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Reproductive biology of Venus clam *Gafrarium tumidum* (Roding, 1798) from Southeast coast of India

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Abstract

The reproductive biology of tumid venus clam *Gafrarium tumidum* (Roding) was studied in detail from the Southeast coast of India. Sample size ranged from 10.3 to 41.3 mm. Sexes are separate but not differentiated externally. Annual sex ratio male:female (M:F) deviated significantly from the 1:1 ratio with females dominating. Based on ova diameter progression of gonad smear and histology, four and two maturity stages of gonads were differentiated in female and male clams, respectively. Peak spawning was observed during November and a minor one in April. The monthly average condition index based on wet/dry flesh weight ranged from 7.24 (November) and 14.14 (September) and 8.82 (October) and 14.38 (August), respectively. The condition index observed by both the methods is comparable and corresponds with the spawning season. Water content observed for male and female clams varied negligibly and showed positive correlation with spawning period. Size at first maturity was estimated to be 22.3 mm.

Keywords: spawning, condition index, sex ratio, size at first maturity, *Gafrarium tumidum*

Introduction

Bivalves exhibit various types of spawning i.e., single breeding period to year round spawning. The information on sex ratio, sexual maturity and breeding season is helpful in finding out the annual recruitment, assessment of growth and age for judicial exploitation. Preliminary and detailed biological studies have already been carried out on *Katelysia opima* (Rao 1952), *Meretrix casta* (Abraham 1953) and *Donax cuneatus* (Nayar 1955; Rao 1967), Alagarswami (1966), on *Donax faba*, Thangavelu and Sanjeevaraj (1985), on *M. casta*, and Narasimham, Muthiah, Gopinathan and Gandhi (1988) on *Meretrix meretrix*.

Though extensive studies are made on a number of venerid clams, both in tropical and temperate waters, no information is available on the reproductive pattern of *Gafrarium tumidum*. This paper deals with gonad maturation, condition index, sex ratio, size at first maturity and spawning season of *G. tumidum* from the southeast coast of India.

Materials and methods

Monthly samples of about 50 clams from the natural clam bed at Chinnapalam, Pamban, Southeast coast of India (latitude 8°35′–9°25′ N and Longitude 78°08′–79°30′E.) were collected for 1 year (October′2000–September′2001) and used for studying various aspects of maturation. The size range and range of monthly means of the samples were from 10.3 to 41.3 mm and 24.7–31.5 mm. The sex and the stage of ova developments were ascertained by taking fresh smears of gonad by making a small cut at the middle of the gonad and were examined under light microscope. Fifty ova in each clam were measured using an ocular micrometre precalibrated with a 1 mm stage micrometre. Measurements in the case of irregular ova (early and late maturing) were taken in two axes and the averages of the values were considered. The gonad smears of the clams were observed at monthly interval continuously for their percentage occurrence. The ovarian stages were classified following Ropes (1968).

For assessing the exact state of gonad and to supplement the data obtained by ova diameter progression, histological preparations were made and studied. Approximately 25 individuals, arbitrarily selected with

respect to age and stage of gonad development, were excised, fixed in Bouins fixative and prepared for sectioning by dehydration in ethanol and by embedding in paraffin wax at 60–62 °C (Humason 1972; Kripa 1997) Sections were cut at 8 μm thickness and stained with eosin and examined under microscope and classified into different developmental stages. Chi-square test was carried out to ascertain whether the observed sex ratio differed from theoretical 1:1 ratio (Snedecor & Cochran 1967). The condition index (CI) was calculated as (1) percentage of wet flesh weight in total weight and (2) as percentage of dry flesh weight in wet flesh weight (Narasimham 1988). Difference in the weight between wet and dried body tissues was used to compute the water content of the body tissues. Monthly percentages of maturity stages were worked out and plotted against different size groups to arrive at the size group at which 50% clams mature. The mean value of this size group was considered as the minimum size at first maturity.

Results

Sexes are separate in *G. tumidum*. External differentiation could not be made as well as any recognisable colour difference in the gonad of males and females. In all, four stages in females and two stages in males could be categorized from the observations made on the smear and histological sections.

