

BIOLOGY AND FISHERY OF THE PIG-FACE BREAM, *LETHRINUS*

LENTJAN LACEPÈDE

II. MATURATION AND SPAWNING

BY H. S. TOOR*

(Central Marine Fisheries Research Institute, Mandapam Camp)

INTRODUCTION

During the course of the present investigation, some aspects of spawning habits of *Lethrinus lentjan* were studied. The monthly variations in sex-ratio were also studied to find out any possible correlation with the breeding habits.

MATERIAL AND METHODS

Soon after the fish were procured, particulars of date and locality of capture, total length, standard length and weight were recorded for each fish. Since it was not possible in case of *L. lentjan* to determine the sex by external characters, abdominal incision was made and the sex, stage of maturity and the colour of the gonads were noted in each case. The gonads were carefully removed from the fish and preserved in 5% formalin.

For microscopic examination, ovaries alone were utilized. Ova samples were taken after the ovaries were hardened. There was no appreciable shrinkage of ova due to preservation in formalin. To test whether ova at the anterior, middle and posterior parts of the ovary are distributed uniformly, about 300 ova from each part of a ripe ovary were measured. A small bit of ovary was taken from each part of the ovary, the ova were separated with fine needles and were evenly spread, on microscope slides. The diameters of ova were measured by means of an ocular micrometer and with the optical combination used, one micro-division of the ocular micrometer corresponded to 19.2μ (52 m.d. = 1 mm.). Ova diameter frequency polygons were drawn for each region separately. The distribution of the ova was found to be uniform in three regions. Hence, for all subsequent studies, ova were taken from the middle part of the ovary. About 300 ova were measured from each ovary, and ova below 8 m.d. were not measured in all the cases.

OBSERVATIONS

The period and duration of spawning can be determined from a study of the seasonal changes of the relative proportions of the mature, ripe and

* Present Address—Department of Zoology Punjab Agricultural University, Ludhiana.

spent fish. Similarly, the frequency of spawning can be determined from a study of the size-frequency distribution of intra-ovarian ova. Thus, for a study of the spawning habits it is a necessary prerequisite to make detailed macroscopic and microscopic examinations of the gonads in different stages of development and to fix a scale of maturity of the gonads.

MACROSCOPIC STUDY OF THE GONADS

Testes: The testes first appear as slender, thread-like short structures in the abdomen near the vent. As maturity advances they appear as two prominent strips and when fully mature they extend to the anterior region of the body cavity.

Ovary: The paired ovaries are symmetrical, but instances of asymmetry are not uncommon. Usually, the left lobe of the ovary is slightly longer than the right lobe but there is no difference in their girth. The two lobes form a 'U'-shaped loop and open to the outside by a common oviduct. Fish about 200 mm. in total length have well differentiated gonads and sexes could easily be made out with naked eye. Unlike testes it was possible in case of ovaries, to distinguish the various stages of development by macroscopic examination. The results of the macroscopic and microscopic studies of the ovaries were taken into consideration to prepare maturity scale. The maturity scale adopted for *L. lentjan* is as below:—

Stage I: Immature; ovary is short and its two lobes appear as two flesh-coloured thread-like structures extending to slightly less than one-third of body cavity; ova of Group (a) (1—5 m.d.) are present.

Stage II: Maturing; ovary is short and plump, about the thickness of a pencil, flesh-coloured extending up to half of the body cavity; ova of Group 'b' (6—13 m.d.) are present.

