STUDIES ON MATURATION, SPAWNING, FECUNDITY AND SEX RATIO IN *BARBUS (PUNTIUS) SARANA* (HAMILTON-BUCHANAN) FROM LAKE KOLLERU, ANDHRA PRADESH*

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Barbus sarana contains only one batch of mature ova in the mature ovaries to be spawned in one spawning act. It spawns during July-September. The fecundity ranges from 11,201 to 224,248 ova. There is a positive curvilinear correlation between total length and fecundity, the latter increasing with length at a rate of less than cube of length. The stock of this species from lake Kolleru appears to be more fecund than that inhabiting Loni reservoir. The sex ratio indicates that females outnumber males in all months and in larger length groups. Females appear to reach a larger length than males.

INTRODUCTION

There are reports on some aspects of spawning biology of *Barbus sarana* from different localities. Ahmed (1945) described its breeding in Punjab, Raj (1945) made a mention of its breeding in small tanks and Job, David and Das (1955) on spawning in Mahanadi river. Chaudhuri (1960) successfully induced this species to spawn from middle of July to end of August by pituitary extract injection, and also induced it to spawn in a small pond at Cuttack by maintaining a flow of accumulated rain water (1962). Qasim and Qayyum (1962) gave an account of spawning habits and breeding season in rivers near Aligarh and nearby areas. Apart from the above studies, there is a brief mention about its breeding and fecundity in Loni

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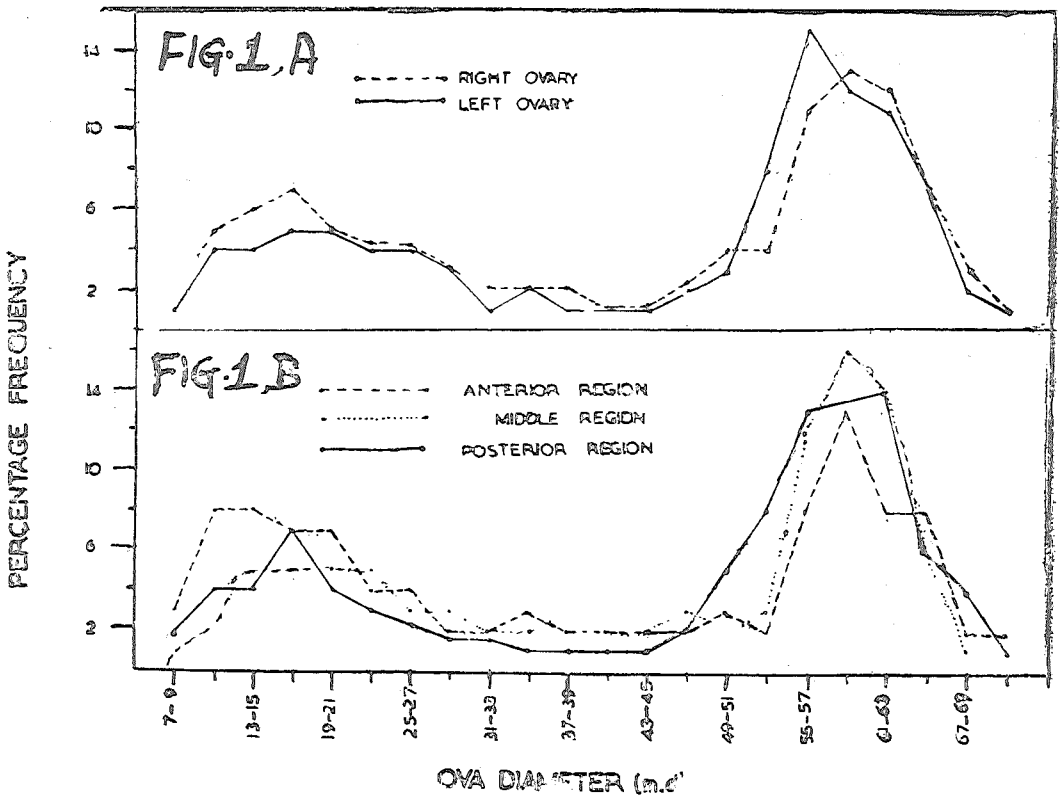

Fig. I. A. Percentage frequency distribution of ova of different diameters in right and left ovaries (peeled for anterior, middle and posterior regions) in stage V.

B. Percentage frequency distribution of ova of different diameters from anterior, middle and posterior regions of right ovary in stage V.

reservoir (Anon. 1969). Natarajan, Govind, Roy and Banerjee (1971) studied its maturation in Tilaiya reservoir.

