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PRELIMINARY OBSERVATIONS ON THE SEASONAL GONADAL CHANGES AND SPAWNING IN THE CLAM *MERETRIX CASTA* (CHEMNITZ) FROM THE MARINE FISH FARM*

By V. S. DURVE

Central Marine Fisheries Research Institute, Mandapam Camp

INTRODUCTION

SEXUALITY and the seasonal gonadal changes in clams have been studied by Loosanoff (1936a, 1936b, 1937a & b), Loosanoff and Davis (1950) and Davis and Chanley (1956). The work of these authors is mainly on the clam *Venus mercenaria*. Stickney (1952) and Rogers (1959) have studied reproductive cycle and spawning in the soft clam *Mya arenaria*. Hornell (1922), Rai (1931), Panikkar and Aiyar (1939), Rao (1951) and Abraham (1953) have made some observations on the breeding and spawning of the clams, *Meretrix meretrix, Katelysia opima* and *Meretrix casta* from the Indian coast.

The present study was undertaken with a view to gaining some knowledge on the sexual cycle and spawning of the edible clam, *Meretrix casta*, from the fish farm of the Central Marine Fisheries Research Institute at Mandapam Camp. The topography and the environmental conditions in the fish farm and the adjoining salt water lagoon are given by Tampi (1959 & '60).

MATERIAL AND METHODS

Weekly samples, each consisting of about 40 adult clams, were collected from pond No. 3 of the fish farm and kept in fresh sea water so as to clear them of their faeces. The clams were later opened individually and fresh gonad smears were studied under microscope to ascertain the sex and the state of the gonad. Gonadal tissues were also preserved every time for histological studies and the sections were stained with Ehrlich's haematoxylin and eosin. The observations were made for a period of 14 months from February 1961 to March 1962 and in all 2072 clams were examined for this study.

Every week about 25 clams were measured and weighed. Their meat was preserved separately in 5% sea water formalin for eight days and then dried on filter paper and weighed individually. The percentage edibility (the ratio of meat weight to whole weight) was then calculated to find out its variation, if any, due to sexual activity like spawning.

RESULTS AND DISCUSSION

The gametogenic activity in the clam *M. casta* begins in November before which all clams are in the state where their sex cannot be determined. Hence,

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the starting point for the description of the gonad development has been taken as from November. The actual gonadal changes in males and females have been discussed below separately.

Males : In November, the gonad of the male clam shows ramification. The follicles make their first appearance and the sexual cells are seen proliferating from the follicular walls. The gonad follicles during this period are occupied with spermatogenic cells, in various stages of development. Nearer the wall are the spermatogonia which are followed by spermatids and spermatozoa. It is found that different follicles of the gonad of the same individual contain sex cells in varying quantities. In some follicles there are all the stages from germinal cells to spermatozoa, while in others, early stages of spermatogenesis alone are seen. Male gonad when full, is shown in section in Plate I, Figs. 1 and 2. The individuals with well-developed gonads are cream in colour.

In December, the gonad sections show partially spawned follicles with somewhat empty lumen (Plate I, Fig. 3). However, in several follicles the spermatogenesis is in progress and the lumen is still filled with mature spermatozoa. This suggests, that considerable period is required for a clam to complete its spawning. In addition, it is also seen that there is a difference in spawning behaviour of individuals. Clams collected at the same time showed wide variation in the extent of their spawning. Some individuals are in fully spawned out condition, presenting translucent gonads and empty follicles while others are with partially spawned follicles or even with follicles containing active spermatogenesis. This indicates that the entire population of clams in the fish pond does not spawn at the same time but every individual clam has a slightly varied spawning period. Similar observations have been made by Loosanoff (1937a) in the case of *Venus mercenaria.*

It may be mentioned here that no definite change of colour of the meat from cream to brown, occurs in this clam after its spawning. Such a change of colour after the spawning period, has been recorded in the oyster *Crassostrea gryphoides* by the author (unpublished). The totally spawned male individuals show empty follicles, sometimes with residual spermatozoa in the state of being cytolysed and reabsorbed by phagocytic cells. (Plate I, Fig. 4.)