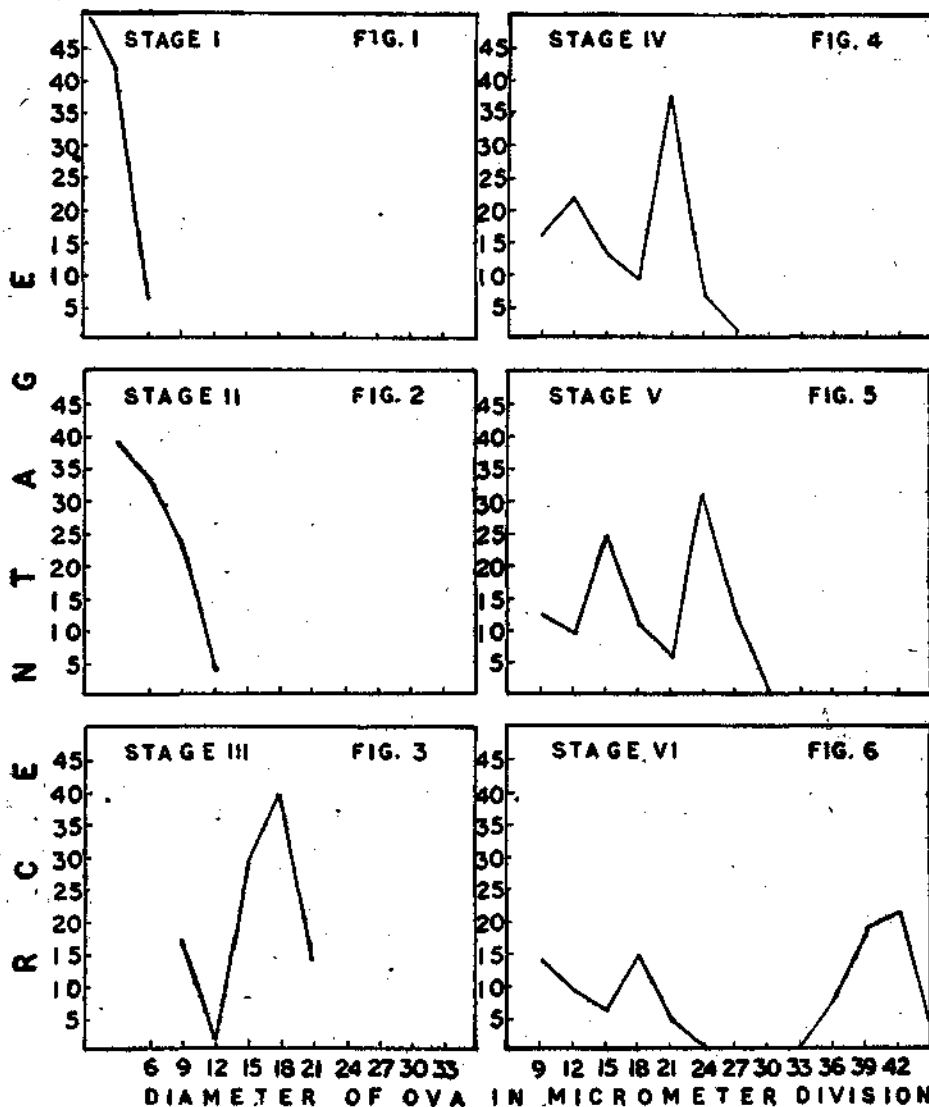
Stage III: Maturing; ovary is light yellow in colour extending up to two-thirds of the body cavity; ovary is longer and broader than in the previous stage; early ova of Group 'c' (14—22 m.d.) are present.

Stage IV: Mature; ovary is yellow in colour reaching three-fourth of the body cavity and about 2—2.5 cm. in thickness; early ova of Group 'd' (23—30 m.d.) are present.

Stage V: Mature; ovary similar to that of Stage IV but thin-walled; golden yellow in colour; ova of Group 'd' (23—30 m.d.) are present; a single oil globule is seen.

Stage VI: Ripe; ovary is much distended and occupies almost the entire length of body cavity; golden yellow in appearance; eggs clearly visible through ovary wall; ova of Group 'e' (31—45 m.d.) are present; oil globule is distinct, measuring 0.14—0.19 m.d.

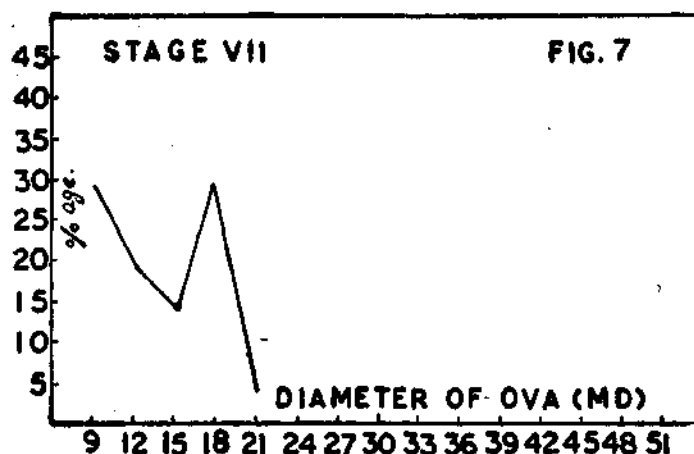
Stage VII: Spent; ovary is shrunken, flaccid, wrinkled and partly filled with ova Groups 'b' and 'c'; a few ova of Group 'e' are present.



