BIOLOGY AND FISHERY OF IMPORTANT GREY MULLETS OF LAKE PULICAT

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नं. १४१, मार्शल्स रोड, एगमोर, चेन्नै – ६०० ००८.

CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE
(Indian Council of Agricultural Research)
141, Marshalls Road, Egmore, Chennai - 600 008.

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R.D. PRASADAM AND C.P. RANGASWAMY

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PREFACE

The grey mullets of the family Mugilidae are widely distributed in the tropical and sub-tropical waters of the world. These fishes form a commercial fishery of considerable magnitude in the coastal waters, estuaries, lagoons and backwaters in India. Among the commercially important species, *Mugil cephalus* grows to the largest size of 65 cm in length. Mullets are euryhaline and eurythermic and are capable of living under extreme environmental conditions. Besides being non-predacious and predominantly detritus and algal feeders, they are efficient converters of natural food. It has been possible to breed mullets under captivity. In view of the above qualities, mullets are one of the most suitable candidate species for fish farming in brackishwaters. As a diversification to the existing shrimp farming, the farmers are evincing keen interest in taking up finfish culture. In this context, mullets assume greater importance as they are excellent food fish and highly esteemed delicacy.

In Lake Pulicat - a brackishwater lagoon on the east coast of India, the grey mullets constitute the second important group in the commercial fisheries, contributing to the tune of 20-27% of the total annual landings. Realising the importance of this fishery, the Pulicat Unit of Central Inland Fisheries Research Institute carried out exhaustive studies on the biology and fishery of commercially important grey mullets during 1966-1979. These studies unfolded a wealth of scientific information on the biology of mullets. In view of the growing importance of finfish in the development of sustainable aquaculture, it was considered useful to summarise the research findings on the biology of mullets for a wider use in future.

The present Bulletin contains scientific information on the biology and fishery of 4 commercially important grey mullet species *viz., Mugil cephalus, Liza macrolepis, L. parsia* and *Valamugil cunnesius* of Lake Pulicat. It is hoped that the information presented here will generate further interest on the subject and serve as a useful guide in mullet farming ventures.

I appreciate the sincere efforts of Dr. R.D. Prasadam, Principal Scientist (Retd.) and Dr. C.P. Rangaswamy, Senior Scientist of this Institute for their painstaking efforts in compiling their research findings and in bringing out this Bulletin.

Chennai
25.3.1998

G.R.M. RAO
DIRECTOR

CONTENTS

1. INTRODUCTION

The grey mullets belonging to the family Mugilidae constitute one of the important groups in the fisheries of brackishwater lagoons, estuaries and coastal waters of India. Mullets are euryhaline, eurythermic and capable of living under extreme environmental conditions. Besides being non-predacious and predominantly detritus feeders, they are efficient converters of natural food. Taking advantage of these qualities, mullets are cultured in the tropical and sub-tropical waters of the world. In Lake Pulicat, the grey mullets constitute the second important group in the commercial fisheries and are represented by 7 species *viz.*, *Mugil cephalus* Linnaeus, *Liza macrolepis* (Smith), *Liza parsia* (Hamilton) *Liza tade* Forskal, *Liza vaigiensis* (Quoy and Gaimard), *Valamugil cunnesius* (Valenciennes) and *Valamugil seheli* Forskal. Out of these, *V. seheli* and *L. vaigiensis* are occasional visitors to the lake, while the others are commercially important.

Out of the 7 species mentioned above, detailed investigations on the biology of 4 commercially important species namely *Mugil cephalus*, *Liza macrolepis*, *L. parsia* and *Valamugil cunnesius* were carried out and the results are presented in this Bulletin. The information would be highly useful in conservation and management of the lake's fishery and aquaculture development.

2. COLLECTION AND ANALYSES OF DATA

The material for the study was collected from the commercial catches of the Lake Pulicat from 1966 to 1979. To facilitate systematic collection of data and samples from the landing centres and fishing grounds, the lake was divided into northern (Tada, Arambakkam, Sunnambukulam and Gummidipoondi centres) and southern (Pulicat, Ponneri and Tirupalaivanam centres) sectors (Fig. 1). Data collected from lake mouth zone were treated separately for better and proper understanding of spawning migration. Total length, weight, gut weight, gonad weight, sex and maturity stages of the fish were recorded.

For studies on food and feeding habits, Pearse's method of eye estimation was adopted. Length (L) - weight (W) relationship was determined by the equation $W=al^b$ and relative condition factor (Kn) by Le Cren's method. Spawning season and frequency were determined by ova diameter studies. Fecundity studies were based on mature ovaries. Age was estimated by Probability Plot method and scale studies.

3. PHYSICAL FEATURES OF LAKE PULICAT

Lake Pulicat is the second largest brackishwater lagoon situated on the east coast of India between 13°24' and 13°47' N latitude and 80°2', 80°16' E longitude (Fig.1). It is about 60 km long and 17 km broad covering an area of 461 km^2 with water spread of 350 km^2. Its

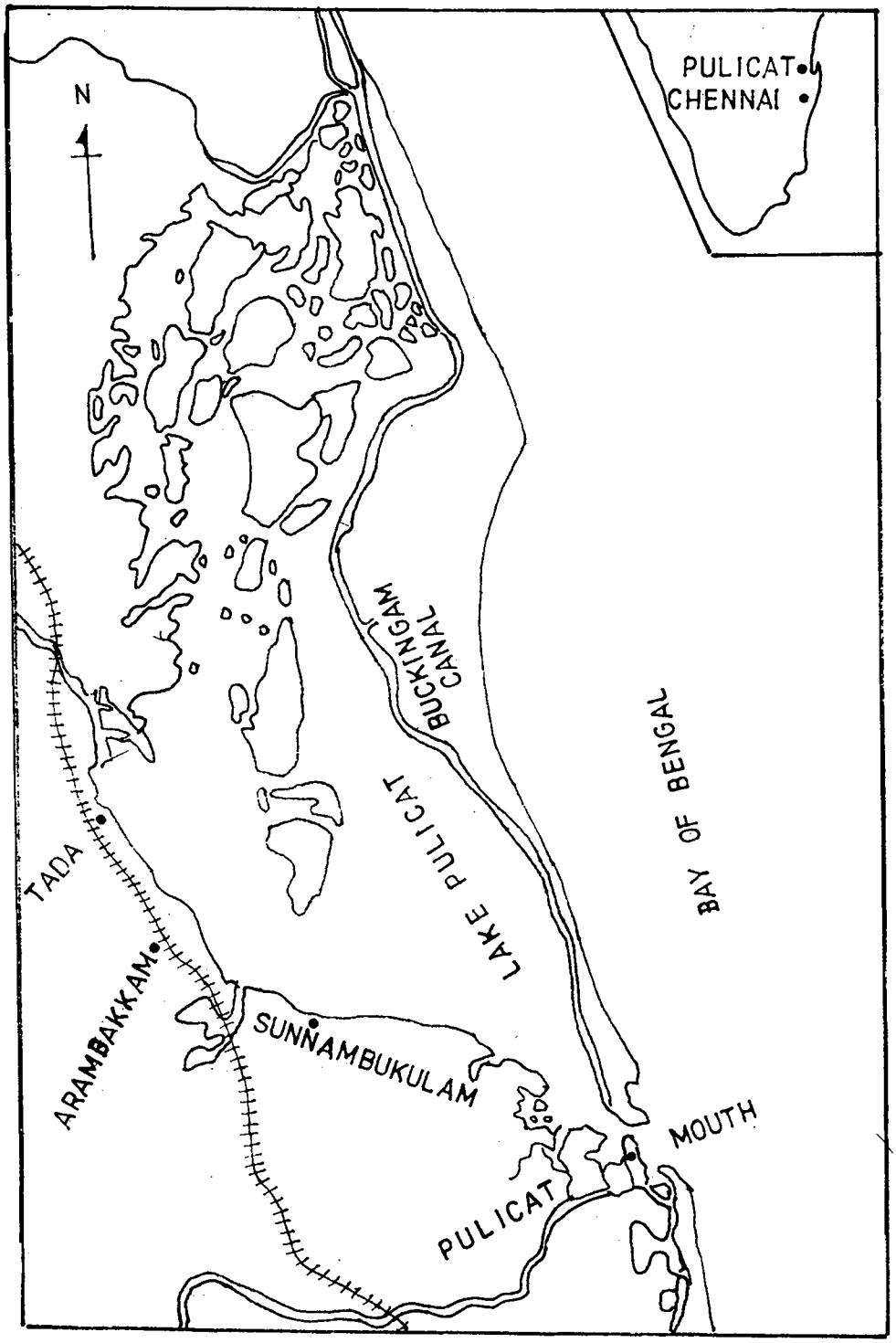


Fig. 1 Map of Lake Pulicat showing fish landing centres

drainage area is about 4406 km^2 . The lake is confluent with the Bay of Bengal at its northern and southern extremities. Nearly half of the lake towards the north is marshy and remained as a tidal flat. During monsoon, this area is inundated with water upto 30 cm depth. Further south of this tidal flat, the lake is shallow with depth upto 2 m. The southern portion of the lake is comparatively deeper with a maximum depth of 6 m. Three seasonal rivers, namely, Swarnamuki and Kalangi in the northern portion and Arani in the southern part drain into the lake. The inflow into the lake during North-east monsoon through Arani river is comparatively greater than that of the two in the northern portion.

The tidal amplitude is about 50 cm around the lake-mouth and gradually weakens towards Annamalaicheri upto which it is felt, which is about 8 km from the lake-mouth. Due to the absence of perennial rivers opening into the northern portion, salinity in this part reaches as high as 55 ppt during pre-monsoon months. The tidal effect for about 3 months during October-December when North-east monsoon is active, is completely masked by large quantities of flood waters drained into the lake through Arani river.

