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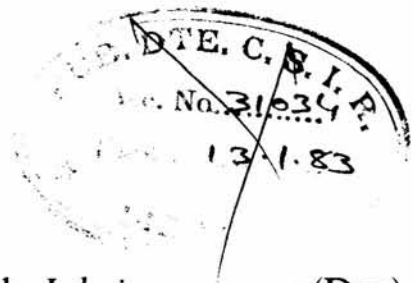

Reproductive Biology of Sciaenid Fish, *Johnieops osseus* (Day), from the South Kanara Coast

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J. osseus spawns throughout the year, releasing 3 batches of eggs in a year. Size at first maturity is 12 cm and fecundity about 46,000 eggs per individual fish. Females outnumber males in commercial catches, although the sex-ratio shows no significant deviation.

Though some information is available regarding the breeding habits and early life histories of sciaenids[1-8] detailed studies on reproductive biology are lacking. The present paper deals with the reproductive biology of *Johnieops osseus*, the dominant species of the sciaenids captured off South Kanara Coast.

Materials and Methods

Samples were collected from different fish landing centres of the South Kanara coast during April 1976 to March 1977. The stages of maturity in *J. osseus* were classified on the basis of appearance and structure of ova in females and appearance of testes in males. Ova diameter was determined according to earlier methods[9,10]. Relative ovary weights (gonado-somatic indices) were calculated using the formula, ovary weight $\times 10^3$/fish weight, and were tabulated against maturity stages. Size at 1st maturity was determined on the basis of (i) percentage occurrence of mature fishes in various size groups; (ii) data on largest common ova diameter; and (iii) relative condition factor K_n with respect to size of fish. For fecundity estimations, ovaries of fully mature (stage V) and partially spent (stage VII A) fishes were utilised. A small sample of ovaries was removed and weighed. The ova in such a piece were dispersed in a small amount of water and spread evenly over a zooplankton counting cell. The number of ova in each square along the diagonal of the zooplankton counting cell were counted using a binocular microscope. Mean of these values gave the number of ova per square. Based on this, the total number of ova for all the 100 squares was estimated. The number of ova in each sample of the ovaries was multiplied by the factor which expressed the ratio between the weight of the sample and the total weight of the ovaries. Sex was noted by cutting open the abdomen. In fishes below 10 cm, both for males and females, microscopic examination was necessary for noting the sex.

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Results and Discussion

Maturation and spawning—Stage I—Immature: Ovaries thin and light pink in colour, occupying $< \frac{1}{4}$ of the body cavity. Ova not visible to naked eye, irregularly shaped, transparent with a clear nucleus. Most of the ova are in the size 0.018 to 0.054 mm, maximum being 0.09 mm. Testes thread-like, occupying $< \frac{1}{4}$ the length of body cavity.

Stage II—Maturing: Ovaries flattened and pink in colour, occupying $\frac{1}{4}$ to $< \frac{1}{2}$ the body cavity. Ova not visible to naked eye. Two groups can be distinguished—small, irregularly shaped and slightly larger, round and transparent with yolk deposition at centre. Total size 0.018 to 0.234 mm. Mode of largest group at 0.081 mm. Testes occupy about $\frac{1}{4}$ the length of the body cavity, semitransparent and ribbon-like.

Stage III—Early mature: Ovaries yellow, occupying $\frac{1}{2}$ to $< \frac{3}{4}$ of body cavity. Ova visible to naked eye through semitransparent ovarian wall. Three groups of ova—immature, maturing and mature. Mature ova completely opaque with heavy deposition of yolk. Total size range 0.018 to 0.522 mm. Mode of largest group at 0.351 mm. Testes ribbon-like, white and opaque, occupy about $\frac{1}{2}$ the length of body cavity.

Stage IV—Late mature: Ovaries yellowish pink occupy $> \frac{3}{4}$ the body cavity. Ova visible through ovarian wall. Ovaries appear speckled due to vacuolation of ova. Four groups of ova—immature, maturing, early mature and late mature. In the largest group of ova, yolk vacuolated at centre with a clear perivitelline space. Size range 0.018 to 0.540 mm. Mode

of larger group at 0.351 mm. Testes ribbon-like, white or creamy white, occupy more than $\frac{1}{2}$ the length of body cavity and also more volume than in the previous stage.