The phagocytic cells are seen scattered in the vesicular connective tissue of the gonad during the period of gonadal activity. They are especially abundant in the individuals with fully spawned follicles. Loosanoff (1937a) observes that these phagocytic-nutritive cells vary in number from season to season, the greatest number being found during the active stages of gametogenesis. He attributes both nourishing and phagocytic functions to these cells.

The male clams with fully developed sperms occur in the samples in fair proportion till April, and their number dwindles thereafter. From June to October, male clams begin disappearing and they may thus be treated as having entered a stage in which their sex could not be determined. The typical gonad of indeterminate stage shows completely obliterated follicles and the interfollicular spaces occupied by the vesicular connective tissue (Plate I, Fig. 5). The so called indeterminate stage, appears to be of a short duration and the gametogenic activity follows immediately for the next spawning period *i.e.* December onwards.

Females: The development of female gametes proceeds in the same way as in males. The gametogenic activity is seen in clams collected in November. The

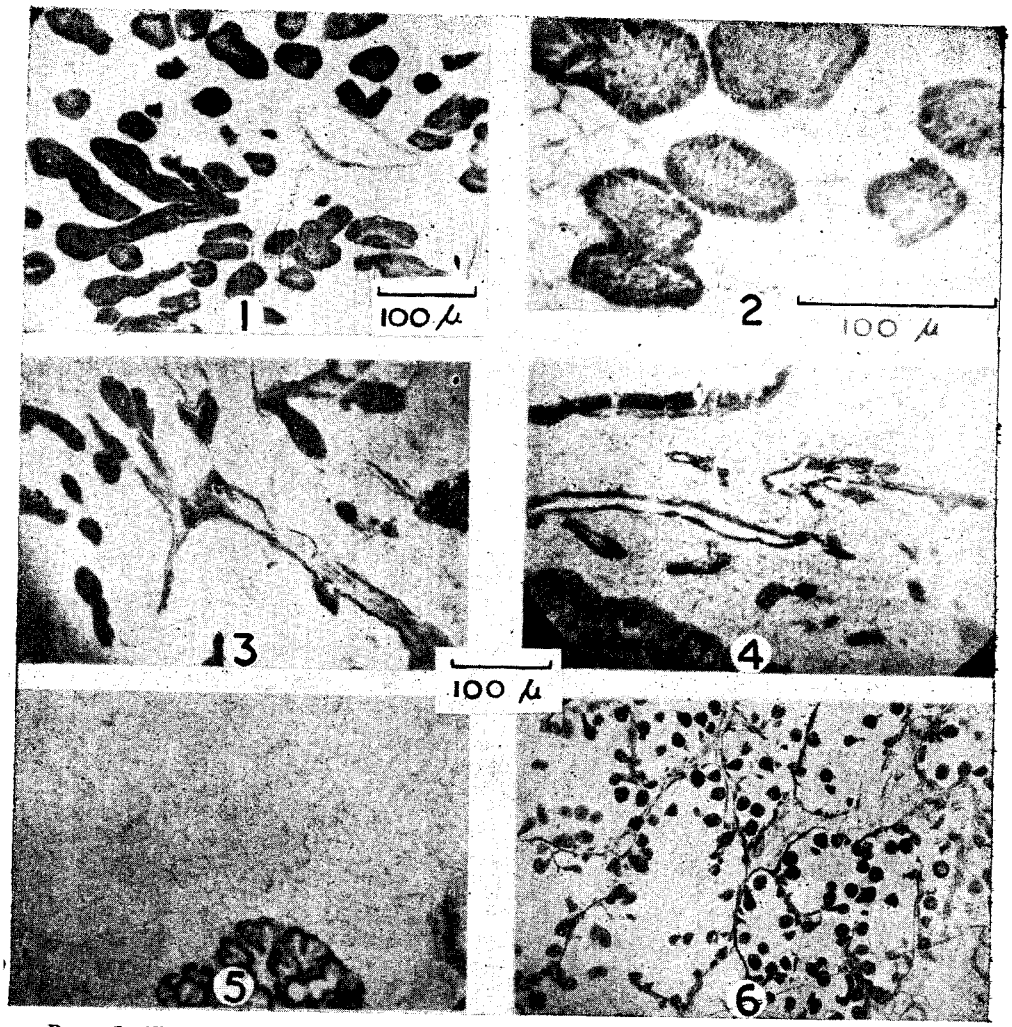

PLATE I. Fig. 1.—Gonad of a male clam showing follicles packed with fully developed sperms.
Fig. 2.—Mature male follicles showing different stages of spermatogenesis.
Fig. 3.—Gonad of a partially spawned male clam.
Fig. 4.—Gonad of a fully spawned male clam, with residual gametes undergoing cytolysis.
Fig. 5.—Gonad of an indeterminate clam showing the vesicular connective tissue.
Fig. 6.—Gonad of a female clam with mature ova.

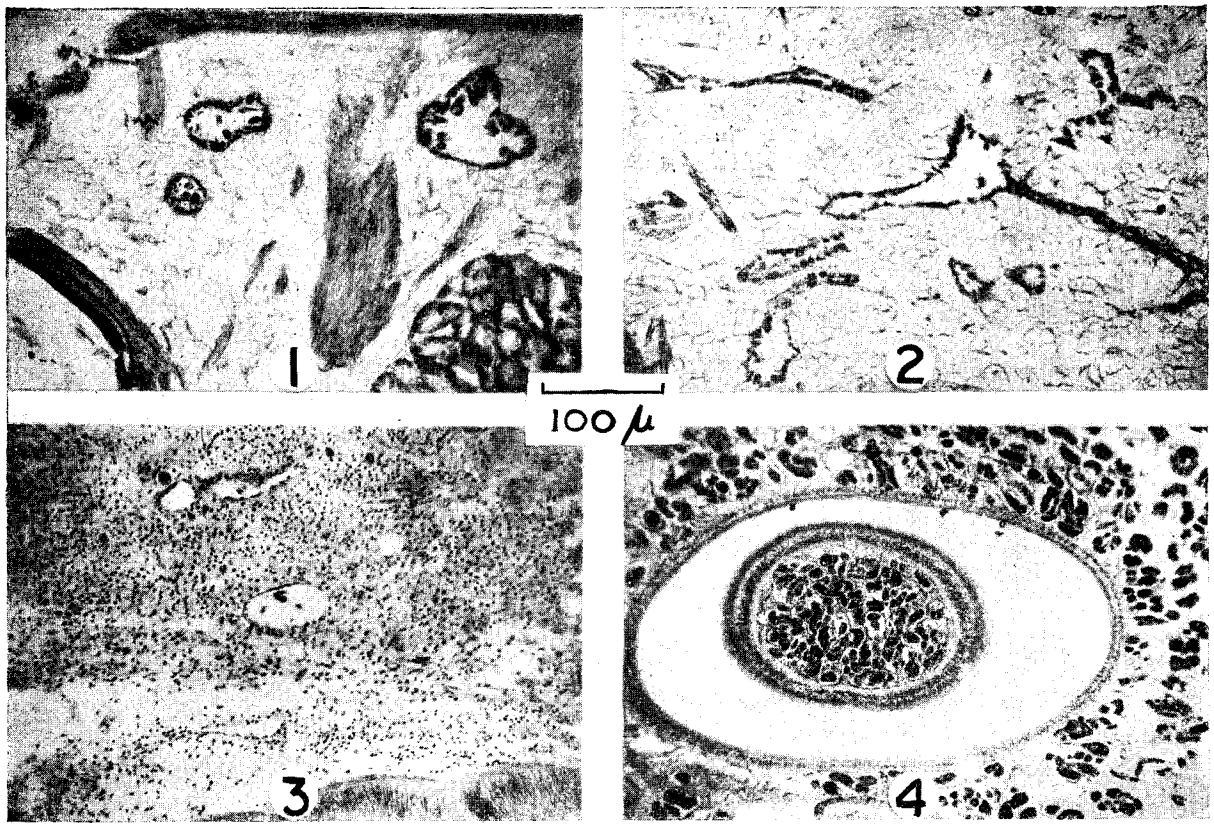

PLATE II. Fig. 1.—Gonad of a partially spawned female clam.
Fig. 2.—Gonad of a fully spawned female clam.
Fig. 3.—Gonad of a female clam showing phagocytic cells and residual gametes undergoing cytolysis.
Fig. 4.—Gonad of a clam parasitized by bucephalid cercariae.

follicles show all the stages of oogenesis *i.e.* germinal cells, oogonia, oocytes and mature ova. The mature ova are seen in great numbers especially in late November and early December. As in males, here also, considerable individual variation occurs and some clams are full with mature ova while others are still with oogenic activity in its early stage.