Ova—diameter frequency polygons of *L. lentjan* in I-VI stages of maturity

DEVELOPMENT OF OVA TO MATURITY

Representative samples of ovaries in different stages of maturity were selected and about 300 ova from each ovary were teased out and their diameter measurements were taken as described earlier. As the frequency distribution of ova diameters taken from the different ovaries of the same stage of maturity was similar in nature, only the ova diameter frequency of ovaries typical of the various stages of maturity described above are presented (Figs. 1—7). The ova are grouped at 3 micro-division intervals, each group represented by its mid-point.



Ova—Diameter frequency polygons of *L. lentjan* in VII stage of maturity

The immature ova of Group (a) (1—5 m.d.) (Fig. 1) which may be termed as the 'general egg stock' are present in the ovaries of all stages of maturity. In Stage II, ova of Group 'b' (6—13 m.d.) make their appearance (Fig. 2). In Stage III (Fig. 3), a batch of eggs 'A' is withdrawn from the general egg stock and is represented by maturing ova of Group 'c' (14—22 m.d.) with a mode at 18 m.d. In Stage IV (Fig. 4) the batch of eggs 'A' shows increase in diameter with a mode at 21 m.d. and a new batch of eggs 'B' is withdrawn from the general egg stock the batch of eggs 'B' is represented by ova of Group 'b' (6—13 m.d.) with a mode at 12 m.d. The frequency distribution of ova of Stage IV also indicates the presence of early ova of Group 'd' (23—30

m.d.). In Stage V (Fig. 5), the two batches of eggs 'A' and 'B' show slight increase in their modal values, 'A' can be followed to 27 m.d. while 'B' can be traced at 15 m.d. In Stage VI (Fig. 6) the ova diameter frequency polygon shows that the two batches of ova ('A' and 'B') are well separated. Mode 'A' is seen at 42 m.d. and the mode 'B' at 18 m.d. The ova of batch 'A' with a mode at 42 m.d. are fully ripe and are the ova destined to be spawned in the ensuing spawning season. The absence of ova of group 'd' (23—30 m.d.) in Stage VI of ovary is significant. It shows that there is quick increase in sizes of ova of Group 'd' (23—30 m.d.). The phenomenon of sudden increase in the ova diameters prior to extrusion has already been explained in other fishes, e.g., in the case of *Sardinella longiceps* by Nair (1959), that "during this process of ripening, the eggs increase in size considerably owing to the absorption of water during the transformation of yolk spherules in opaque eggs into large vesicles in the transparent ova". In case of spent ovary, Stage VII (Fig. 7) the largest diameters of the common ova are represented by 'B' batch of eggs with the modal value at 18 m.d. This group represents the maturing ova of Group 'c' (13—33 m.d.) described earlier.

FREQUENCY OF SPAWNING

The frequency of spawning is determined from the nature of the frequency distribution of ova diameter measurements of the ripe ovary. Hickling and Rutenberg (1936) in a study of the spawning habits of hake, haddock, pilchard and herring, suggested that the frequency distribution of ova may provide information as to the spawning habits of fish. de Jong (1940) followed the method suggested by Hickling and Rutenberg (op. cit.) and studied the spawning periodicities of thirteen species from Java. In India, Karandikar and Palekar (1950) were the first to work on these lines. Prabhu (1956) traced the spawning periodicities of nine species of fishes belonging to seven different families.

On the basis of the observations made by Hickling and Rutenberg (1936), de Jong (1940), Prabhu (1956) and others, Karekar and Bal (1960) have classified the spawning activity in fishes into four types.

The frequency distribution of the ova diameter measurements from a ripe ovary (Stage VI) of *L. lentjan* shows two groups of ova represented by the modes 'A' and 'B' (Fig. 6). These two groups of ova are well separated. The batch 'A' of eggs with a mode at 42 m.d. comprises ripe ova which would be released in a short time. The batch 'B' of eggs with the mode at 18 m.d. is represented by the maturing ova of Group 'c' (14—22 m.d.). As the two batches of eggs 'A' and 'B' (Fig. 6). These two groups of ova are well separated. The batch 'B' will also be released during the same spawning season. This is confirmed by the fact that in a spent ovary (Stage VII) the largest diameter of the ova showed the mode at 18 m.d. (Fig. 7). The ova of batch 'B' when compared to ova of batch 'A' are very small and have undergone only about half the

process of maturation. Probably these ova would take a few months to become fully mature and ready for release during the ensuing spawning season.

