Mahasagar–Bulletin of the National Institute of Oceanography, 11 (1 & 2), 1978, 63–71.

MATURITY AND SPAWNING IN *MUGIL CEPHALUS* LINNAEUS IN GOA WATERS

HARI PADA DAS
National Institute of Oceanography, Dona Paula-403 004, Goa.

ABSTRACT

Maturity and spawning of *Mugil cephalus* Linnaeus were studied from the Goa waters by examination of gonads in fishes collected during the period July 1975 to June 1977. The males of the species were found to mature earlier than females. Six stages of maturity were identified and the season of spawning and the periodicity of spawning were determined by ova diameter measurements and distribution of maturity stages in different months. The gonado somatic index was found to be high from September to February. The spawning season was found to extend from September to February, with a peak during October to December. The sex ratio shows a general preponderance of males. The sex ratio of males to females was found to be 1·77 : 1.

INTRODUCTION

Mugil cephalus Linnaeus commonly known as grey mullet and striped mullet, is widely distributed in the coastal waters and estuaries of tropical and subtropical areas. The maturation and spawning in teleosts are highly variable in tropical waters. Qasim (1973) has made an appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters. Mullets have a seasonal pattern of abundance, reproduction and growth. Devasundaram (1952), John (1958), Sarojini (1958), Luther (1963), Shetty, Chakraborty and Bhattacharya (1965), Rangaswamy (1972), Kuo and Nash (1975) and Rawson (1976) have reported the maturity and breeding of the grey mullet from different regions. Seaward migration of the fish connected with spawning has been specially brought out by Jhingran (1958). The grey mullet (Mugilidae) are marine species which enter brackish and fresh water to feed but spawn in sea (Moore, 1974; Chervinski, 1977). Recognising the importance of the fishery of *M. cephalus* along the central west coast of India, a detailed study on the biology of the species was taken up in Goa waters and the observations on maturity and spawning are presented in this paper.

MATERIAL AND METHODS

The present study is based on the analysis of 1327 specimens measuring from 47 mm to 420 mm in total length during the period July 1975 to June 1977. The material was collected once in a week from the commercial catches of different fish landing centres of Goa. In the laboratory, the fishes were cleaned, measured, weighed and sexed. The gonads were dissected out, weighed, measured and their colour noted. A small part of each ovary was examined for determining the stage of maturity. The gonads were then preserved in 5% formaldehyde solution for further examination.

In all, 148 ovaries in different stages of maturity were examined for ova diameter studies. The diameter of eggs was measured using an ocular micrometer. The distribu–

tion of ova in the ovaries of various size groups at the anterior, middle and posterior parts was found to be uniform. The diameters of 200 ova from the ovary of each specimen were measured. In drawing the ova diameter frequency polygons, the diameter frequencies have been grouped into 3 divisions and their percentages calculated for each month from the stages of maturity. Fecundity and relative condition factor have been dealt with elsewhere (Das, 1977).

Maturation and spawning

Maturation of gonads was studied on the basis of arbitrary classification of maturity stages. Though Kesteven (1942) and Pien and Liao (1975) recognised 8 maturity stages in *M. cephalus* which are: (1) chromatin nucleus stage, (2) perinucleolus stage, (3) yolk vesicle stage, (4) primary yolk stage, (5) secondary yolk stage, (6) tertiary yolk stage, (7) migratory nucleus stage and (8) mature stage, but in the present analysis only 6 stages were found to be pronounced. Kuo and Nash (1975) agree with such classifications and have identified 6 maturity stages in the Hawaii waters. The classification which corresponds with the maturity stages adopted by the International Council for the Exploration of Seas (I.C.E.S.) is based on observations on the formation and extrusion of milt in the testes and ova diameter range and yolk in the ovaries. The maturity stages of the male and female are compared below with the maturity scale I.C.E.S. (Wood, 1930).