Opening and closing of the lake-mouth across the sand bar and shifting of its position along the coast are often noticed. The sea-ward migration of prawns and fishes for breeding and lake-ward migration of immature young ones for feeding, take place through the lake mouth. Hence, it is of strategic importance from fisheries point of view. Though the lake sprawls in the states of Andhra Pradesh and Tamil Nadu, the southern portion lying in the latter is more productive by virtue of the location of the lake-mouth in this part, while the other mouth in the northern sector is defunct.

4. BIOLOGY OF *MUGIL CEPHALUS* LINNAEUS

4.1 Food and feeding habits

The stomach contents consisted of sand (51.9%) decayed organic matter (32.9%), diatoms (6.7%), dino-flagellates (2.5%), foraminifera, (2.7%), algae (1.5%) and miscellaneous items like copepods and tintinnids (1.8%). The qualitative composition of gut contents indicated that the species is iliophagous in its food habits subsisting mainly on decayed organic matter. The feeding activity was low during October-February which was the breeding season.

4.2 Length - weight relationship

No significant differences in the length-weight relationship between juveniles, males and females were found. Hence, a single equation was derived.

$$\text{Log } W = -4.7747 + 2.9128 \log L$$

4.3 Size at first maturity

The mean sizes at which first maturity was attained, were found to be 300 mm for males and 360 mm for females.

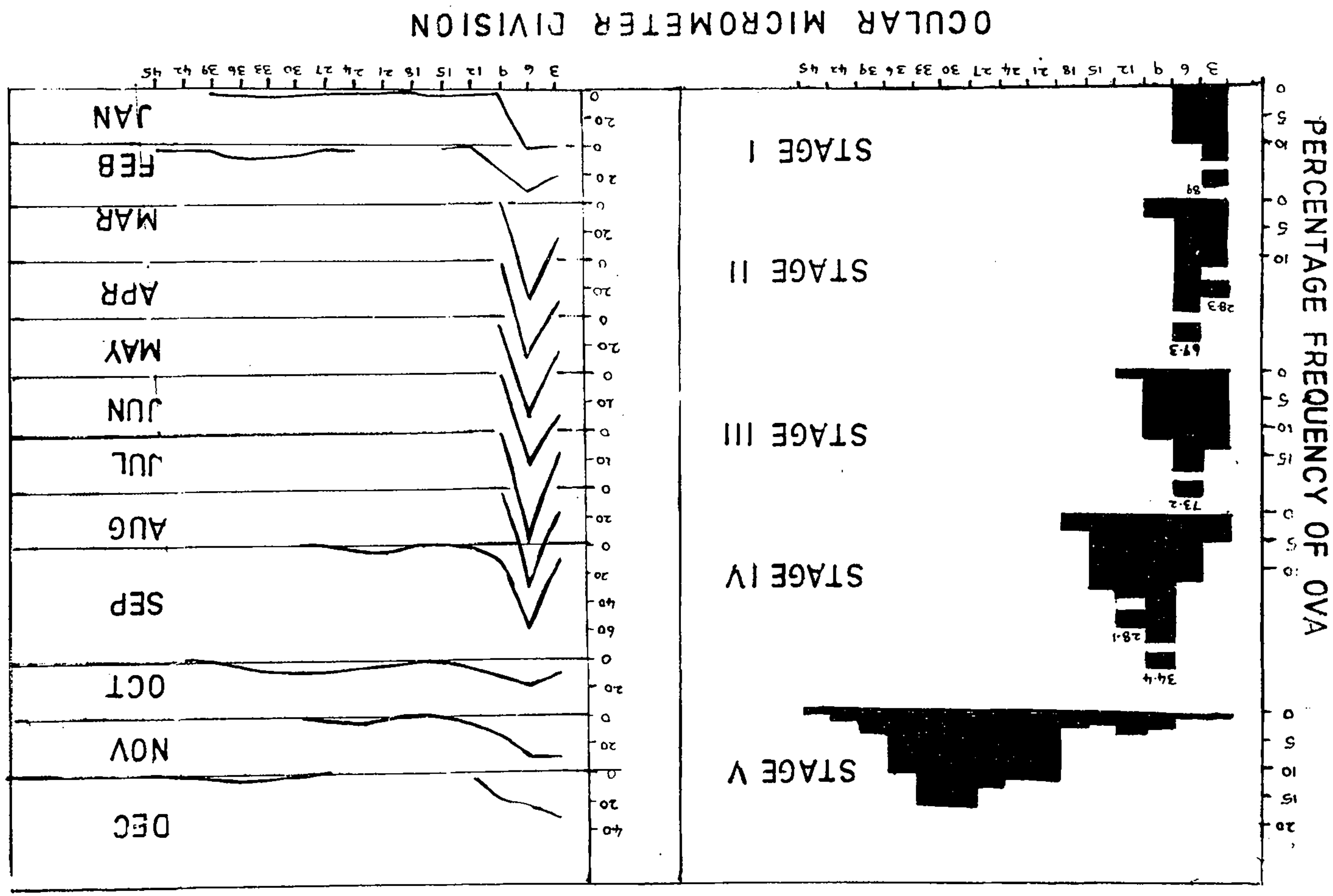


Fig. 2 Size progression of ova of *Mugil cephalus* in different maturity stages and months

4.4 Maturation

The development of ova in different stages of maturity indicated that there was only one distinct group of mature ova with a wide range of size (21-45 ocular divisions). This indicated that the fish has a single spawning and the actual shedding of eggs may be a prolonged one (Fig. 2).

4.5 Spawning season

The size progression of ova during different months indicated a prolonged spawning season from September to February (Fig.2). This was substantiated by the occurrence of mature fish during September to February. However, the occurrence of mature fish in comparatively higher percentages in October (33.82%), November (52.95%), December (50.52%) and January (29.97%) indicated the peak spawning period. The availability of spent fish for more than five months and the young ones during January, February and March further indicated that spawning might be a prolonged one.

4.6 Gonado-Somatic Index (GSI)

The GSI showed higher values in females during October to February indicating the full development of ovaries during the period. The relative condition factor (Kn) was also high during September to February corroborating the spawning season to be from September to February.

4.7 Sex - ratio

Length in relation to sex showed a gradual increase in the numbers of males upto 340 mm after which females were more. In general, the sex-ratio was found to be 1.56 : 1.0 for males to females.

4.8 Fecundity

The fecundity of the species was estimated to range from 4,34,000 to 47,17,000 eggs. High degree of correlation existed between fecundity (F) and various parameters such as fish length (L), fish weight (W) and ovary weight (OW) :

$$\text{Log } F = -5.8006 + 4.3832 \log L$$

$$\text{Log } F = 4.1952 + 0.5973 \log W$$

$$\text{Log } F = 3.7753 + 1.1163 \log OW$$

4.9 Estimate of age

The lengths attained at different ages were found to be 223, 321, 418 and 503 mm for the I, II, III and IV years respectively by Probability Plot method and 214, 319, 406 and 491 mm respectively by scale studies.

5. BIOLOGY OF *LIZA MACROLEPIS* (SMITH)

5.1 Food and feeding habits

The stomach contents consisted of decayed organic matter (42.75%), sand (32.40%), gill raker processes (18.73%), diatoms (2.34%) foraminifera (1.88%) dinoflagellates (0.52%), tintinnids (0.14%), filamentous algae (0.46%), weeds (0.53%) copepods (0.12%) and miscellaneous items (0.13%). The composition of the gut contents pointed to its feeding on the iliotrophic layer subsisting on the lower food chain. Feeding activity was high among maturing and spent fishes and poor among mature ones.

5.2 Length-weight relationship

The relationships for juveniles, males and females were found to be significantly different. The equations derived were as follows :

Juveniles : $\text{Log } W = -4.5188 + 2.7894 \log L$

Males : $\text{Log } W = -4.5802 + 2.8158 \log L$

Females : $\text{Log } W = -4.4473 + 2.7612 \log L$

5.3 Size at first maturity

The size at first maturity for males and females was found to be 160 and 255 mm respectively.

5.4 Maturation

The development of ova in different stages of maturity indicated the presence of two distinct groups of ova- an immature and a mature ones showing that the species has a single spawning frequency (Fig. 3).

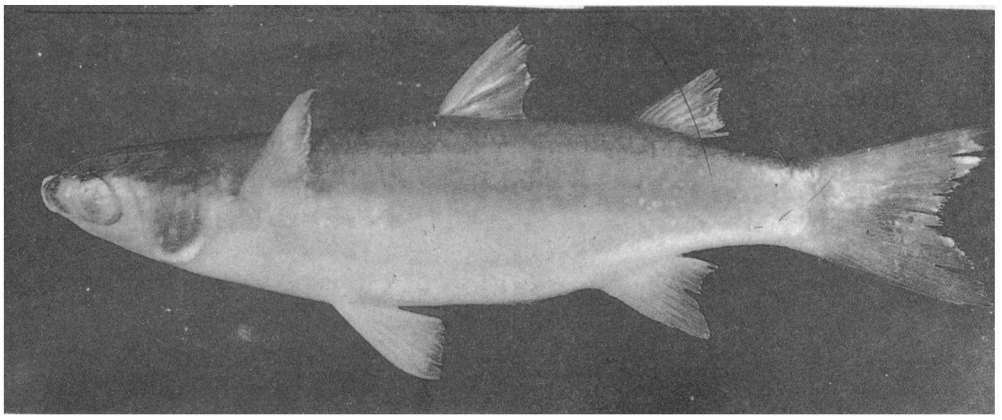
5.5 Spawning season

Mature fish were available throughout the year indicating round the year spawning of the species. However, the peak spawning months were found to be March, July and September. Higher percentage of mature ova were seen during June, September and March (Fig. 4). The year-round spawning was further confirmed by the availability of fry and spent recovering ones throughout the year.

