Indian J. Fish., 60(4) : 47-50, 2013

Reproductive studies on the short neck clam *Paphia malabarica* (Chemnitz) from Dharmadom Estuary, Kerala, India

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ABSTRACT

Maturation and spawning of the short neck clam *Paphia malabarica* was studied from Dharmadom Estuary, in northern Kerala, India. The breeding season was from October to February, with peak spawning in November and December. Sexual activity commenced from March onwards and lasted till September. The peak somatic period was from February to April when more numbers of indeterminates appeared in the population. There was not much difference in the size at maturity (L_m) for females and males; L_m was estimated to be 20 mm for females and 22 mm for males. Chi-square test indicated that the sex ratio differed significantly ($p<0.01$) from the theoretical 1:1 ratio, only in the month of May. The abundance of mature clams showed positive correlation with salinity and negative correlation with temperature.

Keywords: Estuary, *Paphia malabarica*, Reproduction, Size at maturity

Introduction

Reproductive activities of molluscs are controlled by exogenous and endogenous factors. Exogenous factors like temperature, salinity and food supply act as environmental indicators and synchronise the reproductive activities of molluscs within an environment. Endogenous control of reproduction, especially gametogenesis and spawning, is by the endocrine system and is more or less independent of environmental changes (Giese and Pearse, 1974). Often activities such as gametogenesis begin much in advance of favourable conditions. Environmental changes must act as early cues to synchronise reproduction with favourable conditions (Giese and Pearse, 1974).

Detailed study on the fishery and biology of *Paphia malabarica* (Chemnitz) from Indian waters is lacking except for the works from Mulky (Rao, 1988) and Ashtamudi estuaries (Appukuttan, 1993). Though the occurrence of *P. malabarica* has been reported in many estuaries, no detailed study has been initiated especially in the Malabar area. Hence an attempt was made to study the reproduction of *P. malabarica* from Dharmadom Estuary. The objective of the study was to observe the occurrence of different reproductive stages in different seasons and also to determine the season of spawning.

Materials and methods

Fortnightly samples of *P. malabarica* from 3 stations in Dharmadom Estuary were collected from December 2003 to November 2004 using a hand dredge. Samples were pooled and a total of 1,204 clams were examined for sex and stages of maturity. For classification of the gonadal maturity, fresh smears of gonad from individual clams were examined under microscope.

The methodology described by Ropes (1968) was followed in the categorisation of the maturity stages except that the 'early active' and 'late active' phases were clubbed under the maturing stage, as given by Narasimham (1988). Sex ratio was determined and the test of variance of homogeneity (Snedecor and Cochran, 1967) was applied to test the significance of difference in the sex ratio in the monthly samples. It was again ascertained by Chi-square test, to find out whether the observed monthly sex ratio differed from the theoretical 1:1 ratio. Size at first maturity was studied by examining gonad sections of 429 clams measuring 11–30 mm, collected at peak spawning (Narasimham, 1988). Size at maturity was estimated by fitting a logistic maturity model with proportion of maturity on length (King, 1995).

Results and discussion

The temporal distribution of maturity stages of *P. malabarica* in different months during 2003-2004 from Dharmadom Estuary is given in Fig. 1 and 2.

The progress of the reproductive cycle of *P. malabarica* in different months traced from sections examined at regular intervals showed that indeterminate

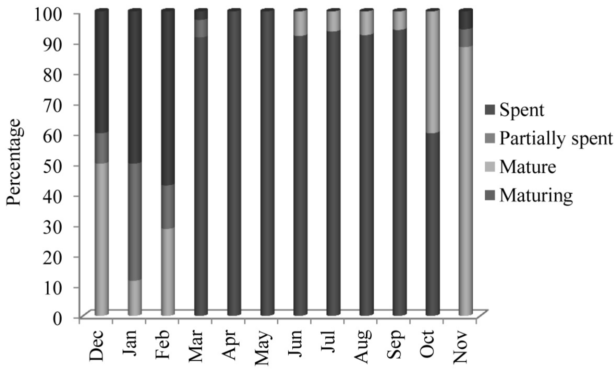

Fig. 1. Temporal variations in gonadal stages of male *Paphia malabarica* in Dharmadom Estuary