Thus, in the ova diameter frequency polygon of the ripe ovary of *L. lentjan*, in addition to the ripe group of eggs, another batch of eggs which has undergone more or less half the process of maturation is also present. Thus the spawning habits of *L. lentjan* correspond to the type 'C' (spawning twice a year. In the ovaries of fishes exhibiting this type of spawning, in addition to the batch in the ripe condition, another batch of eggs which has undergone more or less half the process of maturation becomes apparent) of spawning activities of fishes mentioned above. Therefore, it is likely that an individual of *L. lentjan* may spawn twice in a year.

The question still remains whether all the individuals of this fish spawn at the same time or within a restricted period. If the spawning is restricted to a short period, then the gonads of all adult fishes collected at any particular time will belong to more or less the same stage of maturity. But the occurrence of gravid and spent fishes during two to three months (December—February and June—August) obviously suggests that the spawning will not be strictly simultaneous in all the individuals.

SPAWNING SEASONS

It has been shown by various workers that monthly frequency distribution of ova diameter measurements may help in fixing the spawning season. In the case of fish with a short definite spawning once in a year, the seasonal progression of ova may help to establish the spawning season. But this method is not reliable in case of fish which spawns more than once or when the spawning is not restricted to a definite short period as in *L. lentjan*.

Hence, to ascertain the spawning season, recourse was taken to the most direct method, *i.e.*, noting down the occurrence of ripe and spent fish. The simultaneous occurrence of eggs and larvae together with post-larval specimens would have been definite pointer to the spawning season, but in the present studies attempts to collect the eggs and larval forms of *L. lentjan* were not successful. The juveniles were, however, collected in certain months from the inshore waters where commercial fishing takes place.

In Table I are presented the percentage occurrences of maturity stages of the fish collected from the local landing centres (Theedai, Rameswaram, Vedalai and Kilakarai), during June 1960 to July 1962. Table II shows the percentage occurrence of female fish in various stages of maturity collected from Tuticorin during June 1961 to June 1962.

TABLE I

The percentage occurrence of fish in different stages of maturity of *L. lentjan* from Theedai, Rameswaram, Vedalai and Kilakarai during June 1960 to July 1962

Year & Month	N	Stage						
		I	II	III	IV	V	VI	VII
1960								
June	15	73.33 (11)	26.67 (4)	..	..	..	..	..
July	36	44.44 (16)	30.56 (11)	5.56 (2)	5.56 (2)	..	5.56 (2)	8.32 (3)
Aug.	22	50.00 (11)	31.82 (7)	13.64 (3)	..	..	..	4.54 (1)
Sept.	80	18.75 (15)	42.50 (34)	38.75 (31)	..	..	..	..
1960								
Oct.	51	41.18 (21)	33.33 (17)	25.49 (13)	..	..	..	..
Nov.	52	26.92 (14)	32.69 (17)	34.62 (18)	5.57 (3)	..	..	..
Dec.	67	52.24 (35)	23.88 (16)	10.45 (7)	13.43 (9)	..	..	..
1961								
Jan.	50	66.00 (33)	20.00 (10)	10.00 (5)	2.00 (1)	..	2.00 (1)	..
Feb.	30	66.67 (20)	16.67 (5)	3.33 (1)	..	..	10.00 (3)	3.33 (1)
Mar.	37	24.33 (9)	43.24 (16)	32.43 (12)	..	..	..	..
Apr.	40	47.50 (19)	25.00 (10)	22.50 (9)	5.00 (2)	..	..	..

TABLE I—(Contd.)

The percentage occurrence of fish in different stages of maturity of *L. lentjan* from Theedai, Rameswaram, Vedalai and Kilakarai during June 1960 to July 1962