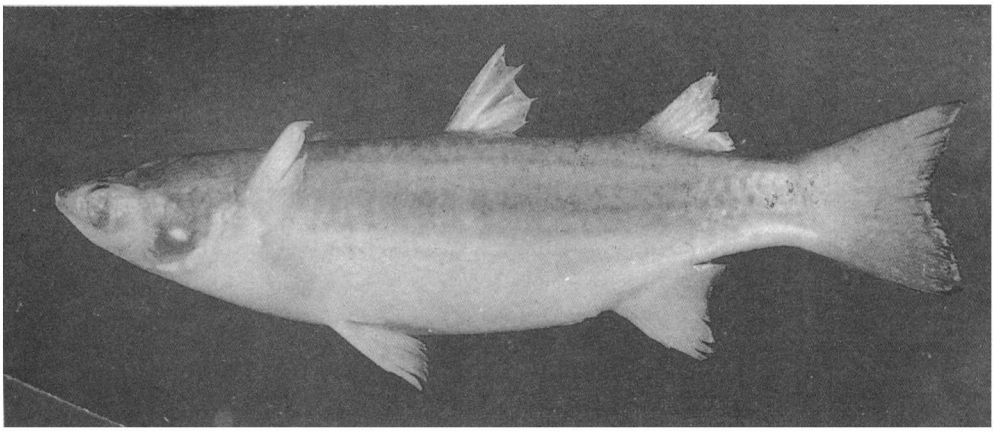
5.6 Gonado-Somatic Index (GSI)

In males the GSI was high during January, March and July while in females during January, March and June, broadly coinciding with the peak spawning season.

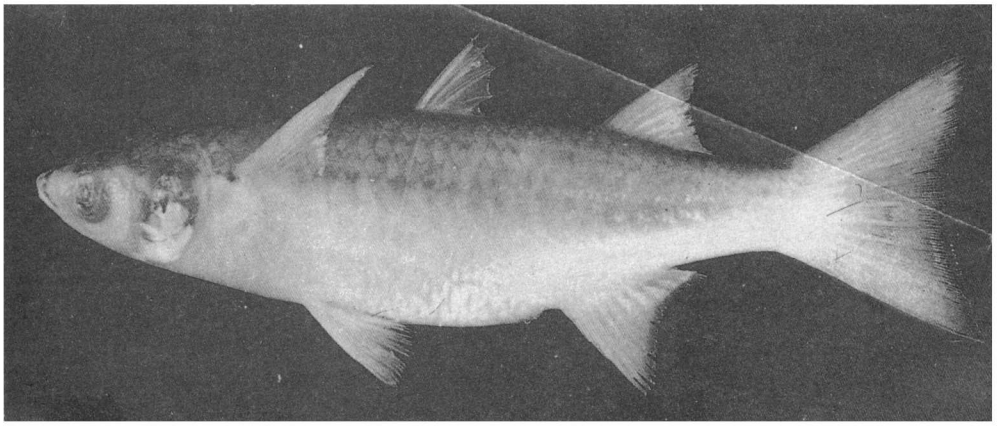
Mugil cephalus Linnaeus



Liza parsia (Hamilton)



Liza macrolepis (Smith)



Valamugil cunnesius (Valenciennes)

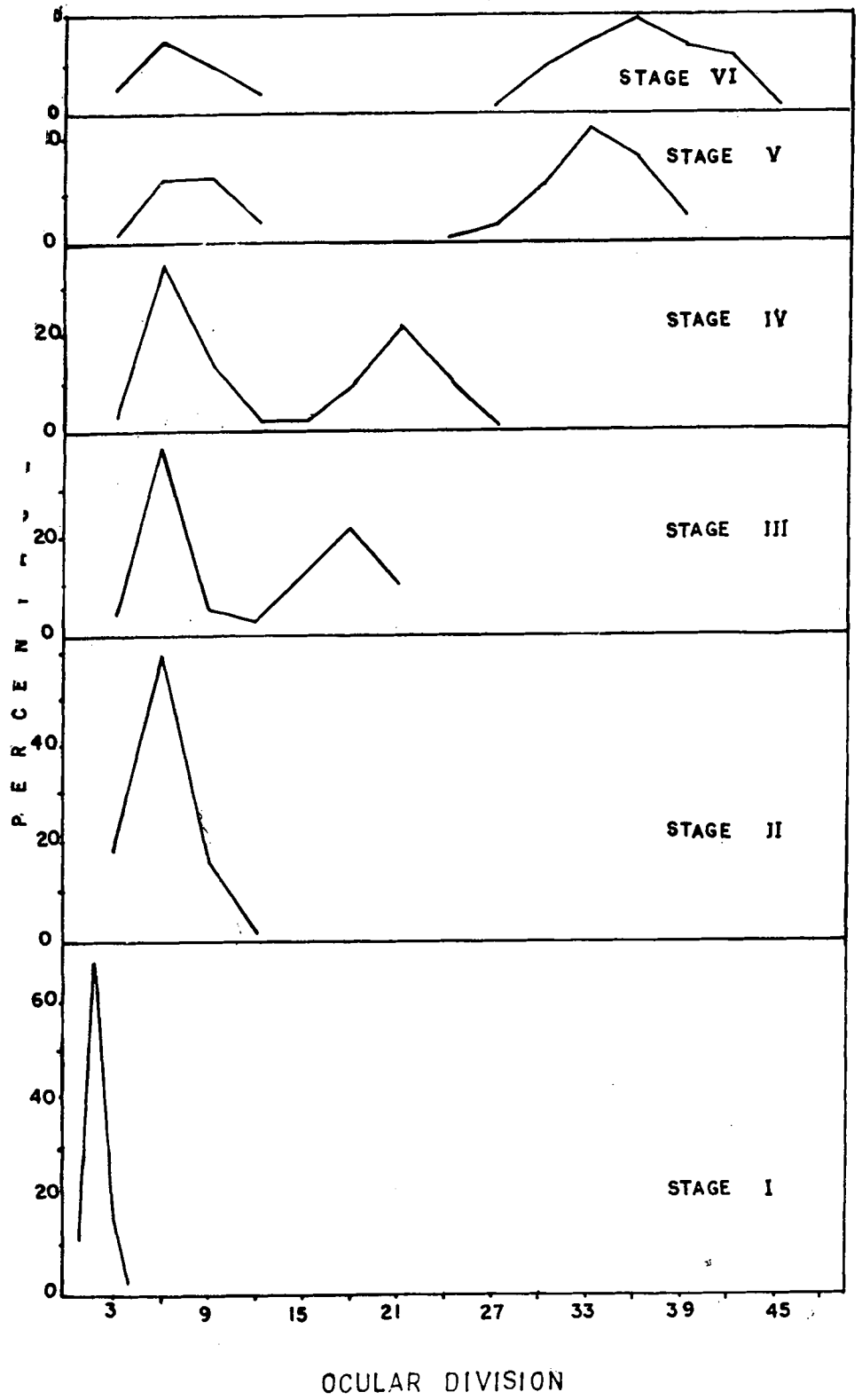


Fig. 3 Size progression of ova of *Liza macrolepis* in different maturity stages

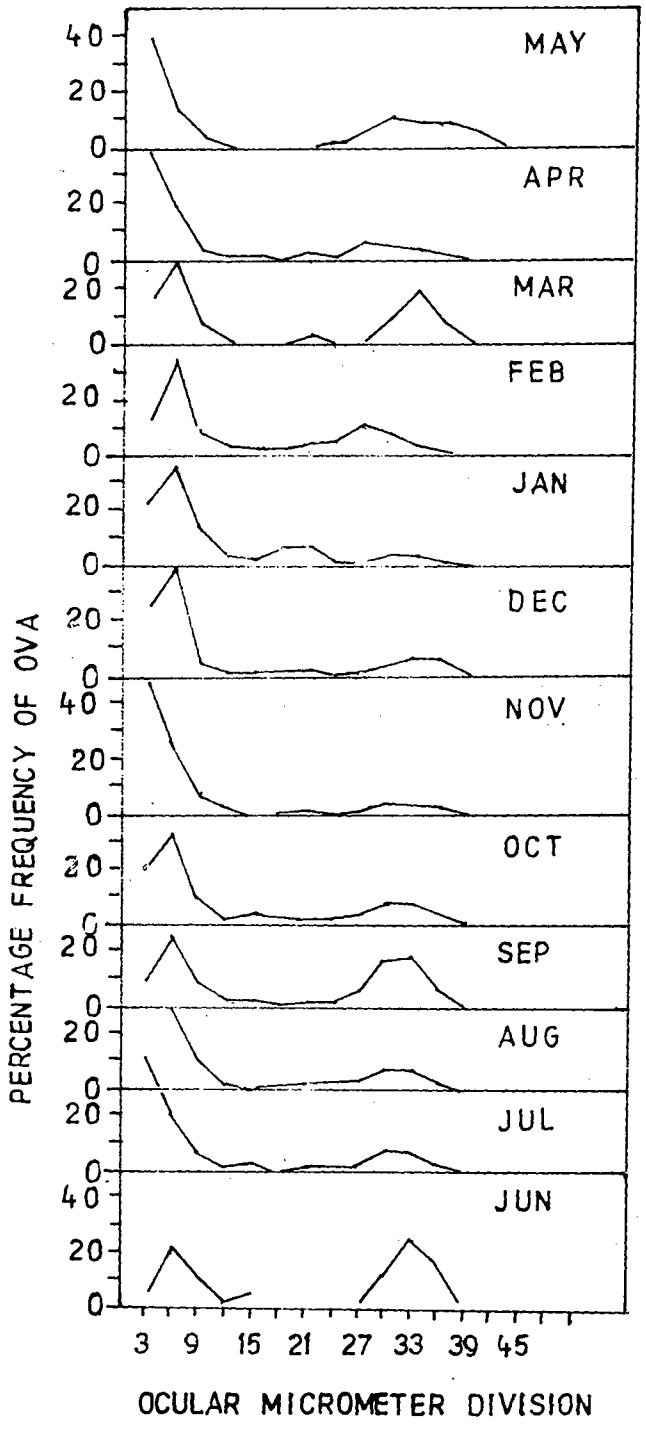


Fig. 4 Ova diameter frequency distribution of *Liza macrolepis* in different months

5.7 Spawning migration

The study did not yield any direct evidence to indicate the spawning migration. However, circumstantial evidences such as availability of mature fish at lake-mouth and non-availability of eggs and larvae inside the lake suggested that the fish migrates to and spawns in the sea. Further, the availability of fry in large numbers at lake-mouth indicated that they enter the lake from the sea through the lake-mouth.

