Proc. Indian natn. Sci. Acad. B 46 No. 1 pp. 105-113 (1980)

Study on some Aspects of Spawning Biology of a Hill Stream Fish *Garra mullya* (Sykes)

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Observations on the spawning biology of a hill-stream fish, *Garra mullya* (Sykes) are presented in this paper. Macro- and microscopic examination of ovaries were carried out for a year to ascertain the maturity stages. The minimum size of maturity observed is 88 mm i.e. the fish matures for the first time in it's life when it is one and half years old. The spawning season is a prolonged one extending from June to November. Chi-Square study shows dominance of females, giving the sex ratio, 1:1.44. Both the sexes congregate during the spawning season and segregate after spawning.

The spawning periodicity based on ova-diameter measurements indicate that the species spawns for a long duration. Analysis of covariance studies have shown that there are no significant differences in distribution, either in relative number of ova or ova-diameter, in the anterior, middle and posterior parts of ovary.

The relative number of ova in differrnt groups showed that the number of smaller ova decreased in proportion to the number of bigger ova, as the spawning season advanced and the species is a fractional spawner.

Introduction

It is known that a fishery which is dependent on a few age classes is much more affected by the success or failure of spawning in any one year than that dependent on many age groups. Hence, determination of spawning season and frequency of reproduction within the season and within the life-span of the fish are essential pre-requisites in assessing the reproductive potential of its population. During last few decades valuable contributions have been made on different aspects of freshwater fish biology, however, many of them dealt with biology of Indian major carps (Khan 1943, Natarajan & Jhingran 1963).

A perusal of literature shows that there is no information on biology of *Garra mullya* (Sykes) except a few remarks by Fraser (1937) and Jones (1941). Therefore, the present study was undertaken to investigate in detail some important aspects, such as spawning periodicity, breeding season, minimum size at first maturity and sex ratio of this species.

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Material and Methods

The material for the present study was collected from river Kham, near Aurangabad, every week from January to December 1974. The freshly caught fish were brought to the laboratory, measured for its length and weighed accurately after removing the surface moisture with blotting paper. There is no sexual dimorphism noticed in this fish. After dissecting, the sex was noted and the ovaries after ascertaining the maturity stages were preserved in 4% formalin for further study on ova-diameter measurements.

Observations

Maturity Stages

Ovaries are the paired, elongated and rounded organs, at full maturity occupy almost complete body cavity. Based on the development of ovaries and following the "International Council for the Exploration of the Sea" classification, seven maturity stages were recognised in *G. mullya*, which were broadly categorised as immature, maturing, mature and spent in the course of the study. Description of the maturity stages are given as below:

Stages	Microscopic Examination	Macroscopic Examination
	IMMATURE	
I	Ova tiny, prominent nuclei, clear cytoplasm, maximum ova diameter 0.42 mm	Ovaries thread-like, colour white
II	Ova increased in size, cytoplasm without yolk deposition, maximum ova diameter 0.60 mm	Ovaries flattened, ribbon-like, granular in appearance
	MATURING	
III	Yolk deposition in ova around nuclei, maximum ova diameter 0.87 mm, mode at 0.57 mm	Ovaries cylindrical in shape
IV	More yolk deposition, nuclei become invisible, maximum ova diameter 1.14 mm, mode at 0.75 mm	Ovaries increased in size, yellowish tinge
	MATURE	
V	Ova fully laden with yolk, maximum ova diameter 1.32 mm, mode at 0.93 mm	Ovaries yellow, ova full with yolk
VI	Ova periphery becoming transparent, maximum ova diameter 1.74 mm, mode at 1.11 mm	Ovaries tightly packed with ova, oozing by slight pressure
	SPENT	
VII	Ova small, few yolked, in resorbing condition	Ovaries loose, sac-like and blood shot

Ova diameter frequency polygons for different maturity stages (I–VI) are presented in figure 1, which indicate the progressive changes taking place in the ovaries.

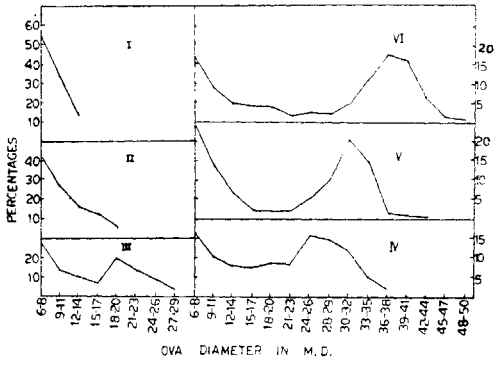

Figure 1 Ova diameter frequency polygons showing the growth of the ova in different stages of maturity.