From late December onwards, the partially or totally spawned individuals begin appearing in the samples. However, a very wide individual variation in the degree of spawning activity is evident. There is also a variation in the germinal activity of the follicles of the same individual. Notwithstanding, it is also observed, at least in some individuals, that while one batch of ova is spawned, the germinal activity continues producing fresh oogonia and oocytes. Phagocytic cells occur in all clams and they are more in those having fully spent follicles (Plate II, Fig. 3). As in males, these phagocytic cells play an important part in cytolyzing and re-absorbing the residual ova. Females with mature ova continue to occur in samples in fair numbers till March. From April, their number dwindles and there are no definite females in the samples collected in October. From November, the gametogenic activity commences again. The sequence of sexual phases in females is shown in Plate I, Fig. 6 and Plate II, Figs. 1-3.

Indeterminates: The data given in Table 1 indicate that the clams in which sex cannot be determined occur throughout the year, in varying numbers. They are in a majority from July to October *i.e.* before the commencement of the sexual activity. It is interesting to note that some of the clams sectioned during this stage showed, along with the vesicular connective tissue, very few shrunken follicles with residual sperms or ova and also a very slight gametogenic activity in some

TABLE 1

Clams belonging to different sexes and also those that were parasitized during the period February 1961 *to March* 1962

No.	Month		No. of specimens examined	Males %	Females %	Indeterminates %	Parasitized %
1.	Feb.	1961	149	44.29	50.34	6.04	
2.	March	„	230	39.13	50.44	10.43	
3.	April		160	23.75	36.88	39.38	0.63
4.	May	,,	160	3.75	25.63	70.63	0.63
5.	June	„	159	1.89	25.78	72.33	1.89
6.	July	,,	200	nil	9.50	90.51	3.50
7.	August	„	115	nil	7.82	92.17	6.09
8.	Sept.	„	160	nil	1.25	98.77	3.13
9.	Oct.		79	nil	nil	100.00	6.33
10.	Nov.		196	9.69	22.96	67.35	2.55
11.	Dec.		120	30.83	41.67	27.50	5.83
12.	Jan.	1962	160	18.75	39.38	41.88	3.75
13.	Feb.		79	13.93	40.51	45.57	11.40
14.	Mar.		105	3.81	22.86	73.33	5.72

follicles. However, the same individuals failed to reveal their true sex in freshly prepared smears. This tends to indicate that these indeterminates may be either males or females in dormant stage or in the stage of minimum gametogenic activity. It is felt that the sexual activity of indeterminate individuals of the clam

M. casta should be studied separately to confirm this observation. Plate I, Fig. 5 shows the section of a typical indeterminate gonad.

Spawning activity : In order to know the spawning periodicity, during the examination of fresh gonad smears, stages were given as full and medium for male gonads and abundant, plenty, many, few and rare to female gonads. These stages were based on the visual observations of the fullness of gonads and the amount of gonadal product that comes out after pricking the gonad at several places with a needle. The gonadal products thus obtained were examined under microscope and the stage was allotted. This procedure, though not adequate and hence open to criticism, was found to give some clue to the progress of spawning in the population of *M. casta* as a whole. The spawning periodicity was also traced by histological preparations made of a few clams from every sample, throughout the period of investigation.

Table 2 shows the distribution of male and female clams belonging to the stages mentioned above, for the entire period of observations. It would be seen that the spawning in this clam appears to be continuous over a prolonged period, with slight peaks in certain months. It is further interesting to see that while male clams slowly disappear from the samples from May, the females continue to occur in samples up to July. However, in 1962 samples, males seem to begin disappearing from February as during February and March the percentages of males is low. Unfortunately, no further data could be collected and hence it could not be ascertained whether the entire sexual cycle in this clam appreciably varies from year to year. There is a definite short resting period from about July to October. It is, however, interesting to note as stated earlier, that in the clam of the present study, the development of gonads after the short resting period and its spawning is a very quick process taking about a month or a little more.

