Seasonality, reproductive biology and ecology of *Mesopodopsis zeylanica* (Crustacea: Mysida) from a tropical estuary (Cochin backwater) in India

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**Abstract:** Mysids from a tropical estuary (Cochin backwater) in India were studied based on samples collected over a period of one year. Four species belonging to three genera were represented: *Mesopodopsis orientalis*, *Mesopodopsis zeylanica*, *Rhopalophthalmus indicus* and *Kochimysis pillaii*, among which *Mesopodopsis zeylanica* was the most dominant species, recorded throughout the year with its peak abundance observed during the monsoon period (June to September). The wide range of fluctuation in their population density was considered to be mainly due to their heterogeneous distribution. Reproduction of *M. zeylanica* in Cochin backwater is continuous throughout the year. The number of embryos carried by a single female ranged from 7 to 12, and was correlated with female length \( (p<0.05) \), tending to increase with increasing the size of the female. Egg size varied between 0.38 and 0.43 mm, with no correlation with length of the female, and size differences were observed in the same brood. Males and females attain sexual maturity after reaching a total length of 5 mm and 4.5 mm respectively. The environmental parameters, salinity and chlorophyll \( a \), have much influence on the population density of mysids.

**Key words:** Cochin backwater, Crustacea, India, Mesopodopsis zeylanica, mysid

**Introduction**

Mysids occupy a wide variety of aquatic environments and are ubiquitous in estuarine ecosystems. Their ecological importance, in particular their role in food chains as a link between the benthic and the pelagic system, is becoming increasingly apparent (Roast et al. 1998). In general, mysids are omnivores, feeding on detritus, zooplankton and phytoplankton, and as such form a link between microbial producers and secondary consumers (Webb 1973) and are responsible for the remineralization of a large portion of the refractile detritus (Fockedey & Mees 1999). Mysids have been recorded in the gut contents of marine and estuarine fishes (Darnell 1961, Stickney et al. 1974, Mauchline 1980) as well as of birds (Moffat 1996), thus playing a part in energy transfer to higher trophic levels (Mees et al. 1994). Life history characteristics of mysid species can vary considerably from one habitat to another (Mauchline 1980) and the knowledge of local population is essential for subsequent studies on related scientific fields (Hanamura et al. 2009).

*Mesopodopsis zeylanica* (Nouvel) is the most widespread and abundant mysid on the west coast of India (Pillai 1968). Compared to other estuaries in India, the mysid fauna of the Cochin backwater remains the least explored population. George (1958) recorded one species of mysid (*Mesopodopsis orientalis* Tattersall) and Biju et al. (2009) reported seasonality and reproductive biology of this species from Cochin backwater. Apart from this, no other information is available on the biology of mysids from this area. This paper deals with the mysid species of the Cochin backwater and summarizes the ecology and breeding biology of the dominant mysid species, *M. zeylanica*.

**Materials and Methods**

**Study area**

Cochin backwater is part of a long chain of lakes and canals, parallel to the coast, extending between 9°40’12” to 10°10’46”N and 76°09’52” to 76°23’57”E. The total area of the backwater is about 157 km², with depths ranging from 2 to 8 m. A large number of rivers discharge into it, and it opens into the Arabian Sea through one major and several minor outlets. Of the three sampling stations (Fig. 1), Fortkochi (S1, harbour entrance) maintains a marine condi-
tion throughout the year. Bolghatty (S2), situated in the northern limb of Cochin backwater, is free from sudden tidal variations and has an intermediate condition with regard to salinity. Thevara (S3), in the southern branch, experiences the maximum tidal variation due to a shipping channel. The distance between stations is approx. 7 km on average.

Sampling procedure and data analysis

Samples were collected as a part of the studies on “Ecosystem Modeling of Cochin backwater” in the period March 2003–February 2004. Weekly samples were taken for one full year cycle covering pre-monsoon (February–May), monsoon (June–September), and post-monsoon (October–January). Zooplankton was collected by day time using a Working Party (WP) net (mesh size 0.2 mm, mouth area 0.6 m²) fitted with a flow meter to estimate the volume of water filtered. The net was hauled for 10 min at the surface using a small boat at a speed of approximately 2 knots. Samples were preserved in 4% formaldehyde. At each station, surface water samples were collected using a clean plastic bucket and measurement of temperature (centigrade thermometer), salinity (Salinometer–Digi Auto3G, accuracy), and chlorophyll a (UV-Visible Spectrophotometer, Model-UV 1650 PC, Shimadzu) (Strickland & Parsons 1972) were made.