Minimum size of maturity

The knowledge of minimum size of maturity is essential to ensure a sustained yield by adjusting the mesh size of the net in such a way that the smaller fish which have not spawned even once may have an opportunity to escape. With this view, 1251 specimens were analysed with 5 mm length groups as immature, maturing, mature and spent depending on the condition of the ovaries (figure 2). It can be seen that all the specimens up to 76 mm in total length are with immature and maturing gonads. The mature females appeared for the first time in 81–85 mm length group. Since their percentage is negligible (1.88), the minimum size of maturity can be fixed in 86–90 mm length group in which 55% fish were mature. The occurrence of spent fish in this group itself confirms this conclusion. The minimum size can thus be decided at 88 mm which corresponds to one and half years age of the fish (Somvanshi 1976).

Spawning Season

The spawning season of a fish can be predicted from *(i)* Occurrence of mature fish, *(ii)* Recruitment of juveniles, and *(iii)* Regression coefficient '*b*'.

(i) Occurrence of mature fish: For this purpose female specimens collected during January to December 1974 were analysed and their percentage in different stages of maturity in different months are depicted in figure 3. It is evident that the females in stage V occurred from April to September in varying percentages, the maximum of 29.09% being in May. The specimens in stage VI occur from June to November with their maximum percentage (60.00) in June which indicates that the breeding season is from June to November with intensive spawning from June to August. This is further supported by the occurrence of spent individuals from July to November except in August.

Fraser (1937) stated that "Egg-bearing females were found in March 1936". However, he gave no information about the spawning season of the fish. Jones (1941) remarked that on 23rd March, 1941

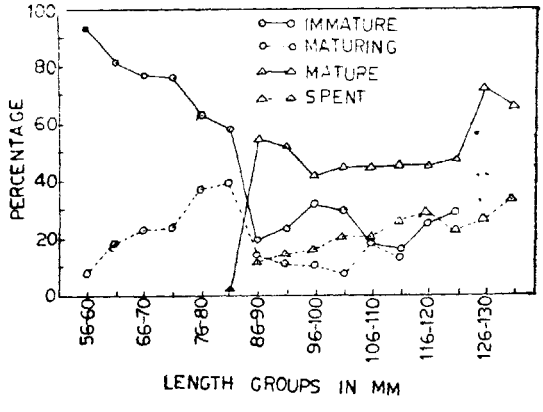

Figure 2 Percentage of immature, maturing, mature and spent females in each 5 mm. length group.

all the migrating fish were adults, full of ova and milt. He too has not indicated the spawning season as his observations were confined to only one day. Ganpati et al. (1951), however, collected eggs of *G. mullya* in June.

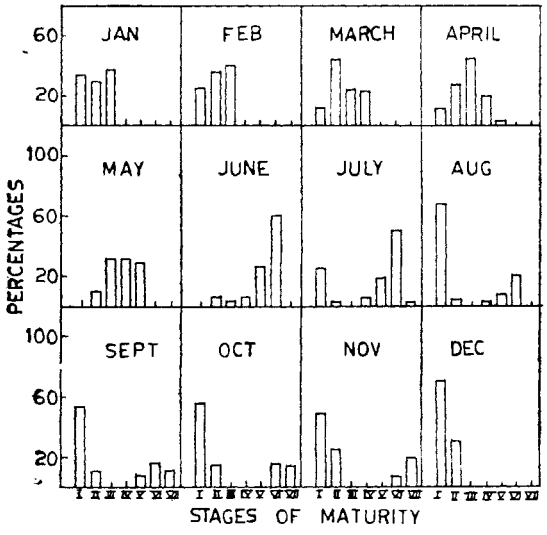

Figure 3 Percentage of females in various stages of maturity in different months.

(ii) Recruitment of Juveniles: The recruitment of juveniles ranging between 21 to 40 mm in total length from September to December (Somvanhi 1976) shows that the spawning commences in June. Ibrahim (1961) collected fry of *G. mullya* and certain carps from July to October and predicted that "breeding of carps in the Godavari extends over a maximum period of four months from July to October".

(iii) Regression Coefficient 'b': In herrings, Hickling (1940), found that in an ndvanced state of maturity the weight•of the fish increascs at the rate nearer to the square than the cube of the length. The least values of '*b*' can be made use of to find out the spawning season of the fish. Therefore, monthly '*b*' values were calculated for females and are presented in table 1, which shows comparatively lower values of '*b*' from June to November and increased gradually from December to May with a fall in April. Thus the lower values of '*b*' from June to November corroborate the findings about the prolonged breeding season lasting from June to November.