Year & month	N	Stage						
		I	II	III	IV	V	VI	VII
May	74	8.11 (6)	24.32 (18)	51.35 (38)	16.22 (12)	..	..	..
Jun.	81	40.75 (33)	23.45 (19)	28.40 (23)	3.70 (3)	3.70 (3)	..	..
Jul.	84	57.15 (48)	32.15 (27)	7.14 (6)	..	..	2.38 (2)	1.18 (1)
Aug.	52	21.16 (11)	48.07 (25)	28.85 (15)	..	..	..	1.92 (1)
Sept.	49	10.20 (5)	59.19 (29)	30.61 (15)	..	..	..	..
Oct.	35	34.28 (12)	65.72 (23)	..	..	..	..	..
Nov.	47	10.64 (5)	53.20 (25)	31.91 (15)	4.25 (2)	..	..	..
Dec.	64	59.37 (38)	12.50 (8)	12.50 (8)	15.63 (10)	..	..	..
1962								
Jan.	52	46.15 (24)	25.00 (13)	19.23 (10)	1.92 (1)	1.92 (1)	5.78 (3)	..
Feb.	77	32.47 (25)	40.26 (31)	23.38 (18)	..	..	..	3.89 (3)
Mar.	70	28.57 (20)	41.43 (29)	24.28 (17)	..	..	..	5.72 (4)
Apr.	59	18.65 (11)	32.20 (19)	35.59 (21)	13.56 (8)	..	..	..
May	24	25.00 (6)	58.33 (14)	8.33 (2)	4.17 (1)	4.17 (1)	..	..
Jun.	23	..	47.84 (11)	30.43 (7)	8.69 (2)	..	13.04 (3)	..
Jul.	31	35.49 (11)	29.04 (9)	16.12 (5)	..	..	12.90 (4)	6.45 (2)

N-number of specimens examined.

Number of specimens in each stage given in parentheses.

TABLE II

The percentage occurrence of fish in different stages of maturity of *L. lentjan* from Tuticorin during June 1961 to June 1962

Year & month	N	Stage						
		I	II	III	IV	V	VI	VII
1961								
Jun.	17	29.42 (5)	29.42 (5)	17.64 (3)	..	..	..	23.52 (4)
Jul.	24	..	29.16 (7)	33.34 (8)	..	..	12.50 (3)	25.00 (6)
Aug.	..	..	..	..	..	..	..	..
Sept.	19	..	36.85 (7)	57.89 (11)	..	..	..	5.26 (1)
Oct.	26	..	19.23 (5)	69.24 (10)	11.53 (3)	..	..	..
Nov.	36	..	5.55 (2)	63.89 (23)	30.56 (11)	..	..	..
Dec.	30	..	10.00 (3)	23.33 (7)	56.67 (17)	3.33 (1)	6.67 (2)	..
1962								
Jan.	24	..	16.67 (4)	4.16 (1)	37.50 (9)	..	25.00 (6)	16.67 (4)
Feb.	34	..	17.65 (6)	32.35 (11)	..	..	17.65 (7)	32.35 (11)
Mar.	29	..	31.03 (9)	62.07 (18)	..	..	..	6.90 (2)
Apr.	28	..	7.14 (2)	67.86 (19)	25.00 (7)	..	..	..

TABLE II—(contd.)

The percentage occurrence of fish in different stages of maturity of L. lentjan from Tuticorin during June 1961 to June 1962

Year & month	N	Stage						
		I	II	III	IV	V	VI	VII
May	23	..	17.39 (4)	30.43 (7)	52.18 (12)	..	..	..
Jun.	2	..	40.91 (9)	18.19 (4)	27.27 (6)	..	..	13.63 (3)

N—number of specimens examined.

Number of specimens in each stage given in parentheses.

The data pertaining to the occurrence of fish in different stages of maturity collected from the local landing centres, i.e., Vedalai, Kilakarai, Theedai and Rameswaram, presented in Table I provide the following information. It may be mentioned here that the specimens collected from these stations were mostly from shore seines and basket trap catches and as such the number of adult fish available from these stations was small. The information gathered from the data collected from the above-mentioned places together with the observations made at Tuticorin are taken into consideration for fixing the spawning period. Considering the data collected in June to December 1960, a small percentage of mature, ripe and spent fish was recorded in July, 1960, which indicated that the spawning had already set in. The fish in Stages IV, V and VI were not recorded during August to October 1960. A single spent specimen was recorded in August which probably indicates that spawning may extend upto August. Spent fish (Stage VII) were not recorded during the period September to December 1960. In 1961, the occurrence of mature Stages IV and VI first in January and then in April—June and again in November and December is in close agreement with the observations made at Tuticorin, showing thereby that the fish spawn twice a year. The appearance of spent fish in February and again in June and July 1961 is further proof that spawning takes place twice in a year. In 1962, the data were collected from January to July. The fish in Stage VI were recorded in January, June and July. The spent fish were recorded first in January and March and again in July. The percentage occurrence of fish in Stages VI and VII of maturity, during June 1960 to July 1962, indicates that peak spawning takes place in January during the first spawning season and in July—August during the second spawning. In addition to this, the length frequency data showed the appearance of Juveniles twice a year, during December to March and again in September to October. This provides further evidence that the fish spawn twice a year.