The present study was attempted to obtain detailed information on maturation, spawning, fecundity and sex ratio of *B. sarana* from lake Kolleru.

Material And Methods

The study is based on 868 specimens of *B. sarana*, 532 females and 336 males, ranging from 92 to 305mm. in total length (TL) collected from the commercial catches in the lake at regular intervals from July 1970 to May 1972. After measuring length and weight of each specimen the belly was cut open to note the sex, colour and general appearance of the gonads which were then removed and preserved in 5% formalin. For measurement of ova diameters small pieces from the anterior, middle and posterior regions of the left ovary were taken. The ova were teased out on microslides and measured under a microscope with the help of an occular micrometer using the method employed by Clark (1934) and De Jong (1940).

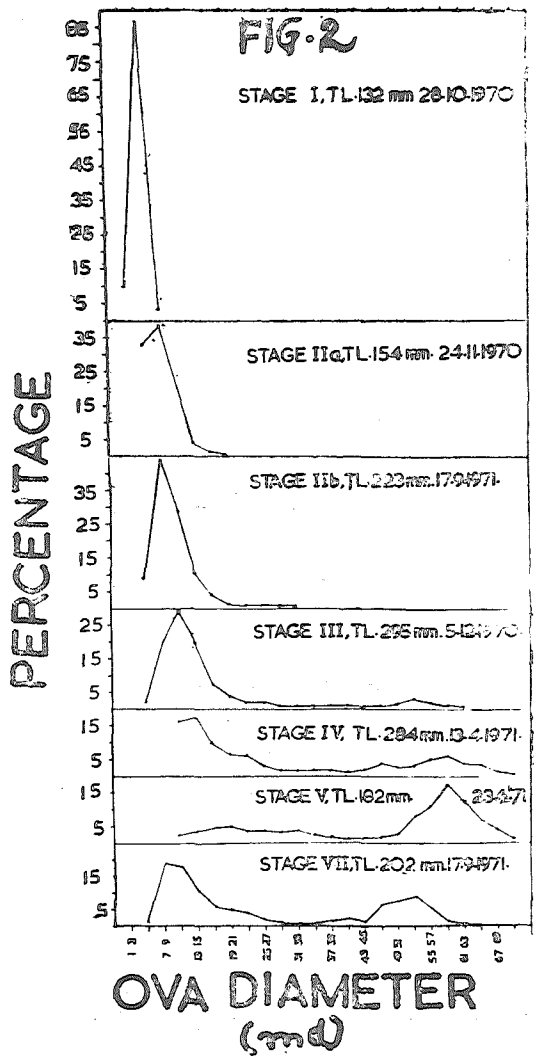

Fig. 2

Ova diameter frequency distribution in ovaries of different stages of maturation.

Estimation of fecundity is based on ovaries in stage V collected during the spawning season. The larger opaque ova above 34 md. (0.49mm.) were counted and fecundity was estimated by the method followed by Bagenal (1966) and Qasim and Qayyum (1963).

Results And Discussion

Maturation

1. *Description of ova*:

Four groups of ova can be distinguished in adults.

a. Immature ova: shape irregular, translucent, yolkless, nucleus clearly visible, diameters range from 3 to 9 md. (0.04-0.13 mm). (This is the only kind in juveniles).

b. Early maturing ova: shape irregular, yolk deposition initiated, yellowish translucent, nucleus visible, diameters range from 6 to 18 md. (0.08-0.26 mm).

c. Larger maturing ova: mostly spherical with globular yolk, almost opaque in the centre with the nucleus faintly visible, translucent near the periphery, diameters range from 15 to 35md. (0.22-0.51 mm.).

d. Mature ova: spherical, opaque, diameters more than 35 md. (0.51 mm).

2. *Distribution of ova in the ovary*:

Since the ovaries of adults contain ova of different sizes it has to be ascertained whether they are randomly distributed or whether there is localisation of ova of particular sizes in different parts of the ovary. This was done by examining an ovary in stage V (mature) from an adult measuring 285 mm. TL. The diameters of 200 each from the anterior, middle and posterior regions of both ovaries were measured and percentage frequency distribution of ova of different sizes in each of them calculated. The data pooled from the measurements made in the three regions of each ovary and the data from the three regions of the right ovary (fig. 1)

