.57	6	7.14	24	28.57	6	7.14	30	35.71	12	14.29	84
Feb.	10	12.05	3	3.611	2	2.411	20	24.10	9	10.84	28	33.73	11	13.25	83
Mar.	10	14.08	-	-	1	1.41	7	9.86	10	14.08	36	50.70	7	9.86	71
Apr.	5	6.02	3	3.618	3	3.618	8	9.64	11	13.25	40	48.19	13	15.66	83
May	2	2.27	3	3.41	2	2.27	9	10.23	10	11.36	32	36.36	30	34.09	88
Jun.	2	2.60	2	2.60	9	11.68	6	7.79	6	7.79	23	29.81	29	37.66	77
Jul.	7	8.97	8	10.25	11	14.12	8	10.25	8	10.25	20	25.64	16	20.51	78
Aug.	8	8.08	6	6.06	6	6.06	18	18.18	13	13.13	32	32.32	16	16.16	99
Sept.	5	7.25	4	5.80	8	11.59	15	21.74	8	11.59	22	31.88	7	10.14	69
Oct.	1	1.64	-	-	3	4.92	8	13.11	9	14.75	29	47.54	11	18.03	61
Nov.	1	1.89	-	-	4	7.55	10	18.87	5	9.43	31	58.49	2	3.77	53
Dec.	1	1.33	3	4.00	2	2.66	19	25.33	10	13.33	35	46.67	5	6.67	75
1989															
Jan.	4	5.71	6	8.57	5	7.14	14	20.00	7	10.00	27	38.57	7	10.00	70
Feb.	5	5.43	6	6.52	10	10.86	21	22.83	8	8.69	33	35.89	9	9.78	92
Mar.	6	8.57	8	11.42	11	15.71	22	31.43	3	4.29	20	28.57	-	-	70

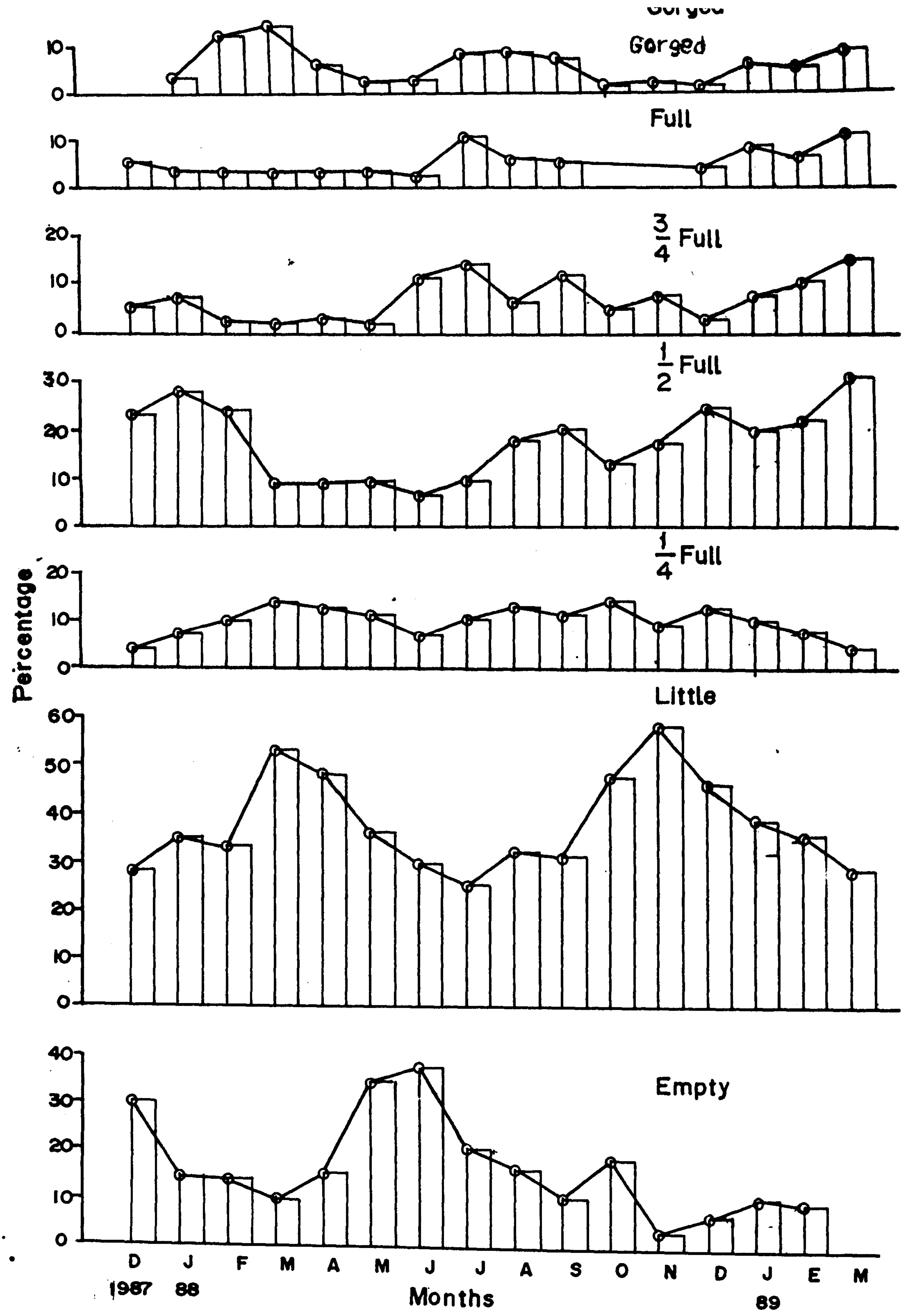


Fig.22 Monthwise intensity of feeding in A. commersoni

TABLE - 24

Intensity of feeding in A. commersoni (length groupwise)

Sl. No.	Length group	Gorged No.	Gorged %	Full No.	Full %	3/4 Full No.	3/4 Full %	1/2 Full No.	1/2 Full %	1/4 Full No.	1/4 Full %	Little No.	Little %	Empty No.	Empty %	Total
1.	16-25	-	-	-	-	-	-	-	-	-	-	-	-	6	100	6
2.	26-35	-	-	-	-	-	-	-	-	-	-	-	-	3	100	3
3.	36-45	-	-	-	-	-	-	2	13.33	2	13.33	7	46.66	4	26.67	15
4.	46-55	3	3.94	2	2.63	2.	2.63	12	15.79	7	9.21	30	39.47	20	26.32	76
5.	56-65	3	1.03	5	1.71	14	4.81	43	14.78	52	17.87	120	41.24	54	18.56	291
6.	66-75	3	1.32	7	3.08	7	3.08	39	17.18	18	7.93	115	50.66	38	16.74	227
7.	76-85	8	5.23	5	3.27	9	5.88	30	19.61	12	7.84	64	41.83	25	16.34	153
8.	86-95	20	13.99	13	9.09	17	11.89	25	17.48	8	5.59	40	27.97	20	13.99	143
9.	96-105	14	8.97	10	6.41	19	12.18	29	18.59	8	5.13	60	38.46	16	10.26	156
10.	106-115	14	15.22	10	10.87	10	10.87	21	22.83	3	3.26	29	31.51	5	5.44	92
11.	116-125	13	38.24	3	8.82	2	5.88	6	17.65	2	5.88	51	14.71	3	8.82	34
12.	126-135	-	-	1	33.33	-	-	2	66.67	-	-	-	-	-	-	3

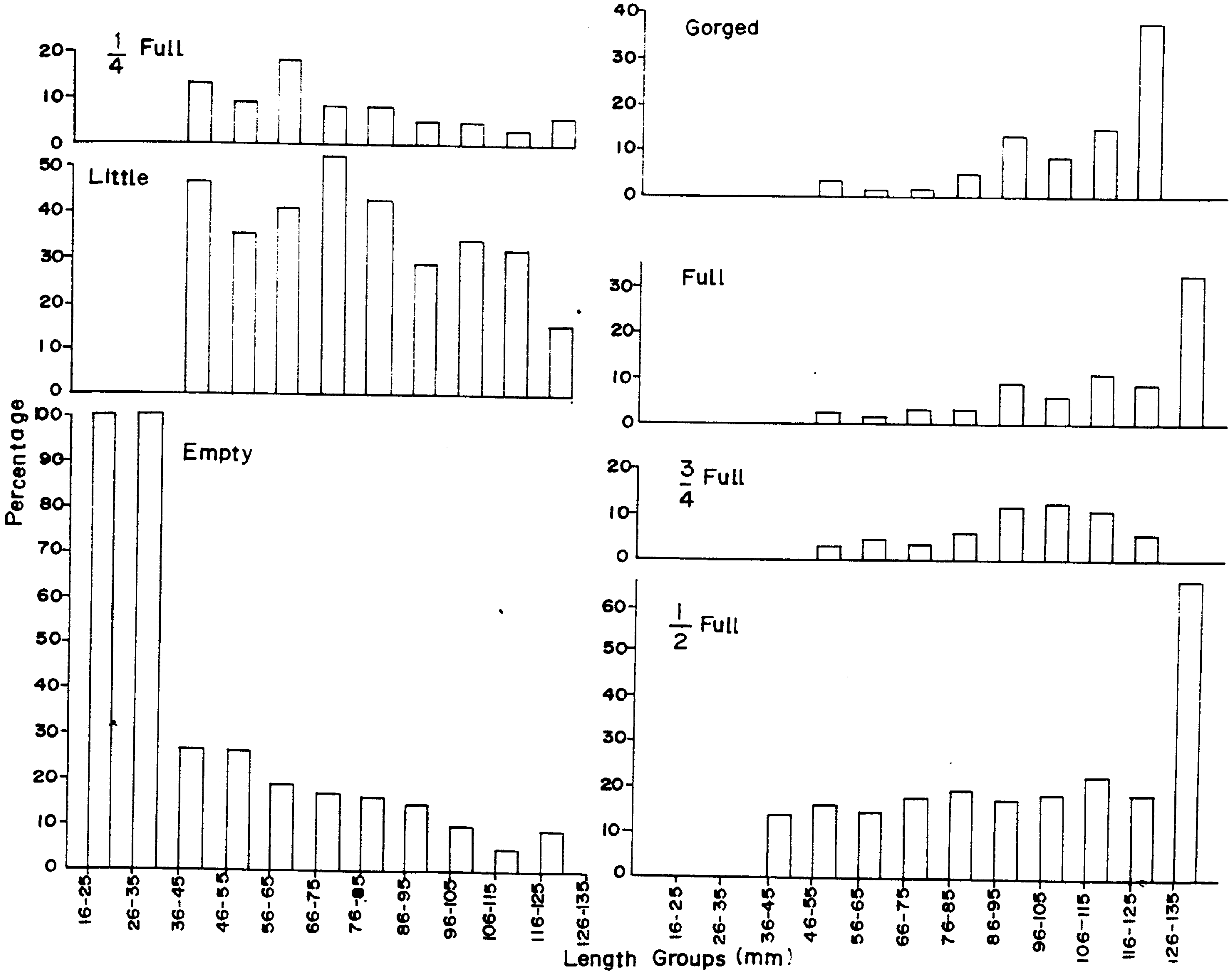


Fig. 23 Length groupwise intensity of feeding in A. commersoni.

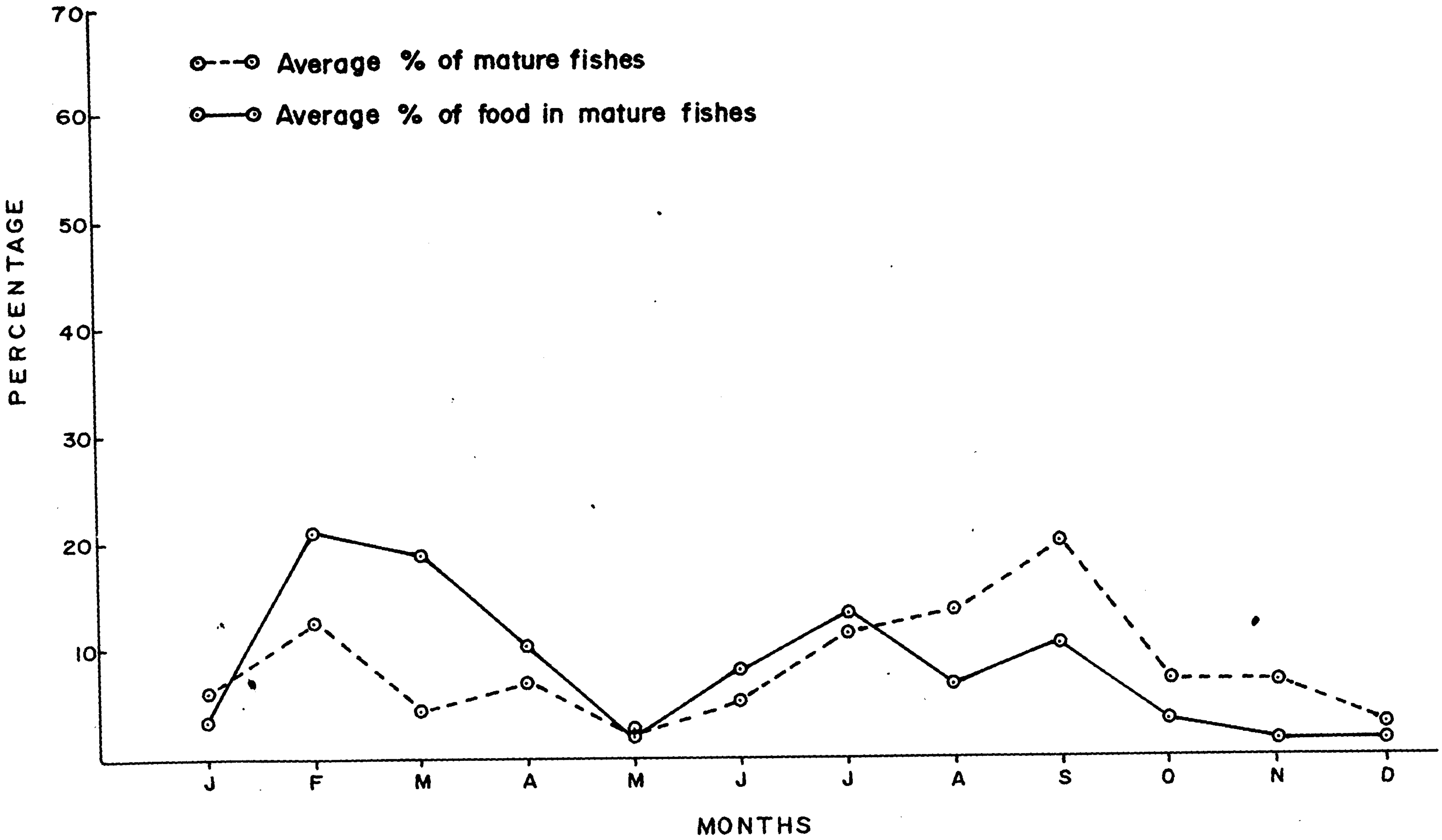


Fig. 24 Relationship between feeding activity and spawning in A. COMMERSONI

TABLE - 25

Percentage of average total weight (gm) of food in A. commersoni monthwise

Sl.No.	Months	No.	Total weight	Average % of total weight of food
1988				
1	January	84	2.1	3.38
2	February	83	14.93	20.58
3	March	71	6.31	10.26
4	April	83	4.42	6.10
5	May	88	2.73	3.56
6	June	77	2.55	3.9
7	July	78	9.08	13.44
8	August	99	5.10	5.89
9	September	69	4.77	7.93
10	October	61	1.200	2.2
11	November	53	1.05	2.38
12	December	75	1.43	2.27
1989				
1	January	70	1.91	3.22
2	February	92	5.27	6.56
3	March	90	5.08	8.32

TABLE - 26

Percentage of average total weight of food in *A. commersoni* length groupwise

Sl.No.	Length groups	No.	Total wt. of food	Average % of total weight of food
1	36-45	15	0.02	0.18
2	46-55	76	0.41	0.66
3	56-65	291	2.99	1.14
4	66-75	227	4.59	1.88
5	76-85	153	5.97	4.11
6	86-95	143	12.10	9.93
7	96-105	156	12.52	9.61
8	106-115	92	18.42	21.48
9	116-125	34	11.54	43.58
10	126-135	3	0.24	7.42

TABLE - 27

Gastro-somatic index in A. commersoni (monthwise)

Sl. No.	Months	No.	Gastro-somatic index
1988			
1	January	84	2.19
2	February	83	3.55
3	March	71	2.96
4	April	83	2.94
5	May	88	2.47
6	June	77	2.50
7	July	78	4.80
8	August	99	2.13
9	September	69	2.92
10	October	61	1.74
11	November	53	3.08
12	December	75	2.29
1989			
13	January	70	2.39
14	February	92	2.51
15	March	70	2.94

TABLE - 28

Gastro-somatic index in A. commersoni (lengthwise)

Sl.No.	Length groups	No.	Gastro-somatic index
1	16-25	6	1.58
2	26-35	3	1.56
3	36-45	15	2.53
4	46-55	76	2.45
5	56-65	291	2.46
6	66-75	227	2.52
7	76-85	153	2.51
8	86-95	143	3.11
9	96-105	156	2.51
10	106-115	92	3.27
11	116-125	34	4.35
12	126-135	3	1.68

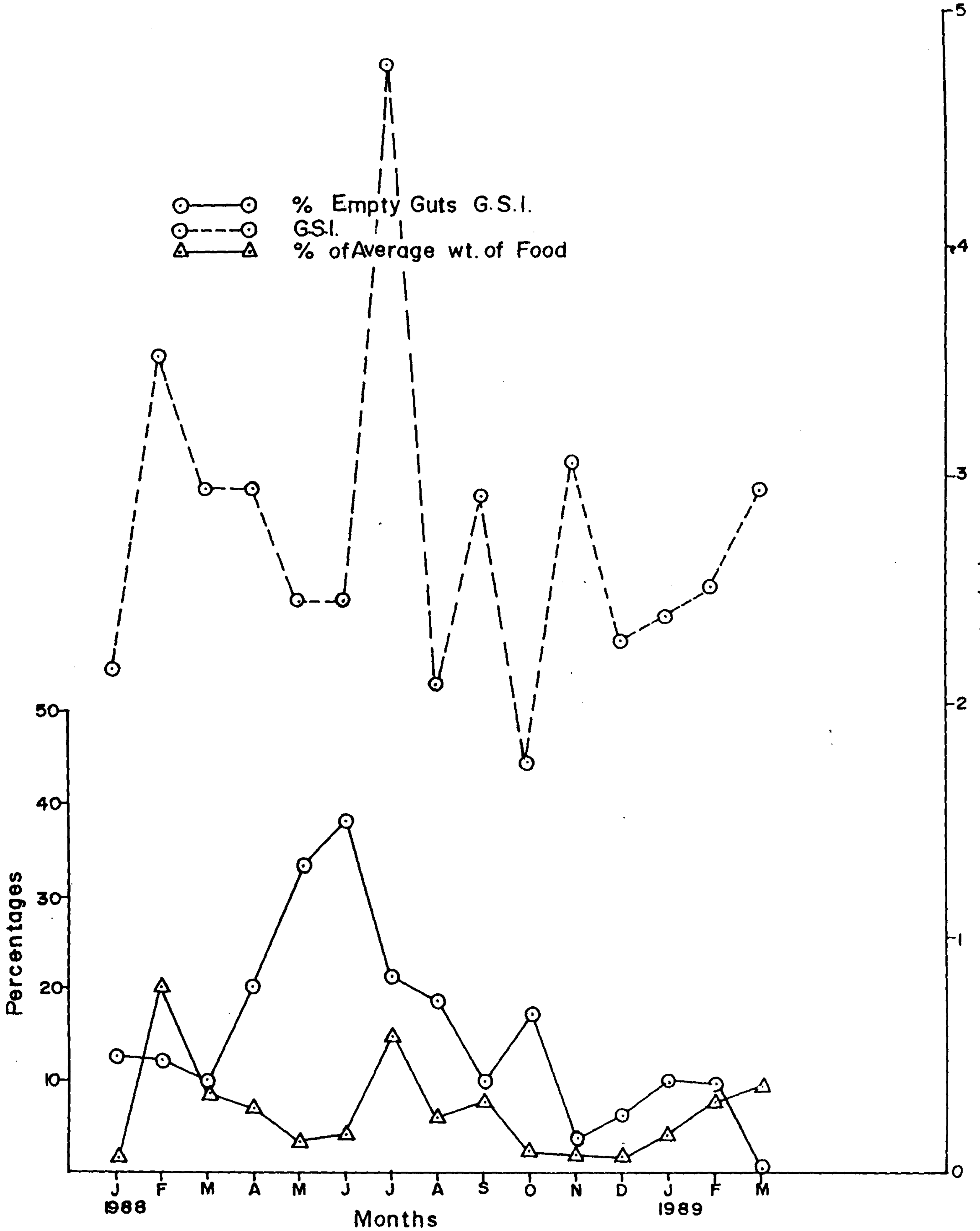


Fig. 25 Monthwise gastro-somatic Index, percentage of empty gut and average food in *A. commersoni*.

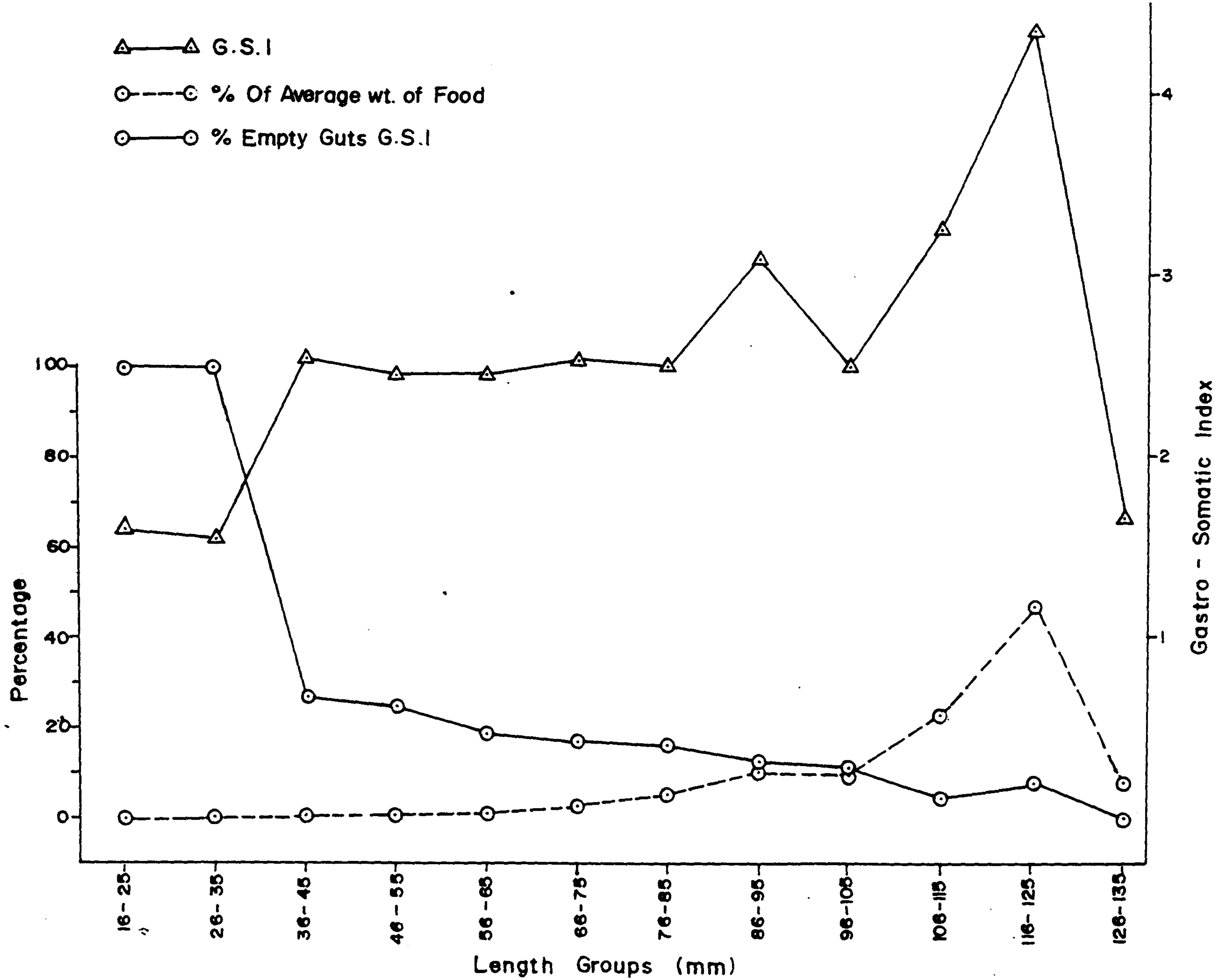


Fig.26 Length groupwise gastro-somatic index, percentage of emptygut and average food in A. commersoni.

VI. CHEMICAL ANALYSIS OF MUSCLE TISSUE

CHEMICAL ANALYSIS OF MUSSLE TISSUE OF AMBASSIS COMMERSONI

INTRODUCTION

Fishes form one of the major food source for human beings. The nutritive value of fish has long been recognised by people. Biological value of the proteins of various species and types of fishes compares more favourablly than that of muscles of beef, pork and mutton (Parulekar, 1964). Since fish represents a much larger source of potential proteins for human consumption than has been utilized, it seems more desirable to bring the most important facts relating to the food value of *A. commersoni*. It is also considered worthwhile to determine how far the type of fish normally consumed by the people acts as a first class protein food and what are the normal fluctuations in the quality of the species of fish with season.