Table 1 *Regression coefficient* 'b' *in female* G. mullya *during different months*

Month	'*b*' value
1974	
January	3.275
February	3.309
March	3.492
April	3.138
May	3.600
June	3.274
July	3.369
August	3.064
September	2.949
October	3.134
November	2.949
December	3.153

Sex ratio

A knowledge of the sex ratio is considered essential in the management of fishery, as it enables one to follow the movement of sexes in relation to season. For sex ratio study, 2309 specimens were examined, out of which 1006 (43.57%) were males and 1303 (56.43%) females. The number of males and females differ significantly (x^2= 38.20, 12 d.f., at 5% s.l.) with their mean ratio 1 : 1.44.

In order to know the distribution of the two sexes during different months, the data were analysed monthwise and are given in

table 2. It is seen that the differences in distribution of the sexes in January, February, March and December are higher and significant, which reflects a differential behaviour within the sexes. The observations from April to November show a considerable increase in the number of males which makes the differences significant, except during the months of September and October. Thus, it can be said that the sexes congregate during the spawning season and segregate as the spawning is over. Hence the variations are significant during post-spawning months. Jones (1941) had described an interesting case of breeding migration in *G. mullya* in large shoals in one of the up-country rivers in Travancore in the month of March, in that he adds "the females were relatively larger in size and more in number than the males". Similar condition was also noticed during the present investigation.

The sex ratio data were also pooled with different length groups to know their distribution among the length groups (table 3). Table 3 shows that the females outnumbered in all the length groups. The Chi-Square values show insignificance up to 76–85 mm length group but in the subsequent length groups, these values indicate high significance. This shows that the females outnumber the males in higher length groups. This may be perhaps either due to the males on being more active are caught at lower ages or died off much faster than the females.

It is interesting to note that the variations in the sex ratio of *G. mullya* are significant after 86 mm total length i. e. the minimum size at maturity. This probably suggests a breeding migration.

Spawning periodicity

With Clark's work on spawning periodicity of fish, many studies on similar lines have been undertaken during recent years. It is agreed that the species which have a wide

Table 2 *Sex composition in* Garra mullya *during different months*

Month	Total No. of Specimens	Male		Female		Ratio	Expected Nos.		Chi-Square value	Remarks
		No. of specimens	%	No. of specimens	%	Male : Female	Male	Female		
1974										
January	137	57	41.61	80	58.39	1 : 1.40	68.5	68.5	3.86	*
February	101	24	23.76	77	76.23	1 : 3.21	50.5	50.5	27.81	*
March	185	76	41.08	109	58.91	1 : 1.43	92.5	92.5	5.87	*
April	186	88	47.31	98	52.68	1 : 1.11	93.0	93.0	0.54	N.S.
May	92	52	55.91	41	43.09	1 : 0.79	46.5	46.5	1.30	N.S.
June	56	23	41.07	33	58.92	1 : 1.43	28.0	28.0	1.78	N.S.
July	144	76	52.77	68	47.22	1 : 0.89	72.0	72.0	0.44	N.S.
August	327	116	51.10	111	48.90	1 : 0.96	113.5	113.5	0.11	N.S.
September	465	201	43.23	264	56.77	1 : 1.31	232.5	232.5	8.54	*
October	452	194	42.92	258	57.08	1 : 1.33	226.0	226.0	9.06	*
November	125	57	45.60	68	54.40	1 : 1.19	62.5	62.5	0.97	N.S.
December	138	42	30.43	96	69.57	1 : 2.29	69.0	69.0	21.13	*
Total	2309	1006	43.57	1303	56.43	1 . 1.44	1154.5	1154.5	38.20	*

N.S., Nonsignificant; *, Significant

Table 3 *Sex composition in* Garra mullya *in each 10 mm length groups*

Length group (mm)	Total No. of speci-ment	Male		Female		Ratio	Expected Nos. of		Chi-Square value	Re-marks
		No. of speci-mens	%	No. of speci-mens	%	Male : Female	Male	Female		
56-65	546	265	48.53	281	51.47	1 : 1.06	273	273	0.47	N.S.
66-75	570	270	47.37	300	52.63	1 : 1.11	285	285	1.58	N.S.
76-85	540	254	47.04	286	52.96	1 : 1.13	270	270	1.90	N.S.
86-95	368	126	34.53	242	65.76	1 : 1.92	184	184	36.57	*
96-105	165	60	36.36	105	63.64	1 : 1.75	82.5	82.5	12.27	*
106-115	83	27	32.53	56	67.46	1 . 2.07	41.5	41.5	10.13	*
116-125	29	4	13.79	25	86.20	1 : 6.25	14.5	14.5	15.21	*
126-135	8	0	00.00	8	100.00		4	4	8.00	*

