

Mysids (Crustacea) from the salt pans of Mumbai, India, with a description of a new species

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Abstract

Taxonomy, distribution and ecology of mysids collected from the salt pans of Mumbai, India, are presented. Two mysid species are represented, of which one species, *Indomysis nybini*, is described as new to science. The new species is distinguished from the related species by the presence of a distal suture in the antennal scale, lack of articulation on the exopod of fourth male pleopod and the presence of spines on the endopod of uropod. The new species, *Indomysis nybini*, is fairly common in Thane salt pan and its population density varied from 0- 425 inds./m³. In Bhayander salt pan the mysids *Mesopodopsis orientalis* and *Indomysis nybini* were both present but never coexisted. In terms of mysid population density, Bhayander (ave. 79 inds./m³) was more productive than Thane (ave. 14 inds./m³).

Keywords; *Crustacea, mysid, salt pan, taxonomy, ecology, India*

Introduction

Salt pans are unique enclosed tidewater impoundments adjacent to creek environments from which crude salt is extracted. They are characteristically exposed to a wide range of environmental stress mainly due to salinity changes. The distinct feature of the brine ecosystem is its simplicity and species diversity in each trophic level is low. Scientific investigations of the salt pans along the coast of India are confined mostly to the *Artemia* population and its biology (Kulkarni 1953; Royan 1979; Ramamoorthy and Thangaraj 1980; Dwivedi et al. 1980). Further studies on the fauna of the salt pans have been done by Deshmukh (1989), Ratan and Ansari (1982), Madhupratap and Haridas (1992), Shirgur and Deshmukh (1994), Mustafa (1995) and Mustafa et al. (1999). These reports indicate that the salt pan ecosystem permits the growth and survival of only selectively adapted organisms, which can withstand the extreme variations in environmental parameters. Hence most of the species in salt pans are potentially organisms for mass culture. Although mysids (Crustacea: Peracarida: Mysida) are fairly abundant in salt pans there has been no detailed study on these organisms. In the present study we provide information on the taxonomy, distribution, and ecology of the two species of salt pan mysids, of which one species *Indomysis nybini* is described as new. The type specimens are lodged in the Reference Collection of the Indian Ocean Biological Centre (IOBC), National Institute of Oceanography, NIO, Kochi.

Area of Study

The salt pan system studied is divided into reservoirs, condensers and crystallizers. The reservoirs receive water directly from the adjacent creek. During each spring tide, water is collected for a period of 2 to 4 days for storage in a reservoir. From the reservoir the water is transferred to the condenser for evaporation and after a few days transferred to the crystallizer. The tides in this area are of a mixed type and are predominantly semidiurnal. The mean height of the spring tide is 3.7 m. The layout of a typical salt pan is given in Figure 1.

Materials and methods

For the present study two salt pan systems, Thane and Bhayander, India, were selected (Figure 2). Sampling was done at monthly intervals from five stations in each system including the creeks for a 15 month period between May 1991 and July 1992. Station details are given in Table I. A circular hand net of 1 m length, having a mouth area of 0.08 m² and a mesh size of 0.1 mm, fitted with a calibrated TSK (The Tsurumi-Seiki Co, LTD) flow meter was used for the collection of zooplankton samples. Hauls were made manually from one end to the other of the different sections of the salt pans (0.4-1 m) during high tide. In the crystallizer hand net operation was often difficult

and hence 1000 litres of water were filtered through a mesh and the number of organisms retained was converted in to m³ values. Zooplankton samples were preserved in 5% buffered formalin. In the laboratory, mysids were sorted from the samples and classified into different groups based on the degree of development of secondary sexual characteristics (Mauchline, 1980). Sexes can be distinguished by the presence of an extended fourth pleopod in males and the marsupium in females. Immature individuals were distinguished from juveniles by the presence of rudimentary oostegites (female) and a longer fourth pleopod (male). Mature females were categorized according to reproductive condition- spent females, females with eyed larvae, females with eyeless larvae and females with eggs/embryos. Total length of the specimens was measured from the tip of the rostral plate along the dorsal surface to the tip of the telson.

Water samples from surface waters were collected using a polyethylene bucket for the estimation of relevant water quality parameters. Further details of the collection and analysis are given by Mustafa et al. (1999).