A. commersoni is one such fish which is consumed in large quantity by the local population during rainy season when other fishes are not available. Hence, it was decided to study the seasonal variations in the chemical composition and nutritive value in relation to some of the biological processes, such as, maturation, spawning and feeding. *A.commersoni* forms a minor fishery in Goa water and most of the landings are sundried by the traditional method of preservation in most of the months of year, except during monsoon season (June-September), when it is consumed fresh.

The studies on the chemical composition of fishes occurring in Indian waters, have been carried out by various workers. Earlier work of Basu and De (1938), Chari (1948), Kamasastri (1961), Parulekar (1964), Kamasastri and Rao (1965), Nair (1965), Antony Raja (1969), Ramaiyan and Pandian (1976) and Solanki et.al (1976) deals with the proximate composition of biochemical components in several teleosteal fishes, but no work on similar lines has so far been carried out in A. commersoni from Goa coast. The present work was therefore undertaken to get an insight into variations in moisture, protein, ash and fat levels in A. commersoni, in relation to biological events of food and feeding; maturation and spawning and growth.

MATERIAL AND METHODS

During the period of February 1989 to January 1990, samples of A. commersoni collected from different fish landing centers of Goa were used for estimating the chemical composition of fish muscles (tissue). Male and female specimens, ranging in size between 46-130 mm in total length were taken in equal number and analyzed separately.

The specimens in fresh condition were cut open in the laboratory, for determining the sex. Head, fins, scales, and general viscera were removed and the remaining part of the fish, including vertebral column was dried at 60 °C and then ground thoroughly in a grinder. Estimates were done in triplicate and mean value for every fortnight was calculated. For graphic representation, mean monthly values were taken.

Moisture: Muscle tissues were dried in an electric oven (60 °C) for 72 hrs and reweighed. The difference in the weight was taken as the moisture content of the tissue. Percentage was calculated by the following formula.

$$\% = \frac{\text{Wet weight of tissue} - \text{dry weight of tissue} \times 100}{\text{Wet weight of tissue}}$$

Ash: For determination of ash 2 gm of oven dried muscle tissue was ashed in a muffle furnace at 550 °C for 5 hrs and weight of the ash taken.

$$\% = \frac{\text{Weight of ash} \times 100}{\text{Dry weight}}$$

Lipids: For the extraction of lipids, chloroform methanol H_2O mixture in 1:2:0.8 v/v method of Bligh and Dyer's as modified by Jeffrier (1969) was used. The lipid content was estimated gravimetrically, using 10 mg dry fish. Percent of lipid content calculated as :

$$\% = \frac{\text{F} \times \text{unknown OD} \times 100}{\text{Weight of sample}}$$

$F = 280$

Unknown OD = Blank - Spectrometer reading

Carbohydrates: For total carbohydrate estimation the Phenol-Sulphuric acid method of Dubois et al. (1956) as modified by Hitchcock (1977) was adopted. 5 mg of oven - dried tissue was taken for carbohydrate analysis.

$$\% = \frac{F \times \text{Unknown OD} \times 100}{\text{Weight of sample}}$$

$$\text{where } F = \frac{\text{con}}{\text{OD}}$$

Unknown OD = Spectrometer reading - Blank

Proteins: For total protein estimation, method by Lowry et al. (1951) was used. About 2 mg of oven dried muscle tissue was homogogenized with 5 ml of 1N/NaOH in water bath and total protein estimated. This method is 10 times more sensitive than the biuret method.

$$F = \frac{\text{Con}}{\text{OD (Standard Soln)}}$$

$$\% = \frac{F \times \text{Unknown OD} \times 100}{\text{Weight of sample}}$$

Unknown OD Spectrometer reading - Blank

Definition:

Premonsoon: The period February to May is considered as premonsoon season.

Monsoon: June to September is considered as monsoon.

Post monsoon: It is defined as period in between October and January.

RESULTS

Moisture: Fig. 27 & 28, Table 29 & 30.

Moisture forms the main bulk of the composition and averaged 70.02%, throughout the period of investigation. It varied from 70.06% to 80.33% in male and 72.56% to 85.21% in females. The lowest value in male was observed in May and highest in August, while lowest value in female was observed in May and highest in July. In premonsoon period average value of moisture was 73.71% in female and 72.57% in male, after which it continuously increased in monsoon season and reached to a maximum of 85.21% in female in July and 80.23% in male in August. In post monsoon season moisture content in female remained almost constant i.e. in November 76.53% and December 76.60%, except in October (74.89%) and January (74.60%) while in male it continuously decreased and reach 74.89% in January.

Ash: The ash content in tissue was found to vary from 6.75% to 15.45% in female and 9.59% to 13.99% in male.

Female: (Table 29, Fig. 27). The percentage of ash content was maximum in February i.e. 15.45% which then decreased continuously till 6.75% in May followed by a sharp increase in the monsoon season and thereafter remained steady. Slight increase in October may be due to spent fishes which were available during this month, while in other months most of the mature fishes were present. In post monsoon season percentage of ash content continuously increased till January. This indicates that ash content was more in mature fishes.

Male: (Table 30, Fig. 28): The percentage of ash content in February was 10.60% and in March 12.40% which decreased to a minimum in May (9.59%). In monsoon season, it fluctuated between 10.15% and 13.99%. It therefore appears that ash content decreases in spent fishes and increases in immature and mature fishes. Ash content remained constant in post monsoon season approximately 11.55% with a slight decrease in January i.e. 10.80%.

Lipids: The range of fluctuations in the percentage of lipid was 6.01% to 10.31% in female and 6.17% to 10.49% in male.

Female: In premonsoon season, it was less except in April (10.31%). In monsoon season, it increased from 8.79% to reach a maximum of 10.17% in September. The lipid content decreased during post monsoon season. This indicates that lipid content was maximum in maturation period (Fig. 27, Table 29). Male: During premonsoon and post monsoon season, lipid content fluctuated very frequently and low values were found in March and September when maximum number of spent

male fish occurred. During September-March period lipid content was less as compared to other months. In post monsoon season lipid content increased continuously and reached a maximum value (9.28%) in December (Fig. 28, Table 30). The fluctuation in lipid content can be attributed to the presence of spent and mature fishes in different months.
Carbohydrates: Percentage of carbohydrate content varied between 0.17% and 2.19% in female and 0.28% and 2.30% in male.

Female: In premonsoon and monsoon season, carbohydrate content in A. commersoni fluctuated between 0.17% and 2.19%. During post monsoon it continuously decreased and reached 1.08% in January. It did not indicate any relationship with maturation and spawning (Table 29, Fig. 27).

Male: The carbohydrate content in male fluctuated throughout the year and it did not show any specific pattern except in post monsoon season when it decreased till it attained 1.19% in January. It, may therefore be surmised, that the carbohydrate content, in male A. commersoni has no distinct relationship with different phases of maturation and spawning (Table 30, Fig. 28).

Proteins: As seen in Table 29 & 30, Fig. 27 & 28 protein content of A. commersoni vary between 34.00% and 51.85% in female and 34.28% to 67.68% in male.

Female: Protein content during premonsoon period showed continuous decrease and a sharp increase in May (51.85%) and June (49.64%). During monsoon and post monsoon period it continuously decreased to 34.00% in December. Low value of protein content in April and October syncronises with post spawning period. Percentage of protein was high in immature fish i.e. 51.85% and 49.64% in May and June respectively and low in mature fish i.e. 40.32 & 37.62 in August & September respectively (Table 29, Fig. 27).

Male: High value of protein was observed in February followed by continuous decrease from 41.08% to 25.34% in April. A sudden increase to 67.68% and 62.41% noticed in May and June prevailed in monsoon season except in July, when a lower value of 36.45% was recorded. During post monsoon season, the protein content remained almost steady except in October whhere it was less i.e. 34.28%.

Highest value in May-June and November corresponds with immature gonads, while in remaining months, spent and mature fishes were dominant (Table 30, Fig. 28). Low value in April, July and October i.e. 25.34, 36.45 and 34.28 was recorded, which may be attributed to spent state of male.

DISCUSSION

The variations observed in the biochemical composition of A. commeroni may be correlated with various known facts of biology. As documented in the earlier part of the thesis, A. commersoni breeds almost throughout the year. The maximum number of mature fishes were found in July - September and again during January - February and spent fishes in October. The rate of feeding greatly varied from month to month. Intensive feeding occurrs during maturation phase while poor feeding during maturing stages. During intervening period, fish feeds moderately and mainly on plankton, crustaceans and fish. Annual cycle, of various biochemical constituents, is discussed in relation to maturation, spawning and feeding.

Moisture cycle: There seems to be no direct correlation between moisture content of various tissues and feeding and spawning but since variations are related to fat, all these factors which affect the lipid cycle may also influence moisture cycle indirectly.

Milroy (1908) observed high value of moisture in spent fishes. Moisture varies inversely to fat content (Fig. 29 & 30). Arevalo (1949) while studying the chemical composition of Saurel observed that the fat content increases with size of full maturity and is inversely related to the moisture content. Lovern and Wood (1937), Venkataraman & Chari (1951) and Jeffrier (1969) who worked on biochemical analysis of muscle tissue of fishes stated that moisture variations were related inversely to the change in the amount of fat and thus indirectly related to maturation and spawning. Paton (as quoted by IDLER & Bitners 1958) while commenting upon the water changes in muscles of migrating Salmo salar stated "it is this increase in the percentage of water of the flesh which maintains the weight of the fish per fish of standard length, although the solids as a whole have diminished".

In the present investigation, low value of moisture and fat in May coincided with high value of protein (in female). Similarly, high value of moisture and fat in July, September and December coincides with low value of protein, and thus corroborates the findings of Paton (1958).

It was reported by Ramaiyan and Pandian (1976) that generally when oil content is high the moisture content is low as in the case of Septipinna taty but reverse is true in the case of Anodoni-ostomachacunda. Vijayakumaran (1979) reported that Ambassis gymnocephalus shows gradual decrease in percentage of moisture with increase in size. High value of moisture content during monsoon and post monsoon season may be due to prolonged breeding season extending from July to February as stated in the earlier part of this thesis. The low moisture content in October and April can be attributed to the spent condition of fishes. However, these low percentages may be due to the immature or maturing condition of the gonad (Parulekar 1964) during these months. Thus the observations reported in the present study agree with those of the earlier report.

Fats: Fats are primarily a source of energy in the diet. They are the most concentrated of all the food materials, furnishing about 9.5 calories of energy as compared to 4 calories by proteins and carbohydrates each. Besides acting as energy bearing materials, the fat and fatty acids form an important constituent of body tissue. Fat serves possibly as insulation under the skin and as padding to keep the bodily organs, blood vessels and nerves in places. Fat gives to the diet particular flavour which is highly prized.

Hutchinson (1904) classified fishes according to their fat content. Fishes yielding less than 2% of fat are termed as lean fishes. Those yielding above 2.5% are designated as medium fishes and those having more than 5% of fat are classified as fat fishes. Accordingly A. commersoni is a fat fish.

The various factors which influence the variations in lipid content of fish are in the size, age, races, sexes, nature of food, feeding activity, spawning condition, season and locality (Venkataraman and Chari, 1951). Intensive feeding in A. commersoni during monsoon and post monsoon season coincides with the occurrence of high fat content in muscles of fish. This period may be ascribed to the abundance of fish food in the environment. Relatively low fat in the muscles observed during May-June and premonsoon months except in April may be similarly due to a fall in the rate of feeding in females. Wilson (1939) observed that the maturing flounder posses high percentage of fat which falls rapidly due to poor feeding activity during spawning. Sekharan (1950) found that the fluctuation in the fat content shows corresponding changes in feeding and maturity of fish.

There was marked relationship between the muscle fat cycle and the cycle of gonad maturation. The highest fat during July to September coincided with the period of peak ripeness. A decline in muscle fat in October corresponds with the period when the fishes were mostly spent especially females of A. commersoni. The low value of fat content in March and September corresponds with spent male fishes of A. commersoni. Channon and Saby (1932) indicated a rise in the fat content of herring's muscles, before spawning followed by a fall after spawning. Lovern and Wood (1937) found a similar trend of variation in the fat content before and after spawning in the case of Scottish herring. Chidambaran et al. (1952) observed that the mackerals are fatty before spawning and lean after spawning. Parulekar

(1964) reported in B. mcclellandi that high percentage of fat lipids in maturation period and decline in post spawning and early maturation period. Vijaykumaran (1979) reported in A. gymnocephalus, appreciable depletion of protein and lipid due to spawning activity of fish. Venkataramani and John (1979) did not find any appreciable variation. As feeding and maturation cycles in A. commersoni were interconnected, the rise and fall in the muscle fat appear to be influenced by both feeding and maturation.

Ash: Ash content was higher in A. commersoni than the value reported in other fishes by many authors like Mac Callum et al. (1969), Parulekar and Bal (1969), Das (1978), but Vijaykumaran (1979) reported high content of ash in A. gymnocephalus which was due to the inclusion of bones and scales during analysis.

There is no distinct relationship between ash content and feeding or spawning cycle of the fish. High ash value in the tissue during monsoon and post monsoon season may likewise be due to intensive feeding during these months which in turn may indicate a high mineral requirement in the fish. Similar finding was reported by Das (1978) in Mugil cephalus i.e. the intensity of feeding in M. cephalus was high from October to February and correspondingly i.e. ash content was found high which corresponds with present findings.

Carbohydrates: Carbohydrate content was very low in comparison to protein, lipids and moisture. This indicates that muscle tissue does not store carbohydrate to any appreciable extent. Similar, findings were reported by Ramayan and Pandian (1976) in 11 different species of clupeids. Vijaykumaran (1979) stated that as in other fishes carbohydrate plays minor part in the energy reserves of A. gymnoccephalus and depletion due to spawning is also negligible, when compared to lipid and protein. Das (1978) has also reported low carbohydrate in fish muscles.

Protein: The proteins in the flesh of fish are important for the tissue building activity of those who consume them. Protein cycle does not show any relationship with intensity of feeding. Low value of protein content in winter may be a consequence of greater utilization of protein for energy requirements in the season. The protein cycle in muscle does not seem to be influenced much by feeding alone, as low rate of feeding during summer and heavy feeding during post monsoon months showed no corresponding decrease or increase in protein. High value of protein in premonsoon period and highest value in May-June does not show direct relationship with protein and maturation period and spawning. In July-August and September when maximum number of mature fishes were found, the protein content was low and low value in

October synchronizing with maturation and spawning period of *A. commersoni*. This fish has shown fairly high range of seasonal variation in its muscle protein. The value remains fairly high throughout the year as reported by Bruce (1924) while studying the chemical composition of the muscles of herring, and further reported that the protein in the muscle substance falls off with the advancing age and with progressive maturation of the gonads. He further remarked that the diminition of protein content in the successive age group concurrently with rising fat content, may be an expression of the same dynamic equilibrium between these substances. Parulekar (1964) reported that the maximum protein content is met in the spawning specimens and the minimum values were associated with the spent and early maturation phases. Vijaykumaran (1979) noticed energy reserves of *A. gymnocephalus* in the form of lipids and protein increases during growth and maturity period. Hence it may be concluded that the biochemical composition of *A. commersoni* is affected by maturation cycle as well as feeding intensity of fish.

From the study of the seasonal variation in the chemical composition of *A. commersoni*, it appears that in males and females, the variation in the percentage composition of moisture, fat and protein are similar and there is no significant difference in the percentages of the different constituents in the sexes. Savant (1963) on a scianid, Johnius dussumieri and Parulekar (1964) on Bregmaceros mc Clellands reported that there was no significant difference in percentage of the different chemical constituents in the two sexes.

TABLE - 29

Approximate Biochemical composition in female A. commersoni

S.No.	Months	Moisture	Ash	Carbohydrate	Protein	Lipid
1.	February	73.17	15.45	0.99	45.17	7.56
2.	March	74.65	12.34	2.19	41.89	7.57
3.	April	74.47	9.50	0.17	40.25	10.31
4.	May	72.56	6.75	0.79	51.85	6.01
5.	June	74.23	11.68	1.04	49.64	8.79
6.	July	85.21	11.40	0.71	44.14	9.99
7.	August	78.73	11.41	1.84	40.32	9.77
8.	September	76.87	10.75	0.72	37.62	10.17
9.	October	74.89	11.54	1.60	38.18	8.36
10.	November	76.53	12.35	1.18	38.75	9.42
11.	December	76.60	14.53	1.22	34.00	9.41
12.	January	74.60	15.43	1.08	42.48	8.98

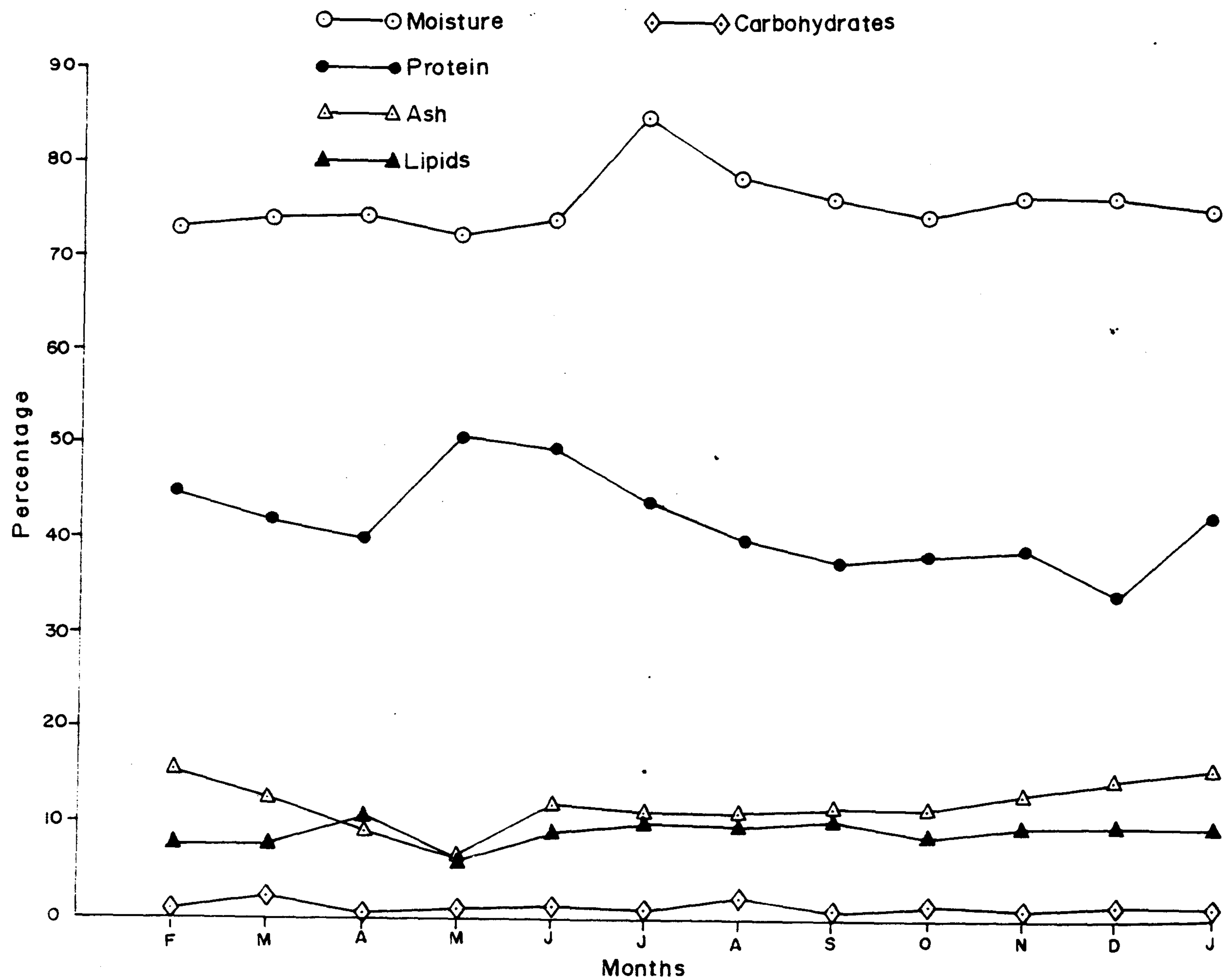


Fig. 27 Proximate biochemical compostion of tissues in female, A. commersoni

TABLE - 30

Approximate Biochemical composition in male A. commersoni

S.No.	Months	Moisture	Ash	Carbohydrate	Protein	Lipid
1.	February	73.30	10.60	0.74	41.08	8.09
2.	March	73.66	12.4	2.30	38.31	6.86
3.	April	73.29	11.55	0.28	25.34	10.49
4.	May	70.06	9.59	1.53	67.68	7.04
5.	June	75.82	10.15	0.98	62.41	10.14
6.	July	79.46	12.50	0.71	36.45	9.29
7.	August	80.33	11.17	2.02	59.50	9.69
8.	September	77.98	13.99	1.49	42.17	6.17
9.	October	79.85	11.79	1.19	34.28	7.80
10.	November	75.99	11.84	0.60	60.64	8.42
11.	December	76.27	11.02	0.91	48.12	9.28
12	January	74.89	10.80	1.19	45.75	7.78

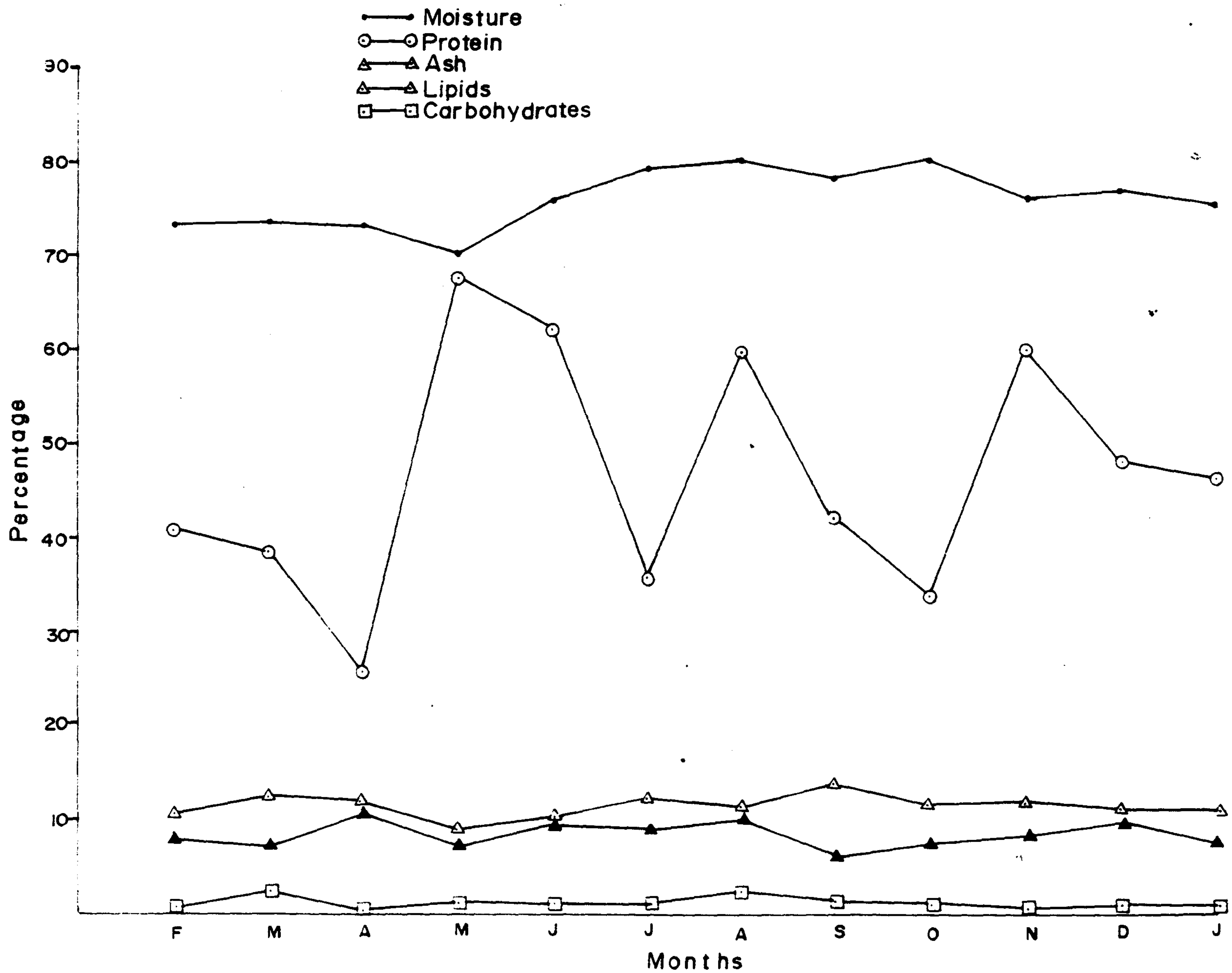


Fig 28 Proximate biochemical compostion of tissues in male, A. commersoni

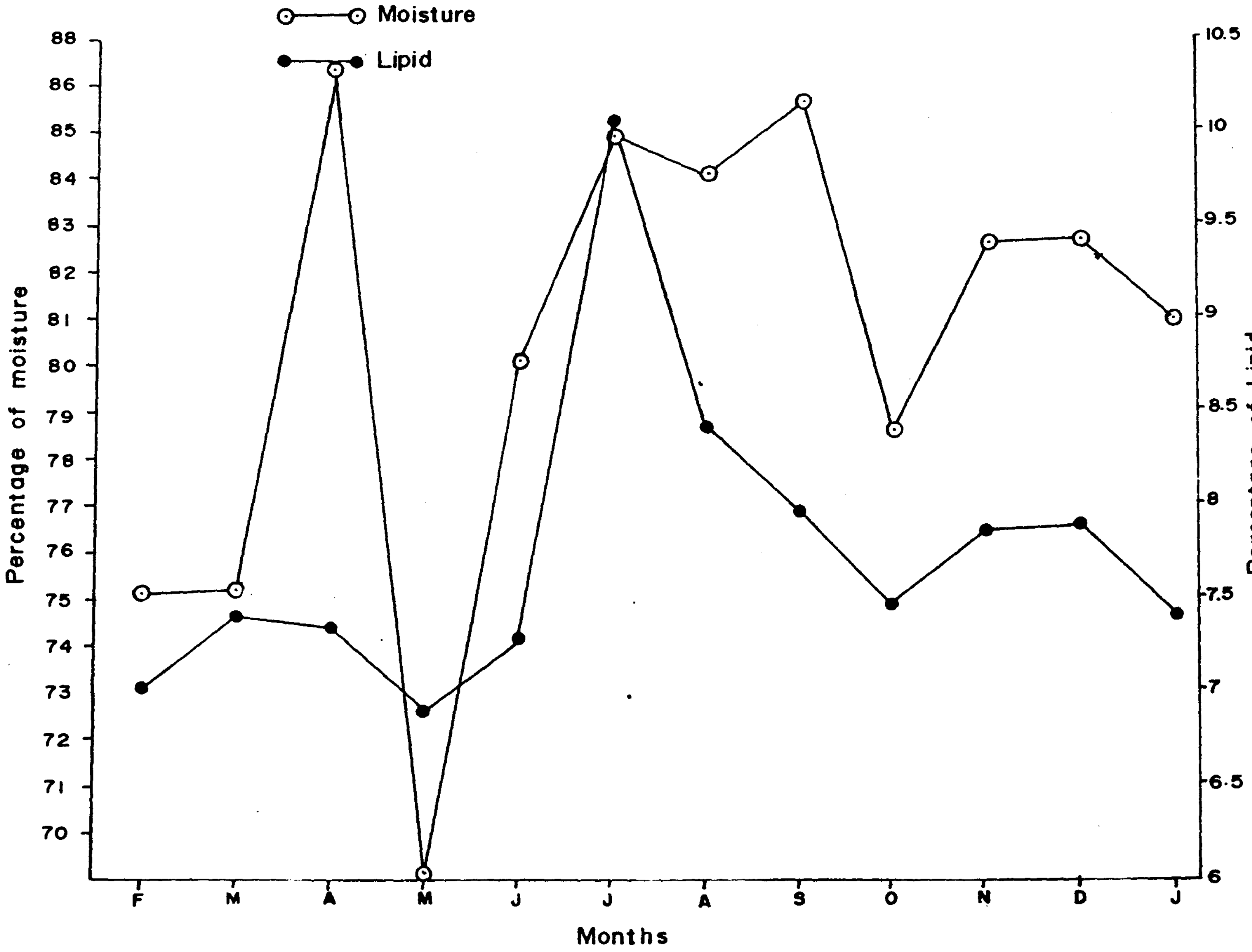


Fig. 29 Percentage of moisture and lipids in female, A. commersoni.

