J. mar. biol. Ass. India, 1999, 41 (1 & 2) : 85 – 95

ON THE BREEDING BIOLOGY OF THE MALABAR SOLE *CYNOGLOSSUS MACROSTOMUS* NORMAN OFF KERALA

A. A. JAYAPRAKASH
Central Marine Fisheries Research Institute, Kochi-682 014.

ABSTRACT

The breeding biology of Malabar sole *Cynoglossus macrostomus* Norman, a small flatfish that supports a commercial fishery in Kerala was studied during 1994-95 and 1995-96 for maturity, spawning, fecundity and sex ratio. Both sexes attain maturity at 97 mm in total length. There are two broods in an year from the spawnings, one during the post monsoon and the other from the second spawning during the premonsoon period. Ova diameter studies showed that the individual fish spawns only once in an year. The fecundity increased with increase in length. The lowest and highest fecundity was 5021 and 64434 in 76 mm and 156 mm size groups respectively. During most of the months males dominated. Mathematical equations describing the fecundity relationships with length and weight of the fish and ovary have been worked out.

INTRODUCTION

DURING the last fifty years, in India, many accounts on the breeding biology of a number of commercially important marine fishes have been published. However, literature on the maturation, spawning, reproduction and eggs and larvae of flatfishes are scanty and mostly pertained to the immediate post independence period. Some of such studies are those of Seshappa and Bhimachar (1955) who described the maturation and spawning of the Malabar sole *Cynoglossus semifasciatus* (= *C. macrostomus* Norman), Pradhan (1964) on *Psettodes erumei*, Seshappa (1974) on *Cynoglossus dubius*, Ramanathan *et. al.*, (1977) on the large scaled tongue sole *Cynoglossus macrolepidotus*, on the eggs and larvae by John (1951), Jones and Menon (1951), Nair (1952a, b), Kuthalingam (1957), Balakrishnan and Devi (1974), and Ramanathan and Natarajan (1979).

The operation of the shrimp trawls and the extension of the fishing activities to deeper areas have resulted in the increased landing of Malabar sole. On an average the annual landings of this species amount to 15,000 t in Kerala. In view of the importance of this species a detailed study on the breeding biology of Malabar sole, *Cynoglossus macrostomus* Norman was undertaken during 1994 to 1996 to update our information on this fish. The results of the studies are discussed in the paper.

The author is grateful to the Director, CMFR Institute for the grant of study leave to pursue. Ph.D. course and also to Dr. N.D. Inasu, Professor, Dept. of Zoology, Christ College, Iringalakuda, for his guidance.

MATERIAL AND METHODS

Samples of Malabar sole for the study were drawn from the shrimp trawl landings at fisheries harbours at Cochin and Neendakara (Quilon) and from the minitrawls operating at Ambalapuzha. Weekly sampling was done at Cochin and fortnightly at other two centres. On an average about 200-250 fishes have been analysed per month from each centre.

Data Base

Centre	Gear	Period	Sample size Nos.	Size range (mm)
Cochin	Trawl	Aug. 1994 to Jun. 95	3399	55-165
		Aug. 95 to Aug 96	4348	95-170
Neendakara	Trawl	Aug. 94 to May 95	2614	60-160
		Sep. 95 to Oct. 96	5337	40-165
Ambalapuzha	Minitrawl	Oct. 94 to Sep. 95	4267	55-150
		Oct. 95 to Oct. 96	4627	55-150

Samples were preserved in 5% formalin and in the lab details such as total length of the fish (mm), weight (g), maturity stages, length (mm) and weight of the gonads (g) etc. were collected. For studying the spawning habits the ova diameter measurements from ovaries of various maturity stages were made and the growth of ova during successive stages were traced from the frequency polygons. Ova diameter measurements were taken by the method described by Antony Raja (1964). Nearly 400-500 ova per ovary from 75 fishes have been measured.

Fecundity estimation was based on mature ovaries (stage IV & V) from 88 fishes. The gravimetric method (Bagenal, 1957)

$$F = 1/2\ (n_1/w_1 + n_2/w_2)\ W$$

was followed, where F = absolute fecundity, W = total weight of the ovary in gram, w_1 and w_2 are weight of subsamples of either lobes of ovary and n_1 and n_2 represent ova from the sample weighing w_1 and w_2 respectively. For weighing an electronic balance was used.

For sex ratio studies the entire samples collected monthwise from Cochin, Neendakara and Ambalapuzha amounting to 7747, 7951 and 8894 fishes respectively were analysed.