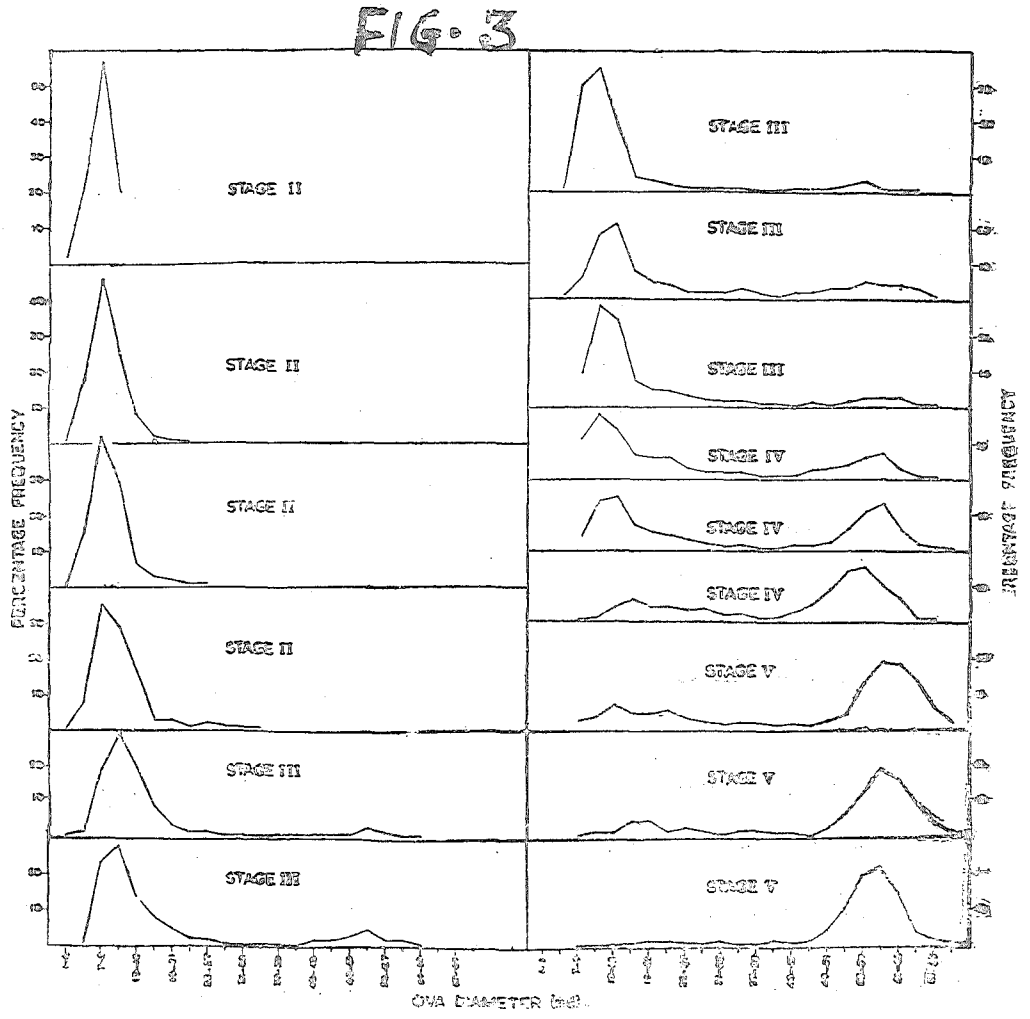

Fig. 3. Ova diameter frequency distribution in a few ovaries representative of each stage of maturation from II to V.

show that the ova of different sizes are randomly distributed. However, to eliminate any possible bias, sections from the three regions were taken for measurements of ova diameters in each ovary (Fig. 1).

3. *Stages of maturation*: (fig. 2 & 3)

The following stages of maturation are recognised in females on the basis of macroscopic study of fresh ovaries and on the basis of measurement of ova diameters in preserved ovaries.

Stage I (Juveniles)

Ovary thin, ribbon like, occupying less than half the length of body cavity, light pink. Ova not visible to naked eye irregularly shaped, transparent, without yolk, nucleus clearly visible, oviducts narrow, long. Ova belong to group *a* above.