From Table II it can be seen that the fish in Stages II to VII of maturity were recorded at Tuticorin during June 1961 to June 1962. It may be mentioned that the fish examined at this station were taken on hooks and lines and the small-sized specimens below 200 mm. (total length) of Stage I of maturity were not seen in the catches. Fish in Stage IV occurred in June and October to December in 1961 and again in April to June in 1962, but at higher percentage in December 1961 and in May 1962. It may also be seen that the fish in Stage VI of maturity were observed in July and December 1961 and in January and February 1962. The spent fish were first collected in June and July and a single spent specimen was recorded in September 1961. Again the spent fish occurred in January to March 1962 with highest percentage of 32.35% in February 1962. From Table II it may be noticed that the fish in Stage VI and Stage VII occurred twice in a year and it can, therefore, safely be concluded that there are two spawning seasons one from December to February and the other from June to August. Spawning appears to take place for a period of three months each time.

The data available from both Tuticorin and the local fish landing centres (Theedai, Rameswaram, Vedalai and Kilakarai) which are separated by about 95 kilometres, show that there are two spawning seasons for *L. lentjan*, more or less at the same time in both the localities. The conclusions already drawn from the frequency distribution of ova-diameter measurements together with the evidence of the occurrence of ripe (Stage VI) and spent fishes (Stage VII) and the occurrence of juveniles twice during a year, clearly point out that the fish spawns twice a year, during December to February and June to August.

SIZE AT FIRST MATURITY

To determine the size at first maturity of the fish, the percentage occurrence of female fish in Stage III and above during spawning seasons was taken into consideration. The fish were grouped at 20 mm. interval (standard length). The data are presented in Table III.

TABLE III

The percentage occurrence of females in different stages of maturity of L. lentjan in various size groups

Size groups (S.L.) mm.	No. of fishes examined	Stages of maturity		
		III & IV	V & VI	VII
1	2	3	4	5
241—260	72	100.00 (72)	..	..

TABLE III—(contd.)

The percentage occurrence of females in different stages of maturity of *L. lentjan* in various size groups

	1	2	3	4	5
261—280		64	85.94 (55)	14.06 (9)	..
281—300		51	68.62 (35)	31.38 (16)	..
301—320		52	30.77 (16)	65.38 (34)	3.85 (2)
321—340		45	2.22 (1)	75.56 (34)	22.22 (10)
341—360		33	..	72.73 (24)	27.27 (9)
361—380		7	..	28.56 (2)	71.44 (5)
381—400		9	..	22.22 (2)	77.78 (7)

Number of specimens in each stage given in parentheses.

It has to be mentioned that the fish measuring between 200—240 mm. standard length were either in Stage II or in Stage III of maturity. The data presented in Table III has revealed that all the fishes below 260 mm. standard length were in Stage III and Stage IV only. It may be further seen from the same Table that only 14.06% of the fish in size group 261—280 mm. standard length were found to be either in Stage V or in Stage VI of maturity. As the size of the fish increased, an increase in the percentage of ripe (Stage VI) and spent fish (Stage VII) was observed. However, a high percentage of fish in size group 281—300 mm. was still in Stage III and Stage IV of maturity. From Table III it may further be seen that in the next group, *i.e.*, 301—320 mm. standard length, percentage occurrence of fish in Stages V and VI was higher (65.38%) while the fish in Stages III and IV and in Stage VII were in low percentage, *i.e.*, 30.77% and 3.85% respectively. Here is an indication that the fish about 300 mm. standard length may spawn for the first time. All the fish above 340 mm. standard length were found to be either ripe (Stage VI) or spent (Stage VII) and, therefore, the minimum size at first maturity for females can safely be fixed at 300 mm. standard length. The minimum size of male specimens in ripe condition was found to be 287 mm. standard length.

From the age and growth studies, it has been noticed that *L. lentjan* measuring about 300 mm. standard length is about three years old.

Apart from this, size at first maturity in case of females was also found out from the ova diameter distribution in the ovaries of fish of different size groups. During the spawning period, i.e., January and February 1962, the fish above 240 mm. standard length were examined, excluding the spent fish. About one hundred ova in each case were measured and the largest common egg diameter was taken into consideration.