Gonad smear

In early maturing clams, the ova were irregular in shape. The average size of the ova was <45 μm, in the late maturing stage clams, most of the ova tend to assume a spherical shape and some of them are still irregular in shape. The ova measured between 45 and 58 μm. In the matured clams, almost all the ova assumed a perfect spherical shape and measured 72 μm and above. Very few ova were found to be in a near-spherical shape. In the spent clam, the smear contained only very few perfect spherical ova and measured 72 μm and above.

Percentage of maturity stages

The percentage occurrence of various stages of gonads based on the ova diameter is presented (Fig. 1).

From the figure, the occurrence of all the four maturity stages in all the months of observation in varying percentages was quite evident. Late maturing and matured stages of gonad ranged from 6.5 (November) to 77.5% (February), respectively. The lowest percentage (6.5%) occurrence of late maturing gonad along with highest percentage of spent gonad (80.6%) were observed during November. Similarly, a lower magnitude of matured gonad (13.1%) and moderate percentage (36.1%) of spent gonad were observed in April. Occurrence of spent gonad was observed throughout the study period in varying magnitude ranging from 6.2% (August) to 80.6% (November).

Histology

Regular observation on the histological preparations yielded valuable data on the progression of the ova.

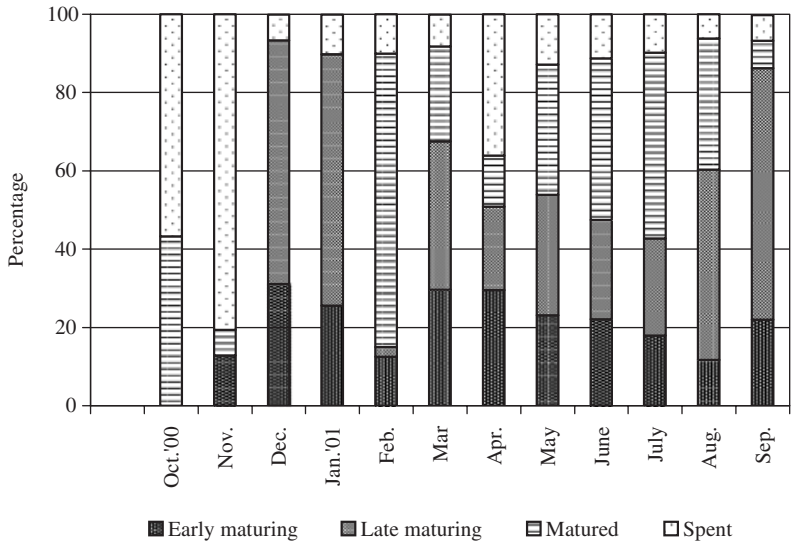

Figure 1 Various stages of maturity in female *Gafrarium tumidum*.