Stage	Gonadial condition of *Mugil cephalus* female	Male	Maturity scale of I.C.E.S.
I (Immature)	Dull brownish occupying $\frac{1}{3}$ body cavity. Ova irregular and transparent. Maximum diameter of ova 0·081 mm.	Whitish, thread like occupying $\frac{1}{2}$ body cavity.	I-II
II (Maturing I)	Dull brownish occupying $\frac{1}{2}$–$\frac{2}{3}$ body cavity. Ova round, partially yolk laden. Maximum diameter of ova 0·123 mm.	Whitish, occupying $\frac{1}{2}$ body cavity.	III
III (Maturity II)	Blood red occupying $\frac{1}{2}$–$\frac{2}{3}$ body cavity. Ova round and fully laden with yolk. Maximum diameter of ova 0·163 mm.	Whitish, occupying $\frac{1}{2}$ body cavity.	IV
IV (Mature)	Yellowish, occupying $\frac{1}{2}$–$\frac{2}{3}$ body cavity with some ova visible to the exterior. Yolk vacuolated, perivitelline space present. Maximum diameter of ova 0·247 mm.	Creamy white occupying $\frac{1}{2}$–$\frac{2}{3}$ body cavity.	V
V (Oozing)	Yellowish, sometimes brown occupying nearly the entire body cavity. Maximum diameter of ova 0·627 mm.	Creamy white occupying $\frac{2}{3}$ body cavity.	VI
VI (Spent)	Deep red, hollow sacs, Flaccid with blood vessels prominent over the surface occupying not more than $\frac{1}{3}$ the length of body cavity. Maximum diameter of ova vary from 0·043 to 0·209 mm. A few degenerating ova often occur.	Fish in this stage not obtained.	VII

Length at first maturity

Qasim (1973) mentioned that maturity is clearly linked up with the growth rate of fishes and hence the two phases, pre and post maturity should be closely distinguished. The size of first maturity was determined by grouping the specimen into 20 mm size

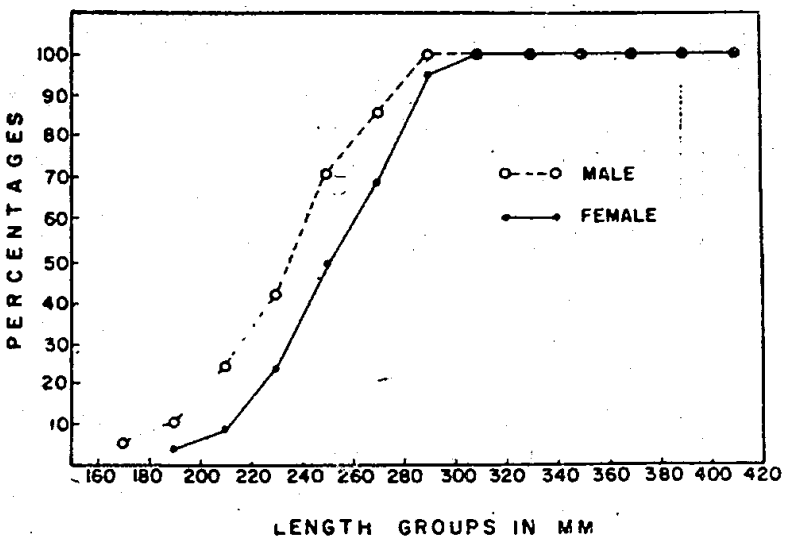

Fig. 1. Length at first maturity of *Mugil cephalus*.

groups and by classifying them into immature, maturing and spent, depending upon the condition of gonads. Fig. 1 represents the relationship between maturity and length which shows that at 190 mm all females were immature and the percentage of maturing stages of females increased with length upto 310 mm, when all the individuals examined were found to be mature. In the case of males, all were immature at 170 mm and the percentage of maturing individuals increased till 290 mm when all the males mature. Thus, the males attain complete sexual maturity at 280–300 mm and females slightly later between 300–320 mm. The occurrence of spent fish in the same size group of 300–320 mm supports this conclusion.