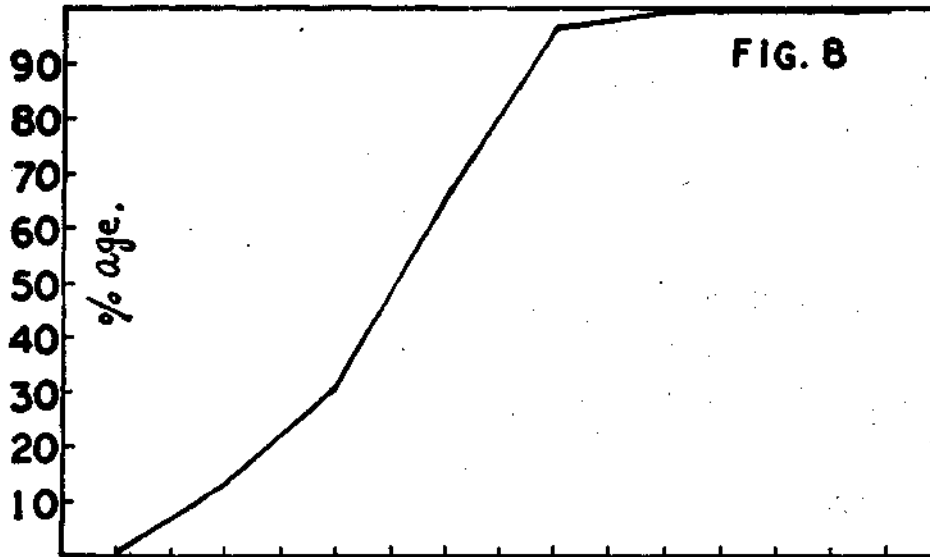


FIG. 8. Size at first maturity in females of *L. lentjan* based on percentage occurrence of the ovary in stages V & VI.

On the basis of these studies (Figs. 8, 9) and Table III, it may be concluded that few fish may attain maturity at 280 mm. were found to be in ripe condition. The size of the fish at first maturity as determined from the ova diameter studies give further support to the conclusion already drawn from the percentage occurrence of the fish in different stages of maturity in relation to the size of fish, that *L. lentjan* attains first maturity at a size of 300 mm. standard length, when it is about three years old.

SEX RATIO

As already stated, the sexes in *L. lentjan* cannot be distinguished by external characters. In all the cases the sex of the fish was noted after dissection. In case of small fish, microscopic examination of gonads was necessary, but in case of fish above 200 mm. total length sex was determined by macroscopic examination.

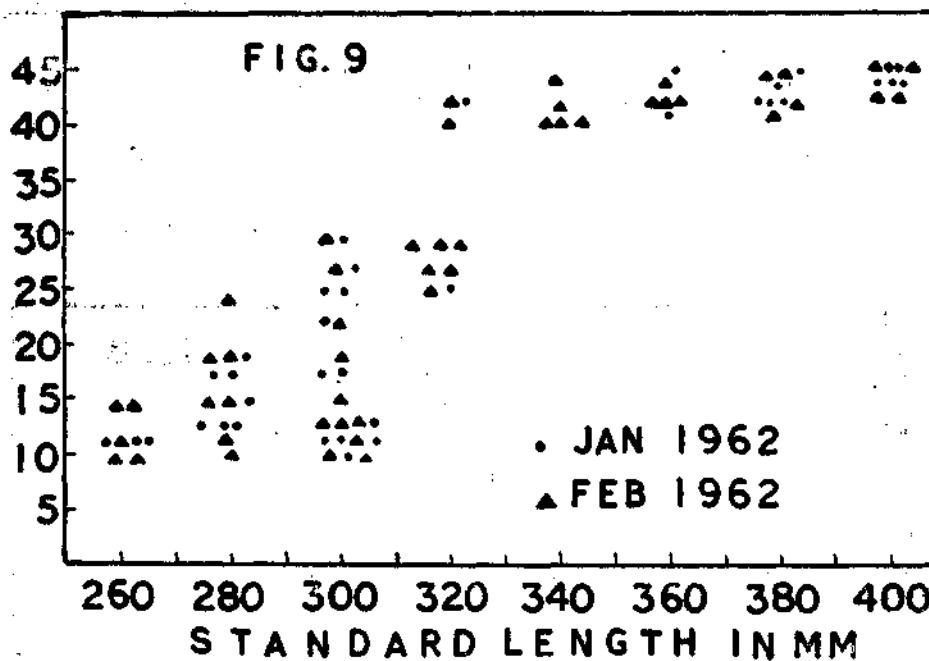


FIG. 9. Size at first maturity in females of *L. lentjan* as determined by the ova-diameter studies during January & February 1962.