Results

The population density of mysids and hydro-biological factors such as temperature, salinity, and dissolved oxygen prevailing in the different sections of the two systems are shown in Tables 2 and 3. In the Thane salt pan, the only species of mysid found is the newly reported *Indomysis nybini* (Table II). Mysids were fairly common during July 1991 to March 1992 and were most common in the reservoir stations (T2 and T3). Maximum population density was recorded at station T5 in September 1991 at a temperature of 27.0°C, salinity 26.6‰ and dissolved oxygen of 4.6 mg/l; high densities were also recorded at T3 in September 1991 at a temperature of 28.2°C, salinity 24.2‰ and dissolved oxygen of 5.2 mg/l and T2 in February 1992 at a temperature of 26.0°C, salinity 80.3‰ and dissolved oxygen of 4.7 mg/l. Abundance peaks were dominated by juveniles in most of the months (Figure 3). In other months, numbers were sharply reduced and remained low resulting in low intensity of breeding.

In Thane salt pan, all sexual and developmental stages of this species were present. The percentage composition of adult males, females (spent females, females with eyed larvae, females with eyeless larvae and females with eggs), immatures and juveniles were determined for each month and are given in Figure 3. The frequency of adult males, females, immatures and juveniles changed from month to month during the study period. The total length of adult females ranged from 5.0-7.2 mm indicating that the length did not vary significantly between months. The length of adult males ranged from 4.2-5.7 mm (Table 4). The mean length of adult female (6.0 mm) was greater

than that of adult males (5.0 mm). When the mysids were longer than 3.0 mm the sexes were usually distinguishable, males having longer fourth pleopods and females having small developing marsupia. Some immature males (4.6 mm) and females (5.3 mm) collected during the months of September and November were larger than the mature ones collected during same months (Table 4). In Thane salt pan, the smallest brood (6) recorded was that of a female in the size class 5-5.5 mm and the largest brood (16) was that of a female in the size class 7-7.5 mm. The number of embryos in a marsupium was significantly correlated with female length. Relationship between length of female and brood size of *I. nybini* in Thane and Bhayander salt pans are plotted in Figure 4.

Compared to the number of mysids in the Thane salt pan, mysids were very well represented in the zooplankton samples from the Bhayander salt pan. Mysids were absent only during September 1991. Population density of mysids varied from 0 to 3875 inds./m³ (ave. 79 inds./m³). Mysids were more common at the creek (Sta. B1) and condenser (Sta. B4) than at other locations. The maximum population density was observed in August 1991 followed by a second peak in July 1992. The mysid population of the Bhayander salt pan system was represented by two species *Mesopodopsis orientalis* Tattersall and *Indomysis nybini* (Table III).

M. orientalis occurred in the Bhayander system almost throughout the study period. The total number of mysids per sample ranged from 0 - 3875 inds./m³ (ave. 71 inds./m³). In general this species was more common in the creek (Sta. B1) than in other localities. The highest numbers occurred in August at stations B4. Juveniles dominated the samples, constituting 92% of the population. Low to moderate numbers occurred at salinities ranging from 19.0 to 62.2‰ and a few individuals were found in salinities as low as 1.2‰ and as high as 90.2‰. The population was predominantly composed of juveniles, adult and immature females. The percentage composition of developmental groups was determined for each month and is given in Figure 5.

Both sexes of *M. orientalis* attained their maximum size in October with males reaching up to 8.6 mm and females up to 9.8 mm in total length (Table IV). Juveniles ranged in length from 1.3 to 4.0 mm. Some of the developing embryos in broods were lost in a majority of the females; very few of the females collected had intact broods. Brood size was significantly correlated with length of females (Figure 6). The minimum number of embryos in a brood was 10 (6.0 mm) and the maximum was 18 (8.1 mm).

Indomysis nybini occurred in the Bhayander system during February to May and July 1992 and was represented only in 8 collections. This species was conspicuously absent in the creek. Numerical abundance varied from 0-392 inds./m³ (ave. 13 inds./m³). The highest number (392 inds./m³) occurred at station B2 in July 1992. In that sample, 65% of the population consisted of immature males (3.0-3.4 mm) and females (3.8-4.4 mm); juveniles formed only 1% of the population

and the remaining portion was made up of adult males and females. The salinity and temperature recorded at station B2 were 15.0‰ and 28.0°C respectively. Moderate numbers of mysids occurred at station B4 in March at a salinity of 129.0‰. At that time, 90% of the population consisted of mature males and females. Few or moderate number of mysids occurred at other stations in a salinity range of 51.3-85.7‰.