RESULTS

Sexes are separate and can be recognised in fishes above 60-70 mm in total length, by dissecting. Unlike in other teleosts the gonads are not placed within the body cavity but lie parallel on either side of the body embedded in the musculature. The ducts from the respective gonads originate from the anterior side, unite and open on the blind side of the body. The testes are very small. In a fully grown fish of 150 mm in total length the ovaries may measure 40-47 mm compared to a maximum of 7 mm length attained by the testes.

MATURITY STAGES

Based on the macroscopic and microscopic examination of the gonads, the following maturity stages have been recognised.

Stage I : (Immature virgin). *Ovaries:* Transparent, slender, cylindrical and constitute 6.6% of Tl of fish. Av. Gonado-somatic Index (GSI) 0.21. Ova range in diameter from 0.025-0.051 mm. *Testes:* Bud like, opaque and measure 1 mm.

Stage IIa : (Developing virgin). *Ovaries:* Amber colour, yolk formation in few ova. Length 10-15% of fish Tl. Ova 0.07-0.13 mm, mode at 0.103 mm. GSI 0.34 *Testes:* Bud like, opaque, length 2 mm

Stage IIb : Recovering *Ovaries:* Thin, thread like and 35% of fish Tl. Ova of 0.03 to 0.25 mm with mode at 0.15 mm, GSI 0.511. *Testes:* Larger in size than Stage IIa, muscullar and flesh coloured.

Stage III : (Maturing). *Ovaries:* Enlarged, yellowish, 21-40% of fish T1. Ova yolked & opaque. Advancing ova with mode at 0.23 mm and developing ones 0.15 mm. GSI 1.2. *Testes:* 3 mm in length, thick & flesh coloured.

Stage IV : Mature. *Ovaries*: Yellow to yellowish orange, 30-35% in fish T1. Ova diameter upto 0.41 mm, mode at 0.36 mm and 0.28 mm. GSI 5.5. *Testes:* upto 5 mm, whitish and muscular in appearence.

Stage V : Mature. *Ovaries:* Swollen, cyst thin, occupy 37% of fish Tl. A few transparent eggs visible. Ova upto 0.62 mm. Modes at 0.41 mm and 0.21 mm. GSI 6.4. *Testes:* Length upto 6 mm, whitish and muscular.

Stage VI : Ripe. *Ovaries:* Swollen, turgid and 40% of fish Tl. Ova transparent with several oil globules, largest on 0.8 mm, mode at 0.54 mm and 0.26 mm. GSI 7.13. *Testes:* Swollen, whitish and 7 mm in length.

Stage VIIa : Partially spent. *Ovaries:* Grayish, decreased in thickness but length 40% of fish Tl. Mode of ova at 0.33 mm and at 0.21 mm. Few unspawned eggs. GSI 0.8. *Testes:* Slightly flesh coloured, reduced in size.

Stage VIIb : Fully spent. *Ovaries:* Very thin, ribbonlike and grayish. No reduction in length. Most of the eggs resorbed. Ova of size 0.03 to 0.25 mm with mode at 0.05 mm. *Testes:* Shrunken with wrinkles, length 5 mm.

Distribution of ova in the ovary

The frequency polygons of the diameter measurements of about 500 ova each from the anterior, middle and posterior regions of both the right and left ovaries (Fig. 1 a, b) indicated a similar pattern in the distribution of immature, maturing and mature groups of ova in the different regions of the ovary. The pooled data also yielded similar result. (Fig. 1c and D).

Development of ova to maturity and spawning

Ova diameter measurements from ovaries of 75 fishes of various maturity stages were taken for this purpose and the frequencies plotted as in Fig. 2. In stage II, the group of ova marked (A) of size 0.1 mm grow to 0.41 mm in stage IV. The group of ova (B) of size