N.S., Nonsignificant; *, Significant

range in diameters of intra-ovarian eggs may have several groups of ova which mature and shed periodically during the breeding season (Prabhu 1956 and Qasim & Qayyum 1961). With a view to determine the spawning periodicity in *G. mullya*, ovaries of mature females were collected during the breeding season and preserved in 4% formalin for further study. An eye-piece micrometer giving 0.03 mm to each micrometer division (m.d.) was used, however, for convenience the measurements are expressed in m.d. Ova measuring 6 m. d. and above (as ova less than 6 m. d. were present in all the maturity stages) were considered and the frequency curves are drawn using a class interval of 3 m. d.

Distribution of ova in an Ovary :

Slight differences in distribution of ova from anterior, middle and posterior regions of ovary in mackerel were noticed by Sekharan (1958). In order to see whether such condition exists in *G. mullya*, ovaries from three mature fishes ranging between 86 and 126 mm in total length were studied. Ova from the anterior, middle and posterior regions of each ovary were measured and their frequencies are presented in figure 4, which shows a uniform distribution. This was statistically tested by analysis of variance method and it was found that there is

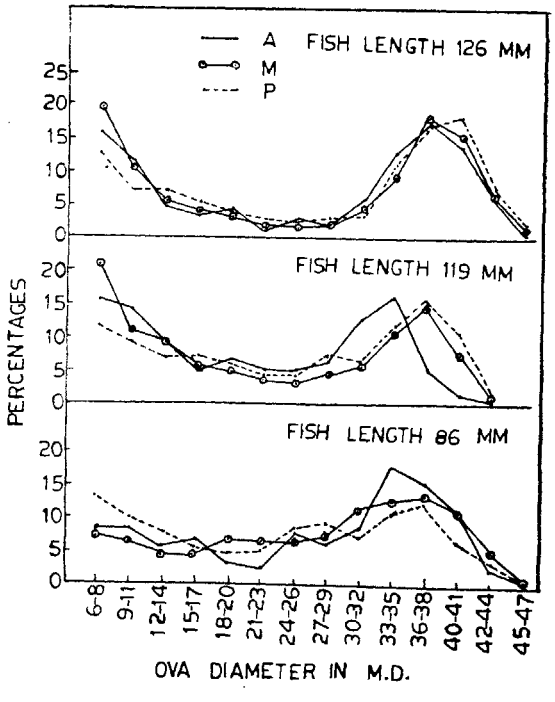

Figure 4 Distribution of ova of different sizes in the three regions of mature ovary.

no significant difference in the distribution of ova at 1% s.l. as well as 5% s.l. in all the three cases. The data pertaining to distribution of average ova diameter has also shown no significant difference in the diameters of ova at both 1% s.l. and 5% s.l. in the three cases studied.

It is thus evident that the distribution of number of ova and their diameters in the three regions is uniform. Hence ova from the middle region were measured for the spawning periodicity study and the results are presented monthwise graphically in figure 5a and b. The graphs clearly indicate two modes representing the immature and mature stocks of ova. The maturing ova are not represented by any distinct mode, however, in some cases the presence of these ova is indicated by a small mode in addition to those of immature and mature ones. In some ovaries which are well advanced towards maturity, in each month of the breeding season, this mode of maturing ova disappears indicating its advancement towards maturity and inclusion in the mode of mature ova. Thus the batch of mature ova gets separated. The range of mature ova (yolked) is 21 to 58 m.d., more than half of the total range of the diameters of the intra-ovarian eggs, which indicated prolonged spawning periodicity (Prabhu 1956). Whether the mature eggs are spawned in fractions or at one time only is also discussed in the subsequent matter.