All sexual and developmental groups of *I. nybini* were present in the Bhayander salt pan. The smallest brooding female was 4.5 mm and carried 6 embryos. The largest brooding female measured 7.2 mm and carried 20 larvae. The average size of brooding female was 5.5 mm. The average brood size was 10.2 embryos; the broods carried by the females were in different stages of development. Mature males measured between 4.4 and 5.9 mm and juveniles were between 1.3 and 3.0 mm (Table IV).

Taxonomy

Subfamily Mysinae Haworth

Genus *Mesopodopsis* Czerniavsky

Mesopodopsis orientalis (Tattersall, 1908)

(Figure 7A- F)

Macropsis orientalis W. Tattersall 1908: 236, Plate 22, Figures 1-9.

Mesopodopsis orientalis: W. Tattersall 1922: 482; Nair, 1939: 175; Nouvel 1957: 323; Murano 1988: 298.

Materials examined

Bhayander: 7 mature males, 30 immature males, 4 spent females, 3 females with eyed larvae, 5 females with eyeless larvae, 10 females with eggs, 25 immature females and 150 juveniles, Creek (B1), May 1991; 2 females with eyeless larvae, Creek (B1), August 1991; 16 mature males, 2 spent females, 5 females with eyeless larvae, 3 females with eggs and 255 juveniles, Creek (B1), October 1991; 2 mature males, 3 immature males, 1 female with eggs, 4 immature females and 17 juveniles, Creek (B1), November 1991; 18 mature males, 13 immature males, 9 spent females, 3 females with eyed larvae, 6 females with eyeless larvae, 11 females with eggs, 31 immature females and 22 juveniles, Creek (B1), December 1991; 4 mature males, 1 spent female, 2 females with eyeless larvae and 6 females with eggs, Creek (B1), February 1992; 42 mature males, 37 immature males, 10 spent females, 17 females with eyed larvae, 11 females with eyeless larvae, 19 females with eggs, 96 immature females and 31 juveniles, Creek (B1), March 1992; 6 spent females, 2 females with eyeless

larvae and 7 females with eggs, Creek (B1), April 1992; 19 mature males, 21 immature males, 1 female with eyed larvae, 7 females with eyeless larvae, 8 females with eggs, 74 immature females and 81 juveniles, Creek (B1), May 1992; 6 mature males and 2 immature females, Reservoir (B2), August 1991; 2 mature males, 4 immature males, 2 spent females, 1 female with eyeless larvae, 5 females with eggs and 33 juveniles, Reservoir (B2), June 1992; 1 mature male, 3 females with eyeless larvae, 6 females with eggs and 20 juveniles, Reservoir (B3), June 1992; 5 mature males, 12 immature males, 1 spent female, 1 female with eyeless larvae, 1 female with eggs, 21 immature females and 29 juveniles, Condenser (B4), June 1991; 2 mature males, 2 immature male, 2 females with eyed larvae, 2 female with eggs, 6 immature females and 20 juveniles, Condenser (B4), July 1991; 20 mature males, 4 spent females, 11 females with eyed larvae, 4 females with eyeless larvae, 12 females with eggs, 10 immature females and 8002 juveniles, Condenser (B4), August 1991; 1 female with eggs and 2 juveniles, Condenser (B4), November 1991; 2 females with eggs, Condenser (B4), January 1992; 3 mature males, 2 spent females, 1 female with eyed larvae, 13 females with eggs, 4 immature females and 180 juveniles, Crystallizer (B5), August 1991.

Length: adult male 5-8.6 mm, adult female 6-9.8 mm

Remarks

Indian and Southeastern specimens have a minor variation in their morphology. The basal articulation in the exopod of the fourth male pleopod is indistinct in the Southeastern specimens (Pinkaw et al. 2001) while in Indian specimens, a distinct articulation exists in basal part in the exopod of the fourth pleopod (Figure 7C).