5.8 Sex - ratio

Sexes can be distinguished from 80 mm onwards. In general, the ratio was 1.0 : 1.62 for males to females showing slight preponderance of females. Males were dominant in the size range of 131 - 190 mm, while females were dominant in two sizes namely 91 - 130 mm and 191 - 350 mm.

5.9 Fecundity

The fecundity was estimated to range from 1,54,759 to 12,04,837 eggs. Correlation existed between fecundity (F) and various parameters such as fish length (L) and fish weight (W) and were found to be as follows :

$$\text{Log } F = -0.5702 + 2.5648 \log L$$
$$F = 76.3249 + 2.1651 W$$

5.10 Estimate of age

The lengths attained at I, II, III and IV years were found to be 100, 162, 241 and 303 mm respectively by Probability Plot method and 130, 179, 229 and 273 mm respectively by scale studies.

6. BIOLOGY OF *LIZA PARSIA* (HAMILTON)

6.1 Food and feeding habits

The gut contents consisted of decayed organic matter (49.25%), sand (32.35%), gill raker processes (8.91%), diatoms (5.72%), filamentous algae (1.19%), dinoflagellates (1.16%), tintinnids (0.58%), foraminifera (0.36%), copepods (0.27%) and miscellaneous items (0.18%). This indicated that the food of the species was similar to other species of mullets feeding on the benthic layer of the environment. Feeding intensity was high among maturing, spent and immature fish. Majority of mature fish had empty stomachs or traces of food. In females, the gastro-somatic index was the lowest during July, September and March, which were the peak spawning months.

6.2 Length - weight relationship

The relationships derived for juveniles, males and females were found to differ significantly. Hence, separate equations were derived :

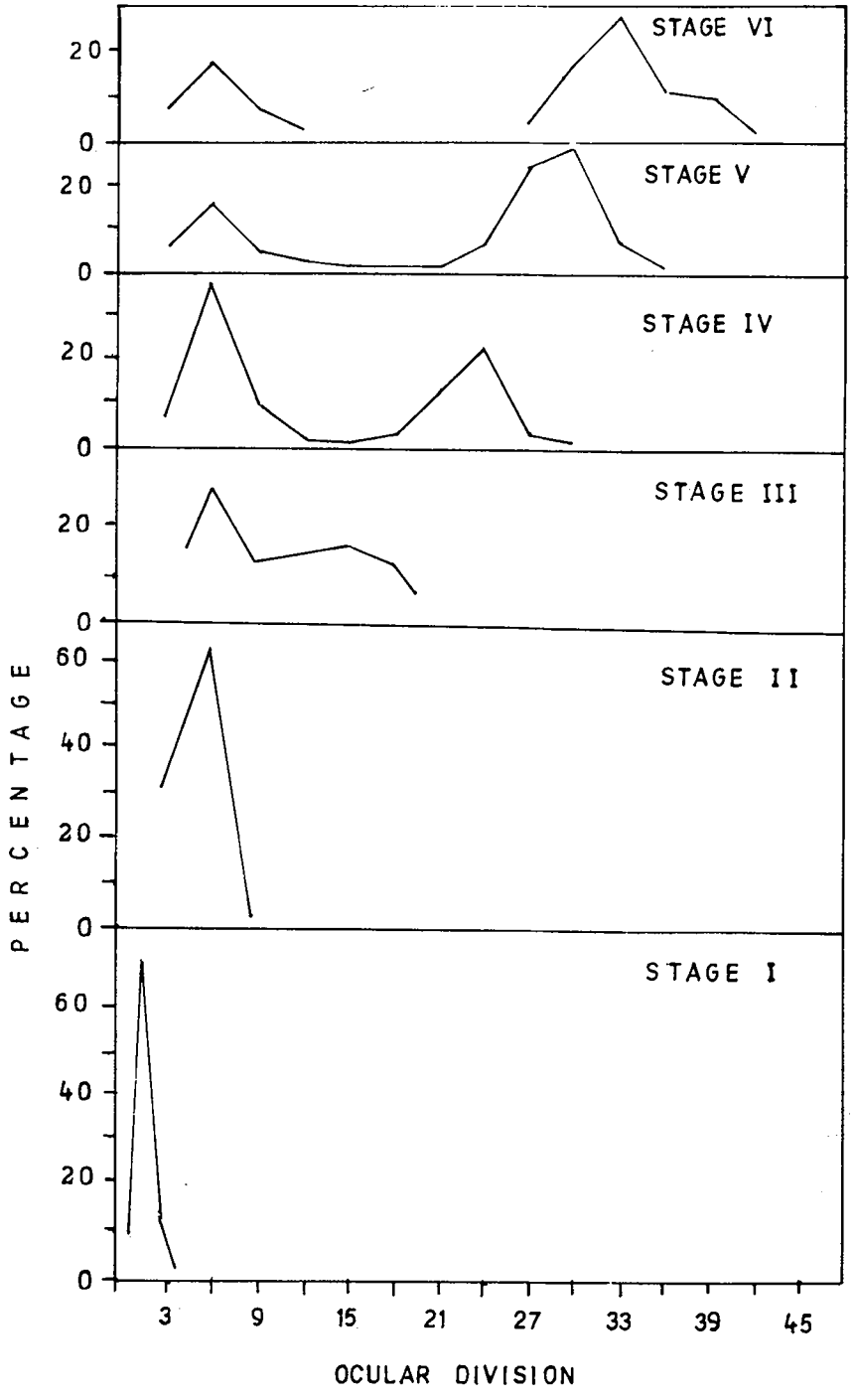


Fig. 5 Development of ova of *Liza parsia* in different stages of maturity

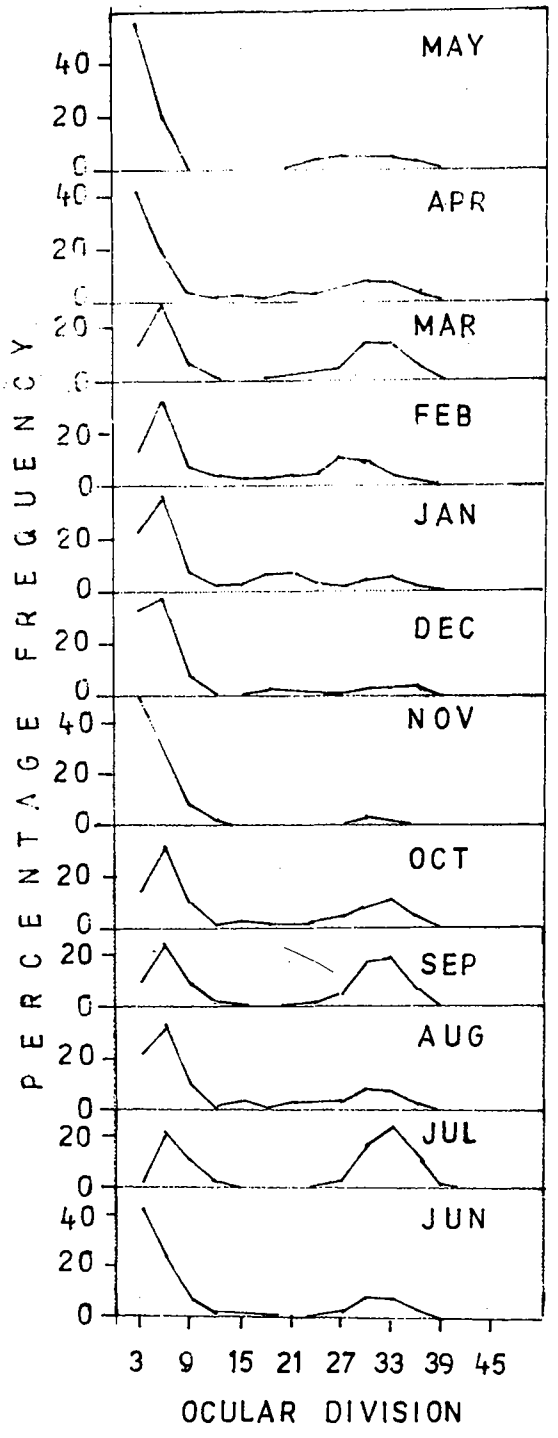


Fig. 6 Ova diameter frequency distribution of *Liza parsia* in different months

Juveniles : Log W = - 4.4393 + 2.7550 log L

Males : Log W = - 4.4541 + 2.7625 log L

Females : Log W = - 4.7780 + 2.9225 log L

6.3 Size at first maturity

The size at first maturity was found to be 145 mm for males and 165 mm for females.

6.4 Maturation

The development of ova in different stages of maturity revealed the presence of two distinct groups of ova - an immature and a mature ones indicating that the species has a single spawning frequency (Fig. 5).

6.5 Spawning season

Mature females were available throughout the year with peaks in July, September and March (Fig. 6).