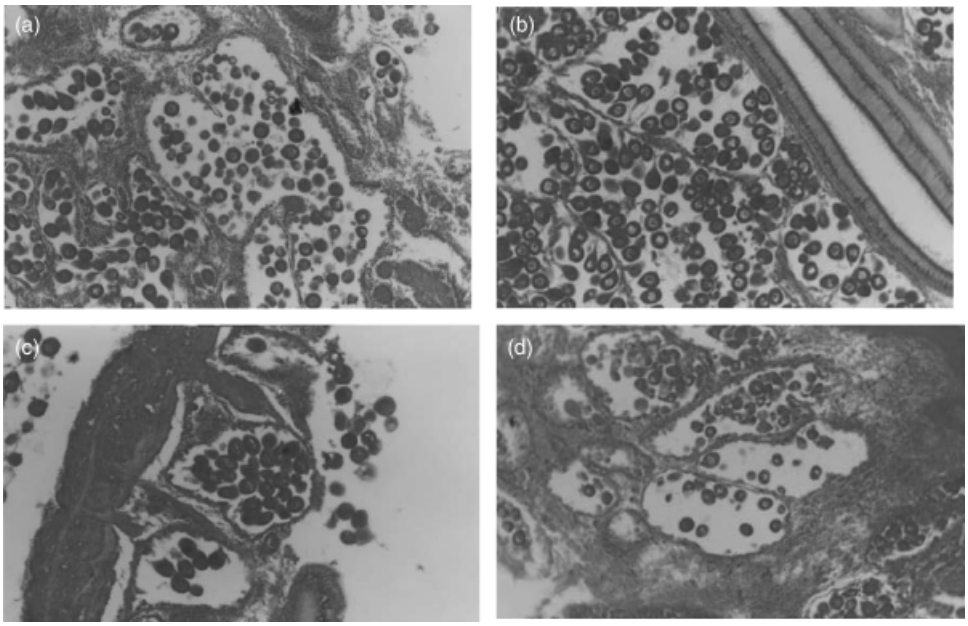

Figure 2 Female gonad *Gafrarium tumidum*. **a. Early maturing gonad** – All irregular ova (< 45 μm) **b. Late maturing gonad** – Most of the ova assuming spherical shape, few are irregular (45–58 μm). **c. Matured gonad** – perfect spherical, densely packed ova (> 72 μm). **d. Spent** – Follicles are mostly empty with few residual ova (> 72 μm). Magnifications: a and b 10 × 10; c and d 10 × 5.

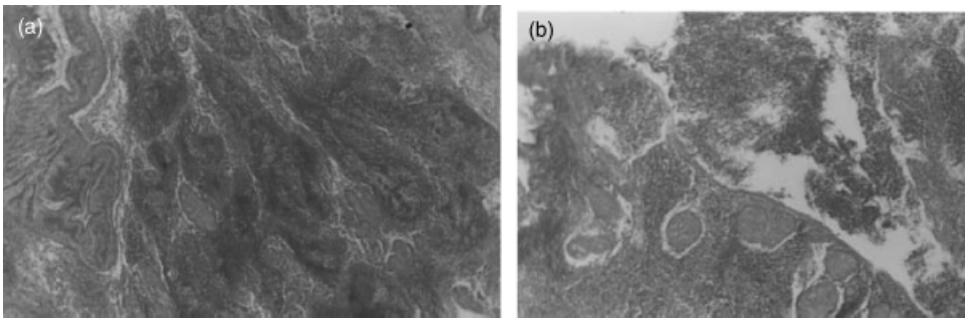

Figure 3 Male gonad *Gafrarium tumidum*. **a. Matured** – Follicles with densely packed spermatozoa. **b. Spent** – Follicles partly empty with residual spermatozoa. Magnifications: a and b 10 × 10.

Four different gonad stages were determined for females from the histological observations such as early maturing, late maturing, matured and spent and two stages, matured and spent, for males, respectively. Photomicrographs of various stages are given ([Fig. 2 (a–d) and Fig. 3 (a,b)]).

Sex ratio

Data on the monthly sex ratio is presented in Table 1. Female clams were more during 9 months with an annual value of 56.9%. Males were found to be more in January, February and May. The χ^2 values during different months are not significant except during October, December and January. The annual male: female ratio was 1:1.3 and it deviated significantly from the theoretical 1:1 ratio.

Condition index based on dry and wet flesh weight

The monthly average values (%) of the CI for all groups combined based on dry meat weight and wet meat weights were calculated for males and females

Table 1 Sex ratio of *Gafrarium tumidum* during 2000–2001

Month	Males (nos.)	Females (nos.)	Male (%)	Female (%)	Ratio	χ^2 value	'*P*' value
October'2000	23	50	31.51	68.49	1:2.17	9.9863	<0.005
November	28	39	41.79	58.20	1:1.39	1.8060	>0.05
December	27	53	33.75	66.25	1:1.96	8.45	<0.005
January '2001	54	51	51.43	48.57	1:0.94	8.5714	>0.05
February	33	27	55.00	45.00	1:0.82	0.6	>0.05
March	41	48	46.07	53.93	1:1.17	0.5506	>0.05
April	30	47	38.96	61.04	1:1.57	3.7532	>0.05
May	34	28	54.84	45.16	1:0.82	0.5806	>0.05
June	41	50	45.06	54.94	1:1.22	0.8901	>0.05
July	32	53	37.65	62.35	1:1.66	5.1882	<0.05
August	19	31	38.0	62.00	1:1.63	2.88	>0.05
September	26	36	41.94	58.06	1:1.38	1.6129	>0.05
Annual	388	513	43.06	56.94	1:1.32	17.3418	<0.005

