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OBSERVATIONS ON THE BIOLOGY OF *HEMIRHAMPHUS GAIMARDI* (CUVIER AND VALENCIENNES) OF PULICAT LAKE

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ABSTRACT

Biology of *Hemirhamphus gaimardi* of Pulicat Lake was studied during the period 1978-80. Separate as well as combined length-weight relationship of males and females were found out. Relative condition was estimated separately for males and females. Fluctuations in the Kn value at different lengths and in different months were studied. Sex ratios were worked out for different months, years and length groups. The smallest fully mature female fish measured 102 mm in length and 50% level of maturity was noticed at 138 mm. The ovary stages were classified based on colour, appearance and size of ova. Multiplicity of modes in the frequency curves of ova diameters indicates that this fish is a continuous spawner releasing eggs in batches. The structure of a ripe egg has been described. Fecundity of the species in the size range 102-161 mm varied from 555 to 9065. Relationship of fecundity and length of fish and ovary weight, and the relationship between fish weight and ovary weight have been studied. Studies on age and growth have revealed that the fish during the first year, grows to about 100-120 mm in length. Body length-scale length relationship has been worked out. Fishery in the lake has also been studied. The fish is caught in far greater numbers during the months of April, June, August, September and November especially from the northern sector of the lake which serves as its breeding and feeding ground.

INTRODUCTION

THE GARFISH or halfbeak *Hemirhamphus limbatus* (*Hemirhamphus gaimardi* Misra, 1959) is the most common species of hemirhamphid found along the Coromandal Coast of India (Day, 1889). It constitutes a substantial fishery in Pulicat Lake, Madras. It is seen in the commercial catches all the year round.

Much of the study on halfbeaks, carried out in India was by Talwar (1962, 1967 a, 1967 b) on the biology of hemirhamphids of the Gulf of Mannar and Palk Bay. The work of Devanesan and Chidambaram (1948) on some common food fishes of the Madras Presidency has been more or less of a taxonomic nature. Nair (1952), Vijayaraghavan (1957) and Kuthalingam (1959) have studied the eggs, post-larvae and juveniles of halfbeaks along the Madras Coast. Bhattacharya (1916) and Job and Jones (1938) have described the young stages of *Hemirhamphus* of Chilka Lake.

Studies on halfbeaks by workers in other parts of the world are by Delsman (1924), Smith (1934), Roughley (1951), Ling (1958), Hattori and Seki (1959) and Collette (1976, 1981).

Except for some notes on the food and feeding habits (Kaliyamurthy and Rao, 1970) and the seasonal abundance and distribution of the species by Rao and Kaliyamurthy (1974) nothing is known about the biology or fishery of this fish in Lake Pulicat. The present paper deals with the various aspects of the biology of *Hemirhamphus gaimardi.*

The authors are grateful to Dr. A. V. Natarajan, Director, Central Inland Fisheries Research Institute, Barrackpore for his keen interest and encouragement in the present work.

Material and Methods

Material for this investigation was obtained from the commercial catches (Konda Valai and Adapu catches) of the northern and southern sectors of the lake from 1978-1980 and also from the departmental velon net catches (10 to 12 meshes per linear cm). The standard length of the fish was taken from the tip of the upper jaw to the caudal fork and recorded in millimetres. The weight of the fish was taken with the help of a physical balance.

Staging of gonads was done according to the maturity scale recommended by the International Council for the Exploration of the Seas (Wood, 1930). The maturity cycle of the species was studied by the macroscopic and microscopic examination of the gonads. To find out whether there was any apparent difference in the distribution of eggs either in the different regions (anterior, middle and posterior) of the same lobe or in the two lobes of the same ovary, measurements of ova were taken from the ovaries of three fish. It is seen from Fig. 1 that there is no significant difference in the relative number of ova of different size groups in the various regions of the ovary. Hence for studying the progression of ova a subsample from the middle region of either right or left lobe of the ovary was taken to represent the entire ovary, and subjected to detailed analysis. About hundred ova from each ovary in different stages were taken at random and their diameters recorded. Many of the ova were not found to be symmetrical and hence were measured according to Clark's (1934) method by using an ocular micrometer, each micrometer division (m.d.) being equivalent to 0.017 mm.

For fecundity studies, ovaries from mature female specimens preserved in formalin were weighed to the nearest milligram. Then a cross section of the ovary was cut and weighed and the ova in this portion were teased out and counted. Only the ova visible to the naked eye were counted. From this number, the total number of eggs in the whole ovary was computed.

The gonadosomatic index was calculated by multiplying the weight of the ovary by hundred and then dividing the product by the total weight of the fish.

Material for the study of scales was taken from the region just below the dorsal fin and above the lateral line and cleaned in water prior to examination. The scales were then projected on a screen by a slide projector maintaining the distance between the screen and the slide uniform throughout the period of study.

Length-Weight Relationship

The length-weight relationship of this fish was computed on the data collected from 452 adult specimens ranging in length from 68 to 180 mm, taken all the year round. The length-weight relationship of male and female was computed separately.

The length-weight relationship in this species conforms to the general allometric formula $W = cL^n$, where W is the weight of the fish in grams, L is the length of the fish in millimeters and c and n are constants. Expressed logarithmically,

$$\text{Log } W = c + n \text{ Log } L$$

The values of ' c ' and ' n ' were calculated by the method of Least Squares (Snedecor, 1961).

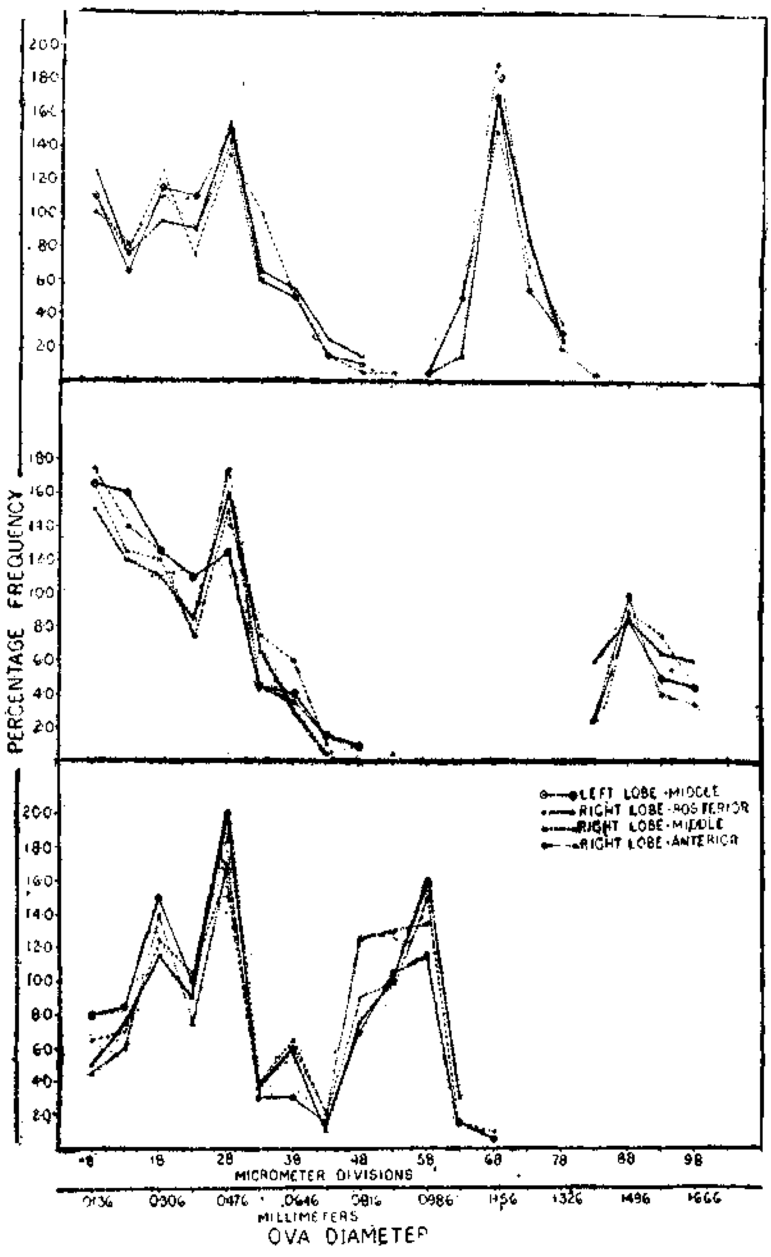

FIG. 1. Measurements of ova in different regions of the ovary of three mature fish of lengths 138 mm, 139 mm and 144 mm (*H. gaimardi*) in sections a, b and c respectively.