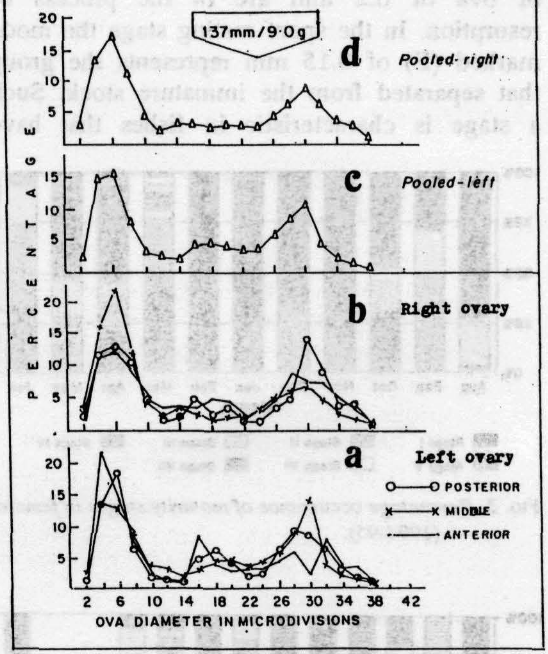

FIG. 1. *Ova diameter distribution in the mature ovary of Malabar sole.*

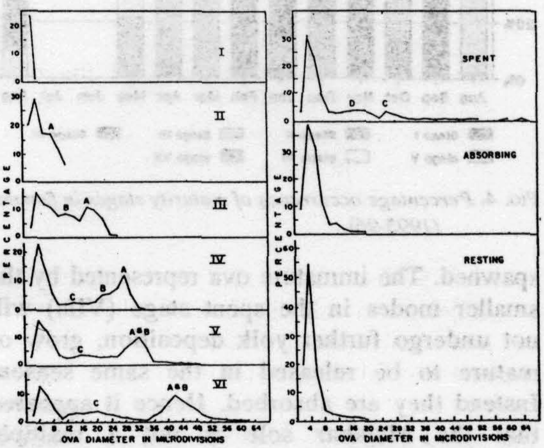

FIG. 2. *Ova diameter distribution in different stages of maturity.*

0.15 mm also grow very fast. These two groups merge in the V stage, shown as (AB). This group further attain a modal value of 0.54 mm in stage VI. In the spent stage these ova are completely shed, at the same time the group of ova of 0.2 mm are in the process of resorption. In the spent resting stage the mode marked (E) of 0.15 mm represents the group that separated from the immature stock. Such a stage is characteristic in fishes that have

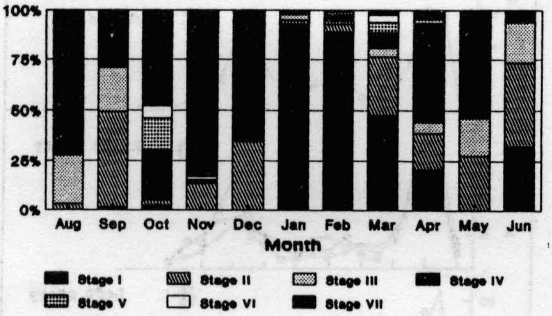

FIG. 3. *Percentage occurrence of maturity stages in females (1994-95).*

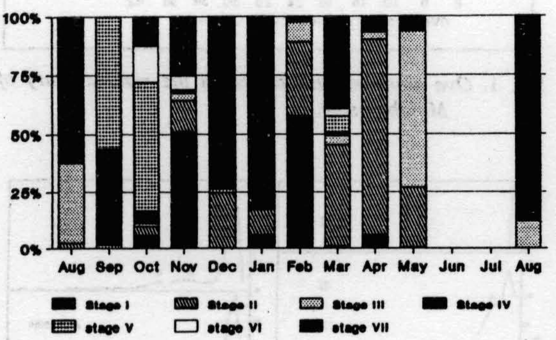

FIG. 4. *Percentage occurrence of maturity stages in females (1995-96).*

spawned. The immature ova represented by the smaller modes in the spent stage (VIIa) will not undergo further yolk deposition, grow or mature to be released in the same season. Instead they are absorbed. Hence it appeared that the Malabar sole is not a multiple spawner.

Spawning

A total of 3232 fishes were examined during August 1994 to June 1995 and 3613

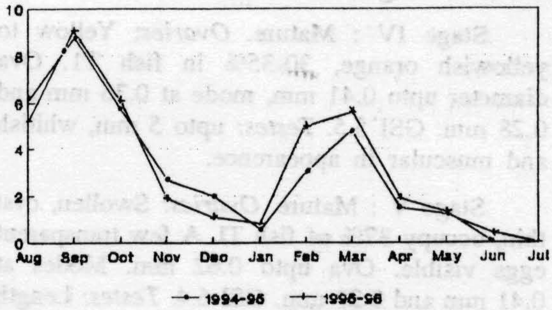

FIG. 5. *Gonado-somatic index in Malabar sole*

specimens during August 1995 to August 1996. The percentage occurrence of the ovary in different stages of maturity are presented in Figure 3 & 4.

During August and September 1994 stage IV, and in October mature and spent fishes were dominant. By November spent fishes were on the increase with corresponding decline in the occurrence of gravid and mature fishes. During January (1995) only immature fishes and again by February gravid and spent stages started appearing again with intensity in March. By May, only spent ones and in June only immature and maturing stages dominated. During 1995-96 also the pattern of occurrence of various maturity stages were similar. The occurrence of various maturity stages at Neendakara (Table 1) also were comparable with that observed in Cochin. The studies indicated that there are two spawnings in an year, the first one during the post monsoon (Sep. -Oct. -Nov.) and the second one during the premonsoon (Feb. - Mar. - Apr.) immediately after the north east monsoon. The new recruits of the post monsoon spawning grow, mature and spawn when they are one year old by next post monsoon. Likwise the new recruits of the premonsoon are ready to spawn at the completion of one year by the next premonsoon. Thus there are two broods in an year from two spawnings, though the individual fish spawns only once as indicated from ova diameter studies.