Stage II a (maturing virgins):

Ovary thin, extending to about half the length of body cavity, light pink or

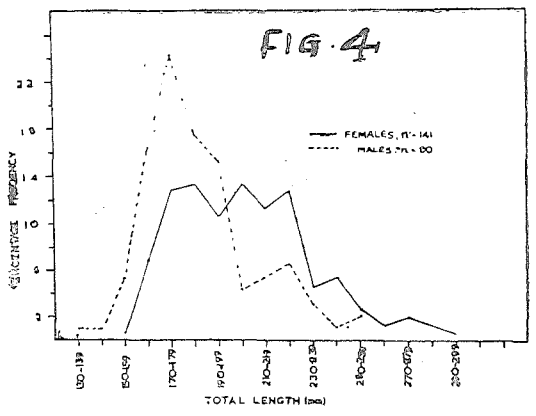

Fig. 4

Length frequency distribution of each sex during spawning season. (data of two years pooled)

whitish. Ova not visible to naked eye, irregularly shaped, yolk deposition initiated in most ova, translucent, nucleus visible, oviducts distinct, long and narrow. Most ova in group *b*, a few in group *a*.

Stage II b (rematuring adults):

Ovary reddish extends to a little more than half the length of body cavity. A few opaque ova sometimes present at posterior end of ovary, in addition to maturing ova of groups *b*, and *c* and a few of *a*.

Stage III (maturing adults):

Ovary golden yellow, slightly lobulated occupies about $\frac{3}{4}$ of body cavity; ova visible to naked eye, oviducts short. Most ova belong to groups *a*, *b*, *c*, and a few to group *d*.

Stage IV (maturing adults):

Ovary light yellow, ovarian blood vessels prominent, ovary lobulated, occupies almost entire length of body cavity, ovarian wall thin, ova opaque, oviducts almost filled with ova. Ova in groups *c* and *d* along with a few in *a* and *b*.

Stage V (maturing adults):

Similar to stage IV but differs from it in having a distended ovary and in having greater number of group *b* ova.

Stage VI (running ripe):

Not encountered in the catches.

Stage VII (spent):

Ovary bloodshot and baggy, with a few of group *d* ova scattered in the tissue and numerous maturing ova in groups *b* *c* and a few of *a*.

4. *Maturation of ova*:

The study is based on measurement of o/a diameters in 106 ovaries in different stages of maturation belonging to specimens ranging from 149 to 305 mm. TL. The percentage frequency distribution of ova in ovaries of different stages of maturation are presented in figure 2 and 3.

The appearance of a new mode at 52-54 md. in the diameter frequency distribution of ova in stage III is indicative of faster growth rate of larger maturing ova in stage II. The smaller maturing ova in stage III form a greater percentage with the mode between 10 and 12 md. They get reduced to smaller numbers when the ovaries are mature and in stage V the mode is between 13 and 15 md. (0.19-0.22 mm). The fact that:

i. the increase in the maximum size of ova from stage III to stage V is not considerable,