In general appearance, *M. orientalis* closely resembles *M. zeylanica* Nouvel 1954 and *M. tenuipes* Hanamura et al. 2008b. *M. orientalis* can be distinguished from *M. zeylanica* by the following points. In *M. orientalis* the frontal plate is semicircular (Figure 7A,B). The endopod of the fourth male pleopod is longer than first segment of exopod, outer apical seta of the exopod is unsegmented (Figure 7C,D) and the distal part of telson armed with 30 to 36 pairs of short spines (Figure 7E,F). In *M. zeylanica* the frontal plate is triangular, the endopod of the fourth male pleopod is shorter than the first segment of exopod, outer apical seta of the exopod is segmented and distal part of telson armed with 48-60 teeth.

Mesopodopsis orientalis closely resembles *M. tenuipes* (both species were previously treated as a single species). *M. tenuipes* differs from *M. orientalis* in having broader cornea, short antennal peduncle, and longer and slender fourth male pleopods.

Distribution

This common mysid is widely distributed throughout the shallow coastal waters of India (Biju and Panampunnayil 2009). It has been recorded from the brackish waters and estuaries

(Panikkar and Aiyar 1937; George 1958; Chandramohan 1983; Gupta and Gupta 1984; Sarkar and Chowdhury 1986; Biju et al. 2009), from the fish and prawn culture ponds in Java (Nouvel 1957), Malaysia and Indonesia (Hanamura et al. 2008b) and Thailand (Murano 1988; Pinkaew et al. 2001; Hanamura et al. 2008b).

Genus *Indomysis* Tattersall

Indomysis nybini sp. nov.

(Figures 8A-L, 9A-R)

Indomysid annandalei : Murano 1988: 50, Figure 5A-H; Grabe et al. 2004: 2326.

Materials examined

Type series

Holotype, Thane Reservoir (T2), adult male (5.7 mm) IOBC 0510-10-50-1999, dissected, 0.9-1.3 m, February 1992. Allotype, Thane Reservoir (T2), spent female (7 mm), IOBC 0510A -10-50-2009, dissected, data same as holotype. Paratypes, Thane Condenser (T4), two adult males (5.2 -5.6 mm) and one brooding female (6.7 mm), IOBC 0510P -10-50-2009), 0.3-0.4 m, July 1991.

Other materials

Bhayander : 4 mature males, 3 immature males, 2 females with eyed larvae, 2 females with eggs, 6 immature females and 14 juveniles, Reservoir (B2), February 1992; 10 mature males, 79 immature males, 2 spent females, 8 females with eyed larvae, 18 females with eyeless larvae, 42 females with eggs, 90 immature females and 3 juveniles, Reservoir (B2), July 1992; 4 mature males, 4 immature males, 3 females with egg, 2 immature females and 2 juveniles, Reservoir (B3), February 1992; 8 mature males, 2 immature males, 12 immature females and 4 juveniles, Reservoir (B3), March 1992; 60 mature males, 5 immature males, 4 spent females, 6 females with eyed larvae, 19 females with eyeless larvae, 21 females with eggs, 7 immature females and 10 juveniles, Condenser (B4), March 1992; 2 mature males and 2 females with eggs, Condenser (B4), April 1992; 2 mature males, 3 females with eyeless larvae, 2 females with eggs and 6 juveniles, Crystallizer (B5), February 1992; 1 mature male and 2 females with eggs, Crystallizer (B5), May 1992.

Thane : 4 mature males, 3 immature males and 1 immature female , Creek (T1), September 1991; 12 mature males, 8 immature males, 4 spent females, 9 females with eyed larvae, 4 females with eyeless larvae, 12 females with eggs, 9 immature females and 2 juveniles, Creek (T1), October 1991; 23 mature males, 11 immature males, 6 females with eyed larvae, 6 females with eyeless larvae, 16 females with eggs, 4 immature females and 1 juveniles, Creek (T1), November 1991; 2 mature