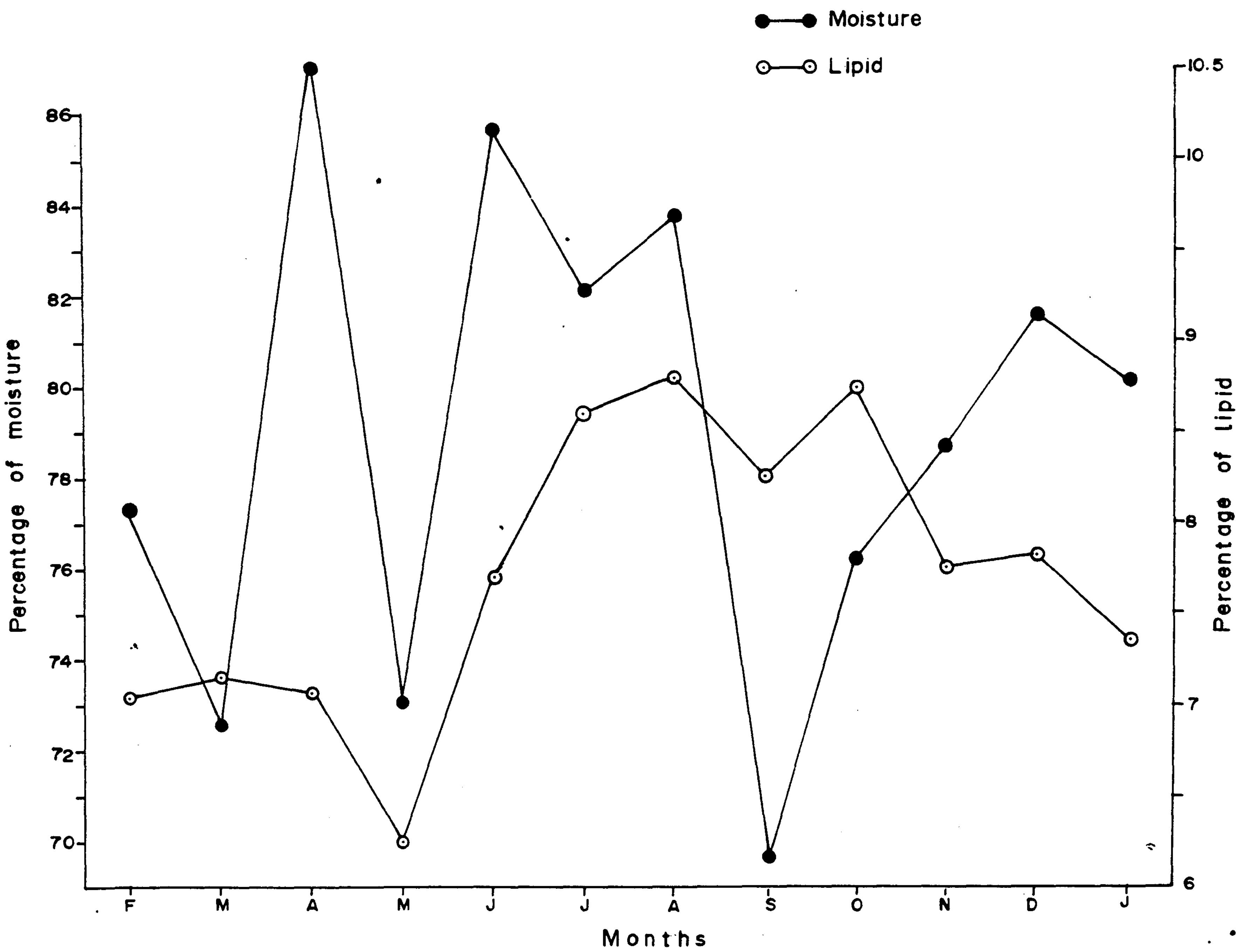


Fig. 30 Percentage of moisture and lipid in male, *A. commersoni*.

VII. LENGTH FREQUENCY DISTRIBUTION

LENGTH FREQUENCY DISTRIBUTION IN A. COMMERSONI

INTRODUCTION:

The knowledge of age and growth of the fish is essential to determine primary objectives which are three folds; to find out year class, rate of mortality and to assess the sustaining power of the fishery stock. A fishery dependent on a few age groups or year classes is likely to be affected by the marked success or failure of the brood produced in any one year. If, however, fishery consists of many age groups, the success or failure of spawning in any one year will have little effect on the total stock.

In tropical regions the determination of age and growth is often particularly difficult (Menon 1953, Bont 1967) as scales and other hard parts may show rings, but these are not necessarily annual. The rings on hard body structure are not properly marked due to lack of well marked seasonal variations in the tropical seas.

The simplest and most suitable methodology for age determination in tropical marine fishes is the analysis of size frequency distribution known as the Peterson's, (1922) method. This method uses the individual lengths of a large number of fishes of a population..It requires unimodal size distribution of all fishes of the same age and is easy to employ if there is no large over lap in the size of individual in adjacent age groups. In principle, it is generally more useful than all other methods (Ricker 1958).

MATERIAL AND METHODS:

A total of 1199 specimens of *A. commersoni* obtained from fisherman's catch were measured from the tip of the snout to the longest ray of the caudal fin. The specimens were observed to fall in the range of 18 to 135 mm, and hence the individuals were grouped with 5 mm length interval, so that the total range of length was represented by 26 size classes or length groups, as shown in Table 32 and Fig. 31. For graphic representation, frequencies were converted into percentage and then plotted against the respective length groups.

RESULTS

The frequency polygons for combined data of 16 months as shown in Fig. 31, Table 32 indicates the presence of two broad modes, first at 61-75 mm and second at 95-105 mm length group. Pearson (1928) in his studies on the natural history of Red-fish stated "the individuals of a large collection are grouped according to their length and each prominent mode or hump in the plotted distribution is assumed to represent an age-class". Accordingly, the commercial catches of *A. commersoni* in Goa water consists of two year classes. The fish at the end of first year is

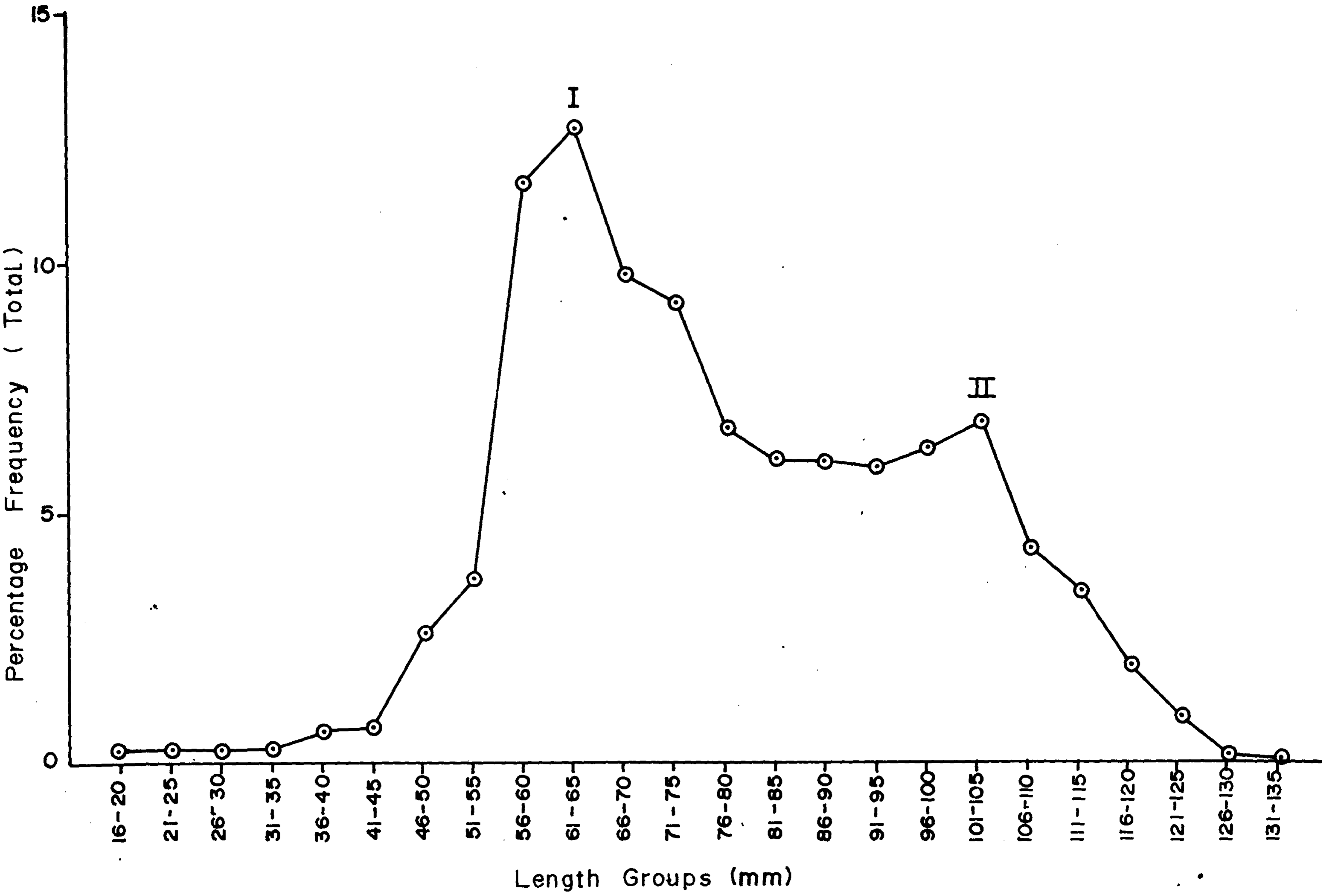


Fig.31 Length frequency distribution in A. commersoni. yearwise (1987-89)

about 65 mm in total length whereas, a two year old fish attains the maximum length of 105 mm. Hence, it may be said, that in the first year of its life, the average monthly growth of A. commersoni is 5.2 mm whereas, in the second year the individuals of this species grow at the rate of 3.31 mm per month.

From Fig. 32, Table 32 it can be noted that monthwise size frequency distribution shows more than one mode in each month and occurrence of modes in different months does not follow a regular pattern, i.e. the movement of a particular mode cannot be traced properly. hence, for the approximation of the rate of growth, the different modes from different months were arranged, as shown below :

From the position of modes, it can be said that the recruitment to the fishable stock is more or less continuous, as represented by the presence of a mode at 65 & 70 mm. for only in seven months of the year. The continous recruitment also reflects on the prolonged breeding habit of the species.

TABLE 31

Growth progression in different months

December '87												
January '88							55	65	80		105	
February							60				105	
March							65	75		95		120
April							65			95	110	
May	20					50	60	80		95		
June				40		60	70		90	100		
July						65	80	90			110	
August						75				105		
September				75				100				
October			70			85			100			
November			70									
December					65		85					
January '89			70		80		95		110			
February	55		70		90		105		115			
March		60		80		100		115				

DISCUSSION

The commercial catches, as indicated by frequency distribution of the different size groups during the entire period of study (Fig. 31, Table 32), appeared to consist of specimens ranging between 18 and 135 mm indicating thereby that the main stay of A. commersoni fishery, depend upon one or two year old fishes. It has been shown - discussions on maturation and spawning that this species attain maturity for the first time at the size interval of 66-70 mm. In view of the fact that majority of the commercial landings of the species consisted of specimens above 65 mm, it can be inferred that the fishery of _A. commersoni_ is supported mainly by fishes which have already attained the sexual maturity. Fig. 32, Table 32, indicates continuous recruitment which implies that _A. commersoni_ has prolonged breeding habit. Bapat & Bal (1958) inferred that recruitment in those marine fishes having prolonged breeding, is more or less continuous. From Fig. 32, Table 32, it can be observed that the mode at 50 mm in May can be traced in June at 60 mm, at 65 mm in July and 85 mm in October. From the study of the position of different modes in different months, it may be said that the length frequency distribution in _A. commersoni_ is of polymodal nature and is the effect of protracted spawning season of the species. This inference is in conformity of the earlier observation of Venkataranujam et al. (1984) and Nair (1984) that _A. commersoni_ has a prolonged breeding season.

Thus, from the study on the length frequency distribution of _A. commersoni_ it can be concluded that this species attains an average size of 65 mm at the end of the first year of its life and 105 mm at the end of the second year. Hence, the average growth during second year appears to be 3.31 mm. In view of the earlier observations on maturation and spawning and relative condition factor that the fish attains maturity for the first time at 66-70 mm length group, it can be said that the age at which it attains maturity is approximately one year. Presence of mature fishes for major part of the year, supports the view that the fish has a prolonged breeding season.

TABLE - 32
Length frequency distribution of A. commersoni (1987-89)

Length group	1987 December	1988 January	February	March	April	May	June	July	August	September	October	November	1988 December	1989 January	1989 February	1989 March	Total
15-20	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
%	-	-	-	-	-	(3.41)	-	-	-	-	-	-	-	-	-	-	(0.25)
21-25	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	3
%	-	-	-	-	-	(2.27)	-	-	-	-	-	-	-	-	-	(1.43)	(0.25)
26-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31-35	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	3
%	-	-	-	-	(1.21)	(1.14)	-	-	-	-	-	-	-	-	(1.09)	-	(0.25)
36-40	-	2	-	-	-	1	-	-	-	-	-	-	-	1	3	-	7
%	-	(2.38)	-	-	-	(1.14)	-	-	-	-	-	-	-	(1.43)	(3.26)	-	(0.58)
41-45	-	3	-	-	-	1	1	-	-	-	-	-	-	-	-	3	8
%	-	(3.57)	-	-	-	(1.14)	(1.30)	-	-	-	-	-	-	-	-	(4.29)	(0.67)
46-50	-	4	4	2	3	5	2	-	-	-	2	-	-	-	7	2	31
%	-	(4.76)	(4.82)	(2.82)	(3.61)	(5.68)	(2.60)	-	-	-	(3.28)	-	-	-	(7.61)	(2.86)	(2.59)
51-55	6	8	7	2	4	3	3	-	-	-	-	-	2	-	6	4	45
%	(13.04)	(9.52)	(8.44)	(2.82)	(4.82)	(3.41)	(3.89)	-	-	-	-	-	(2.67)	-	(6.52)	(5.71)	(3.75)
56-60	20	8	14	11	16	16	16	-	-	-	2	5	12	1	5	13	139
%	(43.48)	(9.52)	(16.87)	(15.49)	(19.28)	(18.18)	(20.78)	-	-	-	(3.28)	(9.43)	(16.00)	(1.43)	(5.43)	(18.57)	(11.59)
61-65	11	12	4	13	19	14	10	6	4	-	-	14	24	5	6	10	152
%	(23.92)	(14.29)	(4.82)	(18.30)	(22.89)	(15.91)	(12.99)	(7.69)	(4.04)	-	-	(26.42)	(32.00)	(7.14)	(6.52)	(14.29)	(12.67)
66-70	7	5	6	3	11	7	11	2	10	4	8	16	9	5	8	5	117
%	(15.22)	(5.96)	(7.23)	(4.23)	(13.25)	(7.95)	(14.29)	(2.56)	(10.10)	(5.79)	(13.11)	(30.18)	(12.00)	(7.14)	(8.69)	(7.14)	(9.76)
71-75	1	4	5	16	1	7	5	4	19	7	8	10	6	8	5	4	110
%	(2.17)	(4.76)	(6.02)	(22.54)	(1.21)	(7.95)	(6.49)	(5.13)	(19.19)	(10.14)	(13.11)	(18.87)	(8.00)	(11.42)	(5.43)	(5.71)	(9.17)

Cont_

Length group	1987 December	1988 January	February	March	April	May	June	July	August	September	October	November	1988 December	1989 January	1989 February	1989 March	Total
76-80	1	6	5	8	2	8	1	8	6	2	7	6	6	3	5	6	80
%	(2.17)	(7.14)	(6.02)	(11.26)	(2.41)	(9.09)	(1.30)	(10.26)	(6.06)	(2.90)	(11.48)	(11.32)	(8.00)	(4.29)	(5.43)	(8.57)	(6.67)
81-85	-	4	2	5	3	5	1	7	6	2	13	-	8	8	6	3	73
%	-	(4.76)	(2.41)	(7.04)	(3.61)	(5.68)	(1.30)	(8.97)	(6.06)	(2.90)	(21.3)	-	(10.67)	(11.42)	(6.52)	(4.29)	(6.09)
86-90	-	1	2	1	5	3	5	9	5	1	8	2	7	7	13	3	72
%	-	(1.19)	(2.41)	(1.41)	(6.02)	(3.41)	(6.49)	(11.54)	(5.05)	(1.45)	(13.11)	(3.77)	(9.33)	(10)	(14.13)	(4.29)	(6.01)
91-95	-	5	2	4	10	6	4	4	9	8	4	-	1	4	6	4	71
%	-	(5.96)	(2.41)	(5.63)	(12.05)	(6.81)	(5.19)	(5.13)	(9.09)	(11.59)	(6.56)	-	(1.33)	(5.71)	(6.52)	(5.71)	(5.92)
96-100	-	6	9	-	2	2	8	3	10	22	5	-	-	1	3	4	75
%	-	(7.14)	(10.84)	-	(2.41)	(2.27)	(10.38)	(3.85)	(10.10)	(31.88)	(8.20)	-	-	(1.43)	(3.26)	(5.71)	(6.26)
101-105	-	7	9	2	2	1	3	5	15	14	2	-	-	14	6	1	81
%	-	(8.34)	(10.84)	(2.82)	(2.41)	(1.14)	(3.89)	(6.41)	(15.15)	(20.29)	(3.28)	-	-	(20)	(6.52)	(1.43)	(6.76)
106-110	-	3	5	-	4	2	1	17	5	5	-	-	-	3	4	2	51
%	-	(3.57)	(6.02)	-	(4.82)	(2.27)	(1.30)	(21.79)	(5.05)	(7.25)	-	-	-	(4.29)	(4.34)	(2.86)	(4.25)
111-115	-	3	5	-	-	1	2	8	4	3	2	-	-	3	7	3	41
%	-	(3.57)	(6.02)	-	-	(1.14)	(2.60)	(10.26)	(4.04)	(4.35)	(3.28)	-	-	(4.29)	(7.61)	(4.29)	(3.42)
116-120	-	2	2	3	-	-	2	2	3	1	-	-	-	6	1	1	23
%	-	(2.38)	(2.41)	(4.23)	-	-	(2.60)	(2.56)	(3.03)	(1.45)	-	-	-	(8.57)	(1.09)	(1.43)	(1.92)
121-125	-	1	2	1	-	-	1	2	3	-	-	-	-	1	-	-	11
%	-	(1.19)	(2.41)	(1.41)	-	-	(1.30)	(2.56)	(3.03)	-	-	-	-	(1.43)	-	-	(0.92)
126-130	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	2
%	-	-	-	-	-	-	(1.30)	-	-	-	-	-	-	-	-	(1.43)	(0.17)
131-135	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
%	-	-	-	-	-	-	-	(1.28)	-	-	-	-	-	-	-	-	(0.08)
Monthwise Total	46	84	83	71	83	88	77	78	99	69	61	53	75	70	92	70	1199

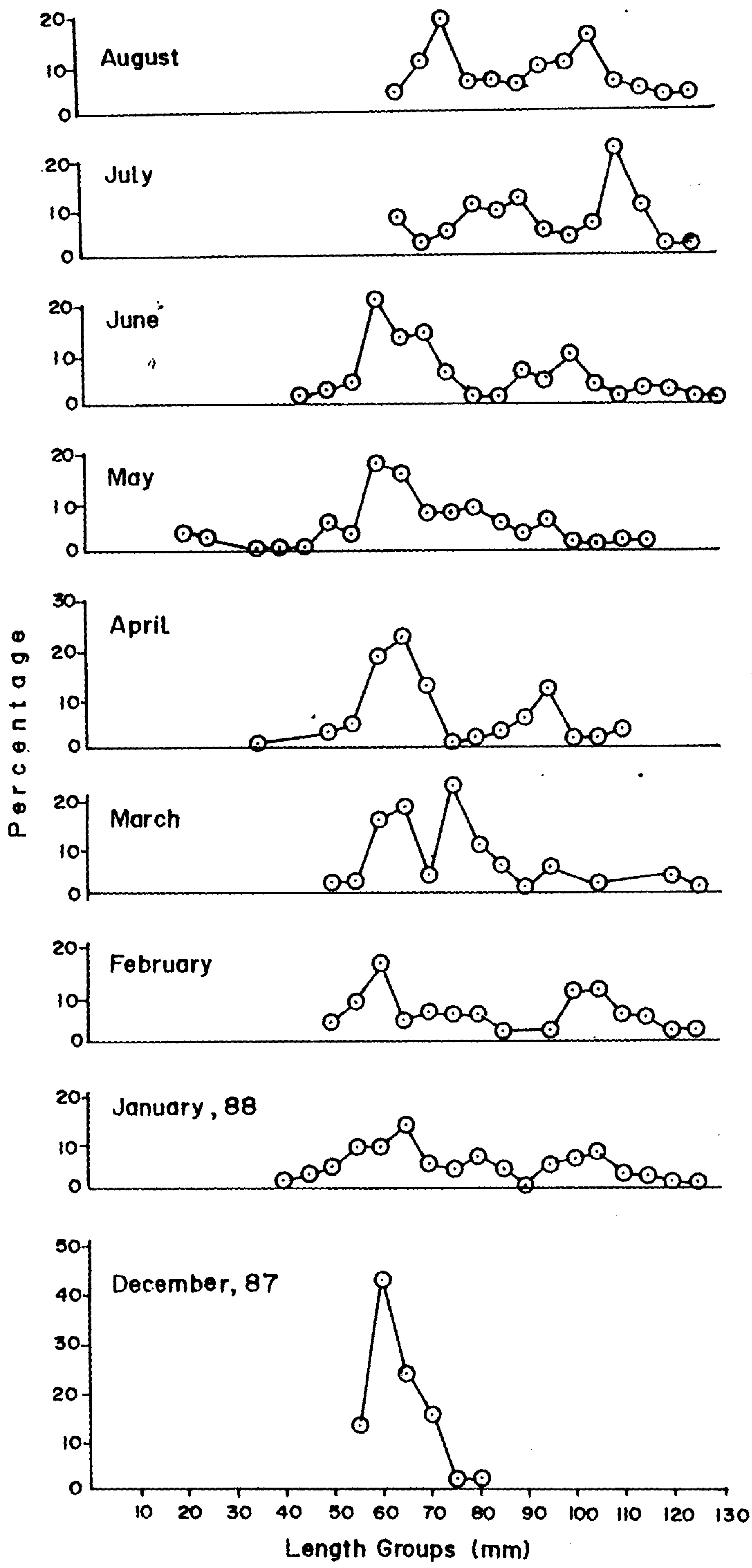


Fig.32 Monthly fluctuation in length frequency distribution in A. commersoni.