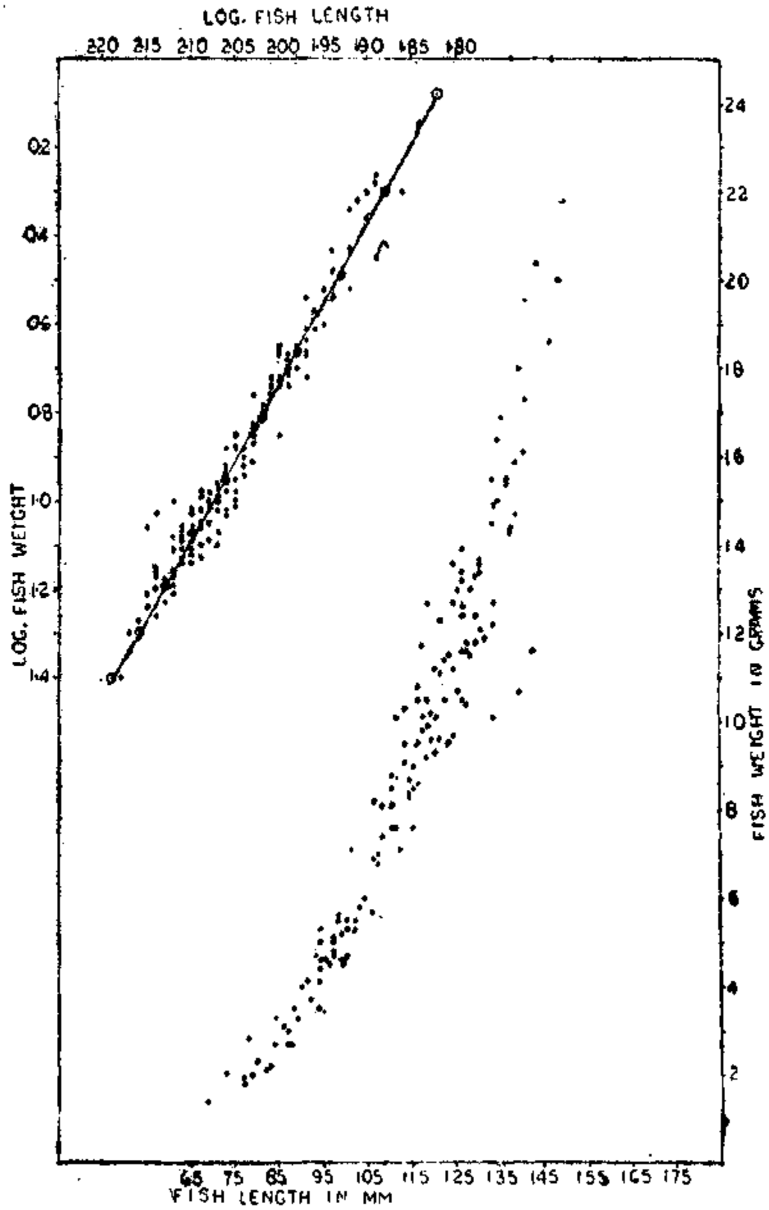

FIG. 2. Length-weight relationship of *H. gaimardi* (males).

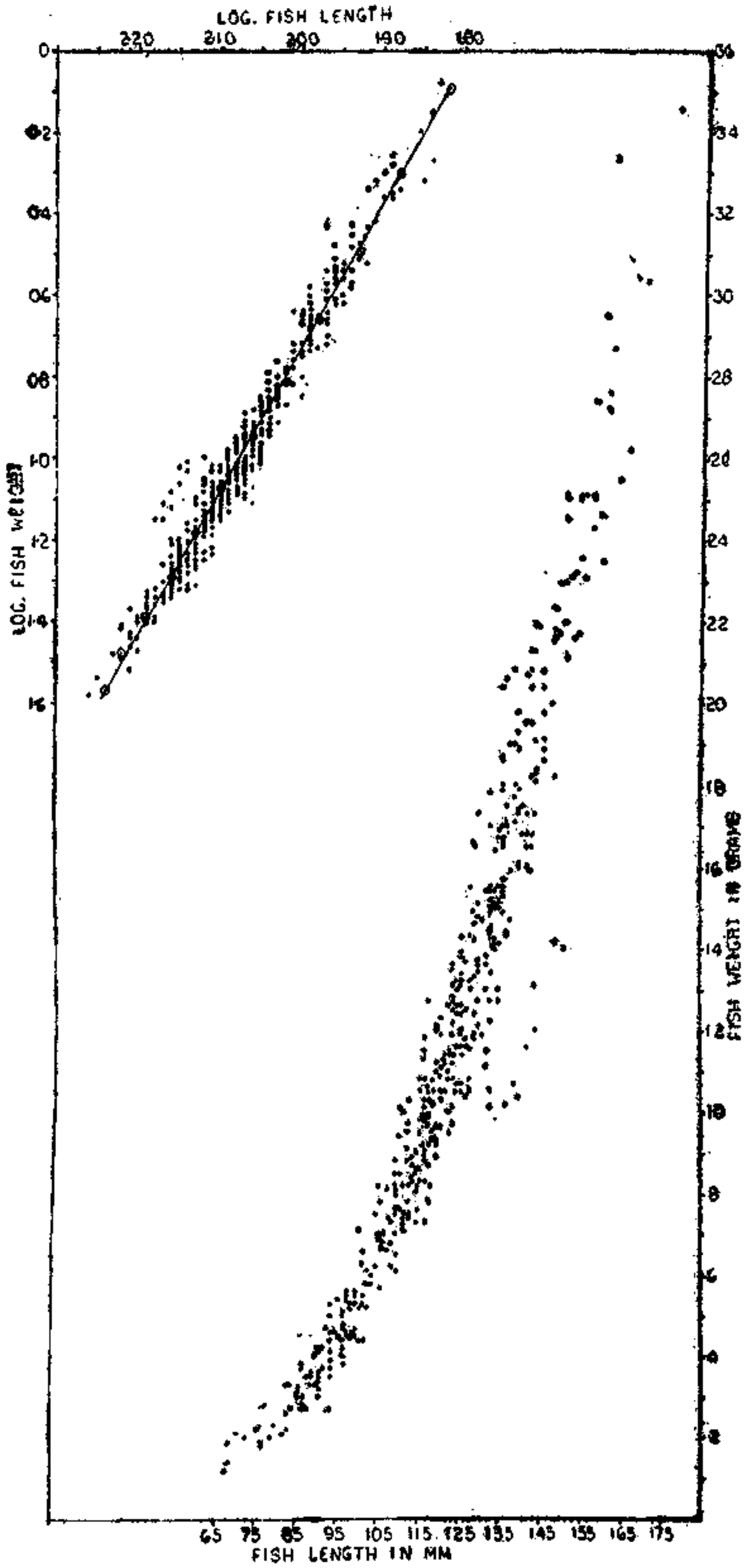

FIG. 3. Length-weight relationship of *H. gaimardi* (females).