Ratios between different size of ova during spawning

To know whether the Malabar sole is mutiple spawner or not the relative number of ova were worked out as described by Antony Raja (1964). The ova from mature ovaries were grouped as : A -ova (from 2-11 m.d); B -ova (12-21 m.d); C-ova (22-29 m.d) and D-ova (31 m.d and above). Since the group A represented immature ova, the remaining three groups were considered in ratio calculations. The average values of the two sets of ratios B + C/D and C/D are given in Table 2. During September the B+C/D ratio varied from 0.75 to 7.3 and C/D ratio from 0.29 to 5.2. In October the B+C/D ratio ranged from 0.6 to 1.8 and C/D ratio from 0.21 to 1.01, whereas during December the B+C/D ratio ranged from 0.57 to 1.94 and that of C/D 0.51 to 1.18. The monthly average ratio of B+C/D and C/D were 2.5 and 1.6 in September, 1.3 and 0.69 in Ocotober, and 1.76 and 1.14 in November respectively. The ratio between B+C/D and C/D were 1.6:1 in September, 1.9:1 in October

TABLE 1. *Percentage occurrence of maturity stages in* C. macrostomus (females) *at Neendakara* 1994-95 to 1995-96.

Month	No. of fish	Sex	I	II	III	IV	V	VI	VII
Dec. 94	101	F	12.9	84.2	—	—	—	—	2.9
Jan. 95	133	F	0.8	28.5	5.3	5.3	1.5	—	58.6
Feb.	48	F	35.4	29.2	18.7	2.1	—	—	—
Mar.	87	F	4.5	61.1	4.2	5.6	7.2	6.1	10.4
Apr.	109	F	11.9	28.4	27.5	15.6	2.8	4.6	5.5
May	76	F	7.8	27.3	64.9	—	—	—	—
Jun.	—	—	—	—	—	—	—	—	—
Jul.	—	—	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	—	—	—
Sep.	95	F	1.1	2.1	35.8	61.0	—	—	—
Oct.	71	F	—	—	1.4	63.3	23.9	8.5	2.9
Nov.	52	F	—	26.9	17.4	1.9	—	—	53.8
Dec.	83	F	32.5	28.9	—	—	—	—	38.4
Jan. 96	47	F	12.8	21.3	—	—	—	—	65.9
Feb.	39	F	35.9	30.7	2.6	—	—	2.6	28.2
Mar.	65	F	7.7	52.3	21.5	12.3	3.2	1.5	1.5
Apr.	46	F	2.2	21.7	69.5	4.3	—	2.2	—
May	110	F	1.8	40.0	25.2	—	—	—	—
Jun.	—	—	—	—	—	—	—	—	—
Jul.	—	—	—	—	—	—	—	—	—
Aug.	—	—	—	—	—	—	—	—	—
Sep.	43	F	—	2.3	4.7	39.5	34.9	7.0	11.6
Oct.	131	F	—	—	6.9	42.7	19.8	0.8	29.8

and 1.8:1 in November. Since there is no decrease in the ratios (Antony Raja, 1964), it may be concluded further, that Malabar sole is not a multiple spawner.

TABLE 2. *Ratios of smaller ova to larger ones during the spawning period in* C. macrostomus *from September to November 1995 at Cochin.*

Month	Tl. Fish (mm)	Stages of maturity	Ratio (B + C)/D	C/D
Sep.	122	IV	1.63	0.97
	128	IV	7.30	5.2
	131	IV	1.4	0.73
	126	V	0.75	0.29
	124	IV	1.8	1.10
Average	126		2.5	1.6
Oct.	134	IV	1.8	0.98
	129	IV	1.5	0.8
	115	V	0.6	0.21
	133	IV	1.4	0.77
Average	128		1.3	0.69
Nov.	128	V	1.26	0.72
	131	V	1.94	1.18
	130	V	1.07	0.53
	129	IV	0.57	0.19
Average	130		1.21	0.65

Gonado-somatic index (GSI)

The (GSI) was calculated for individual fish in different months applying the formula, GSI = ovary weight × 10^2/fish weight. Based on this the monthly average GSI also was calculated.