males, 3 females with eggs, 3 immature females and 14 juvenile, Reservoir (T2), July 1991; 1 mature male, 1 female with eggs and 1 juvenile, Reservoir (T2), December 1991; 11 mature males, 4 immature males, 1 spent female, 2 females with eyeless larvae, 2 females with eggs, 8 immature females and 6 juveniles, Reservoir (T2), January 1992; 99 mature males, 13 immature males, 5 females with eyed larvae, 7 females with eyeless larvae, 12 females with eggs, 14 immature females and 150 juveniles, Reservoir (T2), February 1992; 12 mature males, 2 immature males, 1 spent female, 4 females with eyeless larvae, 5 females with eggs, 8 immature females and 8 juveniles, Reservoir (T2), March 1992; 3 mature males and 12 juveniles, Reservoir (T3), August 1991; 10 mature males, 33 immature males, 5 spent females, 4 females with eyed larvae, 14 females with eyeless larvae, 26 females with eggs, 25 mature females and 65 juveniles, Reservoir (T3) September 1991; 2 mature males, 1 female with eyeless larvae, 5 females with eggs and 3 juveniles, Reservoir (T3), December 1991; 24 mature males, 86 immature males, 5 spent females, 5 females with eyed larvae, 4 females with eyeless larvae, 18 females with eggs, 6 immature females and 40 juveniles, Reservoir (T3), February 1992; 10 mature males, 10 immature males, 1 female with eyeless larvae, 7 females with eggs, 4 immature females and 34 juveniles, Condenser (T4), July 1991; 2 mature males, 7 immature males, 1 female with eyed larvae, 7 females with eggs, 4 immature females and 34 juveniles, Crystallizer (T5), August 1991; 48 mature males, 50 immature males, 4 spent females, 6 females with eyed larvae, 20 females with eyeless larvae, 53 females with eggs, 39 immature females and 155 juveniles, Crystallizer (T5), September 1991.

Description

In both sexes, body slender. Anterior margin of carapace broadly rounded, slightly overlapping base of eyestalks and not produced into definite rostrum (Figure 8A,B), anterolateral corners sharply produced, posterior margin emarginate leaving last two thoracic somites dorsally exposed. Eyes large and well developed, cornea broad and occupying less than half of eyestalk.

Antennular peduncle stout in male, first segment longer than other two segments combined, distal outer corner tipped with few short plumose setae; second segment short, inner distal corner with one short plumose seta; third segment broader than long, inner distal corner with two short plumose setae, dorsal lobe present tipped with four setae; basal part of outer flagellum not swollen, male lobe absent (Figure 8C). In female peduncle slender, first segment relatively longer than in male; setae on inner distal corner of second and third segments longer than in male (Figure 8D). Antennal scale of male narrowly oval, 3 ½ times as long as broad, setose all round, over-reaching antennular peduncle, distal segment distinct and as long as broad; antennal peduncle more than half length of scale, second and third segments sub equal; outer distal corner of sympod sharply produced

(Figure 8E). In female antennal scale longer, far over-reaching antennular peduncle, almost four times as long as broad; antennal peduncle less than half length of scale (Figure 8F).

Labrum with angular anterior margin (Figure 8G). Mandibles well developed with spine row, represented by 2 bunches of pectinate setae. Second segment of mandibular palp long, slender and unarmed, distal border of third segment truncate and armed with one plumose seta and eight pectinate setae (Figure 8H,I). Maxillule outer lobe much broader than the inner lobe, distal margin with row of spines, inner lobe armed with three long stout barbed spines and five pectinate setae (Figure 8J). Maxilla with a prominent basal lobe and deeply cleft distal lobe, second segment of the endopod short and broad, armed with row of pectinate setae on distal and inner border; exopod with hairy outer margin, narrowly ovate with two distal setae (Figure 8K).

First thoracic endopod with prominent lobe on basis, next two segments conspicuously produced internally; dactylus broad, armed with pectinate setae; claw absent (Figure 8L); epipod and exopod present. Basis of second thoracic endopod with row of 12 long plumose setae on inner margin, dactylus with long pectinate setae, claw absent (Figure 9A). Third thoracic endopod sparsely setose; carpopropodus three segmented, first segment longer than other two segments combined; dactylus with long slender nail (Figure 9B). Fourth and fifth thoracic endopods similar; carpopropodus two segmented, first segment more than twice as long as second segment; dactylus with long slender nail (Figure 9C,D). Sixth and seventh thoracic endopods long and modified; ischium long and sparsely setose, merus characteristically bent and setose on inner margin; carpopropodus with two segments, first segment six times as long as second, with one long stout spine on inner distal angle, distal margin of second segment, with 1-3 toothed setae; dactylus with strong nail (Figure 9E,F,G). Eighth thoracic endopod; ischium shorter than in six and seventh endopod; merus with two strong spines on inner margin; carpopropodus with two segments as in sixth and seventh, distal margin of second segment expanded with row of 6 short spines and 2-3 long setae; dactylus with strong nail (Figure 9H,I). Basal part of exopod with outer corner rounded and flagelliform part eight jointed (Figure 9H). Male appendage of eighth thoracic limb small, ovate with row of short setae on distal margin (Figure 9H).