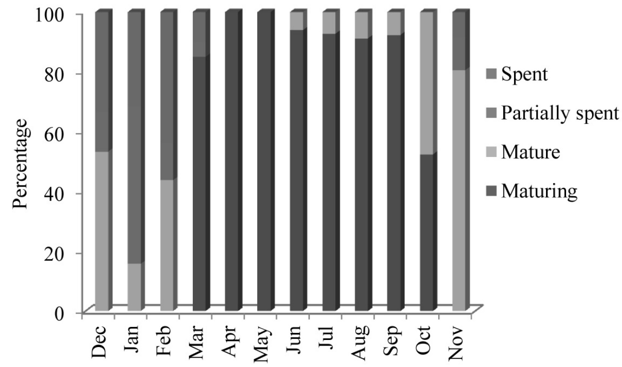

Fig. 2. Temporal variations in gonadal stages of female *Paphia malabarica* in Dharmadom Estuary

stage dominated in February forming 51% of the samples observed in that month, and was overtaken by the maturing stages gradually in March (53.8%), April (73%), May (87%), June (81%) and July (88%). The indeterminates were found up to July. In August and September maturing clams dominated the population (92% and 93% respectively). Mature clams were found in few numbers from June (6%) onwards and in October it reached 44%. In November, 84% of the clams were found to be mature and 51% were mature in December. Partially spent and spent clams were observed from November onwards. In December, about 49% of the clams observed were in partially spent or spent condition and in January 86% of them were in partially spent or spent condition.

While examining the male and female clams separately, it could be seen that maturing clams dominated from March to September for both sexes. Mature clams started appearing from June onwards. In October 48% of females and 40% of the males were in mature condition. In November, more than 80% of the females and about 88% of the males were mature and 11%, and 6% respectively were partially spent.The study thus showed that breeding season commenced in October and lasted till February, with peak spawning in November and December. Sexual activity commenced in March and lasted till September. In November, more than 80% of the males and females had fully ripe gonads possibly indicating that the spawning season coincided with recovered salinity after the monsoon. Peak somatic period could be from February to April when more numbers of indeterminates appeared in the population. The study also reveals that the sexes show synchronism in gonadal development. Gaspar *et al.* (1999) observed that in the bivalve *Donax trunculus* gonadal development is synchronised in both sexes.

Based on information available in published literature and from their own investigations, Joseph and Madhystha (1982) have indicated that tropical and subtropical invertebrates in general have mostly semi-annual or annual breeding seasons. According to them, continuous breeding season as reported by several authors is not really continuous. Mane and Nagabhushanam (1988) while discussing the reproduction of edible bivalves from Ratnagiri coast, have reviewed the important works on reproductive biology of Indian bivalves, especially clams and oysters and suggested that many bivalves of tropical waters have continuous spawning and in few cases discontinuous. In general, the spawning season extends for a few months unlike in temperate waters, where it may be only for a shorter duration. Kripa and Appukuttan (2003) observed that most of the bivalves from Indian waters have wide spawning period with certain peaks. The results of the present study indicated that *P. malabarica* from Dharmadom Estuary has a breeding season from October to February with peak spawning in November-December. Mature clams appeared in the population from June onwards in few numbers. Rao (1988) when studying *P. malabarica* from Mulky Estuary, also observed that mature clams were abundant from October to February and considered that as the spawning season although mature specimens were observed in few numbers in March, June and August. Appukuttan (1993) observed October to January as breeding season for *P. malabarica* in. Ashtamudi Estuary with peak during November-December. In general for *P. malabarica* along west coast of India, the spawning season was observed from September to February (Kripa and Appukuttan, 2003) Hence *P. malabarica* could be grouped under the category of clams which spawn once in a year with short spawning period. Brousseau (1987) reported that in *Mya arenaria* from widely separated populations, spawning occurred at different times with varying frequency. Newell *et al*. (1982), while working on Long Island population of *Mytilus edulis*, suggested that latitudinal effects on the reproductive cycle of bivalves are secondary to the effects of habitat-specific exogenous factors, such as temperature and food supply.

Sastry (1979) while reviewing the various exogenous and endogenous factors which influence the reproductive cycles in bivalves showed the importance of temperature and salinity for initiating spawning in bivalves. Joseph and Joseph (1987) studied the reproductive response of bivalves from Mulky Estuary, taking into consideration the gametogenic activity, gonadal growth and proliferation, initiation of spawning and gonadal activity or dormancy in relation to their environmental factors and indicated that the effects of salinity on reproduction of bivalves are not well understood, but mostly bivalves respond to salinity changes as far as their spawning habits are concerned (Joseph, 1979; Joseph and Madhystha, 1982, 1984; Nagabhushanam and Mane, 1988) Although for tropical species the temperature difference is not much evident, in Dharmadom Estuary the spawning season could be positively correlated with increase in the salinity after the monsoon. Here, the peak spawning period coincided with increase in salinity during the post-monsoon season. There is a sudden dip in salinity in the monsoon season which increases during the post-monsoon season which could be one of the factors which stimulates spawning.