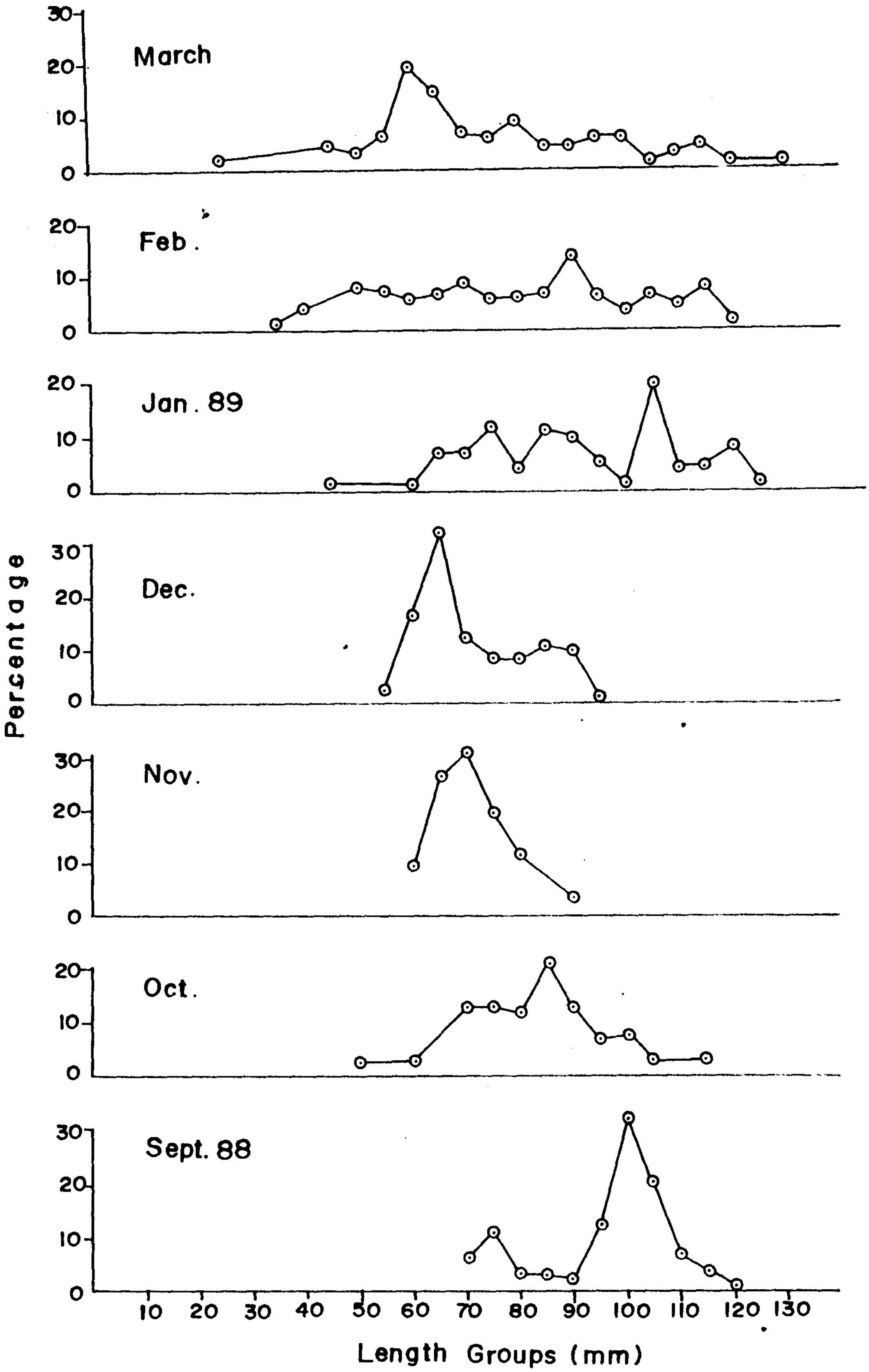


Fig. 32 Monthly fluctuation in length frequency distribution in <u>A. commersoni</u>.

VIII. LENGTH WEIGHT RELATIONSHIP

LENGTH AND WEIGHT RELATIONSHIP

INTRODUCTION

The study of the length-weight relationship in fishes, has been mainly directed towards two objectives, namely, (i) to provide a mathematical relationship between the two measurements as a means of inter conversion and (ii) to calculate the condition factor (Le Cren, 1951). It also yields information on general well being of the fish, variation in growth, size at first maturity, gonad development and breeding season.

In recent years a more elaborate and satisfactory equation has been evolved by Le Cren, (1951) which explains the length-weight relationship of fish more clearly. The formula $W = al^b$ besides providing means of finding out the details when only one of the variables is known, may also give indication of taxonomic differences.

MATERIAL AND METHODS

Random samples, each consisting of 20 fishes were collected from the local fish landing places once a week. These samples were collected from cast nets and shoresine. The present study is based on the observation of 1154 specimen of <u>A.commersoni</u>. The fishes are cleaned of all extraneous matter and then the total length from the tip of the snout to the tip of longest ray of the lower caudal fin was measured. The fish has forked tail, and hence two lobes were placed into the position (which gives maximum length) and the standard body length was measured to the nearest 1 mm. After blotting the excess water at room temperature (approximately $30^{o}C$) individual fish was placed on the aluminium foil and net total weight determined on a Mettler (H.K. 160 electron) balance to an accuracy of 0.1 mg. Thereafter the sex of each fish was determined by gonad analysis. The fishes were divided into 5 mm size group and the average length and weight for each group was calculated.

Equation : Length-weight relationship was computed based on the equation $W = aL^{b}$ Le Cren (1951) or its logarithmic form $\log W = \log a + b \log L$ where W = weight of fish, L = length of fish, a = constant and b = exponent. a and b are constants to be determined by the method of least square.

Fishes were divided into three groups - male, female and juvenile. Length and weight data were plotted on a logarithmic paper and the regression of log length was calculated by least square method (the straight line is fitted to scatter diagram), and results are presented in Table 38-41 and Fig. 33 to 36.

To test whether there were significant differences in length weight relationship with season and between sexes, covariance analysis (Sokal and Rohlf 1981) was carried out using BMOP Program PLV (Dixon 1981).

A total of 1154 specimens, comprising 456 males, 514 females and 184 juveniles collected from the catches at local fish landing centres during the year January 1988 to March 1989 were used for the study. The specimens had a length range of 18-135 mm and weight range of 0.30-33.88 gm.

RESULTS

Results Table 33 shows the summary of statistical results while Table 34 to 37 indicates ANVO and ANCOVA tests for various groups, Table 38, 39, 40, 41 and Fig. 33, 34, 35, 36 gives means and ranges of group 1 to 23 size of sample and separate pooled data for female, male and juveniles. The logarithmic regression equations obtained were as follows :

Pooled data - $\log W = -2.5151 + 3.2694 \log L$

Female - $\log W = -2.5593 + 3.2953 \log L$

Male - $\log W = -2.5754 + 3.2999 \log L$

Juvenile - $\log W = -21712 + 3.0691 \log L$

Corresponding parabolic equations may be represented as follows :

Pooled data - $W = 0.0000\ 3274\ L^{3.2694}$

Female - $W = 0.0000\ 3624\ L^{3.295}$

Male - $W = 0.0000\ 3761\ L^{3.069}$

Juvenile - $W = .0000\ 1484\ L^{3.069}$

Hence it may be deduced that the increase in weight in relation to length was 3.2694 times pooled data; 3.295 times for female and 3.2999 times for male and 3.069 times for juveniles. These values indicate that increase in weight of male and female was slightly greater than that for juvenile fishes. It is also clear from regression line that weight of the fish increases proportional to the cube of the length.

It is clear (Table 33) that correlation coefficient is highly significant in all the groups. The data when subjected to analysis of covariance indicate that b value did not differ significantly in male and female but was relatively higher in male than female and low (3.0691) in juveniles.

While standard error of regression coefficient was relatively lower in female (0.0363) than male (0.0428) which indicate that, for female, weight in relation to length vary more frequent than male.

Analysis of variance for each group was done separately and F ratio and T ratio was taken out and found significant for each of them.

TABLE - 33

Summary of statistical relation between length weight relation, regression coefficient and correlation coefficient for four groups using equation w = log a + b log L where w is weight (gms), L is total length, a is regression constant and b is regression slop.

Sr. No.	Source of variance	No.	Regression constant (a)	Regression coefficient (b)	S.E. of b	Regression equation log W= log a + b log L	Parabolic equation W = Anti log L	Correlation coefficient (r)
1.	Pooled data	1154	-2.5151	3.2694	0.0217	$W = -2.5151 + 3.2694\ L$	$W = 0.00003274\ L^{3.2694}$	0.9763
2.	Male	456	-2.5754	3.2999	0.0428	$W = -2.5754 + 3.2999\ L$	$W = 0.00003761\ L^{3.2999}$	0.9653
3.	Female	514	-2.5593	3.2953	0.0363	$W = -2.5593 + 3.2953\ L$	$W = 0.00003624\ L^{3.2953}$	0.9709
4.	Juvenile	184	-2.1712	3.0691	0.0620	$W = -2.1712 + 3.0691\ L$	$W = 0.00001484\ L^{3.0691}$	0.9648

TABLE - 34

Female

Source of variance	df	SS	MS	F	Tabulated value	P1%
Between groups	32-1	57675.15	57675.15	148.15	7.44	0.01
Within groups	36-2	13235.66	389.28			
Total	35	70910.81				

Value of F at 1% level is significant.

To confirm the above values, the T-test was performed by formula

$$t^2 = F$$

In the present case, it is noted that df between groups = 1 and substituting the values in the above formula it can be written as

$$t^2 = F$$

$$12.1716^2 = 148.15$$

$$148.147 = 148.15$$

$$148.15 = 148.15$$

This confirms that F test was significant.

The same analysis was done separately for males as given below:

TABLE - 35

Male :

Source of variance	df	SS	MS	F	Tabulated value	P 1%
Between group	1	48218.26	48218.56	165.84	7.56	.01%
Within group	30	8722.76				
Total	31	56941.32				

F value is at 1% level.

T - Test :

F = 165.84

T = 12.87

$T^2 = F$

$12.87^2 = 165.84$

165.63 = 165.84

This further confirms that F test was significant.

TABLE - 36

Juveniles :

Source of variance	df	SS	MS	F	Tabulated value	P 1%
Between group	1	33666.73	33666.73	78.89	7.44	01%
Within group	34	14508.35	426.716			
Total	35	48175.08				

F value was more than tabulated value therefore F test was significant at 1% level T - test F = 78.89, t = 8.88, df

= 1

$$t^2 = F$$

$$8.88^2 = 78.89$$

$$78.85 = 78.89$$

This test confirms that F test is significant.

2 Test : ANCOVA

The result can be summerized through analysis of covariance as shown below :

TABLE - 37

Final ANCOVA : Table

Source of variance	df	SS	MS	F
Adjusted mean among (al3)	2	23.08	11.54	0.7152
error deviation form a common stop	42	774.44	16.134	

An analysis of covariance (ANCOVA) was performed on the weight-length regression given for the year class 1988-89. In this case of both sexes the assumption of parallelism of slope were rejected at PL .05% df1 in male, female and juvenile was 16, 17 and 18 respectively. df2 in male, female and juvenile was 456, 514 and 184 respectively. F - value was less than tabulated value therefore this test is not significant.

Monthly variation in b in male and female : (Table 42, Fig 37) Monthly relationship between W (dependent variable) L (independent variable) data from January 1988 to March 1989 for each year class was determined by following regression equation.

$$\log W = \log a + b \log L$$

In the case of females the regression coefficient (b) varied from a minimum of 2.9463 in November to a maximum of 3.8127 in August, while in the case of males it varied from a minimum of 3.0375 in January to a maximum 4.3215 in October. A single regression equation for combined values of male, female and juvenile for the entire period gives the `b' value as 3.2694. Both these and combined regression were highly significant at PL 0.001 level.

Variation in the mean b value with 95% confidence limits for both the sexes as a function of season are plotted in Fig. 37. There is high and frequently significant degree of seasonal variation in b values in each sex, and further more a significant difference was noticed between the sexes in all the months except in June when b value in male and female was almost same, 3.3741 for female and 3.3782 for male.

DISCUSSION

The length weight relationship was studied separately for male, female and juvenile and combined in A. commersoni. It was seen that weight increases faster than length which is 3.30 times in males, 3.32 times in females, 3.06 times in juveniles and 3.27 times when taken as pooled values. Nair et al. (1983) reported in A. commersoni that female weight increases faster than length which is 2.98 & 3.13 times in female and 2.88 & 2.95 times in male. Ever since Herbet Spencer enunciated the cube law in 1871, it has become an absolute concept in describing the length weight relationship of fishes. According to this Law, the weight of fish equals the cube of the length times "a" constant, which is symbolically expressed as $W = aL^3$, where `W' is weight, `L' the total length and `a' is the constant. This relationship assumes a constancy of form and specific gravity on the part of the fish. Henson (1899) found constant `a' to have fluctuations and Heinckle (1908) suggested the use of this factor as an index of well-being of the fish. This factor is invariably called as `coefficient of condition', length-weight factor etc.

Fulton (1904), Crozier and Hecht (1913) and Hecht (1916) found the cube law inadequate in explaining the length-weight relationship of fishes.

Allen (1938) suggested that the value `a' in an ideal fish is 3 and that it should agree with the `cube law'. But according to Hile (1936) and Martin (1949) the value of `a' generally ranges between 2.5 and 4.5. On the other hand, Carlendar (1969) observed that the value of b can range from below 2.5 to above 4.5. Le Cren (1951) contend that the length weight relationship of fishes serves two purposes namely, to determine the mathematical relationship between two variables, length and weight and to measure the variations from expected weight for length of individuals or groups of fishes. Le Cren (1951), fitted regression lines by least squares and tested for significant differences using analysis of co-variance.

The determination of all exact nature of the relationship that exists between the length and the weight of the fishes has been recognised as an important part of fishery biological studies in recent decades.

In <u>A. commersoni</u> value of `a' in female (-2.5593) and male (-2.5754) indicates that there is no significant difference in obesity of male and female. Sivakami (1987) reported that `a' value in <u>Ompok bimaculatus</u> is not significantly different in males and females. Nair et al. (1983) also reported in <u>A. commersoni</u> female (-1.5546 & -1.6782) and male (-1.5020 & -1.5402) which is not significant in male and female.

The standard error in regression coefficient of length weight relationship is relatively higher in male than in females, which indicates, that for male, weight vary more frequently for a given length than females in <u>A. commersoni</u> and Shamsul Hoda (1976) reported that in <u>Nemipterus japonicus</u>, SD error is in male than in female.

Several workers have reported, that females are heavier than male in smaller sized fishes while males are heavier than females in larger sized fishes (Olson and Merriman 1946; Jingran 1963 and Khan 1972). In the present case, also the length weight regression line of female, lies above length weight line of male. Hence, females are heavier than male, as is clear from Table 39 and Fig. 34.

In almost all the work so far reported, the value of the regression coefficient b (in the equation $W = aL^b$), has been found to be approximately 3 (and not beyond the generally recognised limits of 2.5 and 4.5). It is quite clear from the results that the weight of fish does not increase more than 4, and it remains approximately 3. The present work on <u>A. commersoni</u> for the whole year showed that the b value varied significantly as a function of season within a given sex and furthermore that significant differences existed between the sexes in the same year. The clear deviation of \`a' value of 3 emphasizes that one ought to be skeptical of the uncritical use of isometric \`b' value when estimating "condition" in fatty fish. As growth is defined as the change of length of preferably, weight with time (Jones, 1976) it automatically follows that growth and `condition' are closely related. Although there has been much discussion regarding how `condition' should be quantified (Le Cren, 1951, Hopkins et al., 1986) there is little doubt that precise value of regression coefficient (b) in power curve expression will play an important role in determining the accuracy of estimating body weight from length and in estimating `condition'. A b-value of 3 is indicative of cubic growth or isometry while deviation from this value is indicative of non isometric growth or allometry (Martin 1949).

Significant differences in length weight relationship are known to occur in various fish species, depending on age, sex and season (Martin 1949; Bagenal and Tesch 1978). In <u>A. commersoni</u> the b value in the regression of weight on length for the year 1988 year class varied with sex and season (Table 42 and Fig. 37). It seems reasonable to associate the low `b' value in January and September with weight loss associated with spawning in female. In case of male <u>A. commersoni</u> the extremely low `b' value registered in January and December are not likely to be the result of loss of gonad products (sperm) through mating since the absolute and relative weight change of the testes from mature to spent is negligible as compared to that of the ovary (Jeffers, 1931, Hendirson *et al*., 1984). Male generally spent more time in the locality of the spawning area and have higher activity and mortality rates than females (Templeman, 1948). The low `b' value (3.0375) registered for males after spawning (Fig. 37) probably reflects the metabolic cost of reproduction not registered in loss of reproductive products.

Change in body shape, physiological variation and increase or stagnation in growth rate may influence the weight-length relationship in fish (Ricker, 1979). Such changes will be reflected in the value of b. As mentioned above, comparison of `b' values between males and females of the same age indicates that they have different condition indices (expressed as b) in most months. The difference in `b' values during November was maximum, with female having the lowest "condition" (2.94). The majority of female collected in July and August were still of full roe. The majority of the 1988 year class females sampled in September-October were obviously post spawners as seen from oocyte maturity classification and reduced ovaries. Male at this time still had clear secondary sexual spawning characters. Our data thus confirm that spent *A. commersoni* males were in worse "condition" i.e. had suffered a greater degree of physiological drain than females. In June, two sexes have same b-value i.e. 3.37 which indicates that both were in same physiological condition. From July onwards, difference in b value increases and indicates maturation period, while lowest in November i.e. 2.94 indicates post spawning period.

TABLE - 38

LENGTH WEIGHT RELATIONSHIP IN AMBASSIS COMMERSONI WITH POOLED DATA

Sl. No.	Length groups (m.m)		No. of Obs.	Average L (m.m)	Average W (mgm)	Log L 'X'	Log W 'Y'	Calculated Log W Y	Calculated W
1.	16.0	20.0	3	19.33	60.00	1.29	1.77	1.69	52.55
2.	21.0	25.0	3	21.67	73.33	1.34	1.81	1.85	76.26
3.	26.0	30.0	0	00.00	00.00	0.00	0.00	0.00	00.00
4.	31.0	35.0	3	33.00	310.00	1.52	2.49	2.45	301.79
5.	36.0	40.0	7	38.14	511.43	1.58	2.71	2.65	484.56
6.	41.0	45.0	8	43.75	797.50	1.64	2.89	2.85	758.74
7.	46.0	50.0	23	48.30	1426.96	1.68	3.06	2.99	1048.83
8.	51.0	55.0	42	53.45	1536.50	1.73	3.16	3.13	1460.26
9.	56.0	60.0	128	58.60	1832.90	1.77	3.26	3.26	1973.15
10	61.0	65.0	144	63.07	2299.29	1.80	3.35	3.37	2508.65
11.	66.0	70.0	121	68.10	2912.41	1.83	3.46	3.48	3224.35
12.	71.0	75.0	100	73.04	3654.18	1.86	3.55	3.58	4053.40
13.	76.0	80.0	85	78.24	4818.55	1.89	3.68	3.68	5075.42
14.	81.0	85.0	71	83.04	5989.71	1.92	3.77	3.76	6166.90
15.	86.0	90.0	70	88.07	7063.91	1.94	3.84	3.84	7473.76
16.	91.0	95.0	69	93.18	8680.29	1.97	3.93	3.92	8985.21
17.	96.0	100.0	78	97.96	10187.67	1.99	4.00	3.99	10582.72
18.	101.0	105.0	72	103.21	12333.38	2.01	4.08	4.07	12553.30
19.	106.0	110.0	50	107.86	13671.80	2.03	4.13	4.13	14498.14
20.	111.0	115.0	46	112.76	15921.33	2.05	4.19	4.19	16762.48
21.	116.0	120.0	18	117.28	18337.22	2.07	4.25	4.25	19062.17
22.	121.0	125.0	10	122.80	20756.00	2.09	4.31	4.32	22156.63
23.	126.0	130.0	2	127.50	24880.00	2.11	4.39	4.37	25051.48
24.	131.0	135.0	1	135.00	33820.00	2.13	4.53	4.45	30198.94

TABLE - 39

LENGTH WEIGHT RELATIONSHIP IN FEMALE AMBASSIS COMMERSONI

Sl. No.	Length groups (mm)		No. of Obs.	Average L (mm)	Average W (mgm)	Log L 'X'	Log W 'Y'	Calculated Log W Y	Calculated W
1.	46.00	50.00	4	48.75	1145.00	1.69	3.05	3.00	1323.03
2.	51.00	55.00	9	53.14	2017.00	1.73	3.24	3.13	1758.11
3.	56.00	60.00	35	58.55	1901.52	1.77	3.27	3.26	2418.85
4.	61.00	65.00	62	63.26	2342.95	1.80	3.36	3.38	3122.49
5.	66.00	70.00	49	68.36	2944.04	1.83	3.46	3.49	4031.32
6.	71.00	75.00	34	72.76	3539.39	1.86	3.54	3.58	4950.35
7.	76.00	80.00	16	78.50	4945.00	1.89	3.69	3.68	6358.46
8.	81.00	85.00	14	84.14	6802.14	1.92	3.83	3.78	7992.78
9.	86.00	90.00	18	87.84	7523.68	1.94	3.87	3.85	9210.26
10.	91.00	95.00	41	93.20	8586.34	1.97	3.93	3.93	11192.56
11.	96.00	100.00	53	98.23	10325.96	1.99	4.01	4.01	13311.94
12.	101.00	105.00	69	103.19	12338.26	2.01	4.08	4.08	15656,91
13.	106.00	110.00	44	107.84	13829.55	2.03	4.14	4.14	18105.89
14.	111.00	115.00	40	112.82	16457.18	2.05	4.23	4.21	21009.83
15.	116.00	120.00	15	117.20	18488.67	2.07	4.21	4.26	23819.10
16.	121.00	125.00	8	123.00	20680.00	2.09	4.31	4.33	27928.81
17.	126.00	130.00	2	127.50	24880.00	2.11	4.39	4.38	31439.52
18.	131.00	135.00	1	135.00	33820.00	2.13	4.53	4.46	37955.71

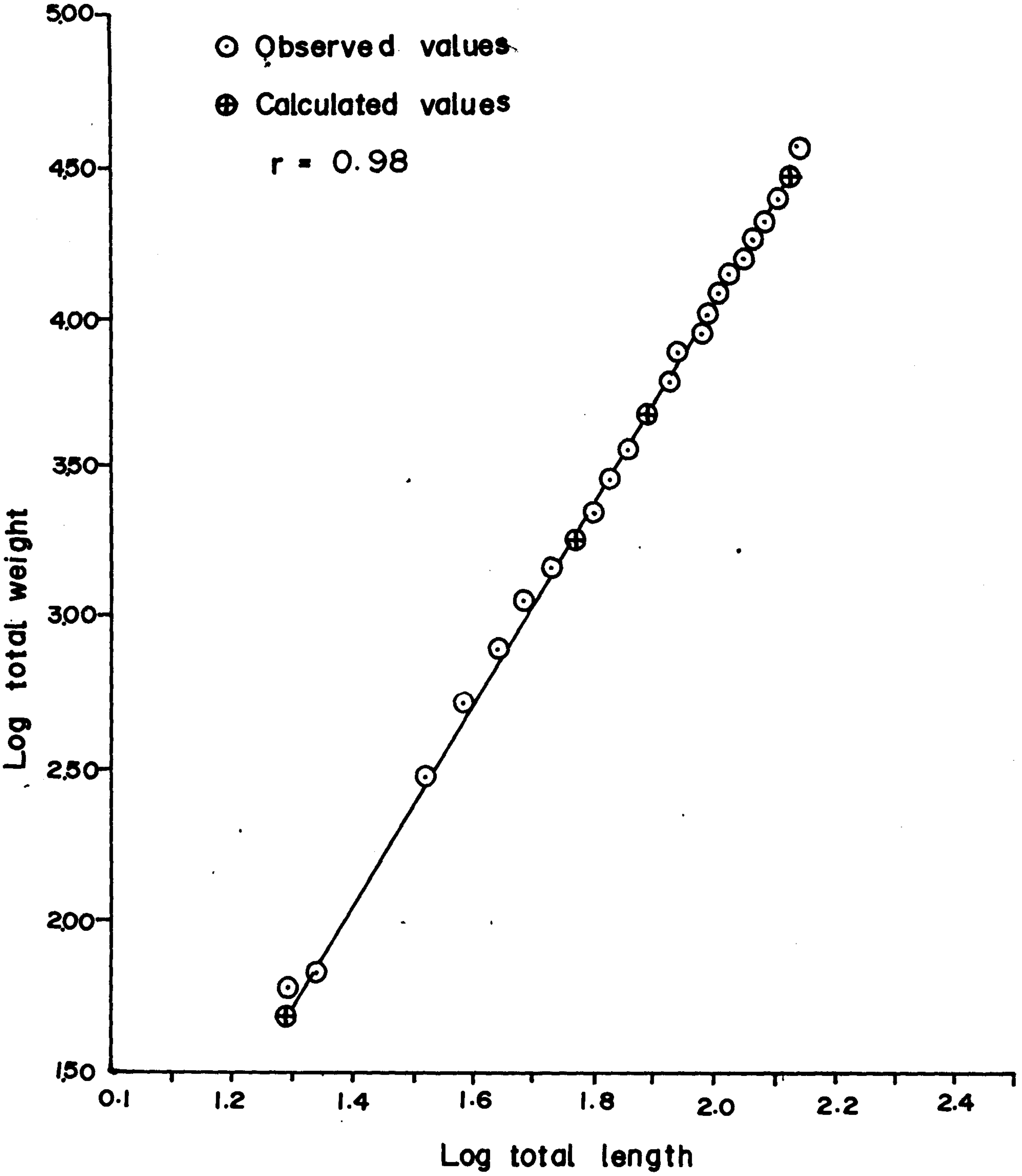


Fig.33. Length weight relationship in pooled data of A. commersoni.