Marsupium in female composed of two pairs of lamellae.

Pleopods in male except fourth rudimentary and single segmented; first to third pleopod short and subsimilar with row of setae (Figure 9J); fourth pleopod biramous with quadrangular sympod, spiny along inner margin; endopod rudimentary with well developed pseudobranchial lobe; exopod long, reaching beyond base of telson, single segmented, barbed in distal part with pointed apex (Figure 9K,L,M); fifth pleopod long, extending beyond sixth abdominal segment, distally armed with long setae (Figure 9N).

In female, pleopods rudimentary unsegmented single lobe (Figure 9O).

Telson little shorter than sixth abdominal segment, 1.25 times as long as broad at base, apex truncate, half as broad at base, lateral margin armed with 5-8 short spines, truncate distal border armed with row of 26-36 short irregularly arranged spines and with pair of long spines at each angle (Figure 9P,Q)

Uropod broad, longer than telson, setose all around, endopod with single small spine on dorsal inner margin in region of statocyst (Figure 9R); exopod longer than endopod.

Length: adult male 4.2-5.9 mm, adult female 4.5-7.2 mm

Etymology

This species is named after first author's son, Nybin.

Remarks

The new species is closely resembles *I. annandalei* Tattersall 1914, but differs from it in the following points

(1) In *I. nybini*, the antennal scale has a distinct distal suture while in the *I. annandalei* it is absent. (2) In *I. nybini*, distal 1/3 of exopod of fourth male pleopod is strongly barbed, whereas in *I. annandalei* it is spiniform. (3) *I. annandalei*, an articulation is present on the exopod of the fourth male pleopods whereas it is absent in *I. nybini*. (4) In *I. nybini*, the fifth pleopod is distally armed with nine plumose setae which regularly increase in length whereas in *I. annandalei*, there are only six. (5) In *I. annandalei* the endopod of the uropod is without spines while in *I. nybini* there is a small spine in the region of the statocyst.

The presence of distal suture on the antennal scale, absence of an articulation in the exopod of fourth pleopod of male, and spine on the endopod of uropod were also noticed in specimens collected from Saudi Arabia (Murano 1998) and Baharin waters (Grabe et al. 2004). Those specimens are also now referred to *I. nybini*.

Discussion

The various physico-chemical parameters studied indicate well defined differences between the creek and salt pan systems. The variability imposed is mainly due to a pronounced difference in salinity. Dissolved oxygen level at times decreased at the condenser/ crystallizer probably associated with relatively higher water temperature due to the shallowness of the area. The observed water quality of the creek environment was comparable to a coastal marine system.

Mysids showed a discontinuous distribution in Thane and Bhayander systems. In terms of mysid population density, Bhayander (ave. 79 inds./m³) was more productive when compared to Thane (ave. 14 inds./m³). It is apparent from a nearly continuous presence of different size class and

maturity groups during July 1991- March 1992 that *I. nybini* in Thane salt pan can survive in a wide range of salinity (10.5-80.3‰). Some immature specimens were larger than mature specimens collected in the same months suggesting that total length alone does not determine maturity and that variations in size at sexual maturity exist within the population. The brood size and body length of females are closely related. Mauchline (1980) and Greenwood et al. (1985) reported that, embryo number is highly correlated with female body size in mysids, although other factors are also important. A relationship between the increasing body size of the female and increasing numbers of embryo in the brood is difficult to demonstrate in species of body length less than 10 mm and with a small number of embryos of less than 15 in the brood (Mauchline 1980). In *I. nybini*, there is a tendency for larger females to carry more embryos than the smaller females; the number of embryos carried by the females of the same body length varied.