6.6 Gonado-Somatic Index (GSI)

GSI values were found to be high in March, July and September which were spawning peaks. Similar observations were made on relative condition factor. This suggested that though the species breeds throughout the year, the peak months were July, September and March.

6.7 Spawning migration

Just as in the case of *L. macrolepis,* the occurrence of fully mature females in large numbers at lake-mouth indicated that the fish congregate at lake mouth while on spawning migration to the sea.

6.8 Sex - ratio

The sex ratio was 1.9 : 1.06 males to females showing a slight preponderance of males. Males were dominant in the size groups of 111-160 mm, while females were dominant in 61-110 mm and 161 - 240 mm size ranges.

6.9 Fecundity

The fecundity was estimated to range from 82,364 to 3,34,290 eggs. Correlation existed between fecundity (F) and fish length (L) and weight (W).

Log F = - 4.0610 + 2.7838 log L

F = - 0.3288 + 2.4492 W

6.10 Estimate of age

The lengths attained at I, II, III and IV years were found to be 100, 135, 167 and 200 mm respectively by Probability Plot method and 115, 149, 179 and 205 mm respectively by scale studies.

7. BIOLOGY OF *VALAMUGIL CUNNESIUS* (VALENCIENNES)

7.1 Food and feeding habits

The stomach contents consisted of decayed organic matter (38.93%), gill raker processes (27.65%), sand (26.70%), diatoms (4.82%), dinoflagellates (0.58%), filamentous algae (0.29%), foraminifers (0.16%), tintinnids (0.15%) and miscellaneous items (0.72%). No seasonal variations in the gut contents were noticed. Feeding activity was high during February, June, September and November and low during January, March, May and July. The qualitative composition of the gut contents indicated that the species is iliophagous in its food habits subsisting mainly on decayed organic matter.

7.2 Length - weight relationship

The relationship between length and weight in juveniles, males and females was found to be not significantly different. Hence, a single equation was derived.

$$\text{Log } W = -4.7894 + 2.8986 \log L$$

7.3 Size at first maturity

The lengths at first maturity for males and females were found to be between 135 and 145 mm respectively.

7.4 Maturation

The development of ova indicated that in a fully mature ovary there were two batches of ova - an immature and a mature ones widely separated from each other. This indicated that the fish spawns once in a season and the spawning is restricted to a distinct and short period (Fig. 7).

7.5 Spawning season

The species breeds during major part of the year except in December, February and March with peak seasons in January, May, June and November (Fig. 8). The availability of mature females during major part of the year except in December, February and March confirmed the above contention.

7.6 Gonado-Somatic Index (GSI)

The GSI values were found to be high during January, May and November months when the gonads were well developed.

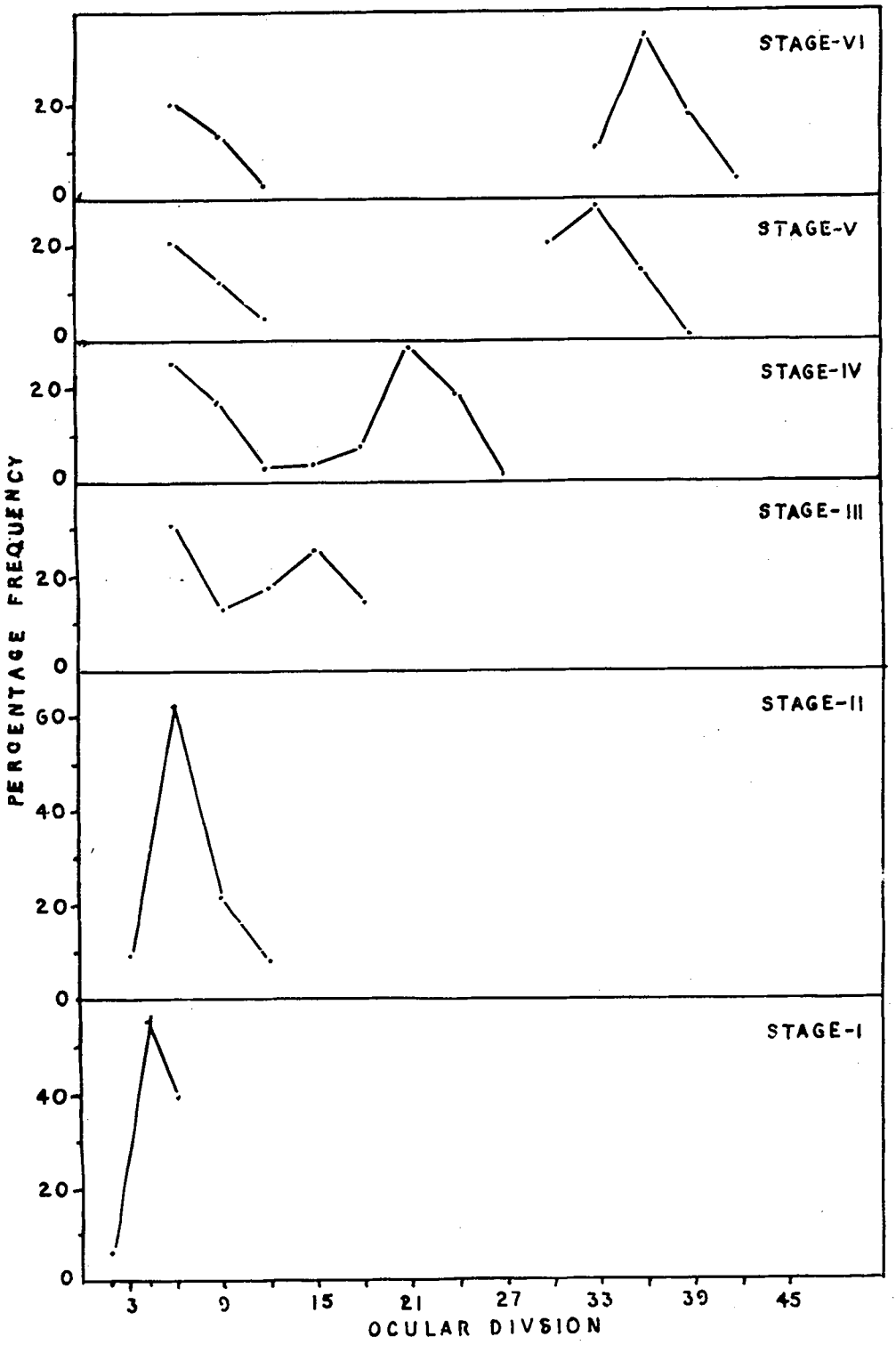


Fig. 7 Development of ova in different stages of maturity in *Valamugil cunnesius*

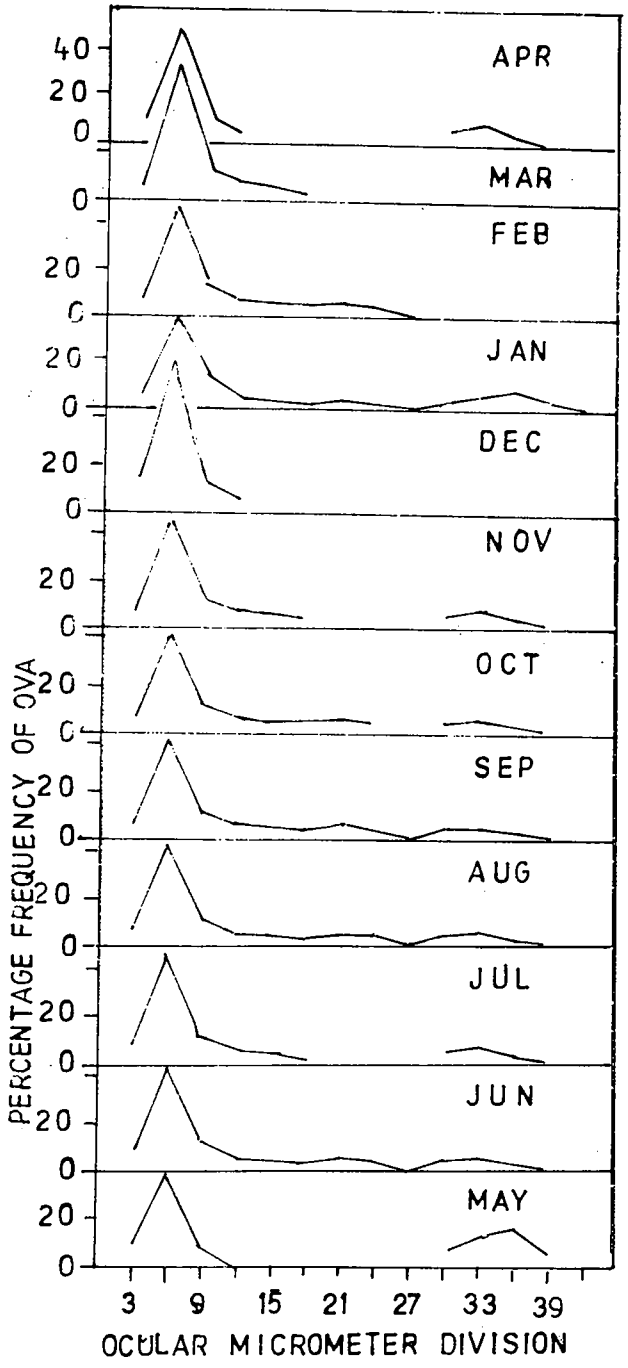


Fig. 8 Ova diameter frequency distribution in different months in *Valamugil cunnesius*

7.7 Sex - ratio

Studies on sex composition revealed the general preponderance of females over males, the ratio being 1.97 : 1.0. Males and females were available in the size range of 61 - 190 mm. However males were found to be more in the size range of 141 - 150 mm.