Kesteven (1942) estimated the size of the fish at first maturity in Australian waters as 275 mm in males and 290 mm in females. Broadhead (1953) in Florida estimated the sexual maturity at an average length of 263 mm in males and 276 in females. The length at first maturity estimated from Pulicat lake by Rangaswamy (1972) was higher than that those determined by Anderson (1958) and Thompson (1963).

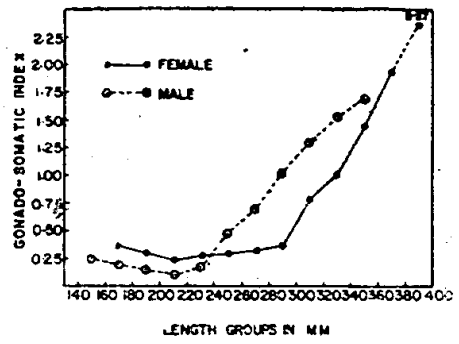

Fig. 2. Gonado-somatic index at different lengths of *Mugil cephalus*.

Gonado-somatic index

The annual cycle of ovarian development represented by the changes in gonado somatic index [GSI (gonad weight / body weight) × 100] (Figs. 2 & 3) and the percentage of oocytes (Figs. 4 & 5) at each developmental stages are illustrated. From Fig. 2 which

illustrates the gonado-somatic index (GSI) at different lengths of fish, it is evident that up to 290 mm in females and 230 mm in males, the GSI was low and thereafter, it gradually increased. The low value synchronizes with the initial maturity stages and the increase in GSI indicates an advancement in maturity.

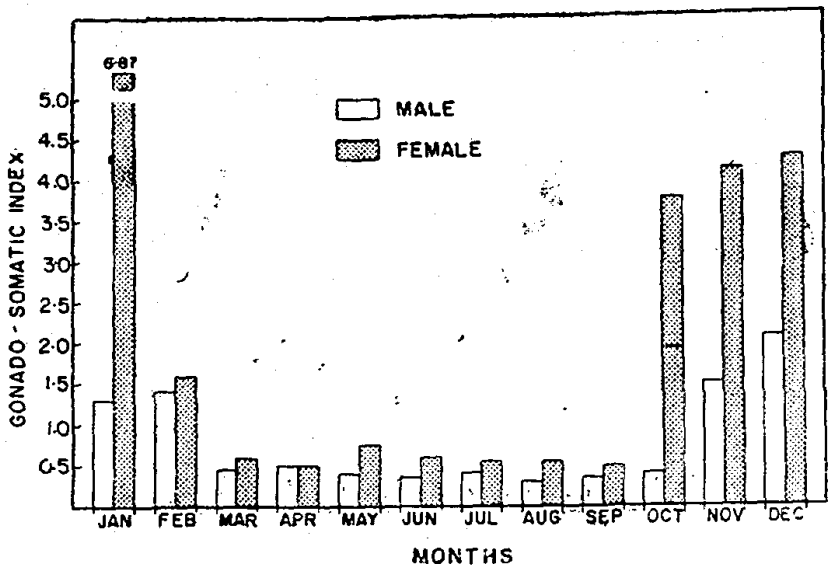

Fig. 3. Monthwise trend in the Gonado-somatic index of *Mugil cephalus.*

Seasonal variations in the GSI (Fig. 3) showed that the index is high in females from October to January. The monthly variations in GSI not only indicate the duration of spawning season but also illustrate the maturation of gonads.

Spawning periodicity

Spawning periodicity in *M. cephalus* was determined by critically examining the distribution of ova-diameter frequencies in different maturity stages. A close examination of frequency polygons shown in Fig. 4, reveals that in stage I, a prominent mode is at 3 ocular divisions (O.D.). In stage II and III, the mode gets shifted to 6 O.D. The stage II represents the immature stock and stage III maturing. Though in stage III, the mode remained at 6 O.D., there is a larger size of ova of diameter ranging between 9 O.D. to 12 O.D. In case of stage IV, the ova at 9 O.D. level was very distinct but the maximum size of ova moved to 21 O.D. After the stage IV, the development of ova seems to be rapid and the separation of mature ova from the immature stock becomes apparent. The mode at stage V was at 30–33 O.D. However, the range in size of the mature ova is rather large from 21 O.D. to 48. O.D.