In the laboratory, mysids were sorted from the samples and classified according to the degree of development of secondary sexual characteristics; adult males- well-developed lobus masculin; immature males- lobus masculinus present but not yet setose; adult females- well-developed marsupium; immature females- incompletely developed marsupium. Adult females with or without eggs/larvae in the marsupium were separated into a different category; female with egg, female with eyeless larvae, female with eyed larvae, and females with fully exposed marsupium (spent females).

Total body length (distance between the anterior margin of the carapace and the apex of the telson) was measured on approximately 20 individuals of each maturity stage, using a binocular microscope fitted with a micrometer eyepiece. In the same manner, eyeless larvae and eyed larvae were measured from the anterior to the posterior end of the uropod when straightened (Hanamura 1999). The egg diameter was measured along the longest axis. Brood size (number of eggs or larvae) was determined only for those females with an unruptered marsupium.

Results

Environmental variables

The surface water temperature varied from 27.3–32.8°C with an average of 29.9±1.3 at S1, 27.2–33.5°C with an average of 30.1±1.5 at S2 and 27.7–32.5°C with an average of 30.3±1.1°C at S3.

The salinity ranged from 0.8–34.5 with an average of 19.4±12.3 at S1, 0–29.2 with an average of 13.9±11.2 at S2, and 0–34.7 with an average of 15.7±12.6 at S3.

The chlorophyll a varied from 7.5–95.7 mg m⁻³ with an average of 20.4±18.2 at S1, 19.8±13.4 mg m⁻³ at S2, and 7–58.3 mg m⁻³ with an average of 15.9±12.4 mg m⁻³ at S2.

Monthly averages of surface temperature, salinity and chlorophyll a at each station are shown in Fig. 2. Details of the environmental properties of Cochin backwater during the study period are given by Biju (Biju 2009).

Mysid fauna in the Cochin backwater

Four species of mysids belonging to three genera, Mesopodopsis orientalis, M. zeylanica, Rhopalophthalmus indicus Pillai, and Kochimysis pillaii Panampunnayil and Biju, were recoded from the Cochin backwater. Population densities of mysids in the backwaters were highly inconsistent. All the four mysid species were present at Bolghatty (S2), three species, (M. orientalis, M. zeylanica and R. indicus) were found at Thevara (S3), while two species (M. orientalis and M. zeylanica) were at Fortkochi (S1). Invariably numerical abundance of all species was high at Bolghatty (S2) followed by Thevara (S3) and Fortkochi (S1) (Table 1).
Seasonal changes in abundance and composition of *Mesopodopsis zeylanica*

*Mesopodopsis zeylanica* thrived in the estuary throughout the year and was the dominant mysid species in the Cochin backwater. Although density fluctuated greatly at each sampling station, there was a showed more or less a similar trend in the timing of their annual peaks (Fig. 3). The highest population density was observed at S2 (14,151 indiv. 1,000 m$^{-3}$) followed by S3 (8,273 indiv. 1,000 m$^{-3}$) and S1 with the lowest density (4,139 indiv. 1,000 m$^{-3}$). Monthly changes in the population structure are shown in Fig. 4. There was a clear seasonal variation: during the pre-monsoon period (February–May) 19.9% of *M. zeylanica* occurred with an average density of 89±168.3 indiv. 1,000 m$^{-3}$ at S1, 220±309.7 indiv. 1,000 m$^{-3}$ at S2 and 150±221 indiv. 1,000 m$^{-3}$ at S3 and this was constituted by 21.6% immature males, 19.4% mature males, 3.4% spent females, 2.3% females with eyed larvae, 5% females with eyeless larvae, 2.5% females with eggs, 10.5% immature females and 35.3% juveniles. Compared to that of other

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**Table 1.** Annual population density (indiv. 1,000 m$^{-3}$) at different stations and total percentage composition of mysids from the Cochin backwater.

| Mysid species          | S1 (Fortkochi) | S2 (Bolghatty) | S3 (Thevara) | Total percentage composition (%) |
|------------------------|----------------|----------------|--------------|----------------------------------|
| *Mesopodopsis orienalis* | 2,129          | 7,086          | 5,277        | 26.10                            |
| *Mesopodopsis zeylanica* | 4,139          | 14,151         | 8,273        | 47.80                            |
| *Rhopalophthalmus indicus* | –              | 12,928         | 1,310        | 25.60                            |
| *Kochimysis pillaii*    | –              | 320            | –            | 0.58                             |

–, absent.