The sexes of 2,587 fishes, examined from Vedalai, Kilakarai, Theedai and Rameswaram during June 1960 to July 1962, were noted. When the sex ratio was computed the ratio between males and females was found to be 1 : 1.11. Sex in case of 135 fishes could not be determined.

The data collected from Tuticorin during June 1961 to June 1962 were treated separately. Out of 604 fishes examined, 289 were males and 315 females, the ratio between males and females being 1 : 1.09. The sex ratio for the pooled data from the five sampling stations was computed and found to be 1 : 1.11 for males and females respectively.

There was no significant difference in the proportions of sexes in any particular month during the period under study. However, during the non-spawning seasons the number of females was slightly higher than that of the males, but during the spawning seasons (June to August and December to February) the numbers of males and females were almost equal, except in a few samples where the males were more in number than the females. Since the number of mature specimens recorded in different months was small, it is rather difficult to conclude how far these slight variations in the sex ratio are associated with the spawning. The data, however, indicate that the males and

females are being fished in almost equal proportions and the possibilities of differential fishing seem to be obscure.

FECUNDITY

The relationship between fecundity and length of the fish and fecundity and the ovary weight were found to be linear. The number of ova spawned during a single spawning season varied between 12, 146 and 77, 922 per individual fish ranging between 30 cm. to 39 cm. in standard length (the details of which will be published elsewhere).

SUMMARY

The present studies have elucidated to a certain extent the important aspects of the spawning habits of commercially exploited pig-face bream, *Lethrinus lentjan* of the Palk Bay and Gulf of Mannar around Mandapam. From the observations on the percentage occurrence of the fish in different stages of maturity in each month during June 1960 to July 1962, the recruitment of the juveniles twice a year and the frequency distribution of ova in Stage VI of maturity of the ovary, it is believed that an individual fish spawns twice a year, during December to February and June to August. The occurrence of gravid and spent fish during December—February and June—August obviously suggests that spawning does not take place simultaneously in all the individuals.

The fish with ripe ovaries were taken on hooks and lines at Tuticorin (Gulf of Mannar) from depths varying between 12 and 15 fathoms, which indicates that the spawning grounds may be far away from the shore.

The size at first maturity as determined from the percentage occurrence of different stages of maturity in relation to size of fish and also from ova diameter studies was found to be 300 mm. standard length. Since fish attaining this length have been found to be three years old it may be said that they spawn for the first time when they are about three years old. The sexes are equally distributed in the commercial catches.

It appears that *L. lentjan*, like other perches, is quite prolific and the number of ova spawned during a single spawning season varies between 12,146 and 77,922 per individual fish ranging from 30 cm. to 39 cm. in standard length.

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude to Dr. S. Jones, Director of the Central Marine Fisheries Research Institute, for invaluable suggestions, criticism and guidance, as well as for all the facilities and help extended to me at the Institute. My sincere thanks are due to Dr. R. Raghu Prasad, Deputy Director, and Dr. R. V. Nair, Senior Research Officer, for their comments and advice in the preparation of this paper.

REFERENCES

- de Jong, J. K. 1940 . A preliminary investigation of the spawning habits of some fishes of the Java Sea. *Treubia*, 17: 307-30.
- Hickling, C. F. 1930 The natural history of the hake, Part III. Seasonal changes in the condition of the hake. *Fish. Invest., London Ser. II*, 12(1).
- Hickling, C. F. and E. Rutenberg 1936 The ovary as an indicator of spawning period in fishes. *Treubia*, 21: 311-17.
- Karandikar, K. R. and V. C. Palekar 1950. Studies on the ovaries of *Polynenus tetradactylus* Shaw in relation to its spawning. *Curr. Sci.*, 19: 154-55.
- Karekar, P. S. and D. V. Bal 1960 A study on maturity and spawning of *Polydactylus indicus* (Shaw). *Indian J. Fish.*, 7(1): 147-64.
- Nair, R. V. 1959 Notes on the spawning habits and early life-history of the oil-sardine *Sardinella longiceps* Cuvier and Valenciennes. *Ibid.*, 6(2): 342-59.
- Prabhu, M. S. 1956 Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Ibid.*, 3(1): 59-90.
- Rait, R. S. 1933 The fecundity of the haddock. *Fisheries, Scotland Sci. Invest.*, 1932, No. 1: 1-42.