It is seen from Fig. 4 that there is only one group of maturing ova. Though this group of ova has a wide range of size, all the ova of this group are destined to be discharged during the period of spawning. The immature group of small ova develops into stage V with a mode at 6 O.D. The presence of one batch of mature ova distinctly separated from the immature ones makes it sufficiently clear that the species has a definite spawning season. Rangaswamy (1972) also reported only one spawning season in *M. cephalus* during the year in the lake Pulicat.

Spawning season

The exact duration of spawning of *M. cephalus* was determined by examining the development of gonads in different months (Fig. 5). From the figure, it is clear that the stage V occurs from September to February indicating that the spawning season lasts for

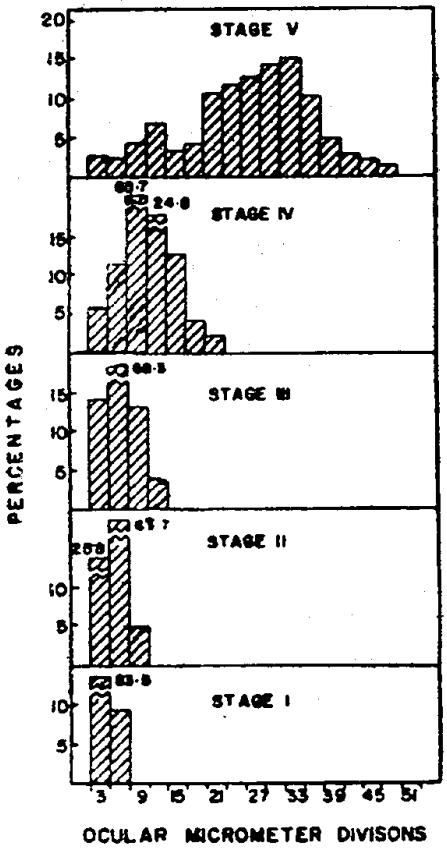

Fig. 4. Development of ova in different maturity stages of *Mugil cephalus*.