Size at first maturity (L_m)

The gonad was not found developed in size group 11-14 mm in females and 11-19 mm in males. From 15 mm onwards ovary was found to be developed in females for the first time, whereas in males, only > 20 mm size testes were fully developed. In 19 mm size groups 30.8% of the clams were fully mature and in 20 mm size 53.8% were mature. In case of male, fully matured appeared from 20 mm (14.3%) onwards and at 21 mm, 54.5% were in fully mature stage. Some clams were indeterminate even up to 24 mm. Above 30 mm size group, there was no relationship between size and stage of maturity, but spent stages were observed from 30 mm onwards. The observed length range for size at maturity and the values derived logistically were compared. It was found that there was not much difference in the size at maturity for females and males in both cases. Observed L_m for females and males were 20 and 21 mm and derived logistically were 20 and 22 mm respectively (Fig. 3 and 4). Hence for *P. malabarica* from Dharmadom Estuary, length at first maturity can be taken as 20 and 22 mm for females and males respectivley. Size at first maturity is determined for the study of the stock and for suggesting management measures for exploitation of the resource. Kripa and Appukuttan (2003) observed that for *P. malabarica,* the length at first maturity was 20 mm along west coast of India.

Sex ratio

Females outnumbered the males in most of the months. Indeterminates were found in the population from February to July. Chi-square test indicated that only in the month of May, the sex ratio differed significantly ($p<0.01$) from the theoretical 1:1 ratio (Table 1). The proportion of mature clams showed positive correlation with salinity and negative correlation with the temperature. Rao (1988) found that for *P. malabarica* from Mulky Estuary, the sexes were almost equally distributed except in August when males outnumbered females.

According to Joseph and Joseph (1988), it is quite likely that in our search for a single factor hypothesis to explain reproductive synchronisation with exogenous or endogenous factors, many aspects are overlooked. Probably most marine bivalves respond to the net result of all exogenous and endogenous factors and synchronise their reproductive activities. Once the clam population reaches maturity, external factors may induce spawning. If the maturity of the clams within a population react simultaneously to environmental change, gametes are released profusely for a short spell, giving a short period

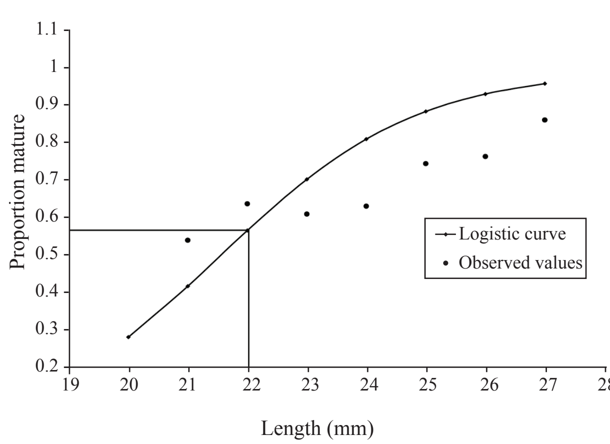

Fig. 3. Logistic maturity curve of *Paphia malabarica* (male)

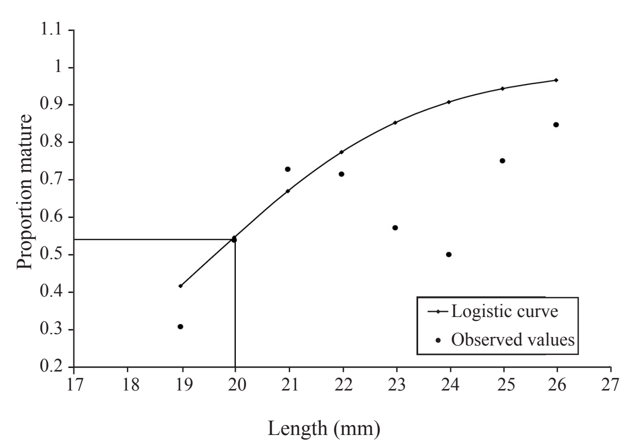

Fig. 4. Logistic maturity curve of *Paphia malabarica* (female)`

Table 1. Sex ratio of *Paphia malabarica* in the population with results of test of significance.

Month	Sex ratio Male : Female	Chi-square value
Dec	1:1.13	0.173
Jan	1:1.16	1.758
Feb	1:0.57	3.719
Mar	1:0.57	3.719
Apr	1:0.67	1.909
May	1:0.56	3.894*
Jun	1:0.89	0.163
Jul	1:0.92	0.095
Aug	1:1.06	0.046
Sept	1:0.95	0.031
Oct	1:0.93	0.059
Nov	1:1.06	0.041

**Significant at 1%level*

of spawning, and hence the extent of spawning depends mainly on the synchrony of the correct stage of maturity and the factors that induce spawning.

Acknowledgements

The author expresses sincere gratitude for technical assistance rendered by V. G. Surendranath and N. P. Ramachandran of Calicut Research Centre of CMFRI. The author also thanks the clam pickers of Dharmadom Estuary who helped in collection of samples for the study.

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Date of Receipt : 09.02.2013
Date of Acceptance : 25.04.2013