Stage V—Ripe: Ovaries fully occupy body cavity, pinkish to white, ovarian wall completely transparent. Speckled nature of ovary more prominant. Ova completely transparent, delicate, with a single oil globule (diam. 0.144 to 0.198 mm). Apart from the largest group, there are 4 more batches of ova corresponding to those in the previous stage. Size range 0.018 to 0.810 mm. Mode of largest group at 0.513 mm. Testes occupy about $\frac{3}{4}$ of the length of body cavity, creamy white, completely opaque, broad and lobulated.

Stage VI—Spawning/Oozing/Running: Females of this stage were not encountered in the present study. Testes in this condition ooze freely with slight pressure on the abdomen.

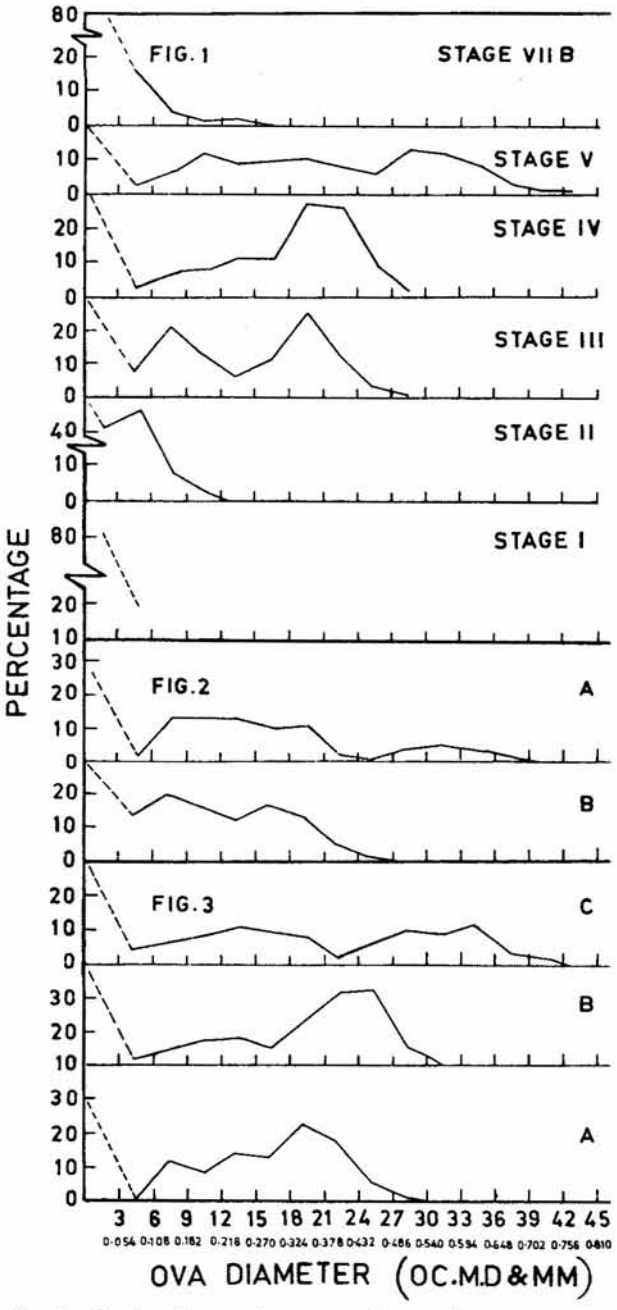
Stage VII A—Partially spent: Ovaries flabby and collapsed, occupy varying amount of space in body cavity. Ovaries resemble stages III, IV and V in microscopic appearance but differ from them in macroscopic appearance (size, compactness and colour). They could be recognised as distinct from the virgin stages only in the fresh condition. Testes collapsed, transparent along the margin due to partial release of milt at spawning.

Stage VII B—Fully spent: Ovaries completely collapsed, shrunken, occupying $\frac{1}{4}$ to $<\frac{1}{4}$ of the body cavity. Immature group of ova are small and not visible to the naked eye. A few large opaque eggs visible to the naked eye are present. Shrunken, completely transparent residual eggs may also be present. Size range 0.018 to 0.324 mm. Mode of largest groups at 0.243 mm. Testes reddish-brown, flabby and shrunken, occupying about $\frac{1}{4}$ the length of body cavity.