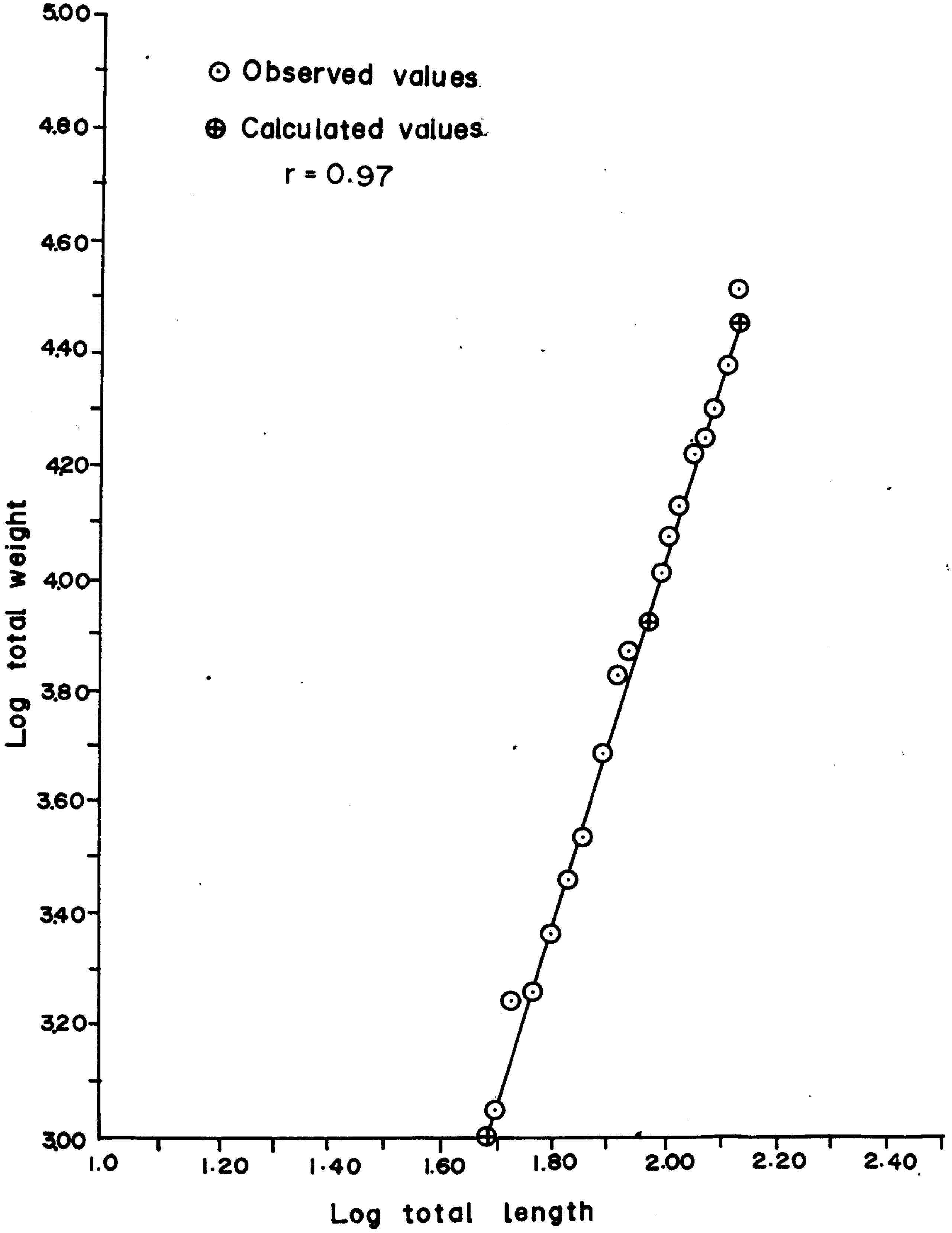


Fig. 34 Length weigth relationship in female A. commersoni.

TABLE - 40

LENGTH WEIGHT RELATIONSHIP IN MALE AMBASSIS COMMERSONI

Sl. No.	Length group (m.m)		No. of Obs.	Average L (m.m)	Average W (mgm)	Log L 'X'	Log W 'Y'	Calculated Log W Y	Calculated W
1.	46.00	50.00	2	49.50	1250.00	1.69	3.09	3.02	1470.05
2.	51.00	55.00	10	53.40	1497.00	1.73	3.16	3.12	1888.07
3.	56.00	60.00	53	58.75	1877.65	1.77	3.27	3.26	2586.62
4.	61.00	65.00	54	63.12	2291.73	1.80	3.35	3.36	3277.70
5.	66.00	70.00	56	68.02	2945.66	1.83	3.46	3.47	4195.63
6.	71.00	75.00	54	73.49	3802.08	1.87	3.58	3.58	5416.02
7.	76.00	80.00	64	78.30	4830.94	1.89	3.68	3.67	6675.30
8.	81.00	85.00	53	82.82	5810.80	1.92	3.76	3.75	8034.48
9.	86.00	90.00	46	88.18	6935.45	1.95	3.84	3.84	9882.34
10.	91.00	95.00	26	93.00	8828.80	1.97	3.94	3.92	11778.78
11.	96.00	100.00	26	97.29	9845.24	1.99	3.99	3.99	13666.79
12.	101.00	105.00	1	104.00	10920.00	2.02	4.04	4.08	17033.81
13.	106.00	110.00	2	108.00	13990.00	2.03	4.14	4.14	19292.94
14.	111.00	115.00	4	112.00	13892.50	2.05	4.14	4.19	21752.94
15.	116.00	120.00	3	117.67	17580.00	2.07	4.24	4.26	25600.75
16.	121.00	125.00	2	122.00	21060.00	2.09	4.32	4.31	28845.78

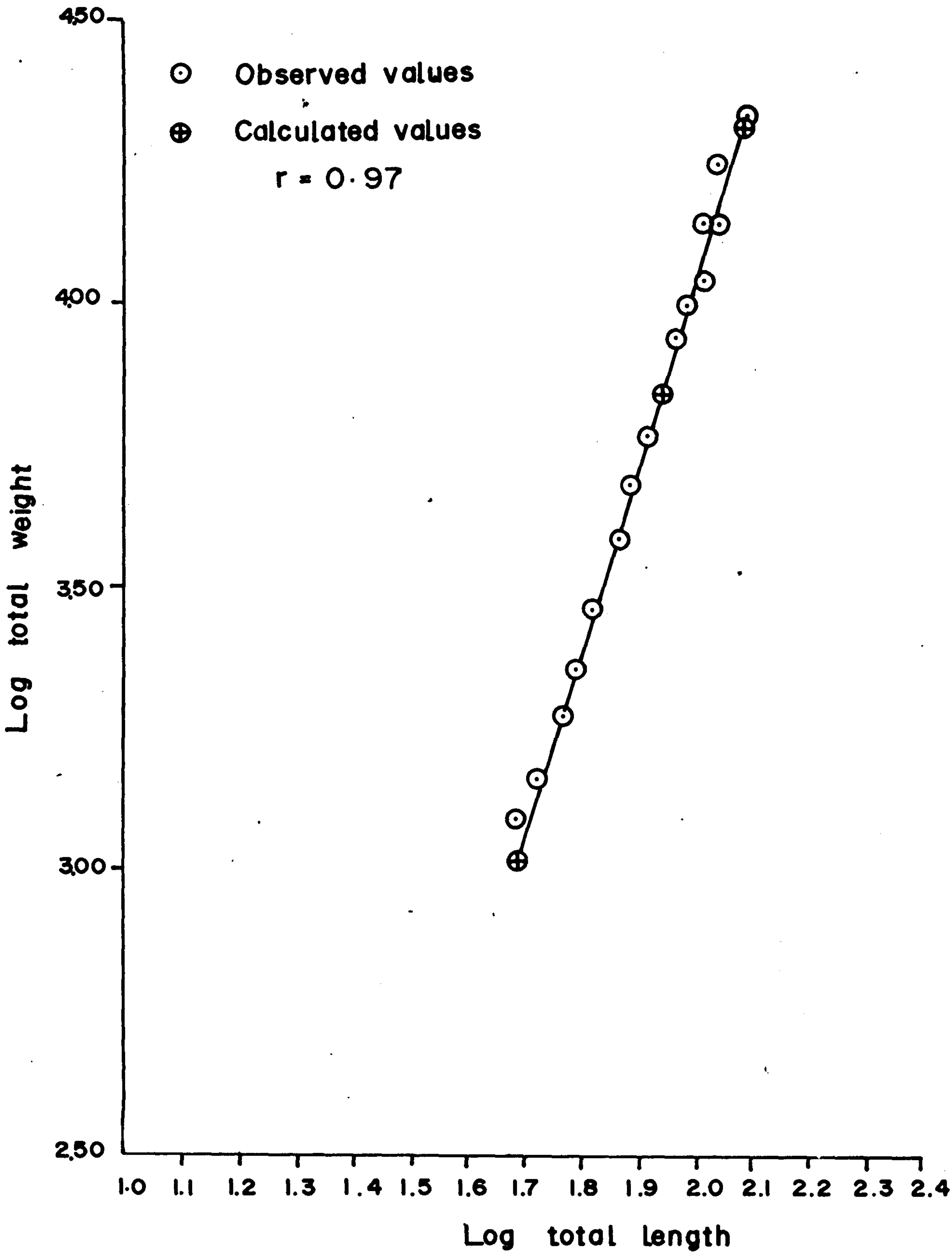


Fig. 35 Length weight relationship in male A. commersoni

TABLE - 41

LENGTH WEIGHT RELATIONSHIP IN JUVENILE AMBASSIS COMMERSONI

Sl. No.	Length groups (m.m)		No. of Obs.	Average L (mm)	Average W (mgm)	Log L 'X'	Log W 'Y'	Calculated Log W Y	Calculated W
1.	16.00	20.00	3	19.33	0060.00	1.29	1.77	1.77	13.16
2.	21.00	25.00	3	21.67	0073.33	1.34	1.81	1.93	18.67
3.	26.00	30.00	0	00.00	00.00	0.00	0.00	0.00	00.00
4.	31.00	35.00	3	33.00	0310.00	1.52	2.49	2.49	67.95
5.	36.00	40.00	7	38.14	0511.43	1.58	2.71	2.68	105.91
6.	41.00	45.00	8	43.75	0797.50	1.64	2.89	2.87	161.35
7.	46.00	50.00	17	48.06	1514.12	1.68	3.05	2.99	214.26
8.	51.00	55.00	23	53.57	1407.39	1.73	3.13	3.14	300.30
9.	56.00	60.00	40	58.48	1719.25	1.77	3.23	3.25	393.05
10	61.00	65.00	28	62.57	2218.21	1.80	3.34	3.34	483.83
11.	66.00	70.00	16	67.63	2709.38	1.83	3.43	3.45	614.07
12.	71.00	75.00	12	71.83	3316.67	1.86	3.52	3.53	739.07
13.	76.00	80.00	5	76.80	4306.00	1.89	3.63	3.62	907.39
14.	81.00	85.00	4	82.00	5382.50	1.91	3.73	3.70	1109.48
15.	86.00	90.00	6	88.00	6550.00	1.94	3.81	3.81	1377.99
16.	91.00	95.00	2	95.00	8750.00	1.98	3.94	3.90	1742.87
17.	96.00	100.00	0	00.00	00.00	0.00	0.00	0.00	00.00
18.	101.00	105.00	1	104.00	13410.00	2.02	4.13	4.02	2300.97
19.	106.00	110.00	4	108.00	11777.50	2.03	4.06	4.07	2583.54
20.	111.00	115.00	2	113.00	9530.00	2.05	3.98	4.13	2968.45

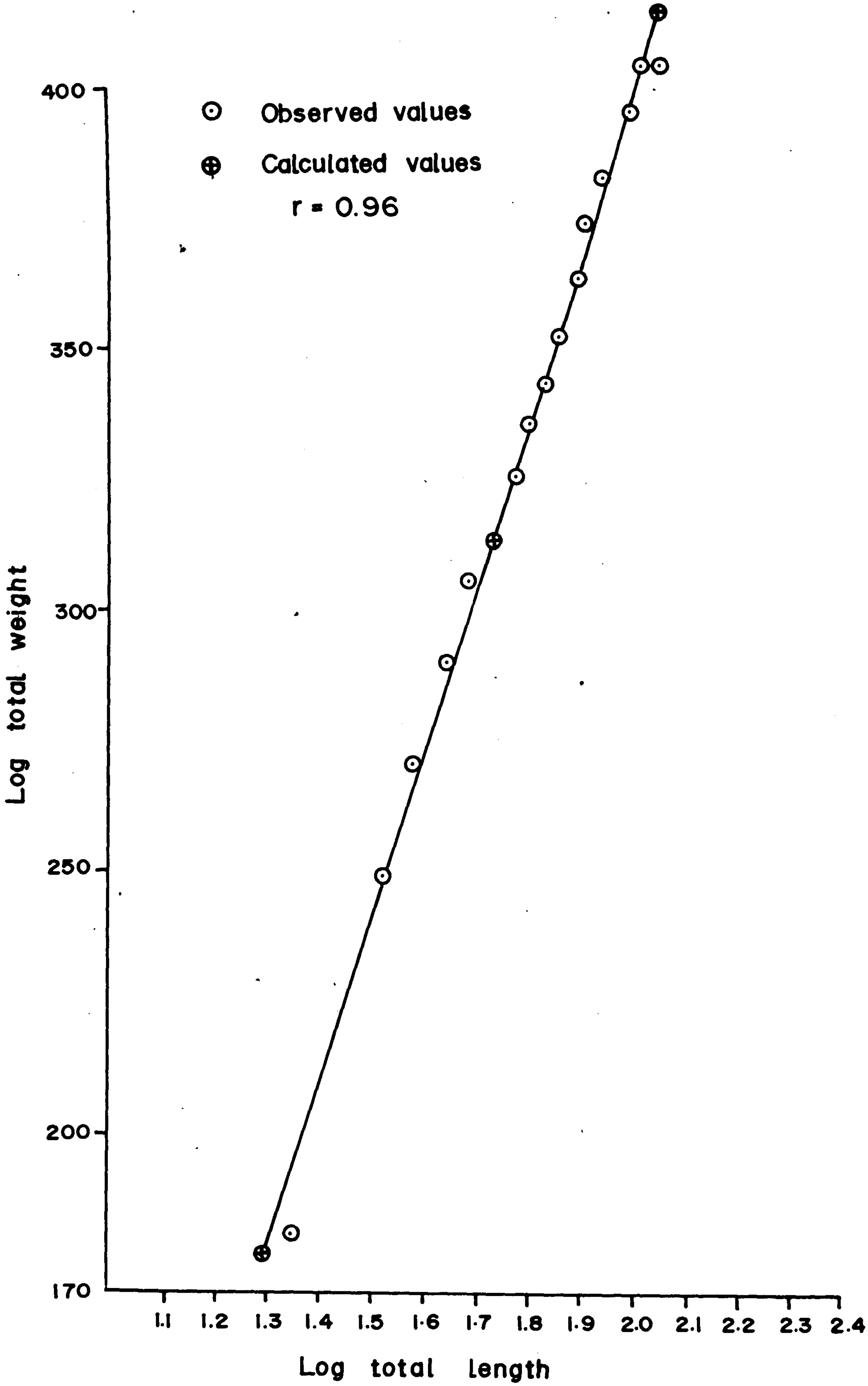


Fig. 36 Length weight relationship in juvenile A. commersoni.

TABLE - 42

The monthly relationship between W (dependent variable) and L (independent variable) data for the year 1988 & 1989 class regression of type ln W = log a + b log L in male and female, combined = using raw data from the whole study period.

	Female				Male			
Months	n	b	a	r2	n	b	a	r2
January 1988	59	3.1181	-2.1851	0.8949	66	3.0375	-2.0691	0.9351
February 1988	96	3.2781	-2.5174	0.9887	50	3.2227	-2.4254	0.9680
March	62	3.2171	-2.4289	0.9774	65	3.1185	-2.2288	0.9190
April	36	3.3614	-2.7145	0.9614	37	3.0989	-2.2527	0.7711
May	15	3.1298	-2.2682	0.9888	43	3.3582	-2.7158	0.9724
June	24	3.3741	-2.7387	0.9589	45	3.3759	-2.7437	0.9889
July	42	3.6968	-3.1267	0.9765	26	3.6785	-3.2729	0.9318
August	53	3.8127	-2.8527	0.7855	36	3.2496	-2.4479	0.9794
September	62	3.1914	-2.3264	0.8486	6	3.2239	-2.4726	0.993
October	26	3.1831	-2.2887	0.9115	23	4.3215	-4.5167	0.6559
November	21	2.9463	-1.9278	0.9358	24	3.5455	-3.0214	0.9637
December	18	3.1777	-2.3263	0.9688	35	3.0687	-2.1346	0.9758

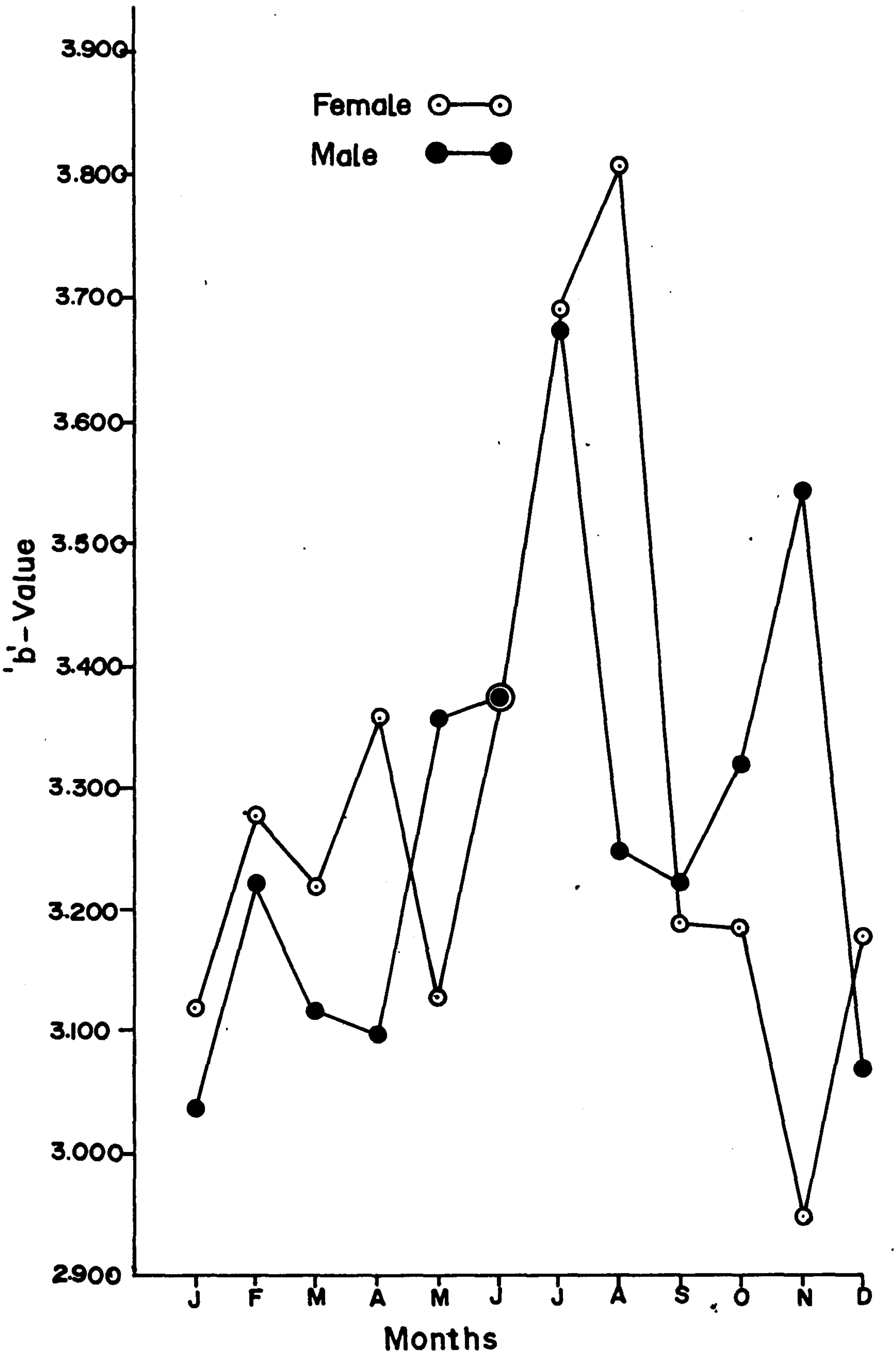


Fig. 37 Monthly fluctuatuion of 'b' value in male & female
A. commersoni

IX. PONDERAL INDEX OR CONDITION FACTOR

PONDERAL INDEX
OR
CONDITION FACTOR

INTRODUCTION

Ponderal index or condition factor is used for obtaining information on seasonal variation of the condition of fish in relation to its environment. The condition of fish is subjected to a great deal of variations depending upon the various factors, nutritional and biological cycles of the species (Chatterji, 1976).

The condition factor of fish is estimated in two ways. The first method is based on the cube law in which the condition factor (K) is calculated by the equation $k = w/cl^3$, where w and l are the weight and length of the fish, respectively, and "c" is constant. If the specific gravity of fish is unit and value of `c' is `1' then $k = w/l^3$. The value of k is generally multiplied by 100 to obtain the value of `k' into a round figure as $k = w/l^3 \times 100$ (Hile 1936).

In the later, cases, however, the relative condition factor (kn) is calculated by the formula $kn = w/al^n$, where al^n shows the calculated weight (from the regression equation) and w is the observed weight. This equation may also be written as observed weight/calculated weight (w/wo) (Le Cren, 1951). The value of `kn' fluctuates around one and any departure from 1 represent the deviation from the regression of weight/length as proportional part of the standard 1.0. This deviation represents all variations in weight not associated with length, for example genetic variations; variations associated with food supply, sexual condition and parasitism (Blackburn, 1960). These variations cannot be evaluated with the help of condition factor (k) unless `n' is actually 3, which is rarely the case.

To obtain the maximum information regarding the growth of fish, the breeding and feeding cycle of A. commersoni, relative condition factor was calculated for the male and female, separately monthwise and length groupwise.

MATERIAL AND METHODS

A total of 1199 specimen, comprising 484 male (only one specimen of male was found in length group 41-45 mm (Hence `kn' value was not calculated) 527 females and rest 187 juveniles, collected from the fish landing centres during the year December 1987 - March 1989 were used for the study. The specimens had a length range of 18 - 135 m.m. and weight range of 0.05 - 33.5 gms.

The regression of weight and length was determined by grouping the fish into 13 groups of 5 mm interval each and by fitting the regression of logarith value of the average weight of the fish on the logarith of the average length of fish belonging to the same group. Length weight relationship was then computed based on the formula $w = cl^n$ where w - weight of fish in gm, l - length of the fish in mm, c and n are constants. kn was estimated from the formula (w/wo) where w = the observed weight & wo = calculated weight of fish (Le cren 1951). From the individual values, the mean ``kn' was calculated separately for males and females for each 5 mm class sequence and for different months of the year. As no significant difference was noticed between male and females, the common equation derived was used for deriving the kn factor. The length-weight relationship derived were used to get the mean relative condition factor (kn) for each month and varying size range separately for male and female.

RESULTS

The value of kn obtained is a quantitative measure of relative heaviness and in this sense is directly comparable between the fish of any length. The fluctuation in mean kn value with respect to size is depicted in Fig. 39 and Table 43. The increase in mean `kn' values under 46-50 m.m size range indicates the gonadal development in fish. The fish <u>A. commersoni</u> was found to mature in the size range of 61-65 mm in male and 66-70 mm in females.

In both sexes, kn value remained high, in size group 46-50 mm and then gradually declined to 61-65 m.m in male and 66-70 mm in female size group. The value of `kn' indicates that most of male and female were probably in spawning stage. The study of gonads also indicated that the size at first maturity was 65 mm for male and 67.5 mm for females. In the size groups between 76-135 m.m in female and 65-125 m.m. in male, `k' value showed major fluctuation which may be attributed to the spawning activity of the species.

The variation in the mean `kn' values between males and females with regards to months in Fig. 40 and Table 44, reveals that fluctuation in `k' value for both the sexes were different thus indicating that the metabolic strain for both the sexes was different. Beginning from January, the `kn' value was higher in female and low in male but `kn' value increased (1.0105) in February in female and decreased (0.9997) in male. The minimum condition exhibited by both the sexes during April (male - 0.9815 and female - 0.9920) may be due to spawning activity or due to feeding activity.

The low value of `kn' during May, June, November and December indicates the presence of 0 - group or spent fishes or may be due to poor feeding activity.

The high condition factor exhibited by both the sexes during July - October in female and July - August in male may be due to maturity and matured condition of gonads but high value of `kn' in October in female indicates high intensity of feeding in female.

In the beginning of the year 1989, progression of curve shows similar trend as observed in the previous year.

DISCUSSION

The condition in fishes can be affected by the onset of maturity as reported by many workers (Le Cren 1951; Weatherly 1979). According to Hart (1946) the point of inflexion is a good indication of length at which the sexual maturity is attained. In the present study, a sharp inflexion (Fig. 39) is noticed in the case of males at length range of 61-65 mm (total length) and female at a length range of 66-70 mm (total length). This is in correspondence with the earlier observation that size at first maturity in male was 65 mm and female 67.5 mm. (vide infra).