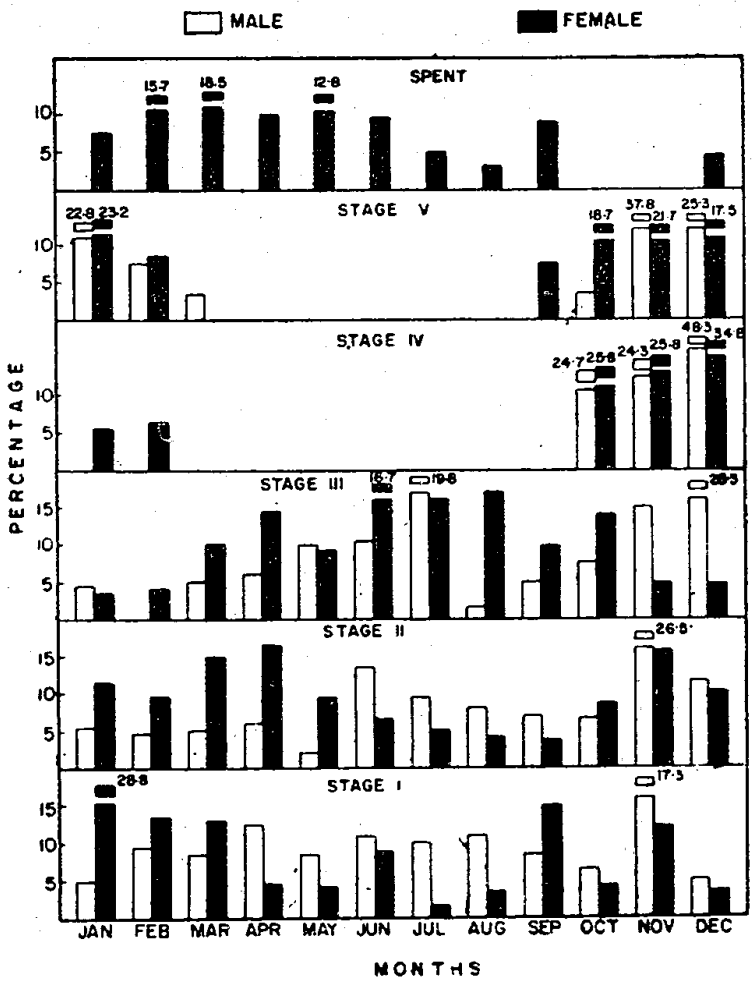

Fig. 5. Percentage occurrence of various stages of maturity in *Mugil cephalus*.

about 6 months. As 88% of the ripe gonads were recorded from October to December, this period appears to be the peak spawning season of the fish. This deduction is further supported by the studies on size progression of ova during different months (Fig. 6). The mature ova separate themselves out from the immature stock from September to February, with a peak from October to December.

Jacob and Krishnamurthy (1942) observed ripe mullets from the Ennore creek during the months October to May. Jhingran and Natarajan (1969) noticed the spawning season of *M. cephalus* in the Chilka lake from September to December. John (1958) reported that in the Kayamkulam lake, ripe *M. cephalus* can be seen from September onwards and the spawning season lasts from September to December. Shetty, Chakraborty and Bhattacharya (1965) recorded the spawning in the Mahanadhi estuary from

September to December. Kuo and Nash (1975) observed the peak spawning of grey mullet in Hawaii water during the months of January and February. While the present investigation confirms these results, it also indicates that the spawning season gets prolonged upto February with a peak in October to December, as recorded from the Pulicat lake by Rangaswamy (1972). However, Rawson (1976) is of the opinion that the spawning season of this species of mullet in the Hawaii area occurs from October to February with a peak in December.

Sex ratio

In *M. cephalus* there are no external characters known which might help in distinguishing two sexes, although during the spawning season, there is a distinct bulging of abdomen in the females. Hence, the two sexes were recorded after examining the gonads of the fish, with a view to determine the incidence of males and females, in the commercial catches of Goa waters. It was observed that in specimen below 100 mm in total length, the sex could not be differentiated and hence such individuals were grouped as unsexed.

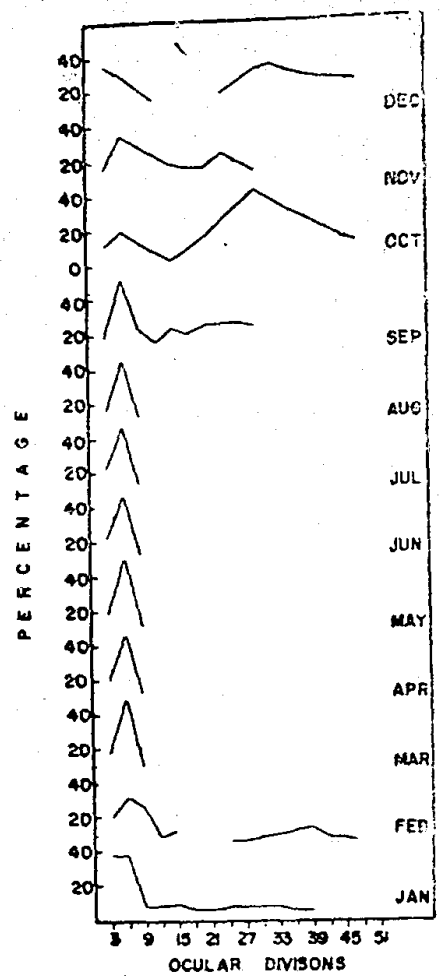

Fig. 6. Size progression of ova during different months in *Mugil cephalus*.