Frequency of spawning—Based on ova diameter frequency polygons of mature and partially spent ovaries, an attempt has been made to ascertain the probable number of batches of ova spawned in an year.

From the immature stock of ova (size range 0.018 to 0.054 mm) in stage I (Fig. 1), batches of ova get separated out and progress towards maturity, as indicated by the progression of modes from stage I to stage V (Fig. 1). In stage V, 4 batches of ova are demarcated. The most advanced batch is seen as a mode at 0.513 mm. These ova which are transparent with oil globules constitute the batch that would be spawned first. Two more groups of ova with modes at 0.351 mm and 0.189 mm follow this group. The rest belong to immature group. The succession of maturing groups of ova indicates that each individual fish spawns more than once.

Ovaries in stage VI have not been recorded in the present study. After the 1st spawning, ovaries may attain a condition shown in Fig. 2A, wherein the



Figs 1 to 3—Ova diameter frequency polygons of ovaries of *J osseus* (1) in various stages of maturity, (2) after spawning (A, early stage; B, later stage) and (3) in recovering phase in the order A to C

percentage of ova of the most advanced group at 0.567 mm shows a decline. These ova, though transparent with oil-globules are shrunken and distorted in shape These are evidently the residual ova, destined to degenerate. The ovaries show considerable reduction in size. Hence, there may not be a possibility of release of another batch of ova immediately. Such ovaries, on recovery, may attain a condition shown in Fig. 3A, where the largest group shows a mode at 0.351 mm. They are all opaque. Figs 3B and C represent further recovery of ovaries as evidenced by change in size and

characteristics of ova. The opaque ova, become vacuolated and form a mode at 0.459 mm (Fig. 3B) which in turn become completely transparent with oil-globules constituting the most advanced group of ova at 0.621 mm (Fig. 3C). These ova which are ripe, would be the 2nd batch to be spawned. After the release of these ova, the ovaries may indicate a condition (Fig. 2B) where the most advanced group of ova show a minor mode at 0.297 mm. They are mostly opaque but some vacuolated ova may also be seen. It is expected that fish with such ovaries would recover further through the stages mentioned above (Figs 3A to C) and then spawn a 3rd time. By this time, most of ova originally withdrawn from the general stock would have been eliminated due to repeated spawning resulting in a condition shown by the fully spent ovaries (stage VII B).

Occurrence of partially spent fishes with ovaries resembling those of virgin fishes in stage III to V further supports the view that individual fish after each spawning returns to the next lower stage up to stage III, thereby indicating that it has spawned thrice. Based on the above evidence, it can be said that there is a possibility of individual fish releasing as many as 3 batches of ova in an year.

Spawning season—This is determined on the basis of occurrence of individuals in different stages of maturity in each month. A total of 915 females and 722 males of *J. osseus* have been examined. Fishes in almost all stages of maturity are present in April, May and August to March (Fig. 4). In all the months except August, September and October, stage VII A is dominant. Stage III is dominant in September and October and stage VII B in August. Freely oozing males (stage VI) are obtained only in October. These observations indicate that spawning takes place throughout the year.

Occurrence of mature, partially spent and spent fishes alone cannot prove that the fish spawns throughout the year, for the length of time the fish remains in each of these stages cannot be ascertained. Hence presence of residual eggs have been used as a criterion to indicate the time of spawning. The residual eggs in *J. osseus* are delicate in nature and hence may easily be broken and resorbed in a short time. Therefore, presence of residual eggs indicates a recent spawning. The residual eggs are encountered in February, April, May, October and December indicating spawning.

Gonado-somatic index—Since the size of the gonads did not indicate the stage of maturity, relative ovary weight was used for this purpose. In females, immature, maturing and fully spent individuals had a gonado-somatic index of < 15. The index for partially spent fishes and most of the fish in stage III ranged from 15 to 60. Fish in the IV and V stages had an index of more than 60.

In males, due to lack of microscopic evidence it was not possible to differentiate partially spent fishes. The immature, maturing, fully spent and partially spent fish had an index up to a maximum of 8. Most of the males in stage III and in stages IV to VI had an index > 8.