Pillay (1954); Sarojini (1957); Narasimhan (1970); Parulekar and Bal (1971); Das (1978); Gowda, Shanbhogue and Udupa (1987) have mentioned that point of inflexion on the curve showing a decrease in value of `kn' with increasing length is a good indication of the length at which sexual maturity is attained. Gradual increase in `k' value from length group 76-85 and onward was due to recovery of weight after spawning in female. Similarly in male from 61-65 length group a gradual increase in `kn' value was observed. Sudden rise in condition factor in male and female at 116-125 mm and 126-135 mm respectively may possibly be due to intensive feeding or stage of gonadal development for next spawning or slight increase in `kn' values of larger fish measuring 135 mm in female and 122 mm in male was perhaps due to obesity of the fish.

Though for fishes which maintain the same shape and chemical composition, growth is isometric though it is not so in fishes which changes their shape as growth advances. It has been emphasised by Le Cren (1951) in his studies on Windermere perch population that, in many cases, the cube law fails to apply in a population as a whole because it includes a range of size classes. In the present case, the regression coefficient `n' is 3, which means that the growth of fish was isometric.

Hart, as quoted by Jhingran (1973), reported that the ponderal index might indicate a broad outline of seasonal cycle. This index has been shown to be correlated with gonadal cycle, rate of feeding etc. A close scrutiny of kn factor in A. commersoni in relation to different seasons shows that the condition of the species was much affected during spawning period. The fall in value during month of April to June corresponds with the main breeding season as has been shown by Das (1978) and Sivakami (1982). During the period of July to October and January - February. `Kn' value (Fig.40, Table 44) remained higher in female which may be attributed to the high percentage of maturing and mature fishes. Similarly, in males during January - March and July - August (Fig. 40, Table 44) ponderal index remains high which indicates the high percentage of mature and maturing males.

Kn value was low in April in both the sexes which indicates the preponderance of either spent fishes or 0-group fish. In November and December, the value was low which reflects, either the increased prevalence of 0-group fishes or on low intensity of feeding. The `Kn' values here cannot be attributed to feeding intensity because of the inverse relationship with gastro-somatic index during May, June and November, December in both the sexes. Nair et al. (1983) reported that `kn' cycle of the female closely follows the seasonal pattern of GSI, the periods of heavy breeding activity showing comparatively high `kn' value and vice-versa in A. commersoni.

Monthly variation in the gastro-somatic index and gonado-somatic index in the species are presented in Fig. 38. In A. commersoni, the fluctuation in the condition factor was more influenced by the spawning cycle than by feeding activity. The ponderal index as related to maturity

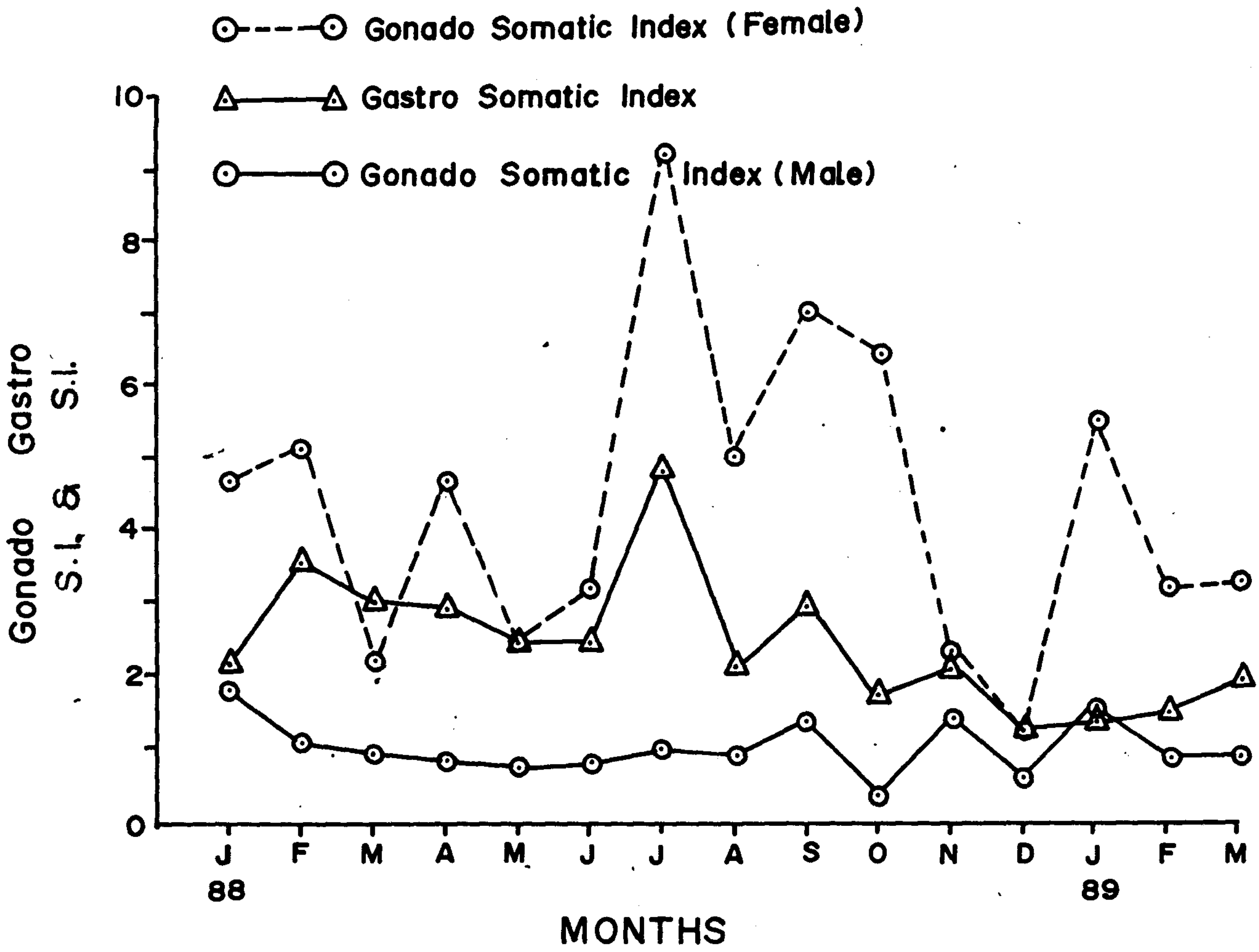


Fig. 38 Monthwise variation in Gonado-Somatic Index and Gastro-Somatic Index in _A. commersoni_.

cycle is elaborately discussed by Parulekar (1964), Parameswaran et al. (1970), Das (1978) and Sivakami (1987). Nair et al. (1983) reported the change in `kn' with the growth of sexes i.e. the immature and first maturity stages show poor `kn' while the adult active breeders show better `kn' and is clearly reflected in the seasonal changes in `kn' with breeding cycle. Here the rise and fall in GSI is closely followed by the `kn' factor in A. commersoni. Similar observations are recorded in the present study, also.Matured fish appearing conspicuously during the month of July support the rise in mean `kn' value.

Active feeding was observed during July, September, October and empty stomachs found to increase in May, June, November and December indicating poor feeding activity during the pre-monsoon and post-monsoon months.

EL - Maghraby et al. (1973) reported that the spawning period affected the weight and consequently condition factor in Mugil. capito. They also observed low `Kn' values in spent fish and high values during spring and summer in mature fishes. Nair et.al (1983) in A. commersoni reported that `kn' value in the immature male show a `kn' value `1' while immature and first maturity stage of females and first maturity stage of males show a `kn' value below `1'. The actively breeding groups, of male and female, show comparatively very high `kn' values while highest groups of male and female show comparatively low `kn' value. Raman et al., (1975) in A. gymnocephalus made similar observations, where the male and females in advanced stages of maturity showed very high `kn'. Present study also show similar results in A. commersoni wherein immature males and females show `kn' value `1' while immature first maturity stage male and female show `kn' value below `1'. The actively breeding male had comparatively high `kn' value.

Thus it may be concluded that `Kn' value was influenced more by maturation cycle than feeding intensity in A. commersoni.

TABLE - 43

Fluctuation of average `K' value at different length groups of A. commersoni

S.No.	Length group of 5 mm. each	Male No.	Male K value	Female No.	Female K value
1.	46-50	2	1. 0063	4	1. 0011
2.	51-55	13	1. 0020	9	1. 0286
3.	56-60	67	0. 9943	35	0. 9964
4.	61-65	59	0. 9833	64	0. 9907
5.	66-70	58	0. 9899	54	0. 9892
6.	71-75	54	0. 9948	39	0. 9893
7.	76-80	64	1. 0017	16	0. 9994
8.	81-85	53	1. 0027	14	1. 0151
9.	86-90	46	1. 0010	18	1. 0118
10.	91-95	27	1. 0089	41	1. 0083
11.	96-100	26	1. 0063	53	1. 0113
12.	101-105	1	0. 9966	69	1. 0141
13.	106-110	2	1. 0103	44	1. 0100
14.	111-115	4	0. 9983	40	1. 0147
15.	116-120	5	1. 0084	15	1. 0105
16.	121-125	3	1.0157	8	1. 0086
17.	126-130	-	-	3	1. 0197
18.	131-135	-	-	1	1. 0300

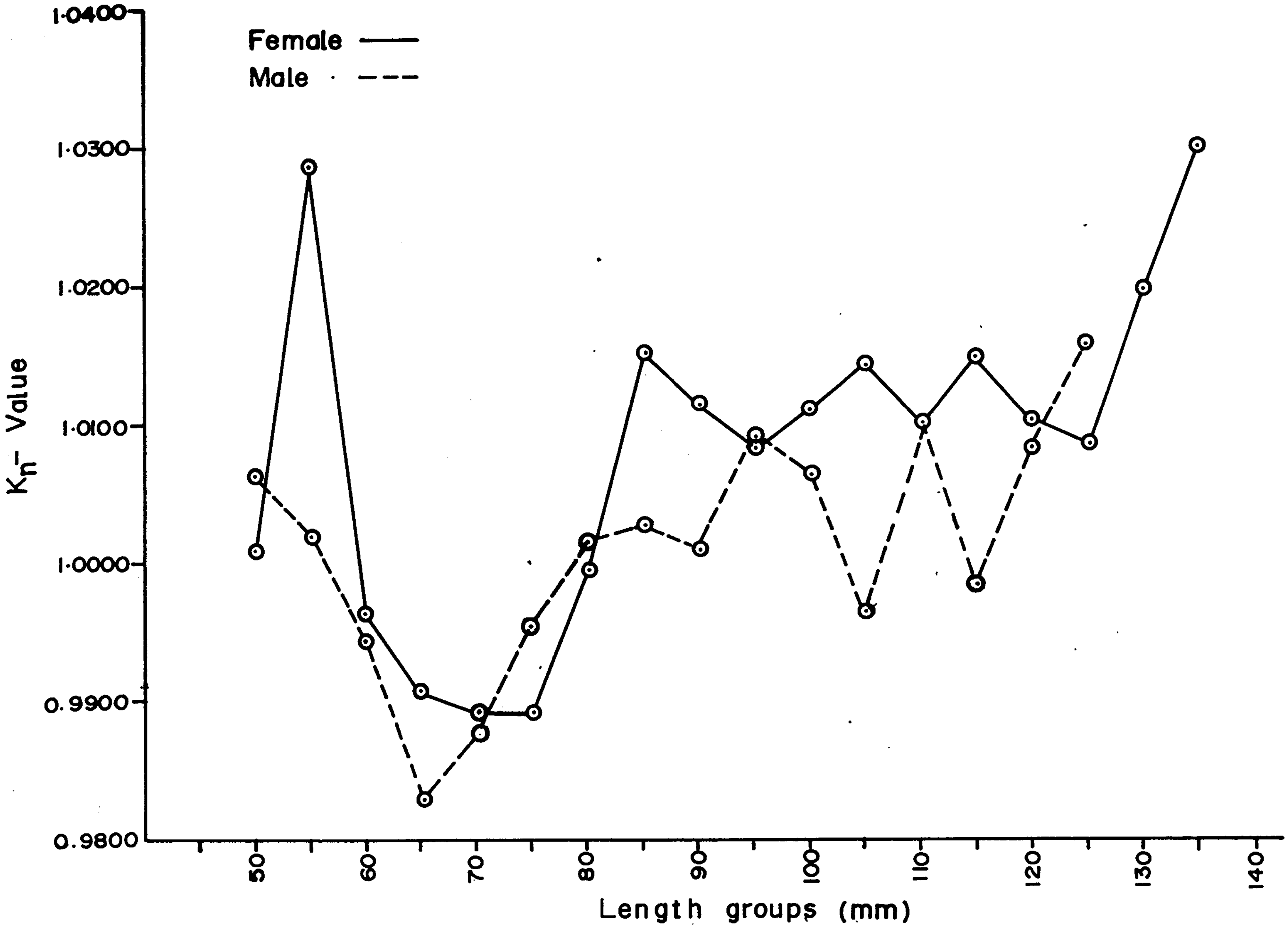


Fig. 39 Length groupwise fluctuation in 'K_n' of male and female A. commersoni.

TABLE - 44

Monthly fluctuation in `K' value of A. commersoni

S.No.	Months	Male		Female	
		No.	K value	No.	K value
	1987				
1.	December	28	0. 9885	13	0. 9933
	1988				
2.	January	39	1. 0044	32	1. 0062
3.	February	25	0. 9997	50	1. 0105
4.	March	46	1. 0020	28	0. 9950
5.	April	37	0. 9815	36	0. 9920
6.	May	43	0. 9876	15	0. 9953
7.	June	45	0. 9962	24	1. 0017
8.	July	26	1. 0055	42	1. 0141
9.	August	36	1. 0096	53	1. 0052
10.	September	6	0. 9870	62	1. 0094
11.	October	23	0. 9931	26	1. 0184
12.	November	24	0. 9991	21	0. 9953
13.	December	35	0. 9999	18	1. 0015
	1989				
14.	January	27	0. 9997	27	1. 0109
15.	February	25	0. 9983	46	1. 0005
16.	March	19	0. 9940	34	0. 9957

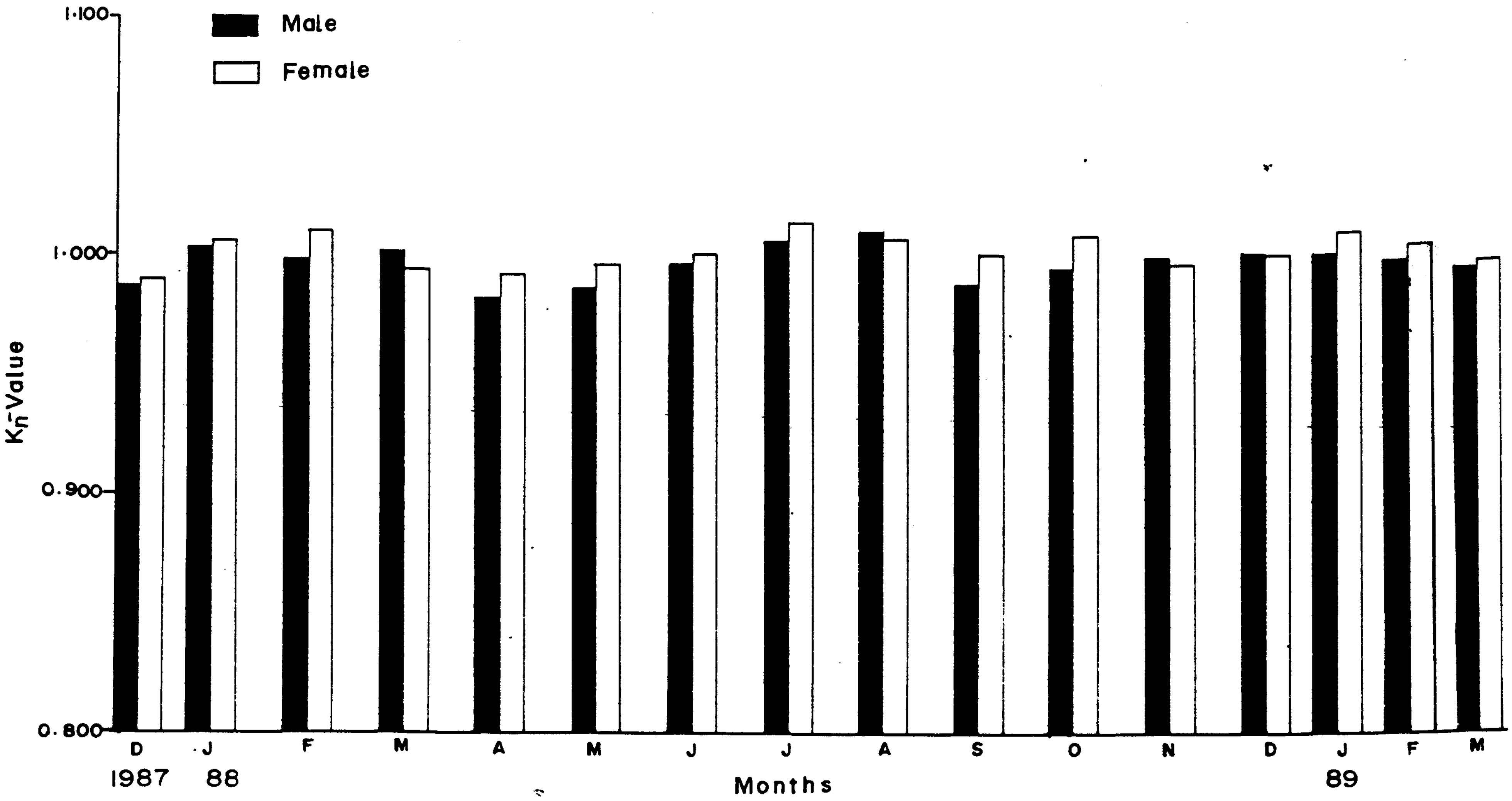


Fig. 40 Monthly fluctuation in 'Kn' value of male and female A. commersoni.

X. MORPHOMETRIC STUDY

MORPHOMETRIC STUDY OF AMBASSIS COMMERSONI

INTRODUCTION

Morphometric studies have been gaining increased importance in fishes in recent years. Their significance is particularly stressed in many works for understanding differences within as well as between species.

A knowledge of biological properties of any species is of paramount importance both for judicious management of its population as well as, to assess its suitability for culture purposes. The available information on the biology of A. commersoni in the literature is scanty. Thus, studies on biological properties of this species in Goa particularly in the estuary of Mandovi river, was undertaken.

Some of the earlier studies on morphometry are those of Radhakrishnan (1957), Pillay (1957), Sarojini (1957), Dutta (1961), Seshappa (1970), Venkateshwaralu (1962) and David (1963). In more recent years work on these line has been published by Ramanathan et al. (1977), Babu Rao and Yazdani (1978) Parimala and Ramaiyan (1980), Srivastava and Seth (1981) and Venkatasubha Rao (1982) among others. Most of these workers used biometry to compare different species or describe regression between selected parameters of single species.

The purpose of the present studies was to determine general equation of relationship of different body part measurements of the species with a view to fill up this gap.

For the commercially exploited species of fishes, it is important to know whether their catches come from a single population or different populations. The knowledge of the different populations of a species is also important in understanding its biology and life history. In view of these factors, an attempt has been made to ascertain whether or not fish of each of the two species that occur in fisheries of the two localities belong to the same population. Eight important morphometric characters are examined for this purpose and results are presented here.

Morphometric measurements have been employed to differentiate population (Blackith and Reyment 1971; to separate stocks of fishes (Sharp et al. 1978: Casselman et al. 1981; Ihssen et al. 1981; and Almeida 1982); Analysis of morphometric data, in general, have frequently been unsatisfactory due to sampling bias associated with varying size of specimen and the overlapping of measurements. Misra and Ni (1983) suggested that the use of multivariate analysis of covariance (Mancova) would overcome this difficulty.

MATERIAL AND METHODS

Material for study was collected during December 1988 to March 1989 from drift net catches along the Mandovi river at Ribandar, Panaji, Dona Paula, and Four Pillars in Goa. 1124 specimens of A. commersoni ranging from 18 mm to 135 mm total length were collected and examined for taxonomic studies. The material included both the sexes and their measurements were recorded carefully after bringing to laboratory. Morphometric measurements were made on eight characters i.e. standard length x as the common character on which regression of the remaining seven measurements (Y1 to Y-7) were determined. Specimens with defects or damaged dimension were left out. All measurements were recorded to the nearest 0.1 mm using vernier caliper to an accuracy of 0.1 mm.

The whole data was divided into 5 mm size groups and the average of each measurement was calculated against each group, as represented in respective table 49 to 55.

The number for individual samples and the pooled samples, therefore slightly varied for the different set of observations. The eight characters their abbreviations and symbols used here are as follows :

Table - 45

Sr.No.	Abbreviations	Description of measurements	Symbols	Regression
1.	S.L.	Standard length	X	
2.	T.L.	Total length	Y1	SL - TL
3.	H.L.	Head length	Y2	SL - HL
4.	B.L.	Body length	Y3	SL - BL
5.	D.D.	Depth through dorsal fin base	Y4	SL - D.D.
6.	D.P.	Depth through pectoral fin base	Y5	SL - DP
7.	D.C.	Depth through caudal penduncle	Y6	SL - D.C.
8.	E.D.	Eye diameter	Y7	SL - E.D.

About four measurements were straight measurements along the body axis and remaining (D.P., DP, DC) were measured across the body in the vertical plane and taken on eyed side of the fish. Seven linear regression relationships namely of the measurements numbered 2 to 8 above were estimated on the standard length (measurement No.1) for the covariance analysis, for which the method followed was as given by Snedecor and Cocharan (1967).

RESULTS

The results of the covariance analysis for comparison among the body measurements are detailed in Table 46. The regression equation of the form $Y = a + b \log x$ for the

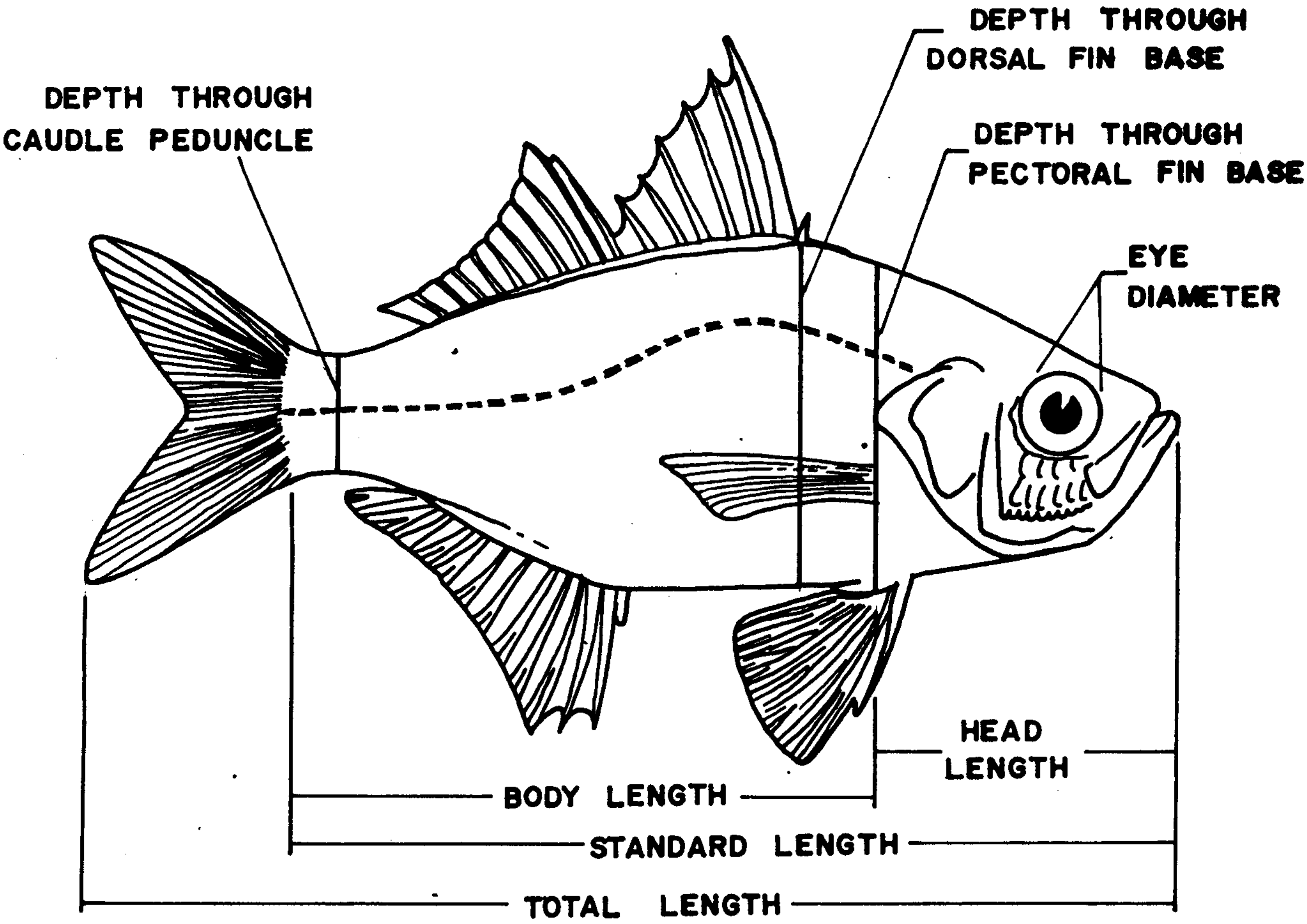


Fig. 41 Sketch of A. commersoni showing various morphometric measurements

overall equation derived after pooling all the centres together is shown in Table 49-55. Figs. 42 to 48 show seven regression lines in a single perspective and drawn to the same scales, so as to give an idea of varying rates of growth of the different characters in relation to the standard length. Table 48 shows allometry of the various dimensions. All regressions have a positive allometry of 31^{o} -59^{o} being almost isometric. Table 46 summarises the result of the covariance tests detailed in Table 49-55. The value of `a' and `b' can be read directly from values given in Table 46.