The curves (Fig. 5) representing the values for both years showed a similar pattern. The high values observed during September and a decline by October indicated spawning. Further decrease in GSI also is seen during April-May which is the result of the second spawning that has taken place during February to April.

These observations clearly indicate that the species has two spawning seasons. But by considering 1) the time required for the new recruits to attain maturity, 2) the sequence of occurrence and monthly progression of various maturity stages, 3) the time required for the spawned fish for a subsequent spawning and 4) from the ova diameter studies it appears that the spawners of September-November period are different from the batch that spawns during February-April.

Size at maturity

The size at maturity of Malabar sole was determined by analysing 1754 males and 1516 females during 1994-95, and 1945 males and 1543 females during 1995-1996. Fishes were grouped sex-wise into 5 mm size groups and percentages of the fish in different stages of maturity calculated. From the maturity curves for both the years (Fig. 6) it was found that 50% of both males and females mature at 97 mm.

Fecundity

Fecundity was estimated from the total number of mature ova destined to be shed (0.3 mm and above) during a spawning season and was based on ovaries (stage IV & V) from 88 fishes of the size range 76 mm to 159 mm.

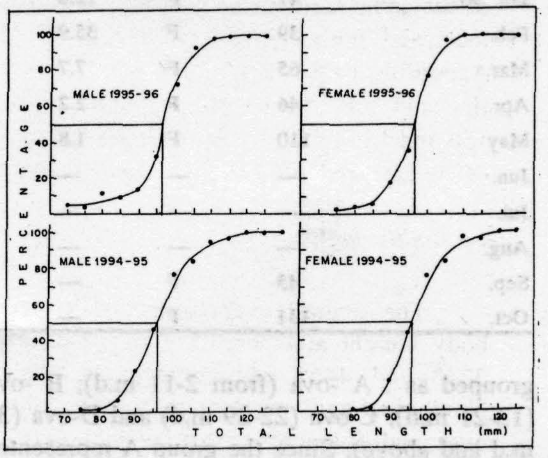

FIG. 6. *Size at maturity in Malabar sole.*

The lowest and highest fecundity of 5021 and 64,434 were in fishes of total length 76 mm and 156 mm respectively. Though there were variations within and between individuals of the same size and size groups, the fecundity increased with increase in length (Table 3). According to Seshappa and Bhimachar (1955) ripe and full ovaries of specimens measuring 156 and 159 mm were found to have a fecundity of 42,200 and 65,900 ova respectively.

TABLE 3. *Fecundity in relation to various size groups of* C. macrostomus

Length of fish TL mm	Weight of fish g.	Length of ovary mm	Weight of ovary g.	Fecundity Nos.	No. of eggs per 1 g. Body wt.	Av. No. of eggs per 0.1 g.wt. of ovary
80	3.05	25.7	0.1316	5,399	1770	4102
85	3.07	28.0	0.1667	8.195	2.669	4916
90	3.68	29.3	0.1298	9,715	2639	7484
95	4.56	31.5	0.2831	12,944	2838	4572
100	4.72	35.8	0.4803	16,778	3554	3493
105	6.10	36.5	0.4148	21.866	3584	5271
110	6.65	42.4	0.4655	26,099	3924	5606
115	7.65	43.0	0.6622	27,759	3628	4191
120	9.16	43.9	0.6899	30,042	3279	4354
125	10.14	47.0	0.8103	34,021	3355	4198
130	10.43	47.2	0.9837	38,008	3644	3864
135	12.99	47.4	1.1772	44,605	3433	3789
140	14.48	52.5	1.2350	50,762	3505	4110
145	15.32	54.0	1.4771	55,186	3602	3736
150	17.35	56.0	1.5207	59,960	3455	3942
155	20.9	56.7	1.6480	62,921	3010	3818
Average					3243	4465

Fecundity factors

The overall average fecundity per gram body weight and per 0.1 g ovary weight was 3243 and 4465 ova respectively (Table 3). Number of eggs per 1 gram body weight (1770 ova) and 0.1 gram ovary weight (4102 ova) were lowest in the smallest size group.

The number of ova per 0.1 g weight of ovary was highest (7484 ova) in fish of total length 92 mm and again in 106 mm and 113 mm. Further, in large size groups the number of ova were lower than the overall average. The number per 1 gram body weight was highest (3924 ova) in fishes of length 113 mm. Here also the values in higher size groups were less than the value observed in fishes of 113 mm. The lowest value of 3010 ova per 1 gram body weight was in 155-160 mm size group. The size group 110-115 mm which represented the one year old fishes are first time spawners and the ova per 1 gram body weight of fish is higher than the 2nd and 3rd time spawners. In the second and third time spawners though the fecundity is more, the number per 1 gram body weight is less than the first time spawners.