ii. although the modal sizes of mature ova in stages IV and V are more or less

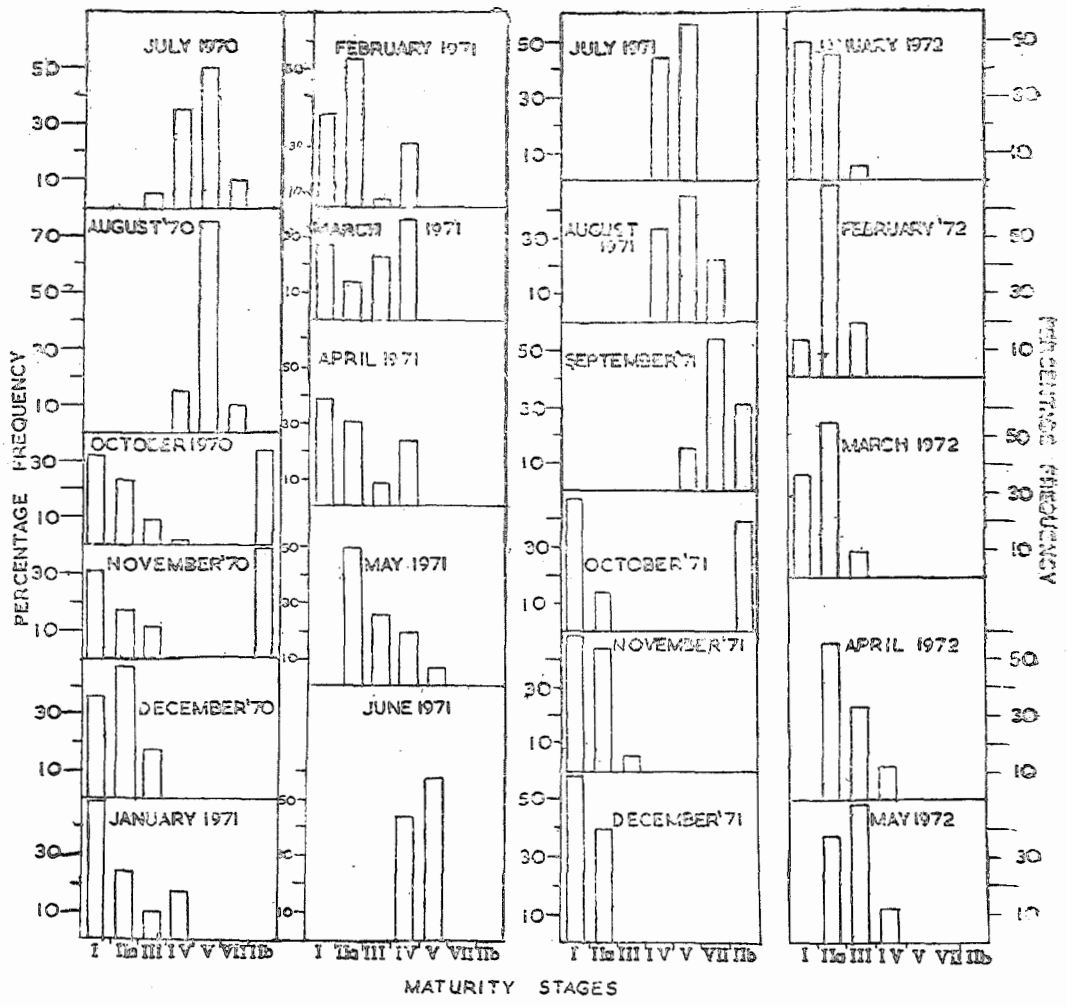

Fig. 5. Percentage frequency distribution of ovaries in different stages of maturation in each month from July 1970 to May 1972.

same, the percentage of these ova in stage V is much greater than in stage IV and iii. the percentage of smaller maturing ova in stage V is less than in stage IV indicating that batches of ova increase in size successively and are added on to the larger sized ova.

The ovaries of spent adults (stage VII) contain a group of larger ova with the mode at 52-54md. (0.76-0.79mm.) in addition to smaller maturing ova. There is no reason to believe that these will yet be spawned in the current spawning season because they are smaller than the ova in stage IV and V; the shape of ova is irregular and most of them are dark in colour. Probably these represent residual ova which will be resorbed.

5. *Length at first maturation and relative importance of different length of groups in the spawning stock*:

Immature individuals were never enco-

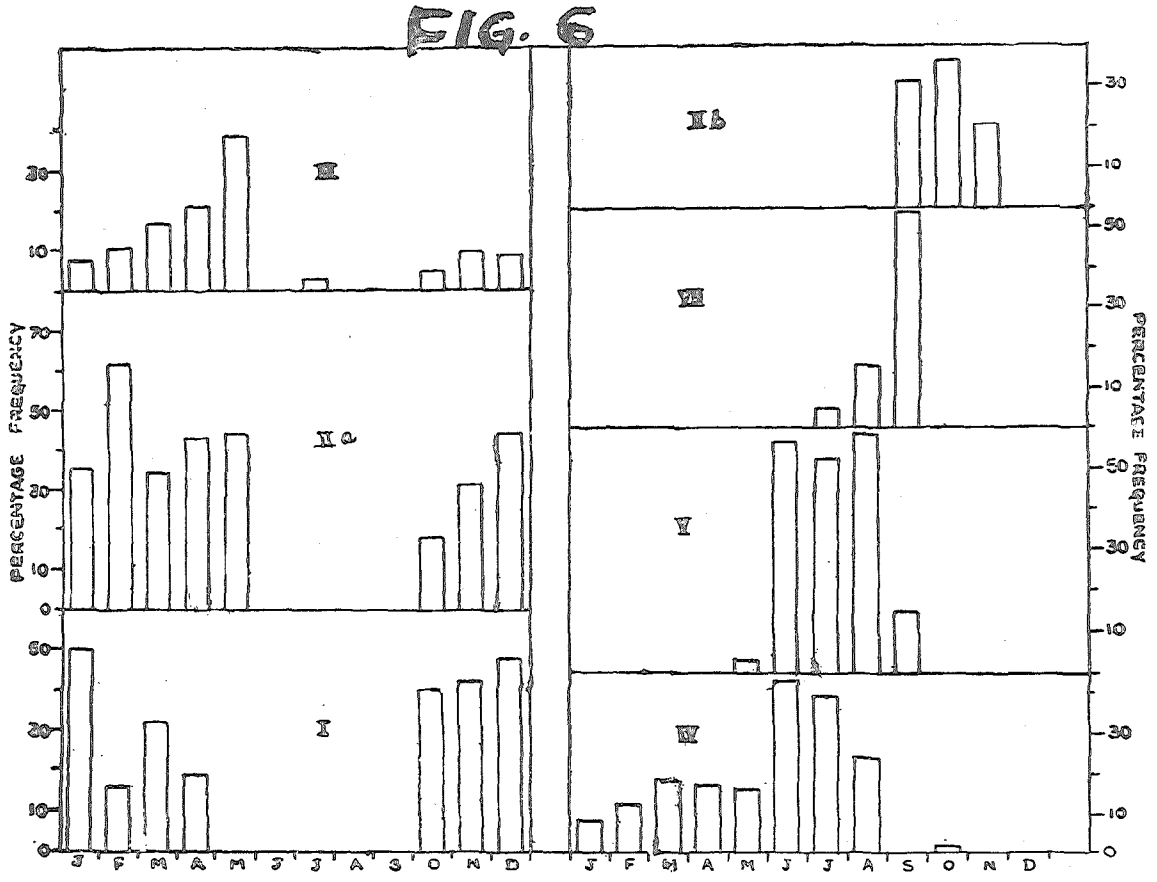

Fig. 6. Percentage frequency distribution of ovaries in each stage of maturation in different months (data of the corresponding months of the two years pooled).

untered in the catches during the spawning seasons of the two-year period. All the fishes were either mature or spent. Hence it was not possible to determine the minimum length at first maturation. An attempt was made to determine the relative importance of the different length groups in the spawning stock, on the basis of the number of mature and spent adults in each length group during the spawning season. For this purpose the data collected over the two-year period have been pooled.

Figure 4 indicates that there is some difference in the length of smallest as well as the largest mature males and females. The smallest mature male recorded is in 130mm. group, and female in 150 mm. group. The largest mature male is in 250 mm. group and female in 290 mm. group. Though the smallest male in the spawning stock is in 130 mm. group, the major mode is at 170 mm. In females the first conspicuous mode is at 180 mm. This suggests the possibility that males spawn for the first time in large numbers when

they are about 170 mm. and females do so when they are about 180 mm.

The above details indicate that males attain sexual maturity at a smaller length than the females. The difference in the size at first spawning and in the maximum size attained in the two sexes may be due to differences in their growth rates or due to the fact that females live longer and hence attain a larger size.

Spawning

1. Spawning habits:

Teleosts exhibit different types of spawning habits (Hickling and Rutenberg, 1936; De Jong, 1940; Prabhu, 1956; Qasim and Qayyum, 1962). Qasim, and Qayyum (1962) divide the freshwater fishes of northern India into three categories based on ova diameter frequencies and breeding habits.

The ova diameter frequency distribution in mature ovaries (fig. 2 & 3) shows that the mature ova form a single and distinct mode that is separated from the immature ova. This condition indicates that finally only one batch of mature ova is produced to be released in one spawning act and that the spawning season is short. The situtation also indicates that each adult female of *B. sarana* spawns only once in the season. This is supported by the fact that partially spent condition does not occur and that spent ovaries contain only a few large residual ova which may be resorbed. *B. sarana* from lake Kolleru approaches category I of Qasim and Qayyum (1962).

2. *Spawning season:*

This is determined on the basis of occurrence of individuals in different stages of maturation in each month of the period of investigations. Data relating to the percentage occurrence of ovaries in different stages of maturation in different months are given in fig. 5. The percentage monthly occurrence of ovaries in different maturation stages from July 1970 to May 1972 obtained by pooling the data of the corresponding months in the two-year period are given in fig 6. The cycle of events indicates that *B. sarana* spawns in the lake from July to September with peak activity during August and September.

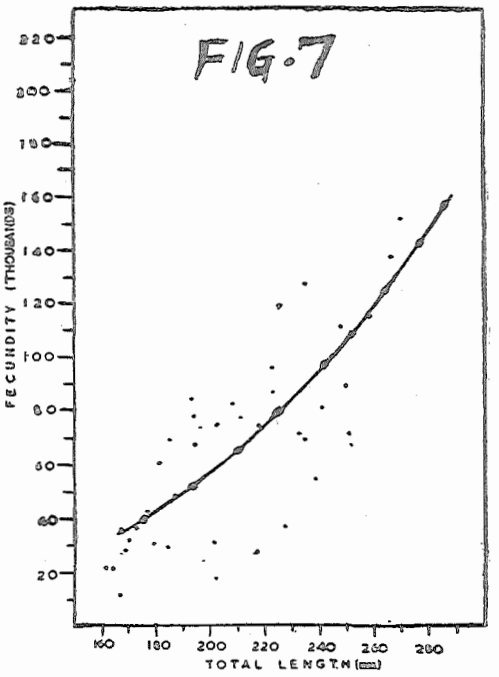

Fig. 7
Relationship between total length and fecundity.