TABLE - 46

Summary of statistical relation between standard lenth and various body measurements Regression coefficient and correlation coefficient for seven groups using equation y = a + b log x where y is the body measurements and x is standard length and a is regression constant.

S.No.	Source of variance	Regression constant (a)	Regression coefficient (b)	SE (+b)	Correlation coefficient (r)
1	Y1	3.2546	1.2826	0.0071	0.98
2	Y2	1.9184	0.3279	0.0057	0.87
3	Y3	2.5437	0.6520	0.0054	0.96
4	Y4	-4.6060	0.4419	0.0036	0.97
5	Y5	-3.6172	0.3934	0.0028	0.97
6	Y6	0.6158	0.1200	0.0014	0.93
7	Y7	0.0179	0.1203	0.0015	0.92

Regression of body measurements and their relationship :

Regression equation W = a + b log L

1. Standard length and total length : Table - 49 Fig. 42

Total length of <u>A. commersoni</u> was observed to be directly proportional to the standard length. The relationship between standard length and total length has been expressed by following equation.

$$\log (T.L)\ Y_1 = \log 3.2546 + 1.2826 \log X\ (SL)$$

Relation was linear (Fig. 42 & Table 49) with a = 3.2546 & b = 1.2826. The correlation coefficient (r) was calculated to be 0.98 and standard error of b + 0.0071.

2. Standard length & Head length : (Fig. 43 & Table 50)

The relation was found to be linear (Fig. 43 and Table 50) with a = 1.1984 and b = 0.3279. The correlation coefficient (r) was 0.8654 and standard error of b -0.0057. Log (H.L) Y_2 = log 1.1984 + 0.3279 log X (S.L), and the relation was linear.

3. Standard length and body length: (Fig 44 Table 51)

The relationship was linear (Fig. 44; Table 52) as is clear from the following equation.

$$(B.L.)\ \log Y_3 = 2.4537 + 0.6520 \log X\ (S.L)$$

The correlation coefficient (r) was 0.9636 and S.D. + 0.0054.

4. **Standard length and Depth through dorsal fin base :** (Fig. 45 Table 52).

The standard length and depth through dorsal fin showed a linear relationship and may be expressed as -

$$(D.D.)\ \log Y_4 = -4.6060 + 0.4419 \log X\ (SL)$$

The value of correlation coefficient (r) was 0.9645 and SD of 0.0036 with a = -4.6060 and b = 0.4419.

5. **Standard length and depth through pectoral fin base:** (Fig. 46 Table 53).

The equation shows linear relationship.

$$(D.P.)\ \log Y_5 = -3.6172 + 0.3934 \log X\ (SL)$$

The correlation coefficient was 0.9730 and S.D. + 0.0028

6. **Standard length and depth through caudal peduncle :** (Fig. 47 Table 54).

The relationship is expressed by following equation :

$$(D.C.)\ \log Y_6 = 0.6158 + 0.1200 \log x\ S.L.)$$

The relationship between depth through caudal peduncle and standard length was linear with correlation coefficient (r) - 0.9275, S.D. + 0.0014, 0.61589 a and 0.1200 b constant.

7. **Standard length and eye diameter:**(Fig. 48; Table 55)

Relationship was found to be linear where a 0.0179 and b 0.1203

$$(E.D.)\ Y_7 = 0.0179 + 0.1203 \log x\ (S.L.)$$

The standard length and eye diameter shows straight line relationship with correlation coefficient (r) 0.9222 and SD of b + 0.0015.

Ratio and percentage of body region and their relationship: (Table 47):

The various body part measurements in ratio and percentage of various body parts against standard length of fish were computed and are given below. It gives a clear picture of comparative account of various relationship between different body measurements.

Table 47

Ratio and percentage of various body regions against standard length and their relationship where X is standard length, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6, Y_7 various body parts.

Sr.No.	Various body regions	Ratio X	Ratio Y	Percentage X	Percentage Y
1	Y1	1	:: 1.34	42.77	57.22
2	Y2	1	:: 0.31	76.48	23.51
3	Y3	1	:: 0.7	58.98	41.01
4	Y4	1	:: 0.36	73.33	26.66
5	Y5	1	:: 0.33	75.08	24.91
6	Y6	1	:: 0.13	88.46	11.53
7	Y7	1	:: 0.12	89.24	10.76

TABLE - 48

Tangent values for different body parts

Sr.No.	Body Regions	Value of b	Angle	Tangents
1	Y1	1.2826	53^{o}	1.3270
2	Y2	0.3279	39^{o}	0.8098
3	Y3	0.6520	59^{o}	1.6643
4	Y4	0.4419	48^{o}	1.1106
5	Y5	0.3934	45^{o}	1.0000
6	Y6	0.1200	35^{o}	0.5890
7	Y7	0.1207	31^{o}	0.6009

Details of the analysis of the data are presented in Table 47 and 48. The regression lines based on the degree of angle (Table 48) as delineated in Fig. 42 to 48 reveals the relative growth of different parts of the body of A. commersoni. The studies indicate that body length has maximum rate of growth and next was total length. The data also show that the relative rate of growth, delineated from the regression line angle is almost similar for the depth through caudal penduncle and eye diameter; which is slowest growing region of the fish. The relative rate of growth of depth through dorsal fin and depth through pectoral fin was also almost similar.

The slowest growing body part however was depth through caudal fin and eye diameter while next to it was head length which is 8 degree higher in its growth than that of the eye diameter.

DISCUSSION

The analysis of morphometric characters of A. commersoni presents strong evidence of stock separations in A. commersoni in the Mandovi river. The groupings (stocks) suggested by Campbell and Winters (1973) and tested in this study were originally based on such factors as difference in growth pattern and commercial fishing pattern. The present study is more detailed and used data collected from a wider area. The results of this study support the observation of Sharp et.al (1978) that morphometrics offer more potential tool than meristics in separating A. commersoni stock. The linear relationship (Fig. 42-48) observed among various parts of body measurements suggest that the growth of the fish was isometric. Godsil (1948) and Marr (1955) reported non linear relationship between various body measurements. Such differences in ratio or proportional growth of body parts may be due to environmental conditions or due to genetic differences (Krumholz and Cavanah 1968), Misra and Choudary (1982) in Caranx kalla reported linear relationship among various body measurements and suggested that growth of fish was isometric.

Present studies on correlation of different body parts show that all these parameters are significant in relation to the standard length. It can be concluded that A. commersoni has linear relationship between standard length and various body measurements, which suggest that growth of fish is isometric.

The body depth and head length were the most important variables in defining the population. In the analysis performed by Sharp et.al (1978) eye diamters and snout length were the two most important variables although body depth contributed significantly as the fourth most important variable. It has no concrete explanation for this difference between the importance of variables in the two studies but the different analytical techniques may have been a factor. Misra and Carscadden (1987) have reported that body depth and snout length were the most important variables.

Morphometric measurements are commonly used to identify a particular fish species from fish faunas, where very similar species live together and many of the species are not yet described. Kurup and Samuel (1979) on Ambassis days, Guha and Talwar, 1981; on Ambassis thomassi, Allen, 1982; on Parambassis altipinnis, Mauge, 1984; on Ambassis gymocephalus (Ambassis bleeker), Martine Heemstra, 1988; on Ambassis species (A. products & gymnocephalus etc)reported and identified, fishes on the basis of morphometric measurements.

TABLE - 49

RELATIONSHIP BETWEEN STANDARD LENGTH AND TOTAL LENGTH IN A. COMMERSONI

Sl. No.	Length groups in (mm)		No. of Obs.	Average Std L (mm) X	Average T.L. (mm) Y	Log X	Log Y	Calculated	Percentage Std. to T.L.
1.	16.0	20.0	5	16.6	21.0	1.2	1.3	24.5	79.0
2.	21.0	25.0	2	24.5	32.0	1.4	1.5	34.7	76.5
3.	26.0	30.0	8	28.6	37.8	1.5	1.5	39.9	75.6
4.	31.0	35.0	16	33.3	45.6	1.5	1.7	46.0	73.0
5.	36.0	40.0	43	38.4	51.7	1.6	1.7	52.5	74.3
6.	41.0	45.0	164	43.5	58.9	1.6	1.8	59.0	73.8
7.	46.0	50.0	169	47.9	64.7	1.7	1.8	64.6	74.0
8.	51.0	55.0	136	52.8	71.4	1.7	1.9	70.9	73.9
9.	56.0	60.0	114	58.2	77.8	1.8	1.9	77.8	74.8
10.	61.0	65.0	96	63.2	84.5	1.8	1.9	84.3	74.7
11.	66.0	70.0	71	68.1	91.0	1.8	2.0	90.5	74.8
12	71.0	75.0	105	73.0	97.3	1.9	2.0	96.8	75.0
13.	76.0	80.0	91	78.2	104.1	1.9	2.0	103.5	75.1
14.	81.0	85.0	55	82.8	109.9	1.9	2.0	109.4	75.3
15.	86.0	90.0	34	87.5	115.6	1.9	2.1	115.6	75.7
16.	91.0	95.0	11	93.0	122.8	2.0	2.1	122.6	75.8
17.	96.0	100.0	3	98.3	129.0	2.0	1.9	129.4	76.2
18.	101.0	105.0	1	102.0	135.0	2.0	2.1	134.0	75.5

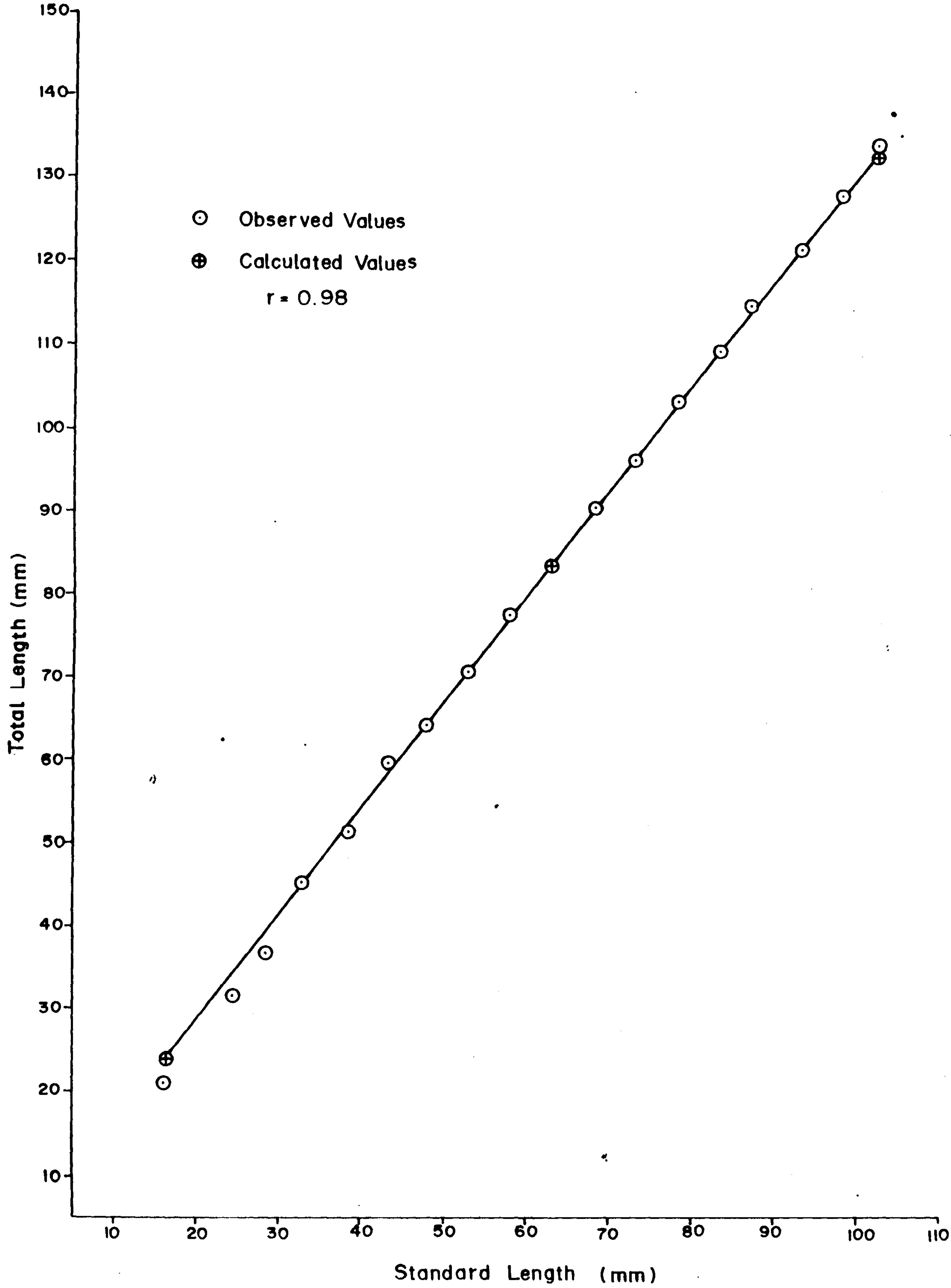


Fig. 42 Total length verses standard length in A. commersoni.

TABLE - 50

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND HEAD LENGTH IN A. COMMERSONI

Sl. No.	Length groups in (mm)		No.	Average Std L (mm) X	Average H.D. (mm) Y	Log X	Log Y	Calculated	Percentage H.D. to Std. L
1.	16.0	20.0	5	16.6	5.0	1.2	.7	4.2	30.1
2.	21.0	25.0	2	24.5	7.0	1.4	.8	6.8	28.6
3.	26.0	30.0	8	28.6	8.0	1.5	.9	8.1	27.9
4.	31.0	35.0	16	33.3	9.9	1.5	1.0	9.7	29.6
5	36.0	40.0	43	38.4	11.2	1.6	1.0	11.4	29.1
6.	41.0	45.0	164	43.5	12.8	1.6	1.1	13.1	29.4
7.	46.0	50.0	169	47.9	14.5	1.7	1.2	14.5	30.4
8.	51.0	55.0	136	52.8	15.7	1.7	1.2	16.1	29.7
9.	56.0	60.0	114	58.2	18.5	1.8	1.3	17.9	31.9
10.	61.0	65.0	96	63.2	19.8	1.8	1.3	19.5	31.3
11.	66.0	70.0	71	68.1	21.5	1.8	1.3	21.1	31.5
12.	71.0	75.0	105	73.0	22.9	1.9	1.4	22.7	31.2
13.	76.0	80.0	91	78.2	24.5	1.9	1.4	24.4	31.3
14.	81.0	85.0	55	82.8	25.8	1.9	1.4	25.9	31.2
15.	86.0	90.0	34	87.6	27.5	1.9	1.4	27.5	31.4
16.	91.0	95.0	11	93.1	29.6	2.0	1.5	29.3	31.8
17.	96.0	100.0	3	98.3	31.3	2.0	1.3	31.0	21.7
18.	101.0	105.0	1	102.0	32.0	2.0	1.5	32.2	31.4

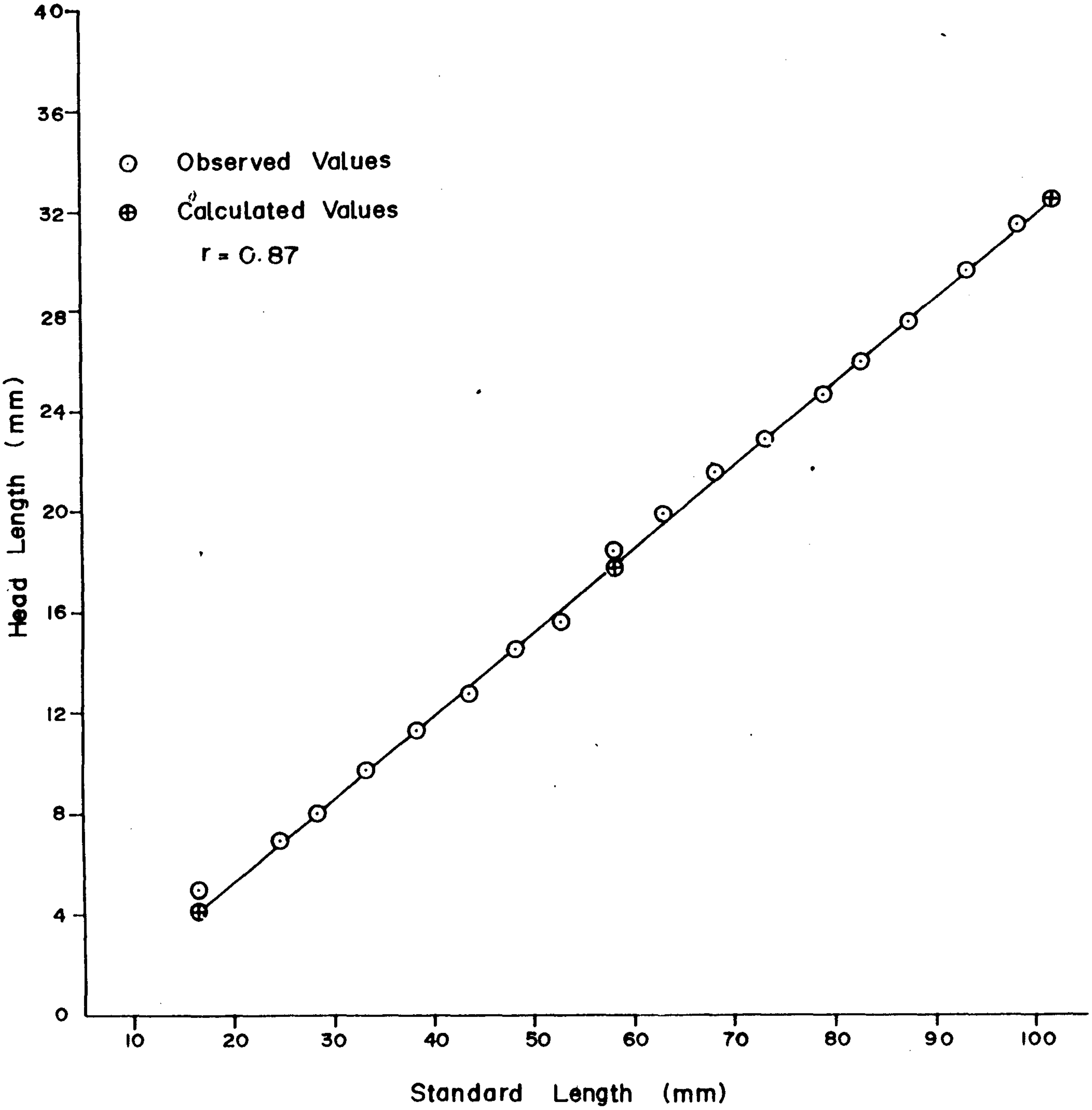


Fig. 43 Head length verses standard length in A. commersoni

TABLE - 51

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND BODY LENGTH IN A. COMMERSONI

Sl. No.	Length groups in (mm)		No.	Average Std L (mm) X	Average B.D.L. (mm) Y	Average Log X	Average Log Y	Calculated	Percentage B.D.`L` to Std. L
1.	16.0	20.0	5	16.6	11.4	1.2	1.1	13.4	68.7
2.	21.0	25.0	2	24.5	17.5	1.4	1.2	18.5	71.4
3.	26.0	30.0	8	28.6	21.9	1.5	1.3	21.2	76.4
4.	31.0	35.0	16	33.3	23.5	1.5	1.4	24.3	70.5
5.	36.0	40.0	43	38.4	27.2	1.6	1.4	27.6	70.8
6.	41.0	45.0	164	43.5	30.9	1.6	1.5	30.9	71.1
7.	46.0	50.0	169	47.9	34.0	1.7	1.5	33.8	71.0
8.	51.0	55.0	136	52.8	37.3	1.7	1.6	37.0	70.7
9.	56.0	60.0	114	58.2	40.1	1.8	1.6	40.5	68.0
10.	61.0	65.0	96	63.2	43.4	1.8	1.6	43.8	68.6
11.	66.0	70.0	71	68.1	46.6	1.8	1.7	46.9	68.5
12.	71.0	75.0	105	72.0	50.3	1.9	1.7	50.1	68.9
13.	76.0	80.0	91	78.2	53.1	1.9	1.7	53.5	68.7
14.	81.0	85.0	55	82.8	57.0	1.9	1.8	56.5	68.8
15.	86.0	90.0	34	87.6	61.0	1.9	1.8	59.7	69.6
16.	91.0	95.0	11	93.1	63.5	2.0	1.8	63.2	68.1
17.	96.0	100.0	3	98.3	45.3	2.0	1.6	66.7	46.1
18.	101.0	105.0	1	102.0	70.0	2.0	1.8	69.0	68.6

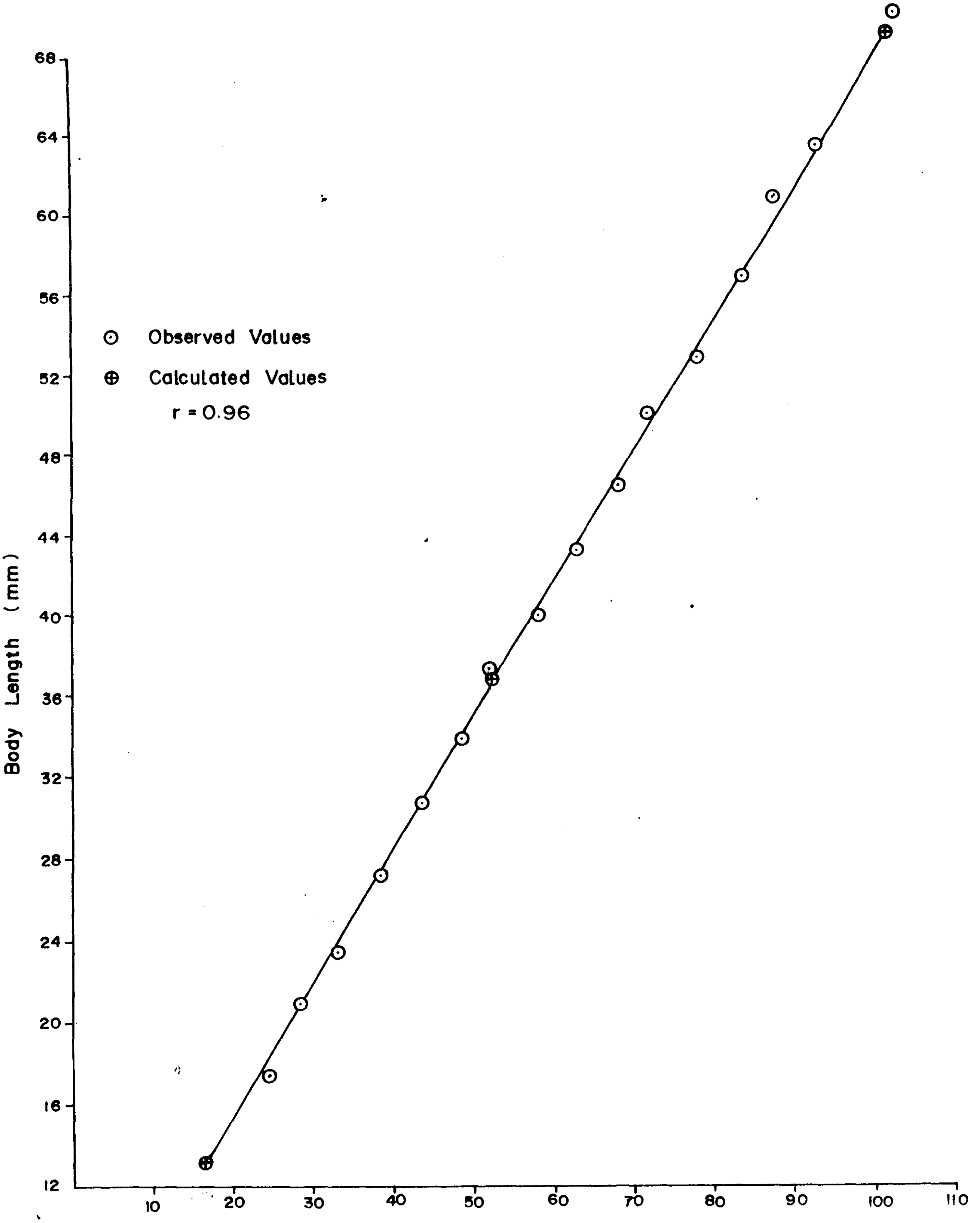


Fig. 44 Body length verses standard length in A. commersoni.