Hence the one year old and first time spawners appear to be more productive with a high fecundity rate compared to the old and larger fishes.

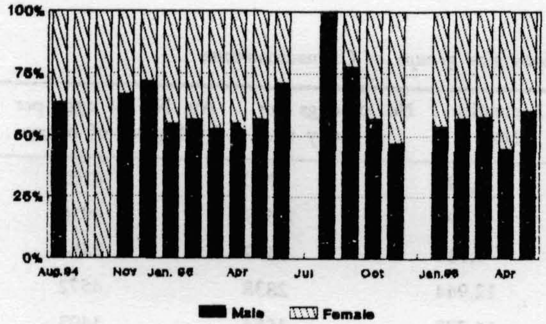

FIG. 7. *Sex ratio in the preadults during 1994-96 at Cochin.*

Relation between size of ovary and length of fish

The length of the fish and length of the ovary showed a linear relationship of the form Y = A + B X, where 'A' and 'B' are two constants and 'Y' & 'X' represent the length (mm) of ovary and fish respectively. Accordingly the results were:

Immature: $Y = -8.16475 + 0.192690\ X$

Mature $Y = -5.31728 + 0.378713\ X$

Fecundity and length of the fish

The relationship was linear and calculated by the least square method (logarithmic values) based on the formula

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

Where F = Fecundity, L = total length in mm, 'a' and 'b' are two constants.

$\log F = -3.2406 + 3.6942 \log L$. ($r = 0.917908$)

In the length-weight relationship of Malabar sole (Jayaprakash, MS) the exponential value is 3.10734 for the mature females. Since this value is lower than that observed in fecundity-fish length relationship (3.6942) the fecundity in this fish increased at a rate greater than the rate of increase of body weight, in relation to length.

Fecundity and weight of fish

The arithmetic values of fish weight and fecundity were converted to log values and the relationship could be expressed substituting the values as

$\log F = 3.36981 + 1.15698 \log W$ ($r = 0.902415$)

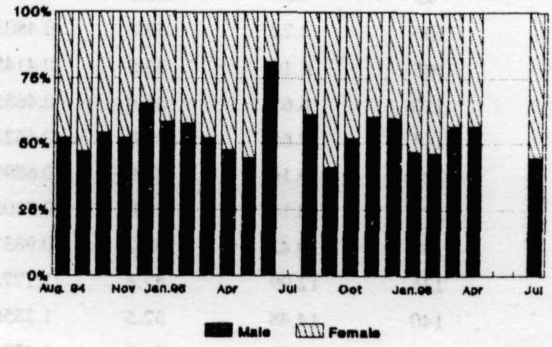

FIG. 8. *Sex ratio in the adults during 1994-96 at Cochin.*

where F = fecundity, W = total weight of fish (g). A straight line relationship was observed between these two variables. The exponential value 1.15 is above unity (unity = 1). Hence the fecundity increases at a rate more than that of the body weight in relation to length.

Fecundity and weight of ovary

The relationship between these two variables can be expressed as $\log F = a + b \log OW$

$\log F = 4.59765 + 0.83282 \log OW$

where F = fecundity, OW = ovary weight, a = constant and b = the exponential value.

Fecundity and length of ovary

The relationship was found to be curvilinear of the form $F = al^b$, which may be expressed in the logarithmic form

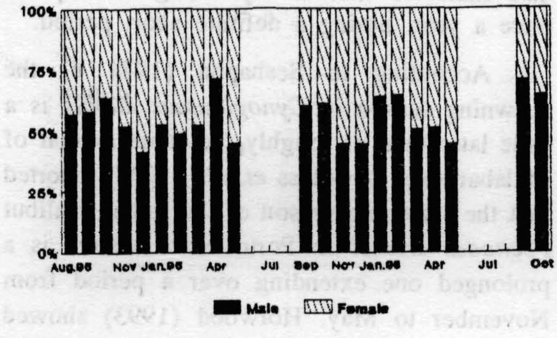

FIG. 9. *Sex ratio in the adults during 1994-96 at Neendakara.*

log F = 0.41209 + 2.475196 log OL. (r = 0.83205)

where a = constant, b = the exponential, F = fecundity and OL = the ovary length (mm).

Sex Ratio

Sex ratio studies in Malabar sole are based on samples from Cochin, Neendakara and Ambalapuzha. The samples were grouped monthwise as well as size group wise. Data from Cochin were further grouped into immature and adults. At other two centres the monthly distribution of sex ratio of adults only were worked out. The observed sex ratios were tested against and expected ratio 1:1 by the method of chi-square (Snedecor, 1961).