7.8 Fecundity

The fecundity of the species was estimated to range from 28,540 to 98,638 eggs.

7.9 Estimate of age

The length attained by the species at different ages estimated by the Probability Plot method were 82, 116, 155 mm for I, II, and III years respectively.

8. FISHERY

8.1 Fishing grounds

Mullets were caught throughout the lake. However, intensive mullet fishing was observed in areas around lake-mouth, Annamalaichery and Avirivakkam in the southern sector and Arangam, Irakkam and Venadu in the northern sector (Fig. 9).

8.2 Fishing methods

Mullets are caught by almost all the important gears of the lake 1) Shore seine : Badivalai, 2) Drag nets : Kondavalai, Panthavalai, Peria Kondavalai, Sillappuvalai. 3) Bag nets : Siruvalai and Oi-valai and 4) Gill nets : Poosanivalai, Kannivalai, Kendaivalai, except stake nets such as Suthuvalai and Kattuvalai and hook and line. However, the effective gears for mullets are briefly described here.

8.2.1 Badivalai

This is a shore seine operated in deep areas in southern sector around lake-mouth, Dhonirevukuppam and Moosamani. This is operated by 15 to 20 men and 1 or 2 boats. Leaving one end of the net on the shore a party lays the net in a semi-circular fashion from a boat and reaches the shore with the other end enclosing an area. The net is dragged closer towards the shore by the two parties and the fish caught are emptied. This net takes a wide variety of fishes and prawns (Fig. 10).

8.2.2 Oi-valai

This is a bag net of circular shape (Fig. 11). About 10 casuarina poles are tied to the circumference and the net is kept in position under water by a party of 10 men holding poles