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**Fig. 2.** Seasonal changes of monthly average of the surface water temperature (a), salinity (b) and chlorophyll *a* (c) observed at sampling sites in the Cochin backwater, India.

**Fig. 3.** Seasonal changes in the abundance of *Mesopodopsis zeylanica* collected in the Cochin backwater, India.

**Fig. 4.** Seasonal changes in the population structure of *Mesopodopsis zeylanica* collected in the Cochin backwater, India. IM, immature males; MM, mature males; SP, spent females; ED, females with eyed larvae; EL, females with eyeless larvae; EG, females with eggs; IF, immature females; J, juveniles.
The highest abundance of *M. zeylanica* occurred in the monsoon period (57.4% of total population) with an average density of 161 ± 231.4 indiv. 1,000 m\(^{-3}\) at S1, 427 ± 502 indiv. 1,000 m\(^{-3}\) at S2 and 325 ± 349 indiv. 1,000 m\(^{-3}\) at S3. All developmental stages of *M. zeylanica* were recorded from June to September (monsoon period), with a comparatively high density and were comprised of 17.6% immature males, 11.6% mature males, 8.5% spent females, 4.7% females with eyed larvae, 5% females with eyeless larvae, 9% females with eggs, 15.5% immature females and 28% juveniles. The three stations showed the same trend during this period. Maximum average density of *M. zeylanica* was observed in August (2,105 ± 1,375 indiv. 1,000 m\(^{-3}\)). After September, the density declined rapidly. In the post-monsoon period, only 22.7% of the total population of *M. zeylanica* was present of which 19.8% were immature males, 20.4% mature males, 10.6% spent females, 1.3% females with eyeless larvae, 2.2% females with eggs, 18.7% immature females, and 27% juveniles. During the post-monsoon period, brooding females are completely absent at S1. The monthly percentage showed that juveniles dominated most of the samples and the percentage composition of each life stage of *M. zeylanica* varied with the season. The monthly percentage compositions of different age groups are given in Fig. 4.

During the study period, *M. zeylanica* showed tolerance to salinities ranging from 0 to 32.5, and temperatures from 27.2 to 33.5°C.

### Discussion

Four species of mysids were collected from the Cochin backwater, of which *Mesopodopsis orientalis* has previously been recorded from various localities in India.
A series of experiments were carried out by Bhat-

low salinity conditions caused by the monsoon (Nair 1939,

show a fully synchronous pattern between the sampling sta-

months. This probably indicates a heterogeneous distribution

This probably indicates a heterogeneous distribution of the mysids.

The dominant mysid, Mesopodopsis zeylanica occurred throughout the year while their peak abundance was observed during the monsoon (June–September). There is evidence of periodicity in the abundance of M. zeylanica in Cochin backwater, and this is comparable to that of M. orientalis from the backwaters (Biju et al. 2009).

Mesopodopsis zeylanica is a euryhaline form; water salinity seemed to have a considerable effect on the abundance of M. zeylanica in the Cochin backwater. For example during the monsoon period, there was an increase of the fresh water inflow that caused a considerable decrease in salinity and an increase in mysid abundance. This suggests that the seasonal abundance of M. zeylanica is mainly determined by water salinity. The population dynamics of M. orientalis in coastal waters has been reported to be correlated with the low salinity conditions caused by the monsoon (Nair 1939, George 1958). Belyaev (1949), Remane & Schlieper (1958), and McLusky & Heard (1971) pointed out that euryhaline species are well adapted to live in an environment with wide fluctuations in salinity, though their capability to prevent excessive changes in their internal environment by maintaining their blood hyper or hypo-osmotic to the medium. A series of experiments were carried out by Bhat-