In Thane and Bhayander the brood size of *I. nybini* varies. For example, during February and March 1992, in Thane, the maximum number of broods for *I. nybini* in the size class 6-6.5 mm was 10-14 while in Bhayander the maximum number of broods in the same size class was 13-20. Similarly, observations made on the brood sizes of *M. orientalis* collected from different localities have some variations (Nair 1939; Hanamura et al. 2008a; Biju et al. 2009; Biju and Panampunnayil 2009, Hanamura et al. 2009). These observations indicate that the number of brood carried by the females varies within different populations of the same species.

The tolerance of mysids to changing salinities at different temperatures varies widely between species and to a lesser extent between populations of the same species in different environments (Panampunnayil 1999). There have been a limited number of studies on the distribution of mysids in the natural environment in relation to salinity and temperature (Whitely, 1948; Hulburt 1957; Cronin et al. 1962; Hodge 1963; Turner and Heubach 1966; Heubach 1969; Quintero and de Roa 1973). The ranges of salinity and temperature in which *I. nybini* occurred at Thane were 10.5 to 80.3‰ and 24 to 32°C while in Bhayander the ranges were 15 to 34‰ and 27 to 44°C respectively and in both the systems, it did not occur in areas where the salinity was less than 10, reveals its limit of existence in low saline waters.

In Bhayander salt pan salinity and temperature fluctuated between 0.9 to 36‰ and 23 to 44°C respectively and *M. orientalis* occurred in salinity and temperature ranging from 1.2-63.6‰ and 23.5-37°C. A series of experiments were carried out by Bhattacharya and Kewalremani (1972) and Bhattacharya (1982) to ascertain the reaction of the adult and juveniles of *M. orientalis* to varying salinities at different temperatures. They recorded that juveniles can tolerate salinities below 3.5‰ after they are acclimatized to various salinities either directly or gradually, whereas adults have the capacity of becoming acclimatized even to fresh water and this ability ensures its wide ranges of

distribution from sea water to fresh water. High and low lethal temperatures were found to be 33°C and 13°C respectively for both adults and juveniles. These observations indicate that the salinity tolerance range of this species in the field (1.2-63.6‰) is greater than suggested from laboratory data (1.75 -35‰).

Mesopodopsis orientalis is probably the most abundant mysid living in Indian coastal areas. This species has a substantial degree of adaptability to salinity extremes as exhibited by its occurrence in the highly fluctuating saline conditions of the salt pan; this ability ensures its wide distribution from seawater to near fresh water conditions. Euryhaline mysid species are well adapted to living in an environment with a wide fluctuation in salinity by their capacity to prevent excessive changes in their internal environment by maintaining their blood concentration hyper/ hypo osmotic to the medium (Belyaev 1949, Remane and Schlieper 1958, McLusky and Heard 1971).

In general, the presence of juveniles and ovigerous females of mysid species indicates their breeding activity. In a salt pan, it is not certain whether they can reproduce in such an extreme situation as the embryonic larvae of mysids are normally less tolerant than adults to wide environmental changes (Mauchline 1980). Juveniles and ovigerous females of *M. orientalis* and *I. nybini* in the salt pan may have entered from the adjacent creek along with other age groups.

The ecology and fishery potential of the salt pans around Mumbai were extensively studied by Shirgur and Deshmukh (1994) and they stated that, the salt pans, which support dense growth of micro and macro- zooplankton, especially mysids, can contribute extensively to aquaculture. Mustafa et al. (1999) reported the micro-zooplankton density in Thane and Bhayander salt pans. In terms of micro-zooplankton population, the Bhayander system is four times more productive than Thane and this may be one of the reasons for the mysid abundance in the Bhayander system during the present study. Micro-zooplankton generally is more important in the diet of mysids than phytoplankton due to their inability to feed efficiently on the smaller phytoplankton cells (Jerling and Wooldridge 1995). *I. nybini* and *M. orientalis* never coexist in Thane and Bhayader systems. There are probably two reasons for this: one is related to discontinuous distribution of mysids in salt pans, secondly it may be due to the negative interaction or interspecific competition explained by Odum (1971) as follows: "It is often observed that closely related organisms having similar habitat or life forms often do not occur in the same place. If they do occur in the same place, they use different food or are active at other times or are otherwise occupying some what different niches".