Available information (Ahmed 1945; Qasim and Qayyum 1962; Natarajan *et al.* 1971) indicates that *B. sarana* spawns from June to September in different localities.

TABLE I

Proportion of males and sex ratio in monthly samples during 1970-'71 and 1971-'72

	1970-'71				1971-'72			
Month	N	males	Proportion of males	Ratio m:f	N	males	Proportion of males	Ratio m:f
July	44	24	0.54	1 : 0.83	71	32	0.45	1 : 1.21
Aug.	25	5	0.20	1 : 4.00	31	12	0.39	1 : 1.58
Sept.	—	—	—	—	14	2	0.14	1 : 6.00
Oct.	66	23	0.35	1 : 1.87	37	15	0.40	1 : 1.46
Nov.	48	13	0.27	1 : 2.69	34	15	0.44	1 : 1.26
Dec.	54	18	0.33	1 : 2.00	31	11	0.35	1 : 1.81
Jan.	66	24	0.36	1 : 1.75	51	29	0.57	1 : 0.76
Feb.	47	17	0.36	1 : 1.82	32	9	0.28	1 : 2.55
March	47	25	0.53	1 : 0.88	14	3	0.21	1 : 3.66
April	33	18	0.54	1 : 0.83	17	7	0.41	1 : 1.42
May	29	13	0.45	1 : 1.23	23	7	0.30	1 : 2.28
June	54	14	0.26	1 : 3.85	—	—	—	—
	513	194	0.38	1 : 1,64	355	142	0.40	1 : 1.50

TABLE II

Sex ratio in relation to length during the two years 1970-'71 and 1971-'72

Length groups (mm.) TL	1970-1971		1971-1972		Peeled for two years	
	males	females	males	females	males	females
90-99	—	—	1	—	1	—
100-109	1	—	—	1	1	1
110-119	2	3	2	1	4	4
120-129	3	6	2	6	5	12
130-139	8	6	11	5	19	11
140-149	12	14	6	9	18	23
150-159	19	18	9	13	28	31
160-169	25	22	16	28	41	50
170-179	24	39	23	13	47	52
180-189	24	31	21	18	45	49
190-199	14	20	18	23	32	43
200-209	7	20	9	20	18	40
210-219	14	14	10	17	24	31
220-229	19	13	9	23	28	36
230-239	12	16	5	8	17	24
240-249	7	15	—	13	7	28
250-259	3	21	—	7	3	28
260-269	—	20	—	5	—	25
270-279	—	21	—	2	—	23
280-289	—	12	—	1	—	13
290-299	—	6	—	—	—	6
300-309	—	2	—	—	—	2
Total	194	319	142	213	336	532
Ratio	1 : 1.6		1 : 1.5		1 : 1.6	

The results of the present work are consistent with the hypothesis(Hora, 1945; Khan, 1945) that monsoon flood is necessary for spawning. Though mature individuals begin to occur in the lake catches during May, spent individuals occur only from July to September. Monsoon in this region starts in late June and lasts till the end of September.

Fecundity

The fecundity of individual specimens in the 40 specimens examined ranges from 11201 in a specimen of 165 mm. TL. and 59 g. weight to 224248 in a specimen of 286 mm. TL. and 390g. weight. There is considerable variation in fecundity in each length group. Figure 7 shows that there is a curvilinear relationship between total length and fecundity. In the logarithimic form the relation between these two variables is expressed as: log F= -1 64188+ 2.78317 log L (F= fecundity and L= total length). The value of the exponent in the length-weight relationship of females is 3.41575 (Murty, in press). Thus, it appears that the increment of fecundity with length is less than that of weight with length in females.

The fecundity of *B. sarana* from Loni reservoir (Anon. 1972) was observed to range from 39213 to 199022 in fishes ranging from 241 to 326 mm. in lengtn and 220-500g. weight. The largest female in the present study measured 286 mm. and 390g. Its estimated fecundity is 224248 which is more than the highest fecundity observed from the Loni reservoir. Moreover, in fishes ranging from 240 to 286 mm. from lake Kolleru (the length range of specimens for which fecundity data are available from Loni reservoir is 211-326 mm.) the fecundity ranges from 69190 to 224248. Thus the present observations indicate that fecundity of Kolleru stock is greater than that of Loni reservoir.