Size at first maturity—Size of *J. osseus* at 1st maturity was determined based on a study of 1366 females and 1050 males. All the stages of maturity were available in both the sexes except for stage VI (running) in females.

Relation between size of fish and maturity—Fishes were grouped sexwise into 1 cm size groups and the percentage occurrence of fishes in various stages of maturity was calculated. Fishes in the maturity stages of III to VI (in males only) and VII A were considered mature, since progression of modes in the ova diameter frequency polygons for females in the above stages of maturity indicated that the largest group of ova would ripen and eventually be spawned. All the fishes up to 8 cm were immature in case of males and 9 cm in case of females. Spent fishes were recorded for the 1st time in 9 to 10 cm size group in case of males and 10 to 11 cm in case of females. Up to the size group of 11 to 12 cm, both male and female fishes of the immature group were dominant. Majority of fishes were mature in the 11 to 12 cm group both in case of males (48%) and females (54%). From this group onwards, mature fishes steadily increased to 100% at 17 to 18 cm group in males and 19 to 20 cm group in females (Figs. 5A and B). Based on the data, the size at first maturity for males was 11.7 cm and for females 11.4 cm.

It is of interest to record that 3 oozing males (14, 15 and 15.33 cm) were encountered at the Kulai-Hosabettu fish landing centre during August-October 1976. It may thus be said from the above data that males mature at a size of 9 to 10 cm and females at 10 to 11 cm. In both the sexes, majority of fishes attain sexual maturity at 12 cm.

Size at 1st maturity as determined from ova diameter—Since some fish mature from about 9 cm, fishes from 7 cm were utilised for this study. The largest common ova diameter was plotted against the size of the fish (Fig. 6A), where 3 groups of ova were noticed, the immature up to 0.054 mm, maturing from 0.072 to 0.270 mm and the mature from 0.270 to 0.630 mm. However, most of the mature fishes had ova ranging from 0.324 to 0.630 mm.

Though some fishes attain maturity at 11.4 cm majority of the fishes mature above 12 cm confirming the earlier observation.

Size at 1st maturity as determined from relative condition factor—Relative condition factor $K_n = \frac{W}{\bar{W}}$ was