Table I. Sex ratio in *Mugil cephalus* during different months.

Months	Males	Females	Ratio males per 100 females	Chi-square value
January	71	75	94·67	0·11
February	85	33	257·58	22·92*
March	67	81	82·72	1·32
April	92	71	129·58	2·71
May	49	53	92·45	0·16
June	78	40	195·00	12·24*
July	74	25	296·00	24·25*
August	96	27	355·56	38·71*
September	38	29	131·03	1·21
October	37	37	100·00	
November	68	26	261·54	18·76*
December	41	32	128·12	1·11

* Chi-square value significantly different at 0.1% level, the tabular value being 10.827.

Table I gives the monthly distribution of the two sexes in commercial catches. The yearwise sex-ratio is given in Table II. It is seen from the sex distribution that the two sexes do not occur in the same proportion throughout the year. The ratio was tested

Table II. Sex ratio in *Mugil cephalus* in different years.

Year	Males	Females	Ratio male per 100 females	Chi-square value
1975	145	137	105·839	0·227
1976	345	179	192·737	52·587*
1977	348	157	221·656	72·240*
Total	838	473	177·167	101·621*

* Chi-square value significantly different at 0.1% level, the tabular value being 10.827.

Table III. Sex ratio in *Mugil cephalus* at different maturity stages.

Stage	Males	Females	Males %	Females %	Ratio males to females
I	593	37	94·127	5·873	16·027
II	83	139	37·387	62·613	0·597
III	38	173	18·009	81·991	0·220
IV	23	15	60·526	39·474	1·533
V	78	63	55·319	44·681	1·238
Spent	—	82	—	100·000	—

Table IV. Sex ratio in *Mugil cephalus* at different length groups.

Length groups	Males	Females	Ratio males to females	Ratio females to males
100–120	28	8	3·500	0·285
121–140	47	12	3·917	0·255
141–160	93	17	5·470	0·183
161–180	85	13	6·538	0·153
181–200	97	19	5·105	0·196
201–220	107	21	5·095	0·196
221–240	113	43	2·628	0·380
241–260	105	37	2·838	0·352
261–280	97	25	2·880	0·258
281–300	68	53	1·283	0·779
301–320	47	84	0·560	1·787
321–340	21	75	0·280	3·571
341–360	31	105	0·295	3·387
361–380	43	87	0·494	2·023
381–400	25	53	0·471	2·120
401–420	18	48	0·375	2·667

by chi-square analysis for differences from the hypothetical ratio 1 : 1. The sex–ratio was significantly different in February, June, July, August and November. The skewed sex–ratios were due to the preponderance of males over females. Similarly, the preponderance of males was evident in the yearwise distribution of 1976 and 1977 whereas the sex–ratio was not significantly different in 1975. However, the final analysis shows that the sex–ratio of males to females was found to be 1·77 : 1. Rangaswamy (1972) also mentioned the sex ratio of males to females as 1·56 : 1 in Pulicat lake.

The sex–ratio for different maturity stages is furnished in Table III. The dominance of males over females was noticed at the maturing stage I, whereas the case was reverse in stages II and III. The ratio more or less reached the equilibrium in IV and V stages. This appears to indicate that the two sexes congregate during the spawning season.

The ratio calculated for different length groups is represented in Table IV, from which it is evident that upto 300 mm the males were greater in number than the females. Among the larger specimens the males were on the decline while the females increased.

ACKNOWLEDGEMENT

The author is grateful to Dr. S. Z. Qasim, Director, National Institute of Oceanography, Dona Paula, Goa for his guidance and constant encouragement in this work. Thanks are also due to Dr. M. J. George, Scientist–in–Charge of Biological Oceanography Division for his helpful suggestions and to Dr. A. H. Parulekar and Shri K. J. Peter, Scientists, NIO for their help.