Hornell (1922) observes spawning in *M. casta* to take place twice a year, during April-May and again in September. Rai (1931) reports that the principal breeding season of *Meretrix* on the Bombay coast lasts from March to June and with favourable weather condition, may even continue for the whole year except during monsoon. Abraham (1953) observes *M. casta* from Adyar-estuary to show peak spawning activity in July-August, October-November, and March to April or May ; the last one being the period of most intense and prolonged activity. He, however, suggests that the period of active spawning does not remain constant from year to year in the same environment, nor does it coincide in any two different environments. Rao (1951) records spawning in *Katelysia opima* from Adyar estuary to commence late in December and end in January.

Percentage edibility : It is well-known that the percentage edibility *i.e.* the ratio of meat weight to whole weight, also indicates spawning period, as during this period, the percentage edibility is found to drop considerably. Table 3 shows the total average percentage edibility and also that in different sexes in the clam *M. casta* for the entire period of observations. It would be seen that the percentage edibility does not change appreciably in any month. It is felt that perhaps because of the continuous breeding period, there is no major loss of gonadal product at a single time thereby appreciably lowering the percentage edibility. It is also likely that if there is a major loss of the gonadal product, it is made up by the development either of fresh gonads or the vesicular connective tissue. Thus the loss of the gonadal products and the development either of gonads or the vesicular connective tissue as the case may be, continue simultaneously. The values of per-

TABLE 2

Males and females of the clam M.casta, *belonging to the different stages of the fullness of their gonads during the period February* 1961 *to March* 1962

No.	Month	Males			Females					
		No. of specimens examined	Full %	Medium %	No. of specimens examined	Abundant %	Plenty %	Many %	Few %	Rare %
1.	Feb. 1961	66	54.54	45.45	74	39.17	27.02	17.57	13.52	2.71
2.	Mar.	90	74.44	25.55	116	53.44	18.96	10.35	12.93	4.31
3.	Apr.	38	94.75	5.25	59	20.34	15.25	28.80	18.64	16.95
4.	May	6	50.00	50.00	41	4.88	7.32	21.95	41.46	24.39
5.	June	3	66.66	33.33	41	29.26	21.95	7.32	36.59	4.88
6.	July	nil	nil	nil	19	10.52	26.33	10.52	36.84	15.79
7.	Aug.	nil	nil	nil	9	22.22	nil	33.33	11.11	33.33
8.	Sept.	nil	nil	nil	2	nil-	nil	50.00	nil	50.00
9.	Oct.	nil	nil	nil	nil	nil	nil	nil	nil	nil
10.	Nov.	19	68.42	31.58	45	35.54	17.77	22.22	11.11	13.33
11.	Dec.	37	67.56	32.43	50	36.00	20.00	18.00	20.00	6.00
12.	Jan. 1962	30	76.67	23.33	63	23.80	22.22	27.00	6.35	20.63
13.	Feb.	11	45.45	54.55	32	25.00	9.37	21.90	40.61	3.12
14.	Mar.	4	100.00	nil	24	16.66	20.83	20.83	20.83	20.83

centage edibility are however low, indicating the poor condition of clams in the marine fish farm. Venkataraman and Chari (1951) observe percentage edibility in *M. casta* from Madras coast, to vary from 5 to 16.

TABLE •» *3

The total average percentage edibility in the clam M.casta *and also that in its different sexes for the period April* 1961 *to March* 1962

No.	Month		Total average	Males	-Average in - Females	— Indeterminates
1.	April	1961	5.98	6.18	6.10	5.75
2.	May	JJ	5.38	5.23	5.43	5.37
3.	June	1)	5.60	5.53	5.73	5.54
4.	July	f »	5.15		5.37	5.12
5.	August	J»	5.41	,,	5.57	5.39
6.	September	1)	4.88	,.		4.88
7.	October	1*	4.22			4.22
8.	November	*!	5.61	5'.49	5'.61	4.61
9.	December	]»	5.20	5.10	5.75	4.57
10.	January	1962	5.80	6.29	5.91	5.54
11.	February	If	5.87	6.46	6.21	5.42
12.	March	>*	5.42	5.74	5.84	5.26

Parasitized clams : During the course of this investigation, a few clams parasitized by bucephalid cercariae were regularly found in the samples. The cercariae were lodged in the gonadal tubules of the clams (Plate II, Fig. 4). The percentage occurrence of such parasitized clams is shown in Table 1. These clams appeared transparent and flaccid.