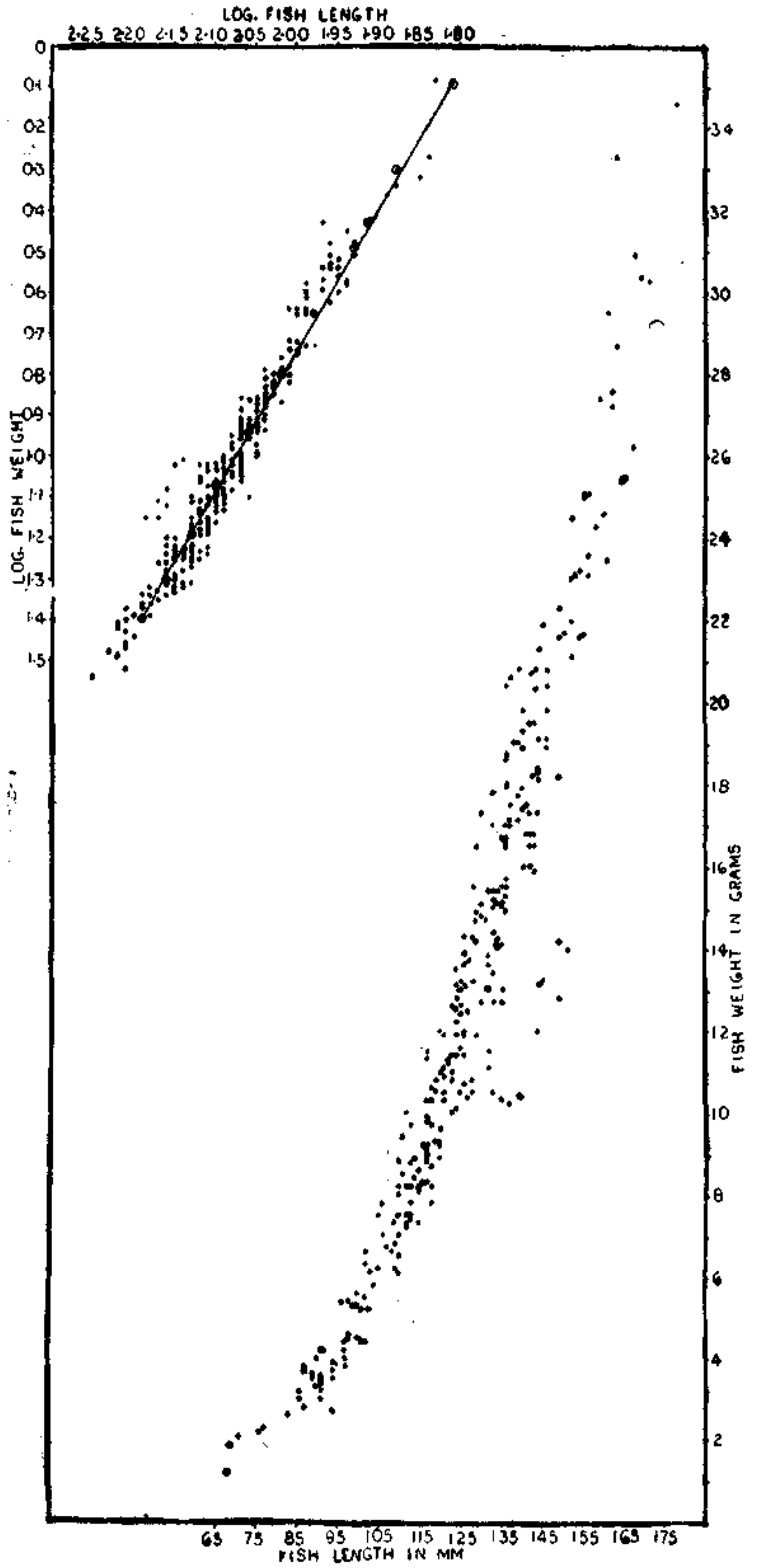

FIG. 4. Length-weight relationship of *H. gaimardi* (males and females combined).

Males : Log W = — 6.2580 + 3.4924 Log L

Females : Log W = — 6.2176+3.4704 Log L

The regression coefficients of males and females were statistically compared by the analysis of co-variance (F-regression test Paulraj and Mullainathan, 1981). The test having shown no significant difference in the relationship between males and females (Table 1), the combined relationship for both males and females was calculated and expressed as

Log W = — 6.2144 + 3.4696 Log L

The curvilinear relationship between the length and weight was established and the log-log relationship is also shown in Fig. 2, 3 and 4.

Relative Condition

The relative condition 'Kn' (Le Cren, 1951) was estimated separately for males and females from the formula $W/\hat{W}$ where W is the observed weight and $\hat{W}$ is the calculated weight of the fish.

Fluctuations in Kn at different lengths were studied (Fig. 5). Kn values were found to be very high in the youngest size groups—65 mm in males and 65 mm and 85 mm in females. These high Kn values can be attributed to the high feeding intensity of the young growing fish. Thereafter there is a rise in the Kn value at 105 mm in males and 125 mm in females. The peaks and troughs in relation to condition in the older size groups can be attributed chiefly

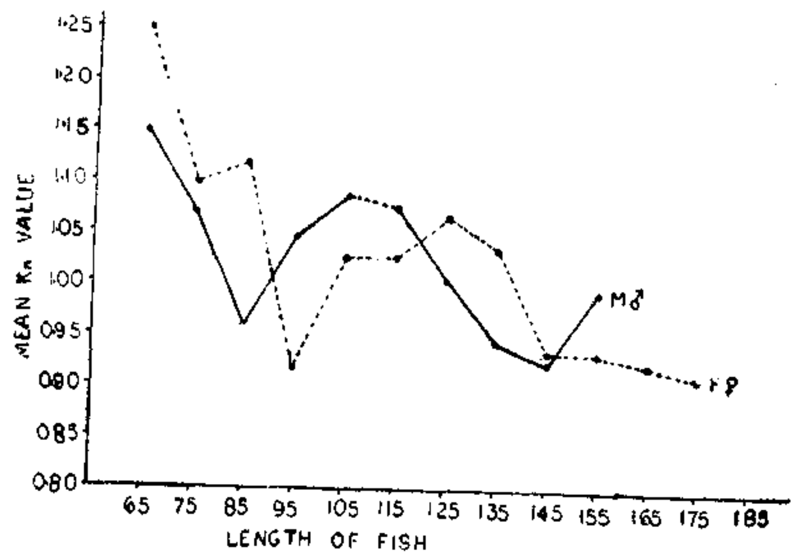

FIG. 5. Lengthwise fluctuations in the mean Kn value of *H. gaimardi*.

TABLE 1 A. *Length-weight relationship* (H. gaimardi) *expressed by the Least Square equation y=a+bx*

Relationship examined	Sex	Regression equation	r^2x 100	SD*	t-regression
x=length of fish	Male	y= —6.2580+3.4924 Log L	98.14	0.0026	61.1764*
y=weight of fish	Female	y= —6.2176+3.4704 Log L	99.94	0.0001	447.6816*

* Highly significant

TABLE 1 B. *Covariance analysis for the regression Coefficients obtained in the length-weight relationship of* H. gaimardi

Relationship examined	F — regression	DF
x = length of fish y = weight of fish	0.3774	1/452

to the maturing process in the fish as manifested by increase in weight of gonads and subsequent loss in weight due to spawning activity respectively.

MATURATION AND SPAWNING

The maturity stages were classified based on macroscopic study of the gonads and microscopic examination of ova.

The ovary in *H. gaimardi* is located just above the alimentary canal in the abdominal cavity and is bilobed. The two lobes are elongated and asymmetrical in length, the left lobe being longer than the right. The two lobes form a U-shaped loop and open to the outside by a common oviduct. As the ovary becomes mature the girth or thickness of the lobes increases. In an immature ovary the lobes are slender.

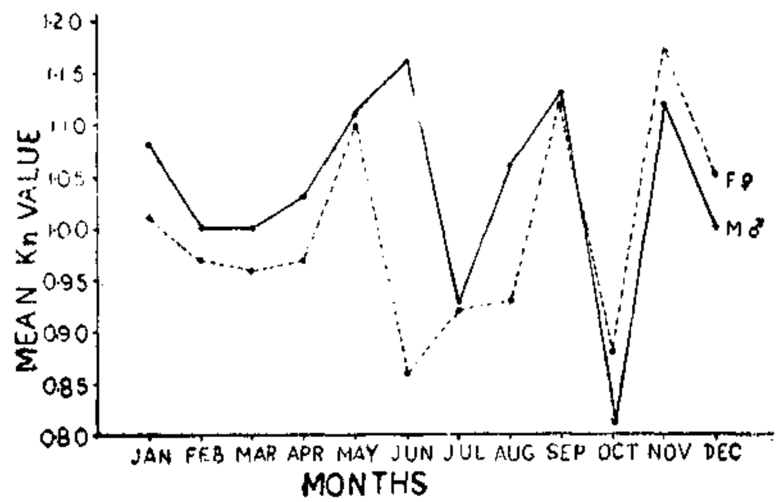

FIG. 6. Monthly fluctuations in the mean Kn value of *H. gaimardi*.

The Kn values during different months (Fig. 6) showed fluctuations clearly coinciding with the maturity and spawning activity of the fish. The peaks in Kn value seen in June, September and November in the case of males and May, September and November in the case of females coincide with the period of maturation of gonads and the subsequent fall seen in June, October and December in males and July, October and December in females reflect the spawning activity.