It has been seen that the ripe specimens were encountered in the catches from June to November, there fore, it is confirmed that the fish spawns throughout the monsoon and post-monsoon months. Similar observations were made by Parameswaran et al. (1972) in common carp, *Cyprinus carpio*. Almost all maturity stages were present during the breeding season and the spent specimens occurred from July to November, showing thereby that due to succession of

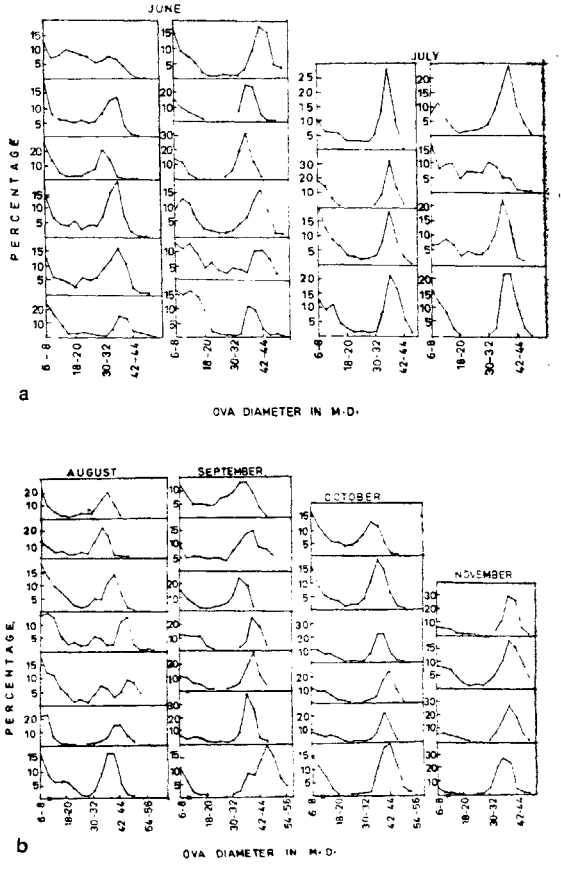

Figure 5a & b Ova diameter frequency polygons in mature specimens of *G. mullya*.

spawning, the breeding cycle of each individual takes an independent course. The species as such spawns for a prolonged period which may be attributed to the continuation of favourable conditions existing during the monsoon and post-monsoon months too, in Peninsular India. Qasim and Qayyum (1961) reported succession of spawning in murrels, as they found such overlaping of maturity stages.

Relative number of ova in different groups:

It is known amongst fishery biologists that the study on ratio of the maturing ova

to the mature ones during the spawning months gives an evidence of spawning multiplicity in the breeding season of the fish (Clark 1934, Jhingran 1961, Antony Raja 1964 and Saigal 1964). For this purpose analysis of ova from mature ovaries were made to know the relative number of ova in different groups as: *A*—ova from 6 m.d. to 10 m.d., *B*—ova from 11 m.d. to 20 m.d., *C*—ova from 21 m.d. to 30 m.d., and *D*—ova from 31 m.d. and onwards. Since the group A represents immature ova, the remaining three groups were considered in ratio calculations. The average values of the two sets of ratios $\frac{B+C}{D}$ and $\frac{C}{D}$ are shown in table 4, for the spawning months June to November, their values gradually decreased from 0.928 to 0.183 and 0.317 to 0.004 respectively. The length, weight of the fish and '*K*' values are also given in the table. It is seen that there is no effect of length and weight of the fish and so also '*K*' values on both the sets of ratios. Saigal (1964) on his observations in *Mystus aor* remarked that the progressive decrease in ratios is not due to the size (weight) variations but is only due to the successive spawning during the breeding season.

Table 4 *Showing average ratios of smaller yolked ova to larger ones and 'K' values for the months of spawning*

Month	Average length of fish (mm)	Average weight of fish (gms)	Ratios $\frac{B+C}{D}$	Ratios $\frac{C}{D}$	'*K*' values
June	114	17.04	0.928	0.317	1.107
July	112	15.97	0.621	0.217	1.088
August	104	13.30	0.625	0.165	1.134
September	104	13.04	0.427	0.146	1.093
October	111	14.58	0.465	0.099	1.031
November	106	13.21	0.183	0.004	1.091

Thus it is clear from the discussion pertaining to the two sets of ratios that in *G. mullya* the number of smaller ova decreased in proportion to the number of bigger ones as the spawning season advanced, indicating thereby that the species under investigation is a fractional spawner having a series of spawning bursts during the breeding season. Jhingran (1961) and Desai (1973) investigated on similar lines and concluded that multiple spawning during a breeding season takes place in *Setipinna phasa* and *Tor tor* respectively. However, Parameswaran and Sinha (1966) in *Notopterus notopterus* and Antony Raja (1964) in *Sardinella longiceps* found a constant ratio between ova of different diameters during the breeding season and rejected the possibility of multiple spawning.

Acknowledgements

The author is thankful to Dr (Mrs) S S Bapat, Reader, Department of Zoology, Marathwada University, Aurangabad, for her guidance and Dr S V Bapat, Joint Director, Central Marine Fisheries Research Institute, for his valuable suggestions.

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