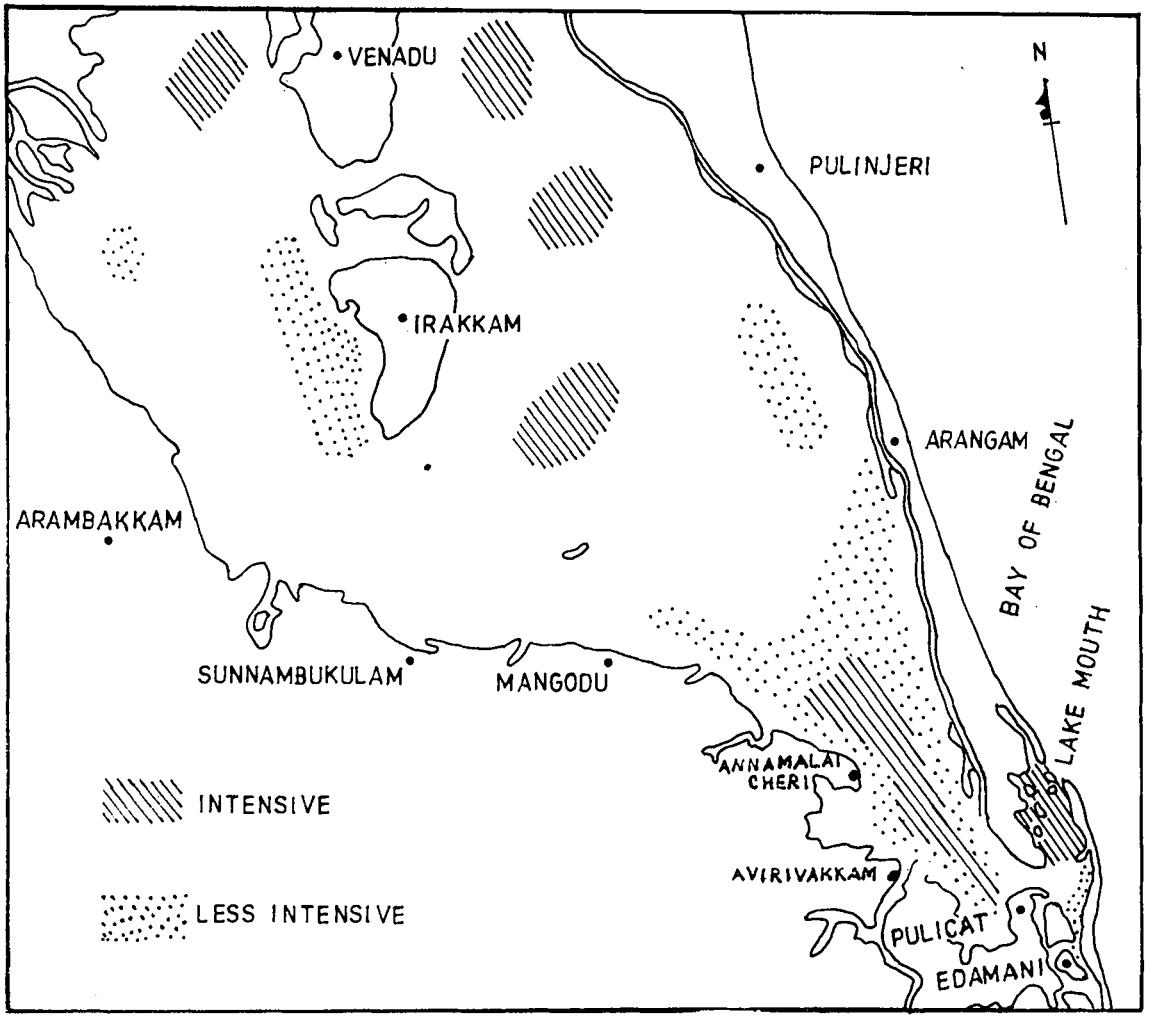


Fig. 9 Fishing grounds of mullets in Lake Pulicat

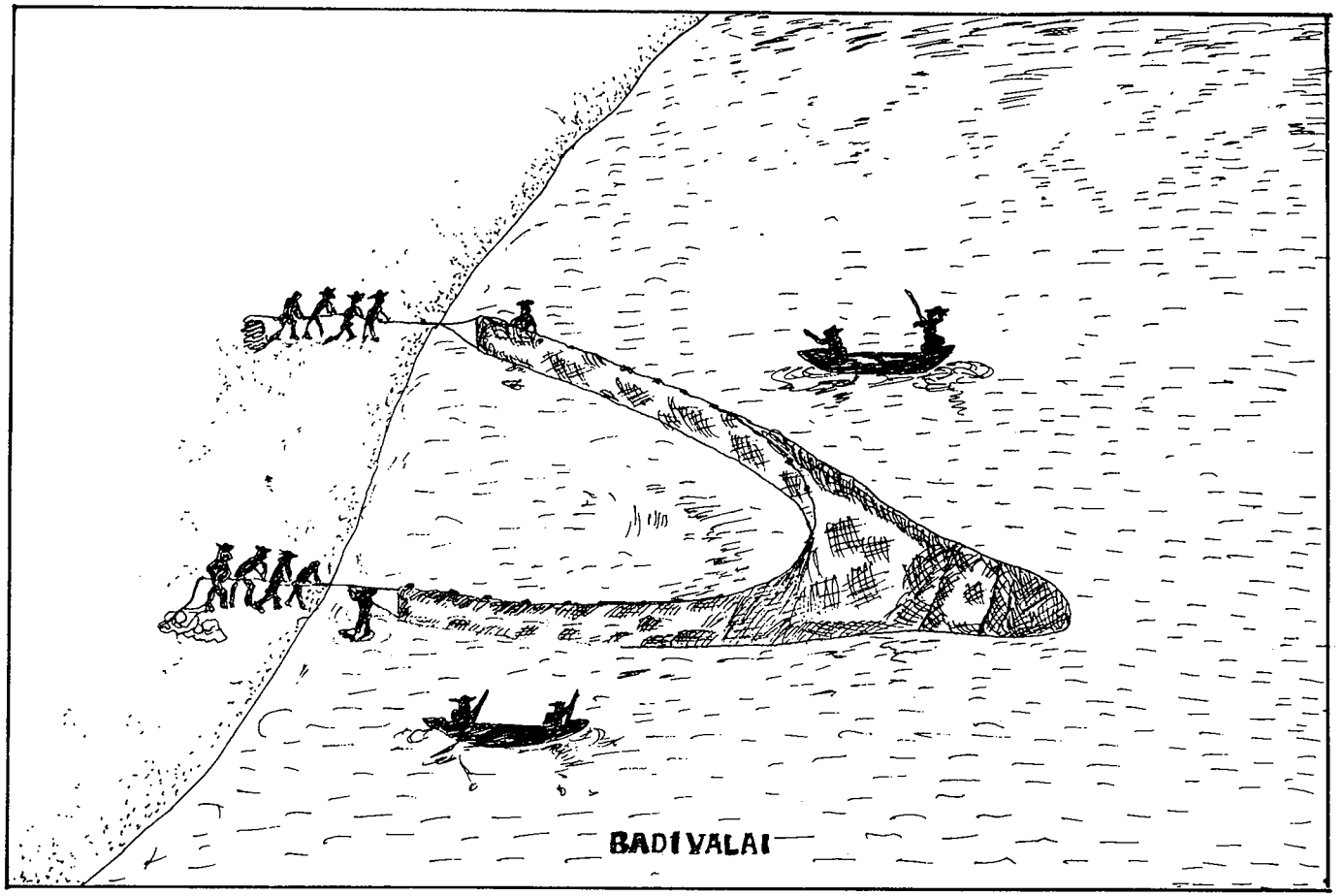


Fig. 10 "Badi Valai" in operation

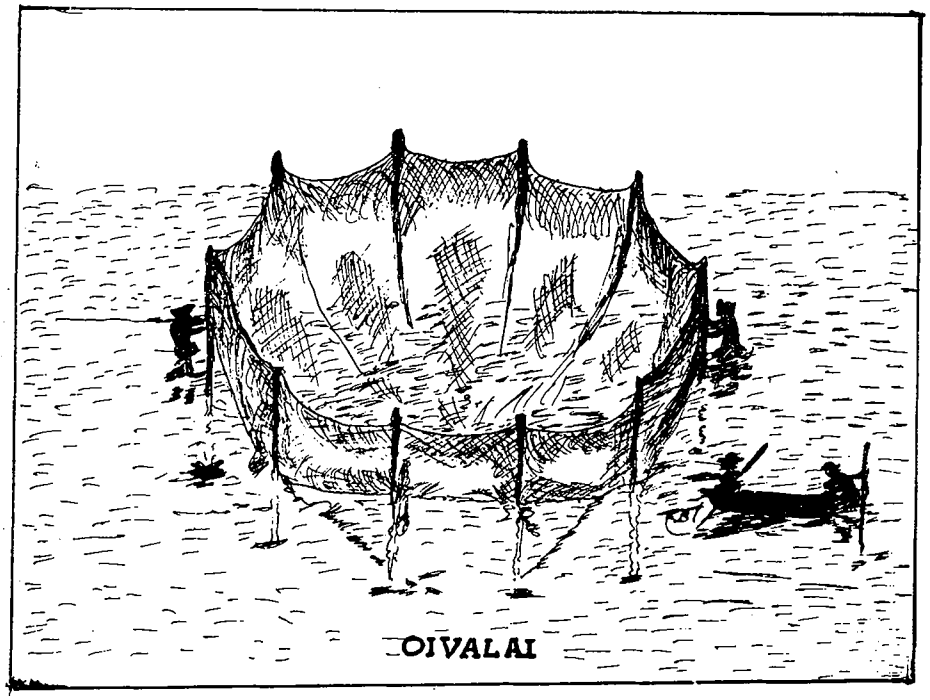


Fig. 11 "Oi-Valai" in operation

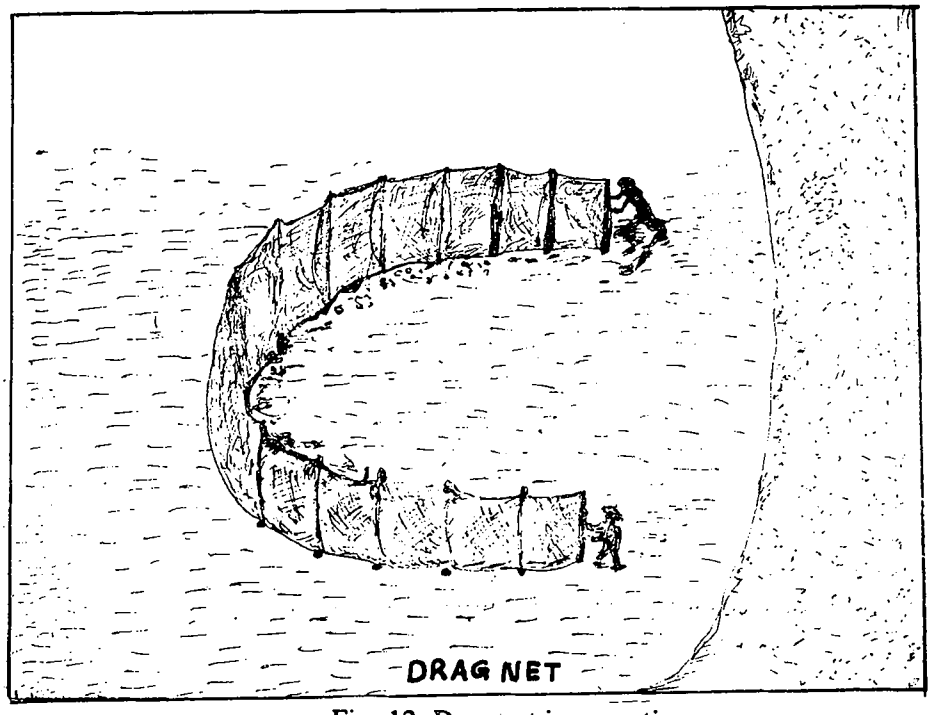


Fig. 12 Drag net in operation

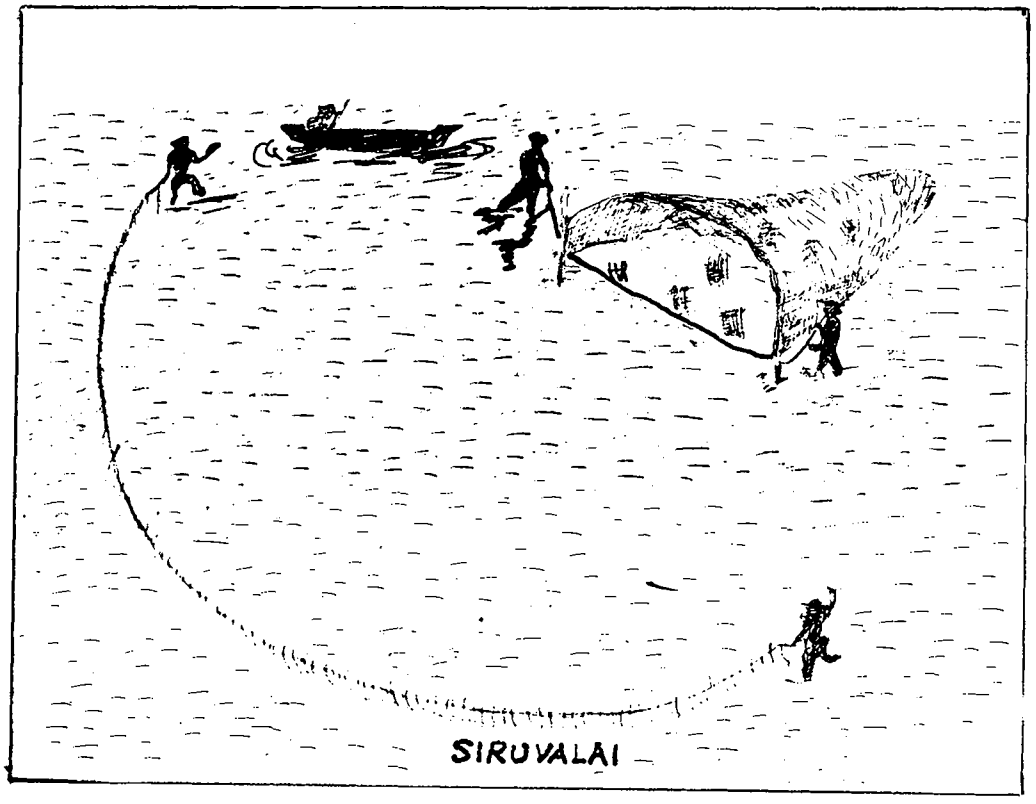


Fig. 13 "Siru-Valai" in operation

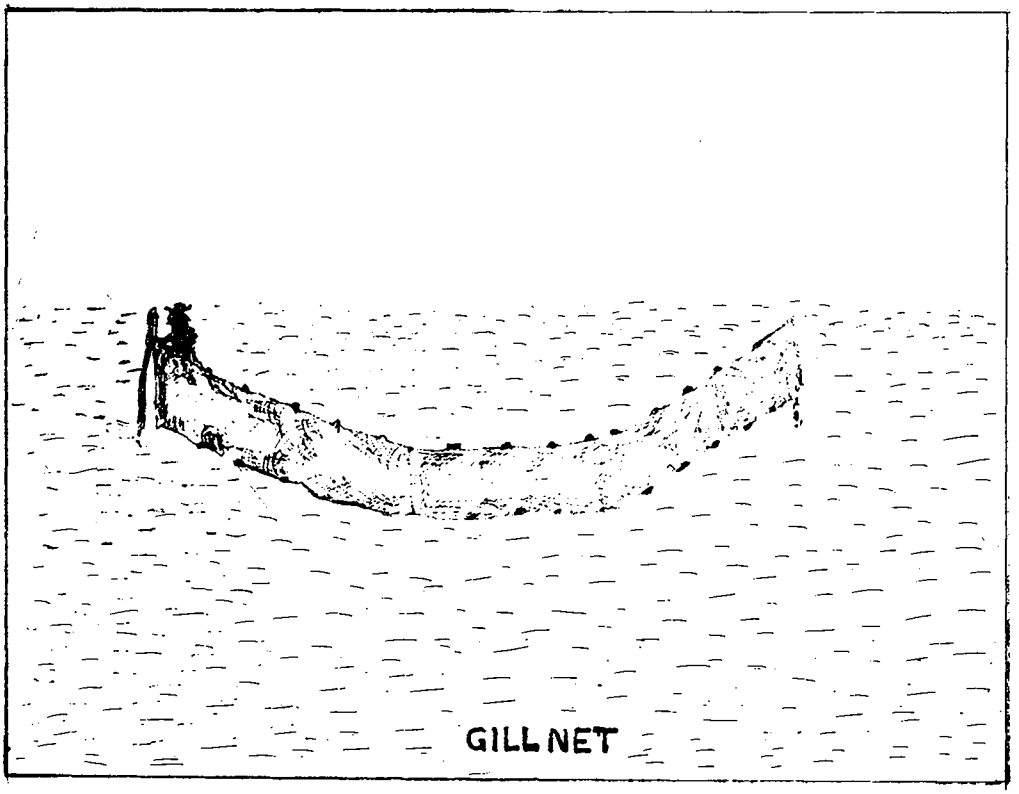


Fig. 14 Gill net in operation

vertically. A scare-line is drawn by two men towards the net and as it passes over the net, the poles are raised with the net tied to them and the tied ends of the poles are brought centrally, closing the opening and trapping the fish inside. This is operated in 1 to 2 meters depth while standing on the bottom or floating. Operation of this net is mostly confined to southern sector, south of Sunnambukulam.