Sex Ratio during different months

The monthwise sex-ratio in the immature fishes at Cochin during 1994 to 96 is given in Fig. 7. The overall sex ratio of M:F was 1.3:1 during 1994-95 and 1.2:1 during 1995-96. During both the years the males dominated except during September October 1994 and November 1995 and April 1996. The sex ratio was significant at 5% level in December '94 June 1995, February and May '96. In the adults, at Cochin males dominated except during September 1994, April/May 95, September 95, January February, April and August 1996 (Fig. 8). The domination of males was noticed also at Neendakara and Ambalapuzha. At Neendakara females were dominant during December 1994, February May, November, December 1995 and May 1996, whereas at Ambalapuzha females dominated during April, July and September 1995 and January to May 1996. The sex ratio of Malabar sole at

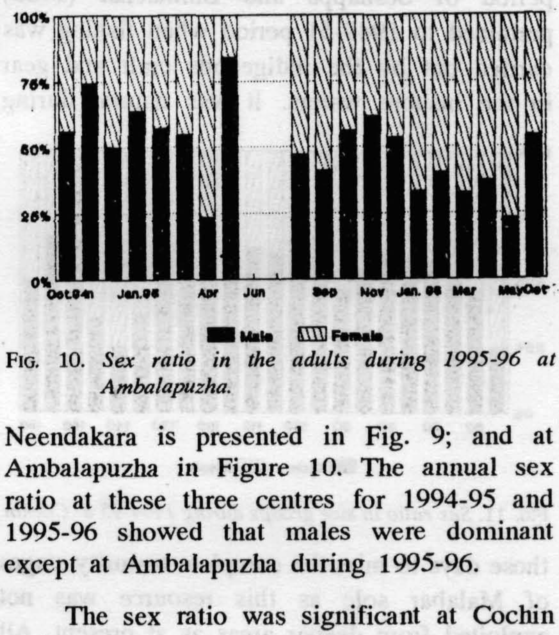

FIG. 10. *Sex ratio in the adults during 1995-96 at Ambalapuzha.*

Neendakara is presented in Fig. 9; and at Ambalapuzha in Figure 10. The annual sex ratio at these three centres for 1994-95 and 1995-96 showed that males were dominant except at Ambalapuzha during 1995-96.

The sex ratio was significant at Cochin during December 94, June, August and December 1995, March, April, May and August 1996. At Neendakara it was during August, September, October '95 and January, February and May 96; and at Ambalapuzha during November 94, April, May and September '95; January, and March to May '96.

Sex ratio in different size groups

The size group wise analyses (Fig. 11 & 12) revealed that the sex ratio was significant in the maturing first time spawners. Males dominated in all the size groups except from 130-135 mm and above. The sex ratio was significant in the spawners belonging to one and two year old groups.

DISCUSSION

Seshappa and Bhimachar (1955) reported that spawning of the Malabar sole *Cynoglossus semifasciatus* takes place in the offshore area and hence the spent and spent resting fishes were not encountered in the catch. The study period of Seshappa and Bhimachar (1955) pertained to 1949-51 period when fishing was carried out by the indigenous craft and gear in the inshore waters. It was natural during those days to miss the complete maturity stages of Malabar sole as this resource was not exploited from deeper areas as at present. All the maturity stages could be observed during the present study.

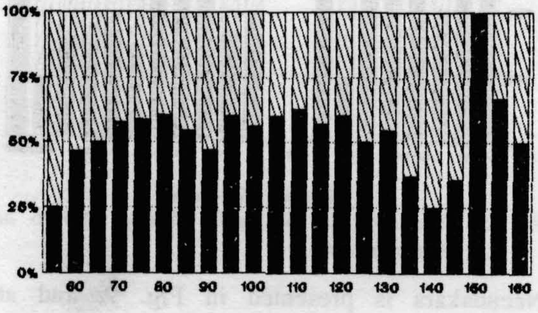

FIG. 11. *Sex ratio in size groups during 1994-95 at Cochin.*

Seshappa and Bhimachar (1955) observed that the spawning season of the Malabar sole starts by September-October and ceases by June. There are no different batches of eggs maturing at different periods in the same season. But different individuals mature at different times, thus prolonging the breeding season. But the present study indicated that there are two spawning seasons and accordingly two broods also could be distinguished. Ramanathan *et. al.,* (1977) observed that in *C. macrolepidotus* the spawning season is from August to October in Porto Novo waters. Ova diameter studies also indicated that the spawning takes place once a year, during a definite short period.