Classification of maturity stages based on colour, appearance and size of ova

Stage I : Ovary pale white in colour, transparent, slender, small and ova not visible to the naked eye. The mode of the largest groups of ova falls at 3 m.d., maximum size of ova upto 28 m.d.

Stage II : Ovary pale white in colour, slightly slender, small, transparent, ova visible to the naked eye. The mode of the largest groups of ova falls at 8 m.d., maximum size of ova being 38 m.d.

Stage III : Ovary pale yellow in colour, ovary lobes become slightly thicker, opaque ova ; modes of the largest groups of ova fall at 18 m.d. and 28 m.d., maximum size of ova recorded being 78 m.d. ; ovary occupying nearly half of the body cavity.

Stage IV : Ovary yellow in colour, lobes of ovary become thicker, opaque ova ; modes of the largest groups of ova fall at 28 m.d. and 48 m.d., maximum size of ova recorded being 83 m.d. ; ovary occupying more than half of the body cavity.

Stage V : Ripe ovary yellow in colour, ovary lobes much thickened, ova attaining a golden yellow transparency, ova have burst from the follicles ; modes of ova falling at 28 m.d., 48 m.d., 58 m.d., 78 m.d. and 88 m.d. ; maximum size of ova being 113 m.d. ; ovary occupying more than half of the body cavity.

Stage VI : Spawning ovary, with large transparent ova, white in colour, modes of ova falling at 28 m.d., 48 m.d., 58 m.d. and 68 m.d. ; maximum size being 88 m.d. ; ovary occupying more than half of the body cavity.

State VII : Spent ovary, lobes of ovary flabby and contracted, a few large transparent ova seen in the ovary, modes of ova falling at 8 m.d., 23 m.d. and 38 m.d. A few ova upto 53 m.d. recorded.

Clark (1934) Hickling and Rutenberg (1936), De Jong (1939), Prabhu (1956) and others have shown that it is possible to determine the time of spawning and the spawning periodicity of fishes by ova diameter frequency studies.

Material for this study was taken from samples collected from April 1978 to November 1980. It is seen from Fig. 7 that several size groups of ova are present in a mature ovary. The first group with a mode at 8 m.d. represents the immature eggs, invisible to the naked eye and far exceeding the numbers in all other groups. The other groups are having modes at 18 m.d., 28 m.d., 38 m.d., 78 m.d., and 88 m.d. The size groups of ova from 18 to 68 m.d. are opaque and visible to the naked eye. The groups of ova between 73 and 93 m.d. include the ripe eggs which are ready for spawning.

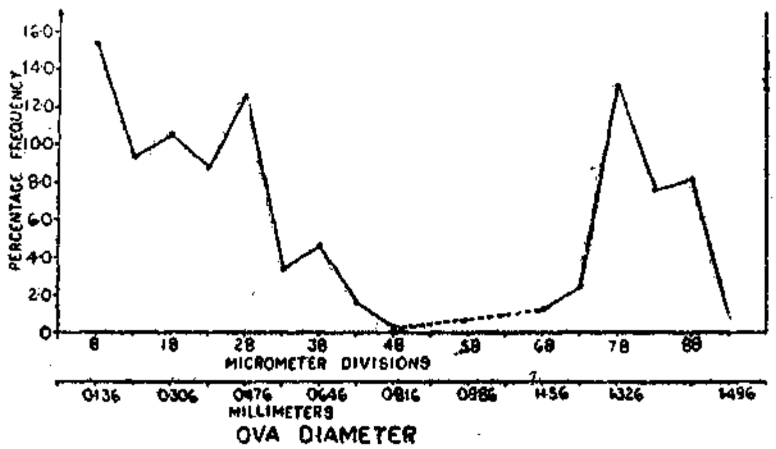

FIG. 7. Frequency polygon of the diameter of 500 ova measured from a matured female fish (*H. gaimardi*).

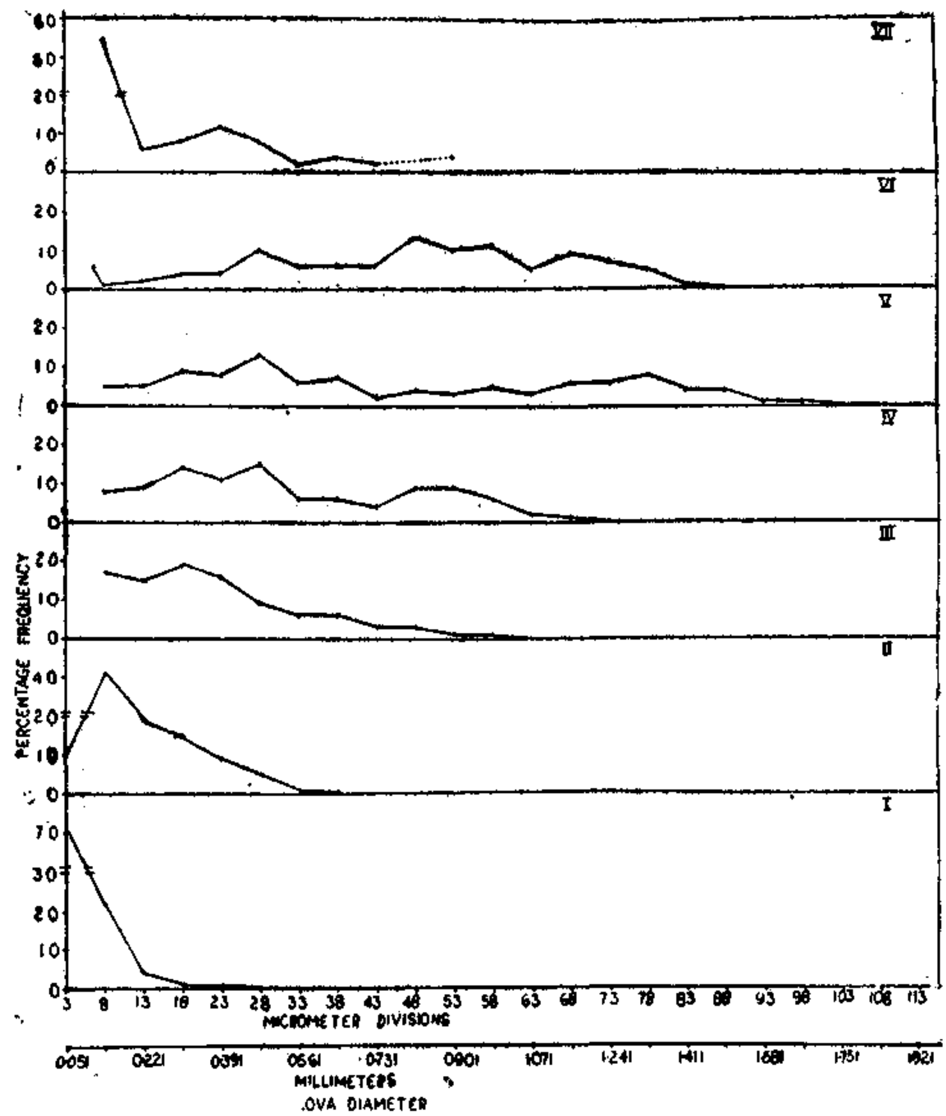

FIG. 8. Ova diameter frequency of *H. galmardi* (April 1978-November 1980).

The frequency distribution of ova diameter measurements is presented in Fig. 8. Ova measuring less than 8 m.d. in diameter were not taken into account from Stage III onwards, since these ova were present in the ovary of all stages of maturity.

The ovary in Stage I contained only minute transparent eggs with a single mode at 3 m.d. In Stage II the ova diameter mode was seen to fall at 8 m.d. In Stage III two modes were seen at 18 m.d. and 28 m.d. In Stage IV modes were observed progressing between 28 m.d. and 48 m.d. In stage V (mature ovary) 5 modes were seen in 28, 48, 58, 78 and 88 m.d. This multiplicity of modes is seen in the frequency curves of ova diameters of all mature females. In Stage VI ovary also, multiple modes are seen at 28, 48, 58 and 68 m.d. In Stage VII the largest eggs must have been released and so the modes are seen only at the smaller sizes *viz.*, 8, 23 and 38 m.d.