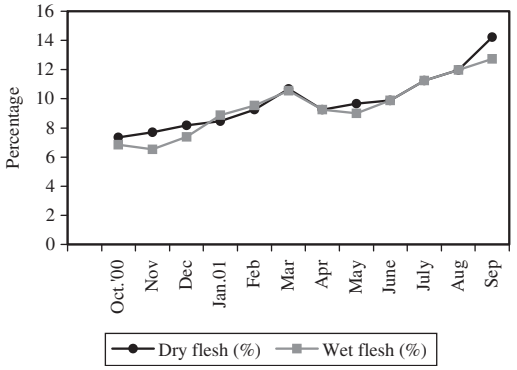

Figure 4 Condition index based on wet and dry flesh weight in male *Gafrarium tumidum*.

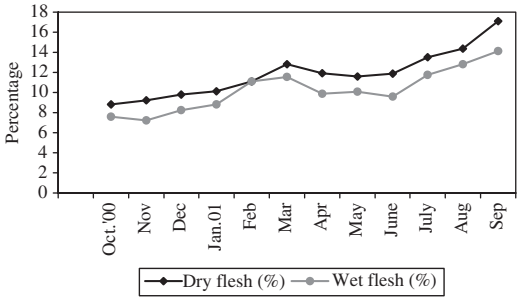

Figure 5 Condition index based on wet and dry flesh weight in female *Gafrarium tumidum*.

and presented (Figs. 4 and 5). The dry flesh weight varied between 8.82 (October) and 14.38 (August) with a mean value of 11.8 and those based on wet flesh weight ranged from 7.24 (November) and 14.14 (September) with a mean value of 10.19 for females. For males it was between 7.35 (October), 14.26% (September) and 6.54 (November), 12.5% (September), respectively. The values of the monthly average CI during the study period showed that the trends in the fluctuations of CI obtained by both the methods are comparable. The fluctuations in the CI in relation to the reproductive cycle showed that the CI values were high when most of the clams had either moderately or well-developed gonads. The low CI values coincided with the months during spawning.

Water content

The monthly average values of the water content recorded are presented (Table 2). The data revealed that the difference between the values obtained for males and females was negligible. The highest values (89.6% and 88.7%) were observed during November coinciding with the peak spawning period. Thereafter the water content decreased and reached low values of 81.7% and 82.0% during March. A noticeable increase was observed during April (84.9% and 84.6%), coinciding with the minor spawning peak. During the rest of the months, the water content ranged from 82.6% to 87.2% and from 83.4% to 87.2% in males and females, respectively.

Size at first maturity

An examination of the percentage maturity stages of different size groups revealed that clams below the size group of 21.4–23.2 mm were either in the maturing stage or in a lesser percentage of fully matured state. Clams of 23.2 mm size and above were in the fully matured state. Hence, the mean value of the size group, i.e. 22.3 mm, was considered as the size at which *G. tumidum* reaches its first maturity (Fig. 6).