According to Seshappa (1974 b) the spawning season in *Cynogloussus dubius* is a little later than or roughly the same as that of Malabar sole. Devadoss *et. al.,* (1977) reported that the spawning season of the Indian Halibut *Psettodes erumei* in Porto Novo waters is a prolonged one extending over a period from November to May. Horwood (1993) showed that the Bristol channel sole *Solea solea* is a

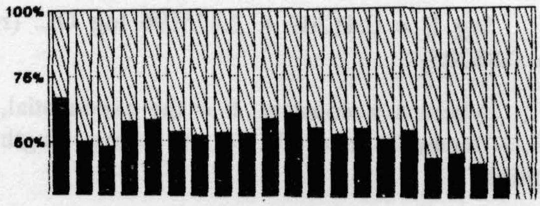

FIG. 12. *Sex ratio in size groups during 1995-96 at Cochin..*

determinate spawner and the duration of the spawning spans about 90 days but an individual fish may not be there throughout the period. Most of the flatfishes in India especially the Malabar sole also appear to be a determinate spawner.

In the present study on the sex ratio in the Malabar sole *(C. macrostomus),* males mostly dominated during most of the period. It is interesting to note that the testes in this species is significantly small compared to the ovaries, a fact which has not been reported so far. It appears that one male alone may not be sufficient to fertilise the eggs that are discharged in spurts by a female during the spawning and in all probability more than one male at different timings may be taking part in the spawning activity to fertilise them. The domination of males in the one and two year old fishes with significant sex ratios and the dominance of females in the older fishes appear to be due to a decline in the reproductive efficiency with increase in age. This is further supported by the low fecundity per 1 gram body weight observed in older fishes.

REFERENCES

ANTONY RAJA, B. T. 1964. Some aspects of spawning biology of Indian oil sardine *Sardinella longiceps* Valenciennes. *Indian. J.Fish;* **IIA** : 45-120.

BAGENAL, T. B. 1957. A short review of fish fecundity. *In:* S. S. D. Gerking [Ed.] *The biological basis of fresh water fish production.* Oxford, Backwell Scientific Publications, pp. 89-112.

BALAKRISHNAN, K. P. AND C. P. L. DEVI 1974. The larvae of some flatfishes from a tropical estuary. *In* J.H.S. Blaxter (Ed.) *The early life history of fish.* Springer Verlag Berlin Heidelberg.

DEVADOSS, P., P. K. M. PILLAI, P. NATARAJAN AND K. MUNIYANDI 1977. Observations on some aspects of the biology and fishery of *Psettodes erumei* (Bloch) at Porto Novo. *Indian J.Fish.,* **24** (1 & 2) : 62-68.

HORWOOD, J. 1993. The Bristol Channel sole *(Solea solea* (L)) : A fisheries case study. *Advances in Marine Biology,* **29** : 215-367.

JOHN, M. A., 1951. Pelagic fish eggs and larvae of the Madras coast. *J. Zool. Soc., India,* **3** (1) : 38-66.

JONES, S. AND P. M. G. MENON 1951. Notes on the bionomics and developmental stages of some Indian flatfishes. *J. Zool. Soc. India,* **3** (1) : 71-83.

KUTHALINGAM, M. D. K. 1957. Life history and feeding habits of *Cynoglossus lingua* (Ham. Buch.) *J. Zool. Soc. India,* **9** : 208-215.

NAIR, R. V. 1952 a. Studies on some fish eggs and larvae of the Madras plankton. *Proc. Ind. Acad. Sci.,* **35** : 181-208.

——— 1952 b. Studies on the post-larval fishes of the Madras plankton. *Proc. Ind. Acad. Sci.,* **35** : 225-244. Sons, New York, 528 pp, illustra.

PRADHAN, M. J. 1964. Observations on the maturity and spawning of *Psettodes erumei* (Schneider). *Indian J. Fish.,* **9** (2) : 580-589.

RAMANATHAN, N. AND R. NATARAJAN 1979. Flatfish eggs and their development. *Aquaculture,* **18** : 349-366.

——— P. VIJAYA, V. RAMAIYAN AND R. NATARAJAN 1977. On the biology of the large-scaled tongue sole *Cynoglossus macrolepidotus* (Bleeker). *Indian J. Fish.,* **24** : (1 & 2) : 83-89.

SESHAPPA, G. 1974. On the fishery and biology of the large Tongue sole *Cynoglossus dubius* Day, at Calicut, Kerala. *Indian J. Fish.,* **21** (1) : 345-357.

——— AND B. S. BHIMACHAR 1955. Studies on the fishery and biology of the Malabar sole *Cynoglossus semifasciatus* Day. *Indian J. Fish;* **II** (2) : 180-230.

SNEDECOR G. W. 1961. *Statistical methods.* Oxford and IBH Publishing CO; Calcutta, Bombay, New Delhi.