8.2.3 Drag nets

A typical drag net is shown in (Fig. 12). A variety of nets classified under this category are operated in the lake. Peria-Kondavalai and Sillappuvalai are operated in northern sector while Kondavalai and Panthavalai are operated both in northern and southern sectors. The principle involved in the design and operation is almost the same in all the nets. There are variations in mesh size, length of net and number of pieces put together in operation. The sticks being smaller in size than the width of a net, the latter gets the shape of a loose bag. These nets are either dragged towards the shore or by joining a number of nets they are operated in a circular fashion enclosing an area. All the drag nets are generally operated in shallow areas of the lake.

8.2.4 Siruvalai

Operation of this net is mostly restricted to lake-mouth area and in less than waist-deep waters. The net is fixed keeping the bottom rope tight and touching the bottom (Fig. 13). A scare line is drawn near the net driving the fish into the bag portion of it. The net is lifted and the catch emptied. Siruvalai takes mostly *L. macrolepis* and *L. parsia.*

8.2.5 Gill nets

A number of nets known locally as 'Kannivalai', Kendaivalai' and 'Poosanivalai' etc. come under this type. The design in general is similar in all these nets, the difference being presence or absence of floats and sinkers. There are variations in mesh size and length nets. The width of these nets is normally about a meter and operated in shallow areas of southern sector (Fig. 14).

8.3 Magnitude of the fishery

Mullet catch fluctuated between 194 tonnes (20.95%) and 382 tonnes (27.95%) with an average of 248 tonnes (21.66%) of the total fish landings of the lake. There were two seasons in the mullet fishery, a major one during May to September and the minor one during February to March. In the mullet landings *M. cephalus* dominated (167 t), followed by *L. tade* (29 t), *V. cunnesius* (27 t), *L. macrolepis* (22 t) and *L. parsia* (3 t).

9. FIELD KEY FOR IDENTIFICATION OF MULLET JUVENILES

In Lake Pulicat, mullet juveniles of different species are available throughout the year and considerable difficulty is felt by fish farmers in recognising the different species in the field. Hence, a diagnostic key useful as a guide in the easy segregation of fast-growing species in the field, for stocking purposes in aquaculture, is provided here.

FIELD KEY FOR MULLET JUVENILES OF LAKE PULICAT

1. Body with a longitudinal streak of lateral line pigmentation; end of maxilla curved down 2

   Body without a longitudinal streak of lateral line pigmentation; end of maxilla not curved down ..... *M. cephalus* (Fig. 15)

2. Pectoral fin elongated and set above middle of body with axillary scale and dull greyish spot at axil 3

   Pectoral fin short and set at middle of body without axillary scale 4

3. Adipose eyelid present; lateral scales 32-33 ..... *V. cunnesius* (Fig. 16)

   Adipose eyelid absent; lateral scale 39 - 41 ..... *V. seheli*

4. Anal with 8 soft rays; fins black in colour ..... *L. vaigiensis*

   Anal with 9 soft rays; fins not black in colour 5

5. Pre-orbital vertical with a slight notch; posterior adipose eyelid broader than anterior in higher lengths ..... *L. parsia*

   Pre-orbital slanting without a notch; Adipose eyelid poorly developed ..... *L. macrolepis*

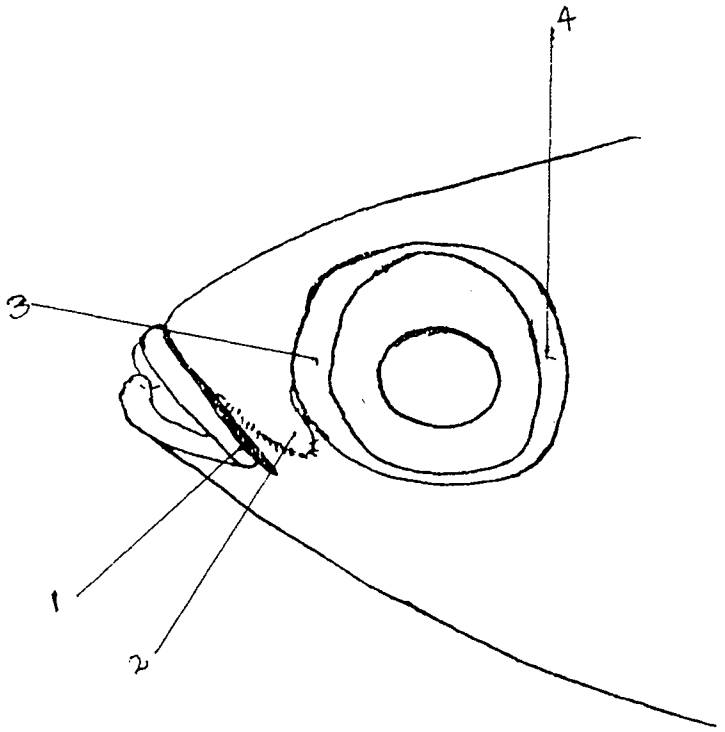


Fig. 15 *M. cephalus* (40 mm) depicting maxilla (1), preorbital (2) and adipose eyelids (3 & 4).

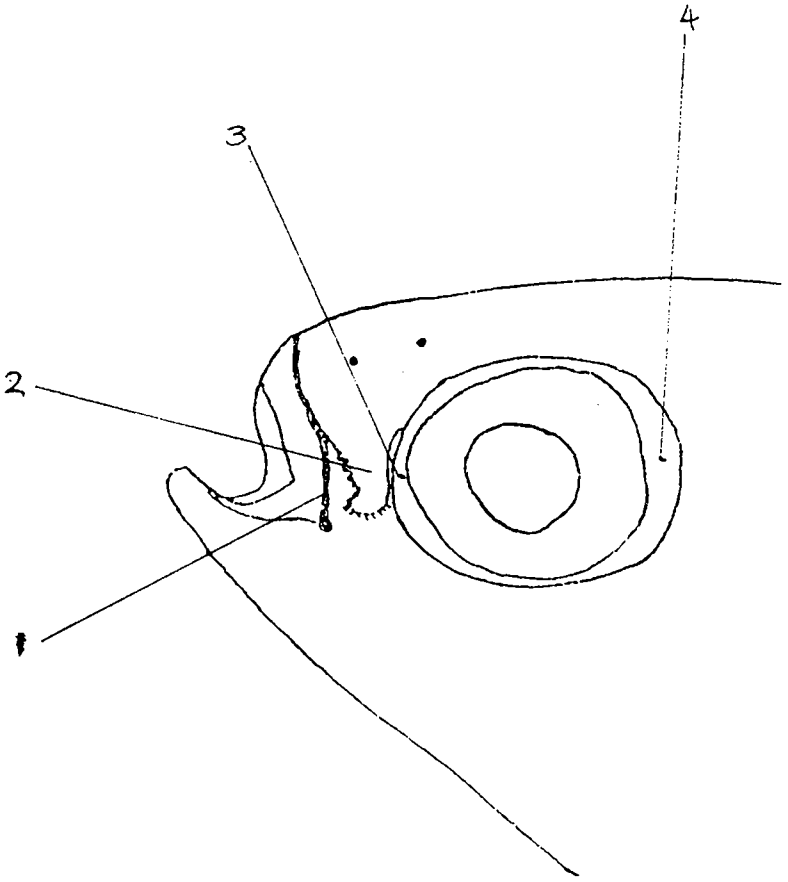


Fig. 16 *V. cunnesius* (47 mm) depicting maxilla (1), preorbital (2) and adipose eyelids (3 & 4).

10. RECOMMENDATIONS

Based on the present study, certain conservational measures are suggested for the improvement of mullet fisheries in the lake.

1. It was observed that intensive fishing was carried out at and around lake mouth and mature mullets which were on their spawning run to the sea were caught in large numbers. This practice, if not checked, would lead to the depletion of the broodstock, which would adversely affect the recruitment of young ones into the lake and the fishery in the long run. Hence, fishing may be regulated at least during the peak spawning periods at lake mouth area.

2. It was observed that many of commercial gears capture mullets of the 0 - year group. This results in capture of uneconomic sizes and poor returns to the fishermen. The capture of 0 - year group therefore must be checked by imposing mesh regulations for the nets and fixing legal minimum size for the fish, so that the younger size groups are allowed to grow to economic and profitable size.

3. It was noticed that mullet fry were caught in large quantities from the shallow areas which serve as tidal nursery grounds. This practice depletes the replenishing stock of mullets. Hence, this practice of indiscriminate collection of mullet fry must be checked.

4. Closing of the lake mouth is a common feature. But the prolonged closure prevents movement of fish from the lake to the sea for spawning and young ones into the lake for feeding. Hence, the lake mouth should be kept open throughout the year.

5. Awareness among fishermen should he created to catch only the commercial sizes and release back the undersized and mature fish into the lake.

11. CULTURE PROSPECTS

Mullets possess several characteristics desirable for aquaculture. Some of the biological attributes are : high degree of ecological and physiological flexibility; bottom feeding habit subsisting on the lower food chain; ready acceptability of formulated feeds; high market demand because of delicacy of flesh. It has been possible to breed mullets under captivity. In view of the above characteristics, mullets are one of the most suitable candidate species for brackishwater aquaculture. Recently, the shrimp farming in the country suffered serious setbacks due to outbreak of viral diseases and farmers are looking for alternate species and technology for brackishwater finfish farming. In this context, mullets assume greater importance as an alternate candidate species for brackishwater aquaculture. Thus, there is great scope for development of mullet culture to augment fish production as a source of protein food. Based on the results of the present study, experiments were conducted on mullet culture by the CIFRI / CIBA and encouraging results were obtained, paving the way for taking up mullet culture on a commercial scale.

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