Multiplicity of modes in the frequency curves of ova diameters from maturing females suggests that the individual fish spawns more than once in each spawning season, as seen in the oil sardine (Clark, 1934). It is evident that this fish is a continuous spawner releasing eggs in batches. The secondary modes indicate the growth of intraovarian eggs which are ready for release in the next batch.

Table 2 presents the percentage occurrence of gonads in various stages of maturity during different months from April 1978 to November 1980. The presence of fully ripe ovaries (Stage V) from January to December further indicates that this fish is a continuous spawner. However during April, July/August and November, the percentage of fishes with fully ripe ovaries was more than in other months, indicating peak spawning activity during these months.

A study of the gonadosomatic index during different months (Fig. 9) revealed that the index values are high during the months of April, August and November coinciding with the peak spawning periods.

Hence it can be concluded from the above observations that this halfbeak breeds continuously throughout the year in Pulicat Lake. A protracted spawning period is noted by Ling (1958) in the Australian garfish *Reporhamphus melanochir*, from late September to early March with two peaks in October/November and February. On the other hand Talwar (1962, 1967a) has observed only short and restricted spawning periods in the halfbeaks of the Gulf of Mannar and Palk Bay area; March/April and November/December in the case of *Hyporhamphus georgii* and *Hemirhamphus marginatus* respectively.

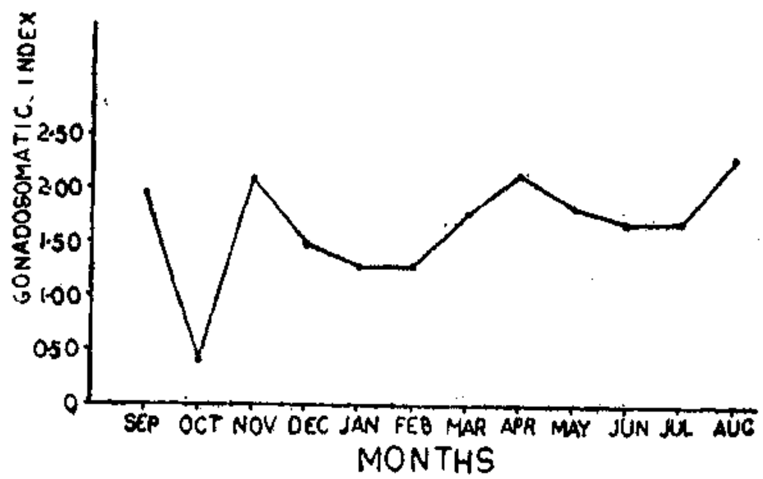

FIG. 9. Gonadosomatic index of *H. gaimardi* for different months (September 1978-August 1979).

The most advanced stages of eggs liberated from a mature ovary are spherical and transparent. The structure of a ripe ovum ready for release from the fish and measuring 95 m.d. in diameter is given in Fig. 10. The outer surface of the ovum is seen to have small spine-like outgrowths. One or two long and

TABLE 2. *Percentage occurrence of ovary in different stages of maturity* (H. gaimardi) *April 1978 to November 1980*

Month	No. of fish	Stages of maturity						
		I	II	III	IV	V	VI	VII
January	92	58.69	7.61	8.70	16.30	8.70	..	..
February	117	31.62	16.24	17.10	23.93	10.26	..	0.85
March	64	28.12	12.50	23.44	26.56	9.38	..	..
April	92	9.78	1.09	9.78	23.91	32.61	20.65	2.18
May	58	8.62	17.24	10.34	44.83	18.97	..	..
June	74	13.51	2.70	10.81	47.30	25.68	..	..
July	79	10.13	6.33	7.59	31.65	35.44	2.53	6.33
August	78	12.82	3.85	10.26	35.90	32.05	2.56	2.56
September	93	25.81	8.60	20.43	33.33	11.83	..	..
October	32	56.25	21.88	12.50	6.25	3.12	..	..
November	37	29.73	21.o2	5.41	10.81	32.43	..	..
December	40	45.00	7.50	10.00	25.00	12.50	..	..

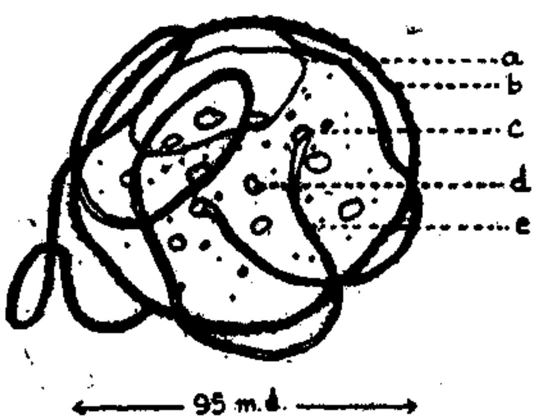

FIG. 10. The structure of a ripe ovum of *H. gaimardi*: a. yolk platelet; b. spine-like outgrowths; c. base of filament; d. oil droplet and e. filament.

coiled filaments are seen arising from the surface of the ovum. The base of the filament is clearly seen. Transparent oil droplets and dense yolk droplets are interspersed in the interior of the ovum. The yolk is also seen in the form of a dense platelet. The presence of filaments in the eggs of other hemirhamphid species and their usefulness in attachment to the weeds after release into the external environment have been noted by many authors (Jones, 1946; Devanesan and Chidambaram, 1948; Roughley, 1951; Ling, 1958; Vijayaraghavan, 1957; Talwar, 1967).

SIZE AT FIRST MATURITY

444 female fish were studied for estimating size at first maturity. Fish with gonads in Stage IV and above were considered as mature. The smallest fully mature female fish measured 102 mm in length and 50% level of maturity was noticed at 138 mm (Fig. 11).

SEX RATIO

Studies on sex ratio have been based on 1474 specimens of length range 68 to 180 mm collected during the years 1978-1980. Percentage of each sex has been computed for each month, year and length group. The observed ratios were tested against an expected 1 : 1 ratio by the method of X^2.

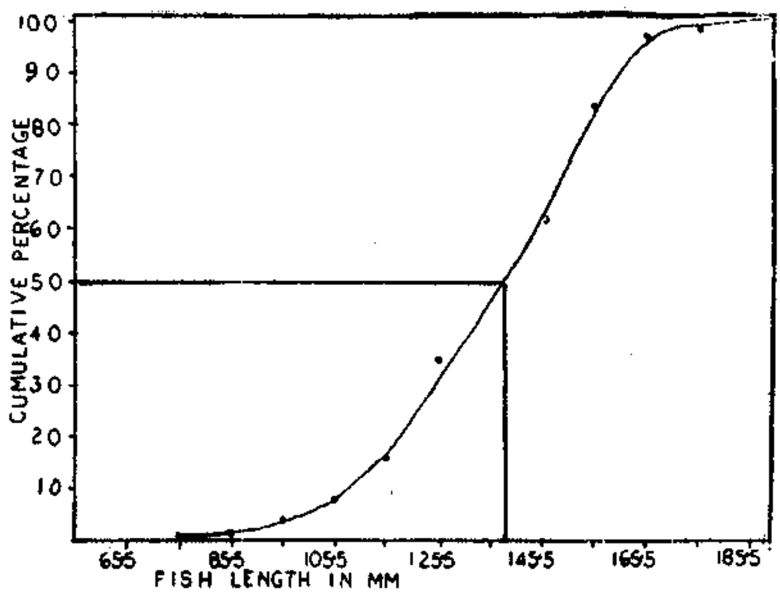

FIG. 11. Relationship of maturity to length of *H. gaimardi* (females).

It can be seen from Table 3 that during the years 1978, 1979 and 1980, the differences in sex ratios from 1 : 1 are highly significant at the 5% level.

X^2 values are insignificant at the 5% level during the months of May, June and November. In all the other months X^2 values are significant, high values of significance being noted in January, August and September with a preponderance of females.

An evaluation of the probability of equal abundance of the sexes in each length group, showed that upto a length of 100 mm there was no significant departure from the expected 1 : 1 ratio. The females, however were significantly more abundant in the higher size groups. It is noted that in the 121 to 130 mm length group the sexes are more or less equally abundant.

Predominance of females in the catches has been noted by Ling (1958) in the Australian garfish. In the case of the halfbeaks of the Gulf of Mannar and Palk Bay there is a predominance of males in the catches (Talwar, 1962, 1967 a, b).