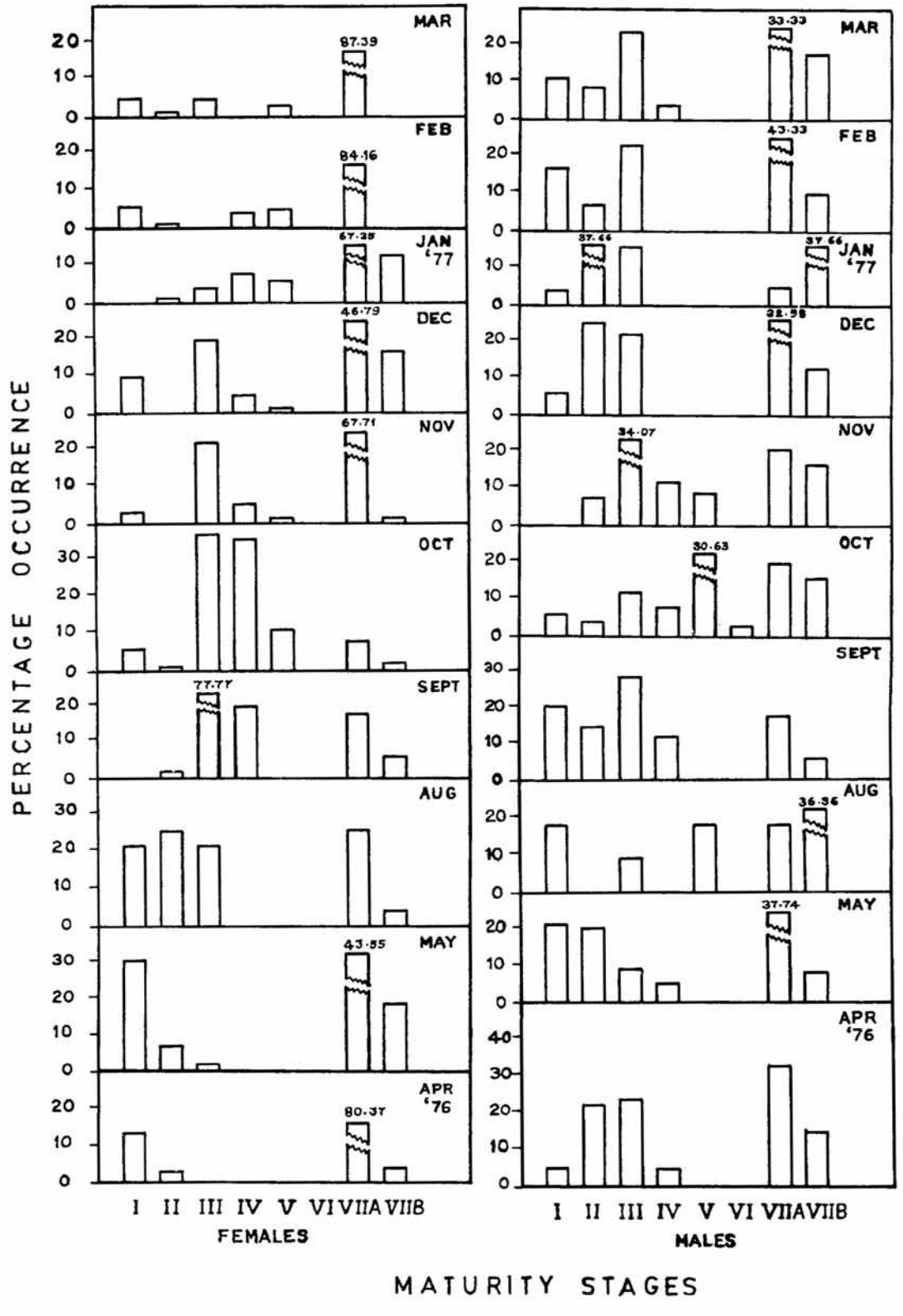


Fig. 4—Percentage occurrence of different stages of maturity of females and males of *J. osseus*

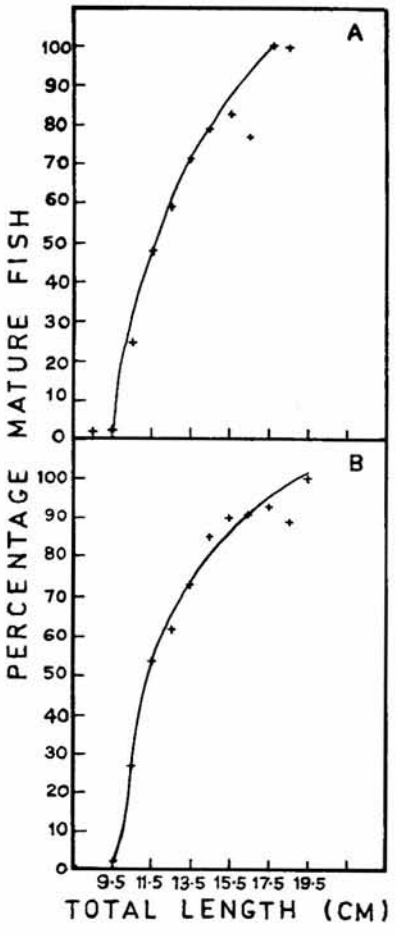


Fig. 5—Size at first maturity of *J. osseus* (A, males; B, females)

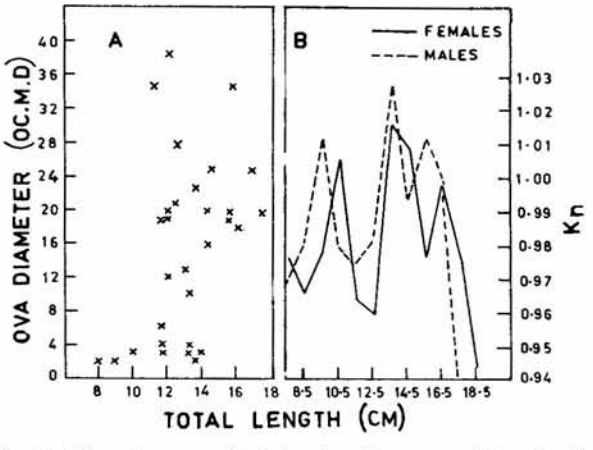


Fig. 6—Size at first maturity in females of *J. osseus* as determined by (A) ova diameter and (B) relative condition factor