REFERENCES

Anderson, William W., 1958. Larval development, growth and spawning of striped mullet (*Mugil cephalus*) along the south Atlantic coast of the United States. *U. S. Fish and Wildlife Service, Fish Bulletin*, **144**: 501–519.

Broadhead, G. C., 1953. Investigations of the black mullet *Mugil cephalus* L. in northwest Florida. *Technical Series, Florida State Board of Conservation*, **25**: 1–31.

Chervinski, J., 1977. Adaptability of *Chelon labrosus* (Risso) and *Liza saliens* (Risso) (Pisces, Mugilidae) to freshwater. *Aquaculture*, **11**: 75–79.

Das, H. P., 1977. The fecundity of grey mullet *Mugil cephalus* Linnaeus along the Goa coast. *Mahasagar–Bulletin of the National Institute of Oceanography*, **10** (1 & 2): 79–82.

Devasundaram, M. P., 1952. Scale studies of *Mugil cephalus* Linnaeus of Chilka Lake. *Journal of the Madras University*, **22B**: 147–163.

Jacob, P. R. and B. Krishnamurthy, 1942. Breeding and feeding habits of mullet (Mugil) in Ennore creek. *Journal of the Bombay Natural History Society*, **47**: 455–457.

Jhingran, V. G., 1958. Observations on the seaward migration of *Mugil cephalus* from the lake Chilka for breeding. *Current Science*, **27**: 181–182.

Jhingran, V. G. and A. V. Natarajan, 1969. A study of the fisheries and fish populations of the Chilka lake during the period 1957–1965. *Journal of the Inland Fishery Society of India*, **1**: 49–126.

John, M. C., 1958. The grey mullets of Kayamkulam lake, India and their fishery. *Copeia*, **3**: 225–230.

Kesteven, G. L., 1942. Studies on the biology of Australian mullet. *Council of Scientific and Industrial Research, Australian Bulletin*, **157**: 147 pp.

Kuo, C. M. and C. E. Nash, 1975. Recent progress on the control of ovarian development and induced spawning of grey mullet (*Mugil cephalus*). *Aquaculture*,**5**: 19-29.

Luther, G., 1963. Some observations on the biology of *Liza macrolepis* (Smith) and *Mugil cephalus* Linnaeus (Mugilidae) with notes on the fishery of grey mulets near Mandapam. *Indian Journal of Fisheries*, **10** (2A): 642-666.

Mac, V., Rawson, J. R., 1976. Population biology of parasites of striped mullet *Mugil cephalus* L *Monogenea, Journal of Fish Biology*, **9**: 185-194.

Moore, R. H., 1974. General ecology, distribution and relative abundance of *Mugil cephalus* and *Mugil curema* on the south Texas coast. *Contribution on Marine Sciences*, **18**: 241–255.

Pien, P. C. and I. C. Liao, 1975. Preliminary report on histological studies on the grey mullet gonad related to hormone treatment. *Aquaculture*, **5** : 31-39.

Qasim, S. Z., 1973. An appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters. *Indian Journal of Fisheries*, **20**(1): 166-181.

Rangaswamy, C. P., 1972. Maturity and spawning in *Mugil cephalus* Linnaeus of Lake Pulicat. *Recent Researches in Estuarine Biology*, p. 47-60.

Sarojini, K. K., 1958. Biology and fisheries of the grey mullets of Bengal. *Indian Journal of Fisheries*, 5(1): 56-76.

Shetty, H. P. C., R. D. Chakraborty and C. G. Bhattacharya, 1965. A report on the fisheries of Mahanadhi estuarine system, Orissa. *Bulletin of the Central Inland Fisheries Research Institute*, Barrackpore, 5(1): 81.

Thompson, J. M., 1963. Synopsis of biological data on the grey mullet *Mugil cephalus* Linnaeus 1758. *Fisheries Synopsis. Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Research Organisation*, Cronulla 1.

Wood, H., 1930. Scottish herring shoals. Pre-spawning and spawning movements. *Scotland Fisheries Board of Scientific Investigation*, **1**: 1–71.