FECUNDITY

Fecundity was determined from the examination of 99 specimens ranging in size from 102 mm to 161 mm and found to vary from 555 to 9065. The fecundity of *Hyporhamphus georgii* of the Gulf of Mannar was estimated to range from 1110 to 3430 (Talwar, 1962) and that of *Hemirhamphus marginatus* of the same area from 4248 to 8930 (Talwar, 1967). Ling (1958) noted that the number of eggs spawned by *Reporhamphus melanochir* is relatively small, ranging from 9000 to 10,000.

Relation between fecundity and length of fish

The relationship of fecundity and fish length was studied by the formula $F=AL^n$, where 'F' is the number of ripe ova, 'L' the length of the fish and 'A' the constant and 'n' the exponent expressing the relationship between number of eggs and the length of the fish. Expressing

TABLE 3. *Sex Ratio*

Year		No. of males	No. of females	Total	% of males	% of females	Chi-square	Significance
				(i) For different years				
1978	..	144	301	445	32.36	67.64	55.39	**
1979	..	201	374	575	34.96	65.04	52.05	**
1980	..	171	283	454	37.67	62.33	27.63	**
Total	..	516	958	1474	35.01	64.99		
Test of heterogeneity : df Sum of 3 chi-squares 2 : 135.07 Pooled chi-square : 132.54								
				(ii) For different months				
January	..	52	133	185	28.11	71.89	35.46	**
February	..	84	119	203	41.38	58.62	6.03	*
March	..	73	101	174	41.95	58.05	4.51	*
April	..	60	113	173	34.68	65.32	18.24	*
May	..	43	59	102	42.16	57.84	2.51	NS
June	..	61	74	135	45.19	54.81	1.25	NS
July	..	43	79	122	35.25	64.75	10.62	*
August	..	19	78	97	19.59	80.41	35.89	**
September	..	38	93	131	29.01	70.99	23.09	**
October	..	8	32	40	20.00	80.00	14.40	*
November	..	22	37	59	37.29	62.71	3.81	NS
December	..	13	40	53	24.53	75.47	13.75	*
Total	..	516	958	1474				
Test of heterogeneity : df sum of 12 chi-square 11 : **157.56 Pooled chi-square : 132.54								
				(iii) For different length-groups				
61-70	..	1	3	4	25.00	75.00	1.00	NS
71-80	..	23	17	40	57.50	42.50	0.90	NS
81-90	..	27	41	68	39.71	60.29	2.88	NS
91-100	..	50	57	107	46.73	53.27	0.46	NS
101-110	..	57	84	141	40.43	59.57	5.17	*
111-120	..	83	140	223	37.22	62.78	14.57	*
121-130	..	169	172	341	49.56	50.44	0.03	NS
131-140	..	81	214	295	27.46	72.54	59.96	**
141-150	..	21	142	163	12.88	87.12	89.82	**
151-160	..	4	72	76	5.26	94.74	60.84	**
161-170	..	..	13	13	..	100.00	..	..
171-180	..	..	3	3	..	100.00	..	..
Test of heterogeneity : df Sum of 10 chi-squares 9 .. 235.63 Pooled chi-square 132.54								

* Differences significant
** Differences highly significant
NS Differences insignificant

logarithmically, the relationship was calculated as

$$\text{Log } F = -2.9295 + 2.9475 \text{ Log } L$$

with the correlation coefficient 'r' being 0.5439, which indicates a positive correlation between the two variables (Fig. 12) as value of 'b' is 2.9475, very close to 3 the fecundity is found to be related to cube of the length of the fish. This agrees with the observations made by Simpson (1951) for plaice and Rao (1981) in case of *Mystus gulio.*

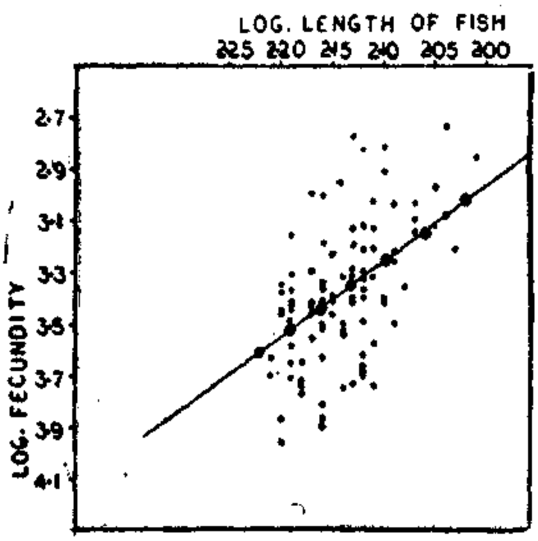

FIG. 12. Relationship between length and fecundity of *H. gaimardi*.

Relation between fecundity and ovary weight

The relationship between fecundity and ovary weight, was found to be

$$\text{Log } F = 1.1191 + 0.8397 \text{ Log } W$$

where F is the fecundity and W is the weight of the ovary. Correlation coefficient 'r' is 0.5961 (Fig. 13). The relationship indicated that the number of ova produced was directly related to the mean weight of the ovary, and is in agreement with Hickling's (1940) observation that a close correlation should be expected between the weight of the ovary and the number of ova produced.

Relation between fish weight and ovary weight

The logarithmic relationship between fish weight and ovary weight, was calculated as

$$\text{Log } Fw = 2.0486 + 0.5276 \text{ Log } Ow$$

where Fw is the weight of the fish and Ow is the weight of the ovary. The correlation coefficient 'r' was found to be 0.4207 which indicated that though there existed a certain amount of linear relationship between these two variables they are not very closely related (Fig. 14).

AGE AND GROWTH

Analysis of length frequency distributions

It has been observed that *H. gaimardi* is a continuous spawner, as a result of which younger fish are seen almost throughout the year. Hence, no clear progression of modes could be seen from the length frequency histograms (Peterson's method) due to the extended recruitment of smaller fish into the fishery.

The length frequency distribution of 1844 specimens ranging in size from 43 to 229 mm, obtained from the *Konda valai* and *Adapu* catches of Pulicat Lake from January 1978 to November 1980 is presented in Fig. 15.

Small-sized fish are seen in March and April indicating that the fish must have spawned some two months before. In July and December also younger fish are observed as a result of spawning in April and October/November respectively.

The 45 mm mode seen in March has shifted to 65 mm by May, 95 mm by June, 125 mm by August/September, 135 mm by October and 145 mm by December. This indicates that this fish has grown to about 100 mm during a period of 10 months.

The modal value at 55 mm in July which might have occurred as a result of spawning

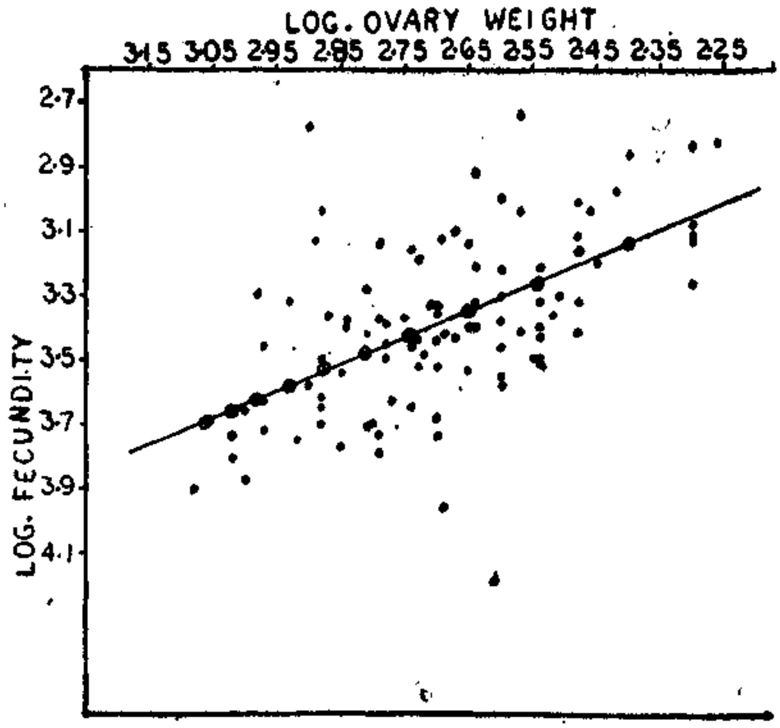

FIG. 13. Relationship between weight of ovary and fecundity (*H. galmardi*).