used to indicate size at first maturity since it was found that the fish does not obey the cube law in its length-weight relationship. Average value of K_n for each length group was plotted against the respective size (Fig. 6B). In females, the point of inflection is at 10.5 cm indicating that some of the fishes start maturing at this size. The curve indicates a minimum value at 12.5 cm showing that majority of the fishes attain maturity around this size. In males, the point of inflection is seen at 9.5 cm indicating that some of the fishes attain maturity at this size. Most of them attain maturity at 11.5 cm as shown by the minimum value of K_n.

Fecundity—Twenty fishes were examined and the results are given in Table 1. It is known from the ova diameter frequency studies that the fish spawns in batches. Therefore, an attempt was made to estimate the probable number of ova that would be spawned in a batch. Females after first spawning return to a condition of the ovary shown in Fig. 2A. Hence, the difference in number of the most advanced group of ova in stage V ovary (av. 23699) and that of the ovary shown in Fig. 2A (av. 7933) would represent the number of ova that were spawned in the 1st batch (15,766). However, it is not possible to estimate the number of ova spawned in the next 2 batches on similar lines though it has been determined that the fish spawns 3 batches of ova. Hence, the difference in number of all the mature ova in stage V ovary (av. 46585) and number of ova that would be released in the 2nd and 3rd batches includes residual ova. The actual number of ova released in 2nd and 3rd batches will be 30,819 residual ova. Thus, the total number of ova released during spawning in an year would be 46,585.

Sex-ratio—Sex-ratios for each month and in different length groups were calculated in 1746 specimens. In most of the months, females were predominant in different size groups. However, males were dominant up to a size of 13 to 14 cm. Ratio of

Table 1—Number of Mature Ova in Individuals of *J. osseus*

Length of fish (mm)	Wt of fish (g)	Wt of ovary (g)	Total No. of mature ova	No. of eggs/body	No. of eggs/ovary
158*	54	3.699	30613	567	8276
136*	33	2.198	9307	282	4234
142*	40	2.93	28249	706	9641
141*	37	2.608	21233	574	8142
157*	49	3.16	29094	594	9207
156	47	2.42	13181	280	5447
154	50	2.578	17742	355	6882
129	27	1.124	4085	151	3634
160	51	2.711	24859	487	9170
133	33	1.458	13539	410	9286
131	35	1.041	6482	185	6226
149	39	1.482	10652	273	7188
180	75	2.956	6666	89	2255
136	32	1.857	12643	395	6808
182	70	3.845	34208	489	8897
140	34	0.692	6649	196	9608
169	60	1.715	7915	132	4615
167	65	2.683	21499	331	8013
174	70	2.542	16570	237	6519
155	45	1.452	13533	301	9320

Stage of maturity V(*) and VII A in the rest

males to females was 1:1.18. The data were subjected to chi-square test and at 5% probability level, chi-square values showed that proportion of males in different months was not significantly different. It was also ascertained whether the ratio in each month differed significantly from the theoretical 1:1 ratio. Chi-square values showed that there was significant deviation from 1:1 ratio only in March.

Evidences such as multiplicity of modes, occurrence of almost all stages of maturity throughout the year and presence of residual eggs justify the conclusion that individual fish spawns more than once in a year. Similar evidences were also used by earlier workers[9,11,12]. Based on the occurrence of partially spent and fully spent fishes in various months and also on presence of residual eggs, it can be said that the species spawn throughout the year intermittently. The observations based on ova diameter frequencies of mature and partially spent ovaries, as described earlier, indicate that individual fish may spawn as many as 3 times. The perennial breeding habit of the fish is further supported by the occurrence of young individuals of < 4 cm in many months as seen in the length frequency studies. Among the various sciaenids studied, *Pseudosciaena senegalensis* and *Pseudotolithus typus* are known to spawn throughout the year[13]. Prolonged spawning habits in sciaenids have also been described in *Pama pama*[1] and *Pseudosciaena sina*[14] from the Indian region.

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