GENERAL CONSIDERATIONS

It would be seen from the account given above that the clam *M. casta* is unisexual, at least in its adult stage. Loosanoff (1937a) observes that in *Venus mercenaria,* the primary gonad of animals of 4, to 6 mm. is distinctly bisexual with a tendency to protandric nature. The adults are, of course, definitive males or females with a few exceptions which he calls as partial hermaphrodites. An account of the primary gonads in the case of *M. casta* or an allied species in India, is not available and this therefore forms a subject of great interest. However, in the adult *M.casta,* no individuals were observed either with partial or functional hermaphroditism.

Adult clams unlike oysters, are not known to have a definite sex change. Loosanoff (1936a, 1937b) mentions that in *V. mercenaria* there is' a potentiality of changing the sex even in the adult condition and the short post-spawning period is the only time when the sex change from male to female could take place. However, he found no evidence of a definite sex change. In India, the sex change in clams has not been reported so far. In *M. casta* there does not appear to be any sex change at least in adult stage as no wide fluctuations in the number of males and females were observed during any time in the year. So also, as stated above, no partial or functional hermaphrodites were observed.

The stimulus for gonad development and spawning in the clam *M. casta* reported here, is difficult to say. The surface temperature in the fish farm is highest (32°-33° C.) during the summer months of March to May. It continues to remain more or less the same till September. From October, it gradually drops and attains the level at around 27°C. in December. It is doubtful whether this fluctuation in temperature could in any way act as a stimulus both in gonad development and spawning activity of *M. casta* in the marine fish farm. It may be recalled that LoosanofF (1937b) observed temperature to play a very dominant role m the development of sex cells and spawning in the case of *V. mercenaria.* LoosanoflF and Davis (1950) observed that the maturation of gonads in case of oysters is dependent on the temperature level which is different from that required for spawning. These authors have also stated in their later communication (Loosanoff and Davis, 1952) that developing gonads show no dependency on seasonal changes in factors like light, tidal rhythms, precipitation, small variations in salinity and certain plankton organisms.

The salinity in the fish farm always remains above 30 ‰ and during the months from July to September or mid-October, the period when the sex of the clam remains indeterminable, the water becomes hypersaline showing the values around 45 ‰ or a little more. It is felt that the hypersaline water during July to mid-October may perhaps be responsible, in some way, for the retardation of sexual activity during this period. It has been observed that higher salinities retard the rate of filtration of water in the clam *M. casta* (Durve, 1963). Prytherch (1928) observed in the case of oysters that gonad development is dependent on the amount of food consumed and subsequently on the amount of water filtered by the oyster.

Abraham (1953) finds that low salinity in the Adyar backwaters near Madras is the cause of spawning in the case of *M. casta* inhabiting that region. The sudden lowering of salinity has also been found to stimulate spawning in Indian oysters (Rao, 1956 and Durve, unpublished). In the present case, as stated earlier, it is difficult to say whether the salinity in the fislr farm could stimulate spawning in *M; casta* especially because there is no appreciable drop in its level.

SUMMARY

The seasonal gonadal changes in the clam *Meretrix casta* from the marine fish farm at Mandapam Camp are studied with the help of fresh gonad smears and histological sections.

The sequence of sexual phases during the year, in bodj -fp^les and females," has been described.

The studies indicate that this clam is a continuous breeder with a break of a few months in late summer. This break appears to be due indirectly to unfavourable conditions in the fish farm, during this period.

The percentage edibility in *M. casta* is found to be low.

An incidence of bucephalid cercariae as parasites in the clam *M. casta* has been recorded.

The observations and the data are discussed in the light of the available literature.

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