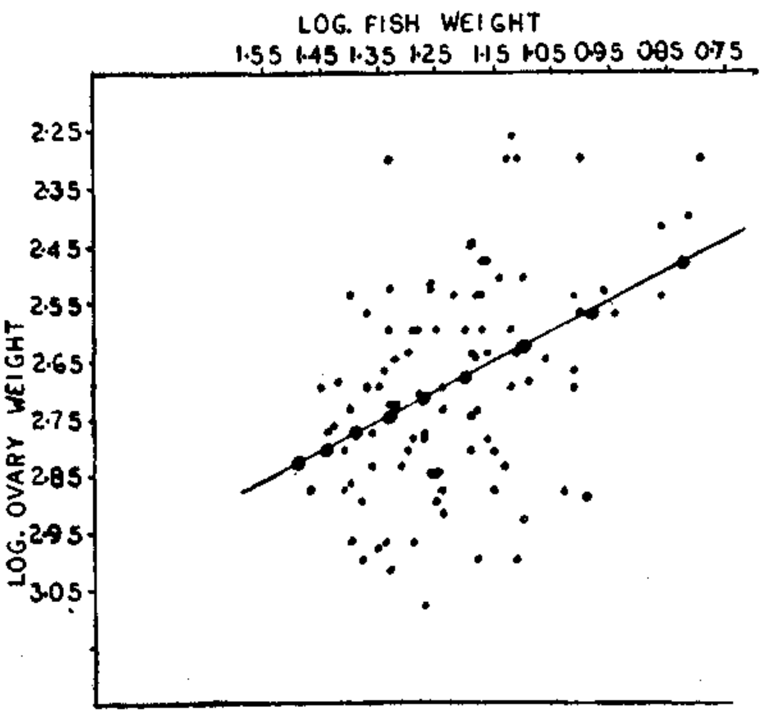

FIG. 14. Relationship between fish weight and ovary weight (*H. galmardi*).

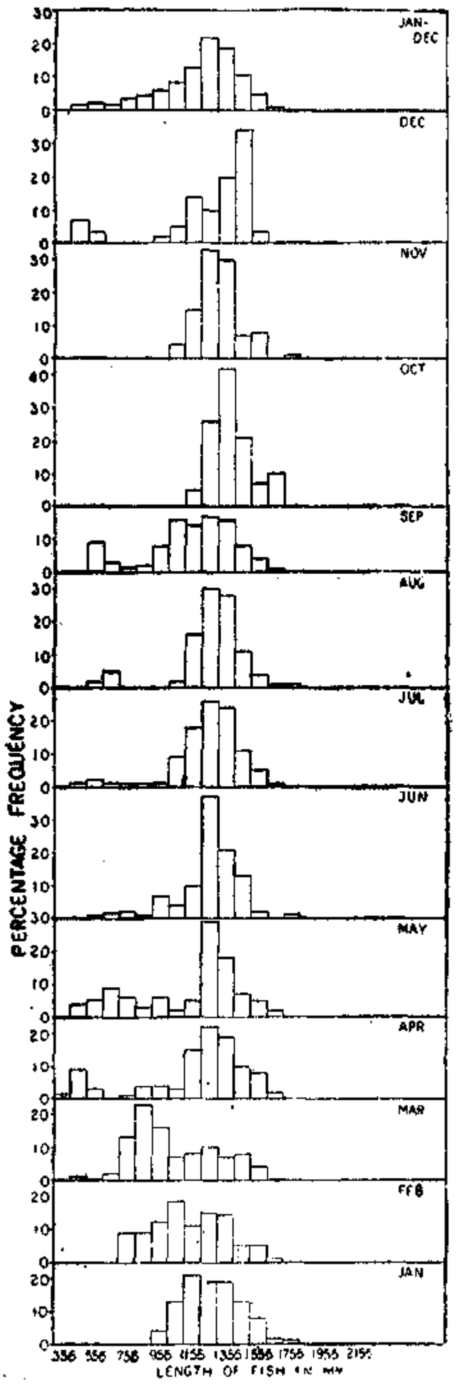

FIG. 15. Length frequency distribution of *H. gaimardi* (December 1978-November 1980).

in April/May has shown a shift to 65 mm in August and reached a size of 150 mm by December/January, thereby showing a growth of about 60 mm in six months. This agrees with the earlier observations of growth of the fish in its first year.

The progression of modes beyond this is not clear and length attained by the fish at the end of one year only can be traced from the length frequency histograms.

Segregation of age groups with the use of probability paper (Harding, 1949; Cassie 1954), was also attempted. According to this it is seen that the fish attained 100 mm at the end of one year and 130 mm at the end of the second year.

Thus it can be seen from the length frequency histograms and probability plot method that during the first year, the fish grows to about 100 to 120 mm. But the growth rate slows down and is found to be about 30 mm in the second year as shown in the probability paper. The faster growth rate during the first year and subsequent slowing down has been noticed by other workers in halfbeak fishes. Hattori and Seki (1959) have noticed that in *Hemirhamphus sajori* the fish had a growth rate of 150 to 200 mm during the first year and 10 to 50 mm during the second year. Talwar (1962) observed that in *Hyporhamphus georgii* the growth rate was 175 mm during the first year, 40 mm during the second year and 20 mm during the third year. Ling (1958) stated that in *Reporhamphus melanochir* a relatively slow rate of growth is seen in the later age groups.

Scale study : Body length-scale length relationship

Radii of scales were plotted against lengths of fish and the relationship was found to be linear (Fig. 16). The regression equation obtained by the method of Least Squares was

$$\text{Log } Y = -0.0703 + 0.7507 \text{ Log } X$$

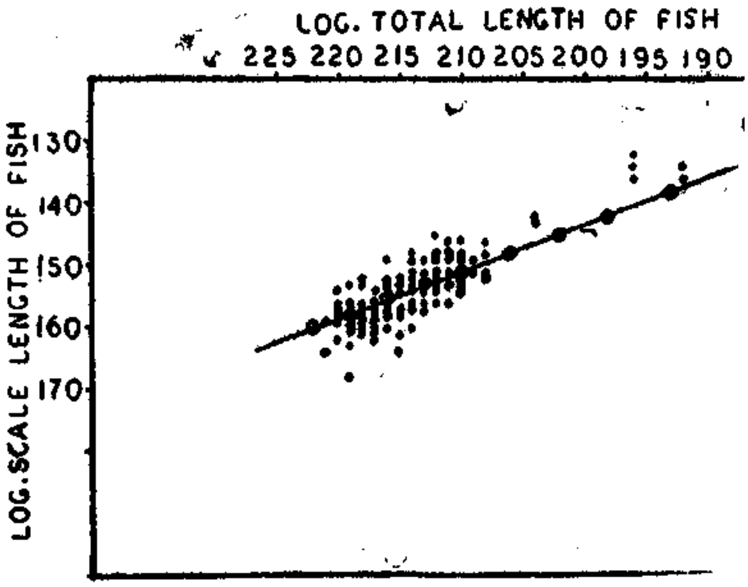

FIG. 16. Relationship between total length and scale length (*H. gaimardi*).

where Y is the scale radius and X is the length of the fish. The correlation coefficient 'r' is 0.7459 showing a positive correlation.

The study could not be continued further as the annular markings on scales were not clear. Similarly no clear markings on the otoliths also could be deciphered. Hence the study of scales and otoliths for age determination had to be abandoned.

FISHERY

It is evident from Table 4 that during the period under study, *H. gaimardi* is caught in far greater quantity from the northern sector than the southern sector of the lake. In 1977-78 the percentages of catches from the northern and southern sectors of the lake were 3.97 per cent and 0.53 per cent respectively, likewise in 1978-79 they were 3.89 per cent 0.78 per cent and in 1979-80, 3.33 per cent and 0.63 per cent. This indicates that this fish prefers the weed — infested northern part of the lake which serves as its breeding and feeding ground. Abundance of juveniles in the northern part of the lake which is characterised by dense growth of algae and *Halophila* sp. has been noticed by Rao and Kaliyamurthy (1974).

The main gear used for catching the fish is known as *Konda valai* which is a type of small drag net with stakes. *Kola valai* is the type of *Konda valai* which is used for Beloniform fishes, and is operated in the Annamalaicheri area (Krishnamurthy and Rao, 1970).