March 2003 4.4–5.3 5.2–6.4 5.2–7.2 4.2–6 1.4–2.8
April 5–5.4 6–6.2 5.6–7.4 4.7–5.8 3.2–4.2
May 4.2–5.2 5.7–5.8 6.2–7.0 5–5.3 1.5–4.9
June 5–5.7 6.2 4.8–6.7 4.5–6.5 2.7–3.5
July 4.2–4.9 5–5.8 5.2–7 4–6.3 3.3
August 5.1–5.3 5.7–6.6 4.9–5.9 5–5.2 1.9–3.5
September 4.7–5 6.2–6.3 5.2–6.9 4.7–5.7 2.1–3.2
October 4.8–5.6 5–7.3 6–6.7 5.6–6.2 2.5–4.2
November 4.2–5.4 6–6.4 5.9–6.8 4.7–5 2.2–3.8
December 5.5–5.6 5.7–6.2 – – 2.7–4.2
January 2004 4.3–5 5.4–5.5 5.3–7.2 4.3–5.9 2.3–3.2
February 5.5–5.6 5.2–6.2 – 6.6 4.4

IM, immature males; MM, mature males; MF, mature females (spent females+females with eyed larvae+females with eyeless larvae+females with eggs) IF, immature females; J, juveniles.

Table 3. Variation in length (mm) of age groups of Mesopodopsis zeylanica in different months.

The mysid abundance is also closely related with phytoplankton production of Cochin backwater. Hanamura et al. (2009) reported that food availability is one of the more important factors controlling the abundance of mysids. The Cochin backwater is highly productive during the monsoon period, which may be due to the nitrogenous input that comes through monsoonal river flow (Jyothhababu et al. 2006), and the feeding activity of M. zeylanica also increased. Therefore, according to changes in phytoplankton biomass, the distribution and abundance also varied. Linden & Kuosa (2004) reported that mysids can alter the size structure and the biomass of the phytoplankton community: directly through selective grazing or nutrient recycling (excretion) and indirectly through predation on the main herbivores and due to the subsequent cascading effects.

The considerable variations in population density of mysids between the three stations may be correlated with the geographical conditions of particular stations. Even though the breeding peak was observed in the monsoon period, the population density was comparatively low at the harbor entrance station (S1) and the shipping channel station (S3). This may be due to the effect of tidal current in these areas. Many workers have described the influence of tidal current on the distribution of zooplankton and mysids (Heubach 1969, Wooldridge & Erasmus 1980, Wooldridge & Bailey 1982, Hill 1991, Hough & Naylor 1991, 1992, Moffat & Jones 1993).

The peak abundance of M. zeylanica was found during the period of low salinity; all development stages occurred in this period. This may be related to reproduction and/or less predation. Estuaries are the breeding ground of many fishes and prawns (George 1958, Rao 1970, Jhingran 1975), and during the monsoon period these animals migrate to the coastal waters from the estuaries because the juveniles may not be able to survive at low salinities. Adults and juveniles of M. zeylanica occurred in great abundance during the monsoon period. They also occurred pre-monsoon (February–May) and post-monsoon (October–January), but in lower abundance. It is apparent from the continuous presence of juveniles that M. zeylanica breeds throughout the year and can survive in a wide range of salinities (0–32.5). The failure to collect brooding females in several months may be due to low densities and to the migratory nature of the species, or it may be due to predation.

An analysis of the population structure of M. zeylanica...
demonstrates the difference in length composition of the population and reveals the reproductive condition of the species. Some immature females collected in April, June, July, October and January were larger than ovigerous females collected in the same months. This reveals that total length alone does not determine maturity.

The number of larvae produced per female of M. zeylanica increased with female size. This relationship between female size and brood size has been shown to exist for many species of mysids (Mauchline 1980). Even though large females carried more young, the number of young also varied even with females of the same length. In the present study, the number of brood carried by females ranged from 7 to 12, being comparable with that of its present study, the number of brood carried by females also varied even with females of the same length. In the present study, the number of brood carried by females ranged from 7 to 12, being comparable with that of its closer congener M. orientalis collected from Cochin backwater (Biju et al. 2009). In mysids, the shortest duration (4 days) of marsupial development is reported for M. orientalis, while the developmental time of its European congener Mesopodopsis slabberi (Van Beneden) was 9 to 19 days (Greenwood et al. 1989). Mysis relicta Loven, a cold-water species, has the longest (240 days) reported development time (Lasenby & Langford 1972). In Cochin backwater, M. zeylanica reproduces all year round. The population consists of mixed age groups due to this continuous reproduction and hence makes it impossible to trace the development of a particular group through to maturity by overlapping generations.

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