TABLE - 52

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND DEPTH THROUGH DORSAL FIN

Sl. No.	Length groups in (mm)		No.	Average Std L (mm) X	Average DD (mm) Y	Log X	Log Y	Calculated	Percentage D.D to Std. 'L'
1.	16.0	20.0	5	16.6	5.2	1.2	0.7	2.7	31.3
2.	21.0	25.0	2	24.5	8.5	1.4	0.9	6.2	34.7
3.	26.0	30.0	8	28.6	9.4	1.5	1.0	8.0	32.8
4.	31.0	35.0	16	33.3	11.2	1.5	1.0	10.1	33.6
5.	36.0	40.0	43	38.4	13.0	1.6	1.1	12.4	34.0
6.	41.0	45.0	164	43.5	14.5	1.6	1.2	14.6	33.4
7.	46.0	50.0	169	47.9	16.1	1.7	1.2	16.5	33.7
8.	51.0	55.0	136	52.8	18.3	1.7	1.3	18.7	34.7
9.	56.0	60.0	114	58.2	21.0	1.8	1.3	21.1	36.2
10.	61.0	65.0	96	63.2	23.3	1.8	1.4	23.3	36.9
11.	66.0	70.0	71	68.1	25.8	1.8	1.4	25.5	37.9
12.	71.0	75.0	105	73.0	27.7	1.9	1.4	27.6	38.0
13.	76.0	80.0	91	78.2	30.2	1.9	1.5	29.9	38.6
14.	81.0	85.0	55	82.8	32.3	1.9	1.5	32.0	39.1
15.	86.0	90.0	34	87.6	34.7	1.9	1.5	34.1	39.6
16.	91.0	95.0	11	93.1	37.7	2.0	1.6	36.5	40.5
17.	96.0	100.0	3	98.3	39.0	2.0	1.4	38.8	38.4
18.	101.0	105.0	1	102.0	46.0	2.0	1.7	40.5	45.1

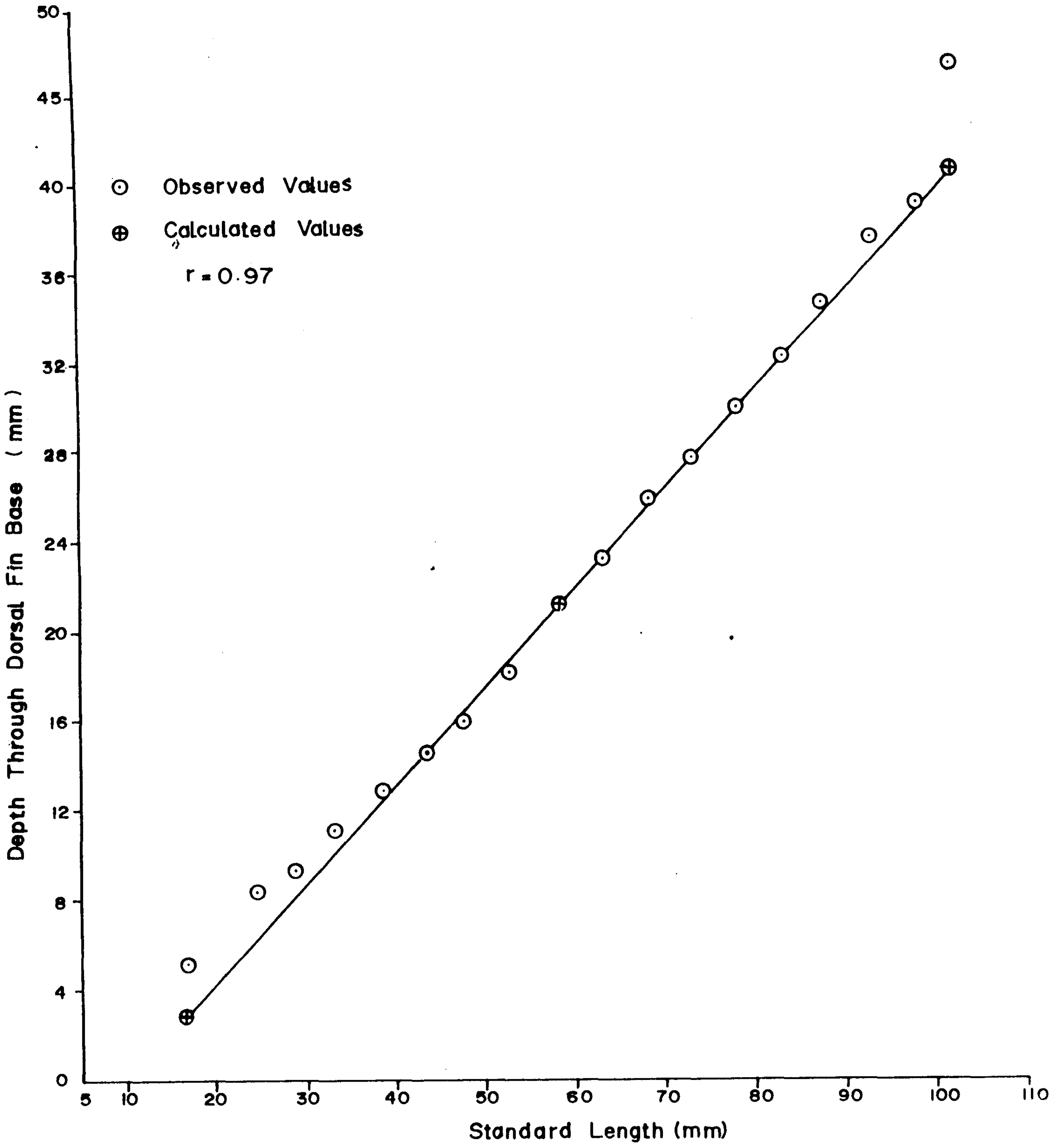
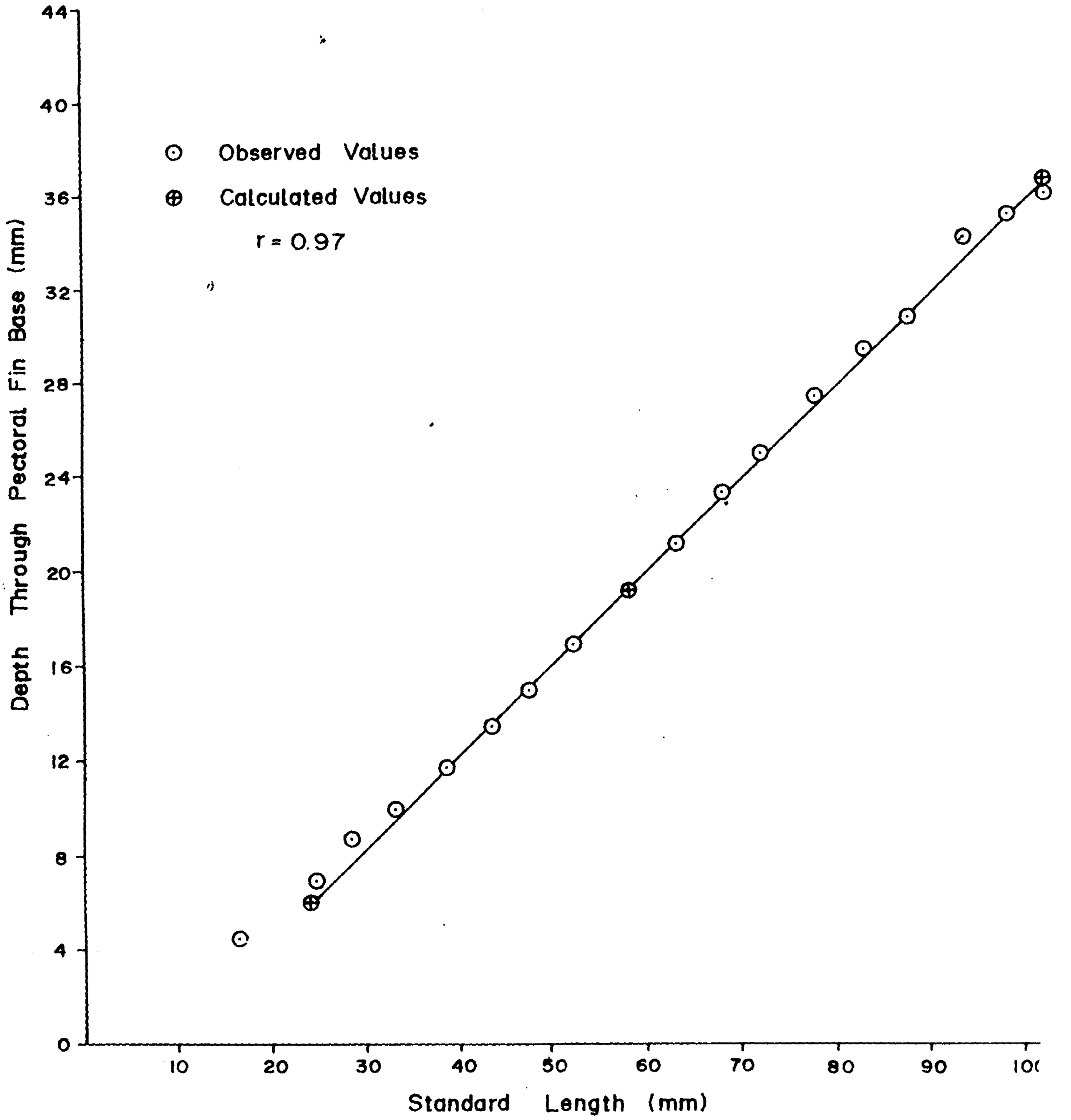


Fig. 45 Depth through Dorsal fin verses standard length in A. commersoni.

TABLE - 53

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND DEPTH THROUGH PECTORAL FIN BASE IN A. COMMERSONI

Sl. No.	Length groups in (mm)		No.	Average Standard (mm) X	Average D.P.(mm) Y	Log X	Log Y	Calculated	Percentage D.P. to Std. L
1.	16.0	20.0	5	16.6	4.6	1.2	.7	2.9	27.7
2.	21.0	25.0	2	24.5	7.0	1.4	.8	6.0	28.6
3.	26.0	30.0	8	28.6	8.8	1.5	.9	7.6	30.6
4.	31.0	35.0	16	33.3	10.2	1.5	1.0	9.5	30.6
5.	36.0	40.0	43	38.4	11.9	1.6	1.1	11.5	30.9
6.	41.0	45.0	164	43.5	13.5	1.6	1.1	13.5	31.1
7.	46.0	50.0	169	47.8	14.9	1.7	1.2	15.2	31.0
8.	51.0	55.0	136	52.8	16.7	1.7	1.2	17.1	31.6
9	56.0	60.0	114	58.2	19.3	1.8	1.3	19.3	33.2
10	61.0	65.0	96	63.2	21.3	1.8	1.3	21.3	33.6
11.	66.0	70.0	71	68.0	23.5	1.8	1.4	23.2	34.5
12.	71.0	75.0	105	72.0	25.1	1.9	1.4	25.1	34.4
13.	76.0	80.0	91	78.1	27.4	1.9	1.4	27.1	35.0
14.	81.0	85.0	55	82.8	29.5	1.9	1.5	28.9	35.7
15.	86.0	90.0	34	87.6	30.9	1.9	1.5	30.8	35.3
16.	91.0	95.0	11	93.1	34.0	2.0	1.5	33.0	36.5
17.	96.0	100.0	3	98.3	22.3	2.0	1.3	35.1	22.7
18.	101.0	105.0	1	102.0	38.0	2.0	1.6	36.5	37.3



. Fig. 46 Depth through pectoral fin verses standard length in A. commersoi

TABLE - 54

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND DEPTH THROUGH CAUDAL PEDUNCLE IN <u>A. COMMERSONI</u>

Sr No	Length groups in (mm)		No.	Average Std L (mm)'X'	Average D.C. (mm)'Y'	Log X	Log Y	Calculated	Percentage D.C. to Std. 'L'
1	16.0	20.0	5	16.6	2.4	1.2	0.4	2.6	14.5
2	21.0	25.0	2	24.5	3.5	1.4	0.5	3.6	14.3
3	26.0	30.0	8	28.6	4.1	1.5	0.6	4.0	14.4
4	31.0	35.0	16	33.3	4.5	1.5	0.7	4.6	13.5
5	36.0	40.0	43	38.4	5.2	1.6	0.7	5.2	13.5
6	41.0	45.0	164	43.5	5.8	1.6	0.8	5.8	13.4
7	46.0	50.0	169	47.9	6.9	1.7	0.8	6.4	13.4
8	51.0	55.0	136	52.8	7.0	1.7	0.8	7.0	13.2
9	56.0	60.0	114	58.2	7.5	1.8	0.9	7.6	12.8
10	61.0	65.0	96	63.2	8.2	1.8	0.9	8.2	13.0
11	66.0	70.0	71	68.1	8.9	1.8	0.9	8.8	13.0
12	71.0	75.0	105	73.0	9.5	1.9	1.0	9.4	13.0
13	76.0	80.0	91	78.2	10.0	1.9	1.0	10.0	12.8
14	81.0	85.0	55	82.8	10.6	1.9	1.0	10.5	12.8
15	86.0	90.0	34	87.6	11.2	1.9	1.0	11.1	12.8
16	91.0	95.0	11	93.1	11.9	2.0	1.1	11.8	12.8
17	96.0	100.0	3	98.3	12.7	2.0	.9	12.4	8.8
18	101.0	105.0	1	102.0	13.0	2.0	1.1	12.9	12.7

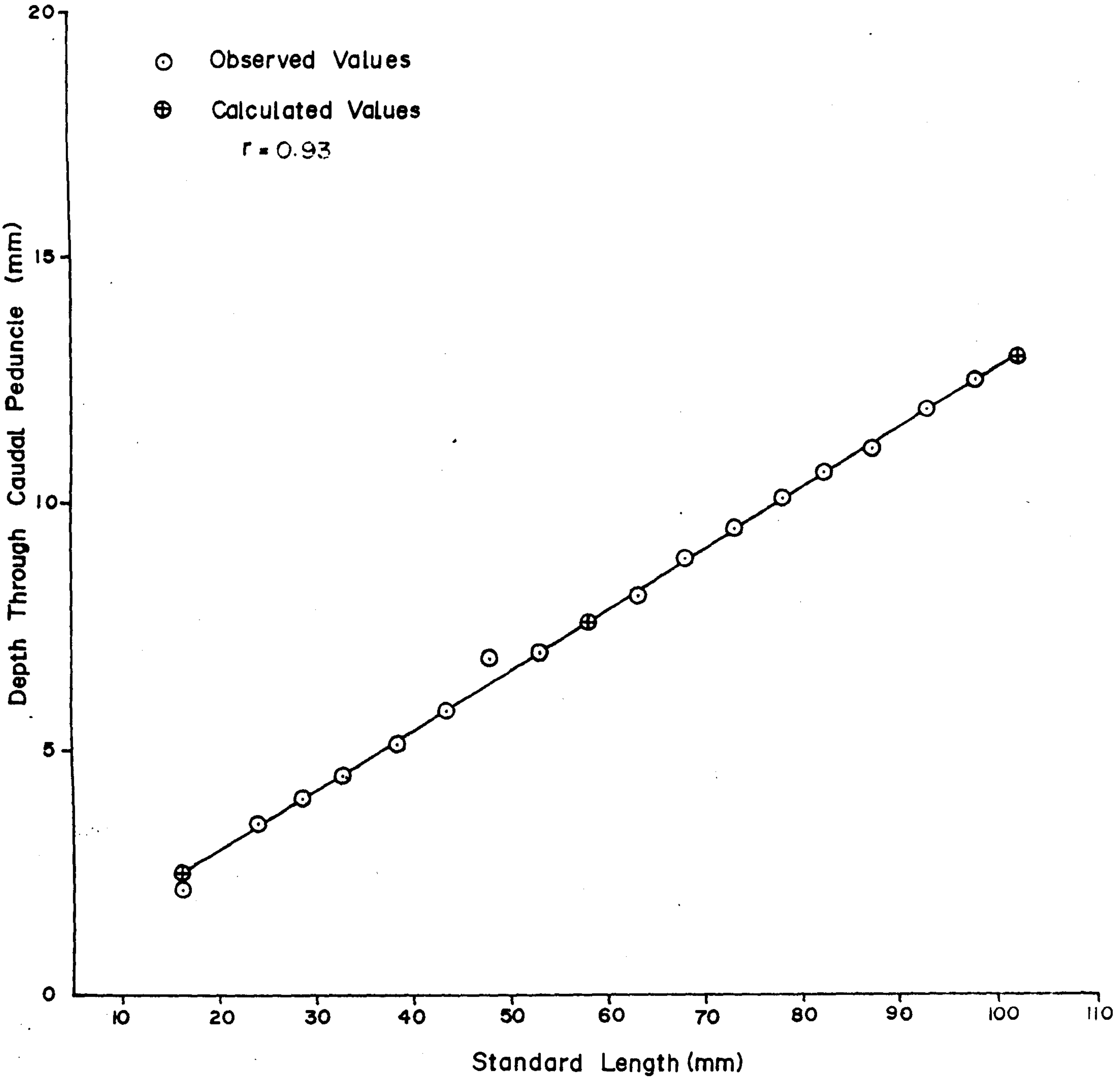


Fig. 47 Caudal peduncle verses standard length in <u>A. commersoni</u>.

TABLE - 55

RELATIONSHIP IN BETWEEN STANDARD LENGTH AND EYE DIAMETER IN A. COMMERSONI

Sl. No.	Length groups in (mm)		No.	Average Std L (mm) X	Average E.D. (mm) Y	Average Log X	Average Log Y	Calculated	Percentage E.D. to Std. L
1.	16.0	20.0	5	16.6	1.6	1.2	0.2	2.0	9.6
2.	21.0	25.0	2	24.5	2.5	1.4	0.4	3.0	10.2
3.	26.0	30.0	8	28.6	3.5	1.5	0.5	3.5	12.2
4.	31.0	35.0	16	33.3	4.0	1.5	0.6	4.0	12.0
5.	36.0	40.0	43	38.4	4.6	1.6	0.7	4.6	12.0
6.	41.0	45.0	164	43.5	5.2	1.6	0.8	5.2	11.9
7.	46.0	50.0	169	47.9	5.6	1.7	0.8	5.8	11.8
8.	51.0	55.0	136	52.8	6.3	1.7	0.9	6.4	11.9
9.	56.0	60.0	114	58.2	7.2	1.8	0.9	7.0	12.3
10.	61.0	65.0	96	63.2	8.0	1.8	0.9	7.6	12.7
11.	66.0	70.0	71	68.1	8.5	1.8	0.9	8.2	12.5
12.	71.0	75.0	105	73.0	8.8	1.9	1.0	8.8	12.1
13.	76.0	80.0	91	78.1	9.4	1.9	1.0	9.4	12.0
14.	81.0	85.0	55	82.8	9.8	1.9	1.0	10.0	11.9
15.	86.0	90.0	34	87.6	10.3	1.9	1.0	10.6	11.7
16.	91.0	95.0	11	93.1	11.2	2.0	1.0	11.2	12.0
17.	96.0	100.0	3	98.3	11.8	2.0	0.9	11.8	7.5
18.	101.0	105.0	1	102.0	12.0	2.0	1.1	12.3	11.8

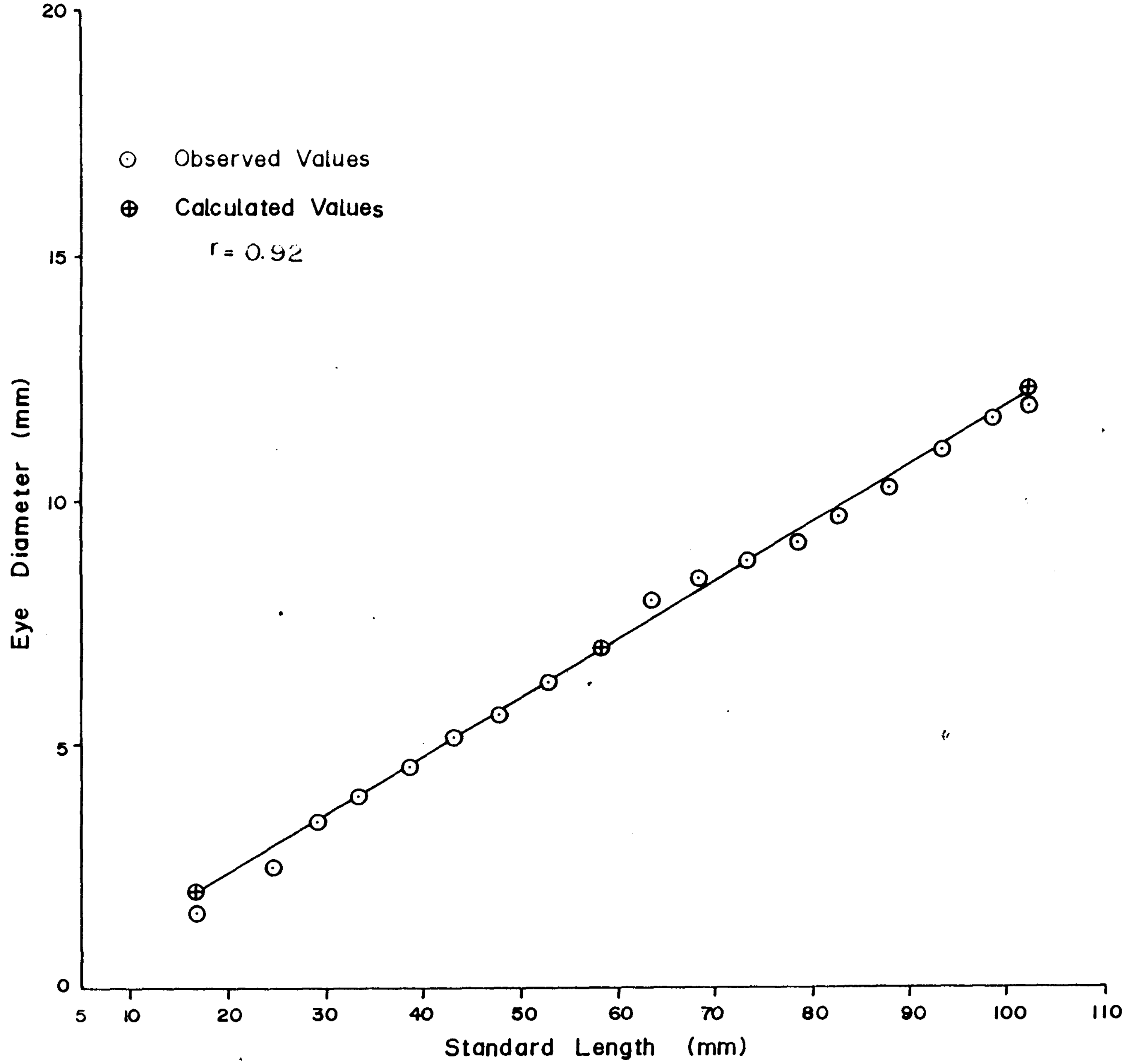


Fig. 48 Eye diameter verses standard length in *A. commersoni*.

XI. SUMMARY

SUMMARY

A total of 1199 specimens of <u>A. commersoni</u> were examined for the biological aspects during December 1987 to March 1989, and some highlights of the results are as follows :

1. Maturation cycle was studied microscopically and macroscopically in 528 females and 485 males, respectively. Six stages of maturity were identified from which the periodicity of spawning was determined. The species does not follow a pattern of periodic spawning but on the other hand during the prolonged breeding period, two peaks, one each in September and February, were observed.
2. An individual has series of unrhythemic spawning bursts. Females ranging in size from 48 mm to 135 mm attain first maturity at length of 67.5 mm and males ranging between 42 mm and 122 mm, attain first maturity at 65 mm length.
3. Gonado Somatic Index (GSI) was high in February & July in female and January & September in male. Highest GSI value was encountered in matured females.
4. The sex ratio differed throughout the year. Males were predominant in May and females in September. Mean sex ratio in female and male was 1.09:1.

5. Fecundity is affected more by ovary weight than any other parameter and ranges between 5211 and 92157. The equation expressing various relationships was found to be -

Log F = -3.6156 + 4.0520 log total length

Log F = 3.4127 + 1.0328 log total weight

Log F = 4.5712 + 1.0893 log gonad weight

6. Food and feeding was studied from stomach content of 1199 fish with size range of 18 mm to 135 mm. Diatoms and copepods were the main item of food in juveniles. As the fish grows in size it prefers crustaceans while in higher size groups, the preference is for crustaceans and fish both. This indicates that juveniles are omnivorous while adults are carnivorous.

7. Intensity of feeding was lowest (3.77%) in Nov. and highest (37.66%) in June. Highest percentage of empty stomach was found in 46-55 mm length group and lowest in 106-115 mm length group. Feeding was poor in juveniles.

8. Seasonal variations in the chemical composition of both the sexes of <u>A. commersoni</u> were studied separately from February 1988 to January 1989. The results indicate that percentage of moisture content was comparatively low in February and September when mature fishes were dominant while the fat content was low in March and October when most of the spent fishes occurred in

catches. The fat content was highest in mature and maturing fishes. As regards proteins, minimum value in spent fishes and maximum in immature fishes was recorded. Percentage of carbohydrate was low. Ash component was rather high as compared to other fishes.

9. An analysis of length frequency distribution indicated that the fishable stock is comprised of two year classes. The species attain an average total length of 65 mm at the end of first year with average rate of growth of 5.21 mm per month and grows to 135 mm at the end of second year with an average rate of growth of 3.3 mm per month. Recruitment to the natural population was more or less continuous which indicates prolonged breeding season in A. commersoni.

10. The length weight relationship, for male, female and juvenile was determined and the corresponding equations were as follows :

1. Pooled date - $W = 0.00003274L^{3.2624}$

2. Female - $W = 0.00003624L^{3.295}$

3. Male - $W = 0.00003761L^{3.069}$

4. Juvenile - $W = 0.00001484L^{3.069}$

11. The ponderal index or condition factor for both the sexes, separately, in respect to size and time was estimated. A sharp inflexion noticed in the case of

males at length group 61 - 65 mm total length and in females at length group 66-70 mm total length, coincided with the minimum size at first maturity. Kn values were influenced more by maturation cycle than due to feeding intensity in A. commersoni. Peak condition was in immature specimens and it gradually decreased with the advent of maturation of gonads.

12. Interdependence between morphomeric measurements of A. commersoni, was investigated. Seven regression equations were formulated so as to arrive at an idea of varying rates of growth of the different body dimensions in relation to standard length. Regression of body measurements and their relationships were as follows :

I. Total length; Y1 = log 3.2546 + 1.2826 log x (SL)

II. Head length; Y2 = log 1.1984 + 0.3279 log x (SL)

III. Body length; Y3 = log 2.4537 + 0.6520 log x (SL)

IV. Depth through; Y4 = log -4.6060 + 0.4419 log x (SL)
Dorsal Fin base,

V. Depth through; Y5 = log -3.6172 + 0.3934 log x (SL)
Pectoral Fin base,

VI. Depth through; Y6 = log 0.6158 + 0.1200 log x (SL)
Caudal Peduncle,

VII. Eye Diameter Y7 = log 0.0179 + 0.1203 log x (SL)

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