The fish is also taken from the *Adapu* catches of the lake which consist of impounding the fish by raising earthen bunds and the stranded fish caught either by hand or cast net (Krishnamurthy and Rao, 1970).

The size of the fish seen in the commercial catches ranges from 68-180 mm. The length frequency data collected during the years 1978 to 1980 show that the fish in the size group 91-160 mm are mostly seen in the catches, maximum numbers being caught in the 121-130 mm size group (22.18%). Fish of size group 131-140 mm also are seen in fairly

Table 4. *Monthly total landings from the lake and percentage composition of* H. gaimardi *in two sectors during December 1977-November 1980*

Year		Months												
		Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total for the year
1977-1978	Total catch (kg)	40262	40861	27817	23960	41722	53497	54228	49623	48335	62750	32859	45559	521473
	Northern sector %	2.89	3.30	1.76	3.37	4.46	1.80	6.50	2.47	4.62	5.95	1.89	5.96	3.97
	Southern sector %	0.62	1.28	0.29	0.47	0.65	0.25	0.23	0.67	0.49	0.43	0.50	0.56	0.53
1978-1979	Total catch (kg)	53280	30784	69146	78516	55282	60586	47590	42004	46771	67731	46296	47181	645167
	Northern sector %	3.55	2.67	3.10	1.26	2.44	5.79	4.76	2.86	7.06	5.51	2.48	5.75	3.89
	Southern sector %	0.80	1.06	1.31	1.02	0.67	0.19	0.43	0.63	0.64	0.78	0.84	0.81	0.78
1979-1980	Total catch (kg)	*	*	*	37285	36416	39862	20594	44527	45166	48002	30840	29470	332162
	Northern sector %				2.58	3.30	1.91	8.96	1.57	3.26	3.22	4.23	4.33	3.33
	Southern sector %				0.24	0.87	0.05	0.35	0.78	0.27	0.27	0.76	2.56	0.63

* No statistics collected during these months.

large quantities (19.03%). Beyond 150 mm size, the numbers seem to decrease.

The above observations indicate that the fish enters the commercial catches in greater quantities after it has attained 1 year, and that the fishery was predominated by 2 year olds.

From the three years' data compiled (Table 4) it could be seen that the species was more abundant in the catches of the northern sector during the months of April, June, August, September and November. It has been already mentioned that the peak breeding season of the species was during April, August, September and November. The abundance of the species during the above months especially in the northern sector can thus very well be correlated with their congregation in weed-infested areas (which are abundant in the northern sector) during these months.

References

BHATTACHARYA, D. R. 1916. Stages in the life history of *Gobius, Petroscirtes* and *Hemirhamphus*. *Mem. Indian Mus.*, 5 (4) : 381-392.

CASSIE, R. M. 1954. Some uses of probability paper in the analysis of size frequency distributions. *Aust. J. Mar. Freshw. Res.*, 5 : 515-522.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*) determined by ova-diameter measurements. *Calif. Fish Game*, 42 : 1-51.

COLLETTE, B. B. 1976. Indo-west Pacific halfbeaks (Hemirhamphidae) of the genus *Rhyncorhamphus* with descriptions of two new species. *Bull. Mar. Sciences*, 26 (1) : 72-98.

———— 1981. Rediscovery of *Hyporhamphus xanthopterus*, a Halfbeak endemic to Vembanad Lake, Kerala, Southern India. *Matsya*, 7 : 29-40.

DAY, F. 1889. *The fauna of British India. Including Ceylon and Burma.* Fishes—Vols. 1 & 2: 548 and 509.

DE JONG, J. K. 1940. A preliminary investigation of the spawning habits of some fishes of the Java Sea. *Treubia*, 17 : 307-327.

DELSMAN, H. C. 1924. Fish eggs and larvae from the Java Sea – A pelagic Scombrescocid egg. *Ibid.*, 5 (4) : 408-418.

DEVANESAN, D. W. AND K. CHIDAMBARAM 1948. *The common food fishes of the Madras Presidency.* Govt. Press, Madras.

HARDING, J. B. 1949. The use of probability paper for the graphical analysis of polymodal frequency distributions. *J. Mar. biol. Ass. U.K.*, 25 : 142-153.

HATTORI, J. AND M. SEKI 1959. A growth study of *Hemirhamphus sajori* by scale and size composition. *Jour. Tokyo Univ. Fish.*, 45 (1) : 27-32.

HICKLING, C. F. 1940. The fecundity of the Herring of the Southern North Sea. *J. Mar. Biol. Ass. U. K.*, 24 (2) : 619-32.

———— AND E. RUTENBERG 1936. The ovary as an indicator of the spawning period in fishes. *Ibid.* 21 (1) : 311-317.

JOB, T. J. AND S. JONES 1938. Studies on the development of the Indian garfish *Tylosurus strongylurus* (van Hass) with notes on the younger stages of *Hemirhamphus gaimardi* (Cuv. and Val.). *Rec. Indian Mus.*, 40 (3) : 245-253.

JONES, S. 1946. Breeding and development of Indian Freshwater and brackishwater fishes—Part II, *J. Bombay Nat. Hist. Soc.*, 46 (3) : 453-71.

KALIYAMURTHY, M. AND K. JANARDHANA RAO 1970. Preliminary observations on the food and feeding habits of some fishes of the Pulicat Lake. *J. Inland Fish Soc. India*, 4 : 115-121.

KUTHALINGAM, M. D. K. 1959. Observations on the food and feeding habits of post-larvae, juveniles and adults of some Madras fishes. *J. Madras Univ., B*, 29 : 139-150.

LE CREN, C. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in perch (*Perca fluviatilis*). *J. Anim. Ecol.*, 20 : 201-209.

LING, J. K. 1958. The sea garfish *Reporhamphus melanochir* (Cuvier and Valenciennes). (Hemirhamphidae) in South Australia : Breeding, age determination and growth rate. *Aust. J. Mar. Freshw. Res.*, 9 (1) : 60-110.

MISHRA, K. S. 1959. An aid to the identification of the common commercial fishes of India and Pakistan. *Rec. Indian Mus.*, 57 (1-4) : 1-320.

NAIR, R. V. 1952. Studies on some post-larval fishes of the Madras plankton. *Proc. Indian Acad. Sciences*, 35 B : 225-244.

PAULRAJ, S. AND P. MULLAINATHAN 1981. Regression (y = a + bx). CMFRI Special publication, 7: 161.

PRABHU M. S. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Indian J. Fish.*, 3 : 59-90.

RAO, G. R. M. 1981. *Studies on the biology and culture of catfishes of Pulicat Lake, India, with special reference to* Mystus gulio (*Hamilton*). Ph.D. thesis Andhra University, Waltair.

——— AND M. KALIYAMURTHY 1974. A note on the abundance and distribution of juveniles of two beloniform fishes in Pulicat Lake. *Indian J. Anim. Sci.*, 44 (10) : 810-814.

ROUGHLEY, T. C. 1951. *Fish and Fisheries of Australia.* Angus and Robertson, Sydney, London, Melbourne, Wellington.

SIMPSON, A. C. 1951. The fecundity of the plaice. *Fish. Invest. Lond.*, (2) 17, (5) : 1-27.

SMITH, J. L. B. 1934. The South African species of the genus *Hemirhamphus* Cuvier. *Trans. roy. Soc. S. Afr.*, 21 : 129-150.

SNEDECOR, G. W. 1961. *Statistical Methods.* Allied Pacific Private Ltd., Bombay. 534 pp.

TALWAR, P. K. 1962. Studies on the food and feeding relationships of the halfbeak fishes (Hemirhamphidae) from the Gulf of Mannar and Palk Bay. *Indian J. Fish.*, 9 (1) A : 1-9.

——— 1967 a. A contribution to the biology of the halfbeak *Hyporhamphus georgii* (Cuvier and Valenciennes) (Hemirhamphidae). *Ibid.*, 9 (1) A : 168-196.

——— 1967 b. Studies on the biology of *Hemirhamphus marginatus* (Forsskal). (Hemirhamphidae — Pisces). *J. mar. biol. Ass. India.*, 9 (1) : 61-69.

VIJAYARAGHAVAN, P. 1957. *Studies on the fish eggs and larvae of the Madras Coast.* University of Madras. Ph.D. thesis.

WOOD, H. 1930. Scottish herring shoals, prespawning and spawning movements. *Scotland Fish Bd. Sci. Invest.*, 1 : 1-71.