Sex ratio

The sex ratio may reveal differential fishing (Kesteven, 1942). It may indicate differences in the growth rate of the two sexes (Qasim, 1966). There is no information on this aspect in this species from any locality in India. The data of the sex ratio for each month and in different length groups are presented in tables I and II respectively. In most months, the numbers of females exceeded males, the ratio of

TABLE III

Test of homogenity (2) for proportion of males in monthly samples during the two years 1970-'71 and 1971-'72 and for the pooled data of the two years.

Year	Df	$\psi 2$	Significance at 5% level
1970-1971	10	19.23	significant
1971-1972	10	15.23	not significant
1970-1972 (pooled)	11	17.93	not significant

TABLE IV

Results of Chi-square test applied to test the significance of observed differences in the sex ratios in monthly samples during the period July 1970 - June 1971

Month	Females	Males	Df	χ^2
July	20	24	1	0.36
August	20	5	1	9.00*
October	43	23	1	6.06*
November	35	13	1	10.08*
December	36	18	1	6.00*
January	42	24	1	4.91*
February	30	17	1	3.59
March	22	25	1	0.19
April	15	18	1	0.27
May	16	13	1	0.31
June	40	14	1	12.52*

*Significant at 5% level

males to females in all the 868 specimens examined being 1:1.6.

The data were analysed to test the significance of differences in the proportion of males in the monthly samples of each year by applying the Chi-square test (Fisher, 1925). The results for each of the two years are presented in table III. At 5% probability level, the χ^2 value for 1970-'71 shows that the observed proportions of males in different months are statistically significant, but the value for 1971-'72 is not significant. The contradictory values of the two years could be due to sampling variation or they may reflect an actual situation indicating variation from year to year. The test was next applied to the pooled data of the two years, but the χ^2 value shows that the proportion of males in different months is not significantly different.

It was next asertained whether the observed ratio in each month differs significantly from the theoritical 1:1 ratio. The Chi-square values for each month during the two years and for the pooled data of the corresponding months in the two-year period are presented in tables IV, V and VI. In the first year there is significant departure from 1:1 in August, October, November and December 1970 and January and June 1971 (Table IV).

TABLE V

Results of Chi-square test applied to test the significances of the observed differences in the sex ratios in the monthly samples during the period July 1971 - May 1972.

Month	Females	Males	Df	χ^2
July	39	37	1	0.69
August	19	12	1	1.58
September	12	2	1	7.14
October	22	15	1	1.32
November	19	15	1	0.47
December	20	11	1	2.61
January	22	29	1	0.96
February	23	9	1	6.13
March	11	3	1	4.57
April	10	7	1	0.53
May	16	7	1	3.52

Significance at 5% level

TABLE VI

Results of Chi-square test applied to test the significance of observed differences in the sex ratios in the pooled monthly samples for the period July 1970 - May 1972.

Month	Females	Males	Df	χ^2
July	59	56	1	0.08
August	39	17	1	8.64
September	12	2	1	7.14
October	65	38	1	7.08
November	54	28	1	8.24
December	56	29	1	8 58
January	64	53	1	0.42
February	53	26	1	9.22
March	33	28	1	0.41
April	25	25	1	0.00
May	32	20	1	3.60
June	40	14	1	12.52

Significant at 5% level

In the second year, significant departure is seen only in September 1971 and February and March 1972 (Table V). The pooled data show significant departure in eight months (Table VI). The significant departure from 1:1 in different months appears to be due to the preponderence of females. It is also seen that there is variation in the monthly sex ratios in the two years. During 1971-'72 the ratio in September, February and March shows departure from 1:1, whereas in the previous year there is no departure in these months (there are no data for September 1970). These differences may reflect an actual situation or sampling variation. However, it is clear from the data that in both years females are preponderent in most months.

The data on sex ratio to length (Table II) show that in most length groups in each of the two years as well as in the pooled data, females outnumber males. In the two years together males were not represented beyond 250mm. group. Females exceed males in most length groups as well as in total even after excluding the largest five length groups in which there are only females.

It appears that females grow faster and attain a larger length. It is probable that the larger females in the length range 250-309mm. are older than the largest males. This problem however, cannot be solved at present because, it has not been possible to determine the age of this species sex wise from the lake and there is no information on the age and growth of this species from elsewhere.

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