Table 2 Water content (%) of male and female *Gafrarium tumidum*

Sex/months	October 2000	November	December	January 2001	February	March	April	May	June	July	August	September
Males	86.8	89.6	87.2	85.3	82.6	81.7	84.6	84.9	85.2	85.7	85.0	86.1
Females	85.5	88.7	86.6	85.6	83.4	82.0	84.9	85.4	86.3	86.0	86.7	87.2

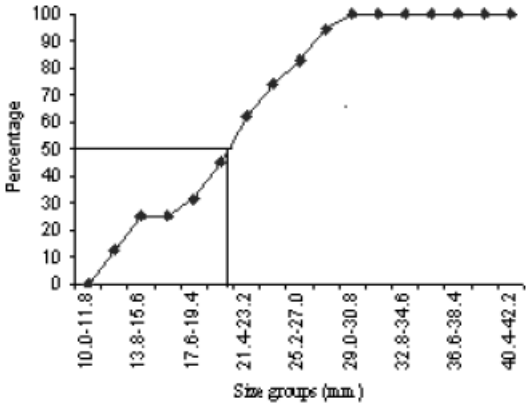

Figure 6 Size at first maturity in *Gafrarium tumidum*.

Discussion

Literature availability on Venus clam *G. tumidum* is very scanty. Hornell (1922) states, 'probably no other bivalve is so universally valued on the shores of Palk Bay as this cockle clam' which forms an excellent food for local fisher folks and shells for lime industry, and annually nearly five tons of these clams are collected at Pamban and Rameswaram area. It is also being exploited for food in many countries in the Indian Ocean. (Nayar & Rao 1985). Hsieh, Chen & Chang (1981) in their study underlines the importance of these clams potential for possible Mariculture in the littoral zones of Penghu, Taiwan. Understanding of the reproductive biology of any organism is a prerequisite for its suitability for aquaculture purpose.

The present study on *G. tumidum* clearly showed the availability of spent specimens along with different stages of maturity indicating the year-round breeding of this species when conditions are favourable. However, based on the lowest percentage of late maturing clams along with the highest percentage of spent clams during November, it may be concluded that this represents the peak period of spawning in this region. A secondary peak in April was also observed when considerable percentage of clams is found to be in the spent stage. The spawning season determined for the present species almost agrees with the finding for *K. opima* (Nagabhushanam & Mane 1975).

Sreenivasan (1983) indicated that *M. casta* spawns during April–September in the Vellar estuary. Thangavelu and Poovannan (1994) found that *M. casta* occurring at Muttukadu was a continuous breeder with two intense spawning periods, one during May and another during September–October based on the high percentage of spent clam availability. Thangavelu and Sanjeevaraj (1985) found ripe clams in all the months showing spawning round the year, when environmental factors are favourable with peak periods during March–April, July–August and October–November. Narasimham *et al.* (1988) observed *M. meretrix* as a prolonged breeder (about 9 months) at Korampallam estuary and concluded that spawning occur when the temperature variation is narrow. They further inferred that there was absence of spawning during November–December when the salinity was very low < 10 ppt.

It could be inferred that the members of veneridae are exhibiting either prolonged/continuous breeding with one to three spawning peaks in a year, even though these clams occupy different ecological habitats such as estuarine, backwater and marine. It is also evident that none of the members spawn actively during the monsoon period. In this study, it attained peak maturity during hotter seasons and higher salinities (31.1–34.3 °C & above 30 ppt) similar to the observations of Baron (1992). However, it spawned actively during November, corresponding to the northeast monsoon, which may be attributed to negligible dilution in seawater salinity (30.4 ppt) in the clam bed.

Sex ratio observed for *G. tumidum* indicated significant departure from the expected 1:1 ratio. The results obtained in the condition index are comparable with those of Narasimham (1988), in blood clam *Anadara granosa*. Water content showed only simple variations between male and females. Water content of animals, especially molluscs are an indicator of spawning period as observed by Alagarswami

(1966), in *Donax faba*, Shunula (1989), in *Anadara antiquata*, which is comparable with the present results.

The size at first maturity estimated for *G. tumidum* (22.3 mm) compares well with the other venerid/arcid species studied. Sone (1994) and Baron (1992) estimated the size at first maturity of *Gafrarium pectinatum* in Tongon waters and *G. tumidum* from New Caledonia to be 20.0 mm. Earlier estimations of size at first maturity for *Katelysia opima* were 24.7 mm (Kalyanasundaram 1982), 21–25 mm for *Anadara rhombae* (Natarajan & George 1983) and for *M. meretrix* it was 21–26 mm (Jayabal 1984).

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