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References

- Belyaev GM. 1949. Osmoregulatory capacities in Mysidacea. Doklady Biological Sciences. SSSR 68: 165-168.
- Bhattacharya SS. 1982. Salinity and temperature tolerance of juvenile *Mesopodopsis orientalis*: laboratory studies. Hydrobiologia 93: 23-30.
- Bhattacharya SS, Kewalremani HG. 1972. Salinity and temperature tolerance of the mysid *Mesopodopsis orientalis* from west coast of India. Journal of Indian Fisheries Association 2: 60-68.
- Biju A, Gireesh R, Jayalakshmi KJ, Haridevi CK, Panampunnayil SU. 2009. Seasonal abundance, ecology, reproductive biology and biochemical composition of *Mesopodopsis orientalis* W.M. Tattersall (Mysida) from a tropical estuary, Cochin backwater-India. Crustaceana 82: 981-996.
- Biju A, Panampunnayil SU. 2009. Mysids from the shallow waters off Maharashtra and south Gujarat, India, with description of a new species. Marine Biology Research 5:345-362
- Chandramohan P. 1983. Mysidacea of the Godawari estuary. Mahasagar 16: 395-397.
- Cronin E, Daiber JC, Hulburt EM. 1962. Quantitative seasonal aspects of zooplankton in the Delaware River Estuary. Chesapeake Science 3: 63-93.
- Deshmukh SV. 1989. Studies on ecology of salt pans at Mulund, Bombay. M.Phil Dissertation. University of Bombay.
- Dwivedi SN, Ansari SKR, Ahmed MQ. 1980. The brine shrimp *Artemia*. Ecology, culturing and use in aquaculture. Proceedings of International Symposium, brine shrimp *Artemia salina*. Corpus Christi Texas. U S A. 3: 175-183.
- George MJ. 1958. Observation on the plankton of Cochin backwaters. Indian Journal of Fisheries 5: 373-401.
- Grabe SA, Price WW, Abdulqaswe EAA, Heard Jr RW. 2004. Shallow-water Mysida (Crustacea: Mysidacea) of Bahrain (Arabian Gulf): species composition, abundance and life history characteristics of selected species. Journal of Natural History 38: 2315 - 2329.
- Greenwood JG, Jones MB, Greenwood J. 1985. Reproductive biology, seasonality and distribution of *Tenagomysis macropsis* W.Tattersall, 1923 (Crustacea, Mysidacea) in a New Zealand estuary. Bulletin of Marine Science 7:538-555.
- Gupta LP, Gupta PD. 1984. On the occurrence of *Mesopodopsis orientalis* W.M. Tattersall (Crustacea-Mysidacea) in fresh water. Bulletin of Zoological Survey of India 5: 185.

- Hanamura Y, Siow R, Chee P-E. 2008a. Reproductive biology and seasonality of the Indo-Australasian mysid *Mesopodopsis orientalis* (Crustacea: Mysida) in a tropical mangrove estuary, Malaysia. *Estuarine, Coastal and Shelf Science* 77: 467-474.
- Hanamura Y, Koizumi N, Sawamoto S, Siow R, Chee P-E. 2008b. Reassessment of the taxonomy of *Mesopodopsis orientalis* (Tattersall, 1908) (Crustacea, Mysida) and proposal of a new species for the genus with an appendix on *M. zeylanica* Nouvel, 1954. *Journal of Natural History* 42:2461-2500.
- Hanamura Y, Siow R, Chee P-E, Kassim FM. 2009. Seasonality and biological characteristic of the shallow-water mysid *Mesopodopsis orientalis* (Crustacea: Mysida) on a tropical sandy beach, Malaysia 4:53-61.
- Heubach W. 1969. *Neomysis awatschensis* in the Sacramento - San Joaquin River Estuary. *Limnology and Oceanography* 14: 533-546.
- Hodge D. 1963. The distribution and ecology of mysids in the Brisbane River. University of Queensland Papers, Department of Zoology 11: 89-104.
- Hulburt EM. 1957. The distribution of *Neomysis americana* in the estuary of the Delaware River. *Limnology and Oceanography* 2: 1-11.
- Jerling HL, Wooldridge TH. 1995. Feeding of two mysid species on plankton in a temperate South African estuary. *Journal Experimental Marine Biology and Ecology* 188: 243-259.
- Kulkarni CV. 1953. Occurrence of brine shrimp *Artemia* sp. in Bombay. *Journal of Bombay Natural History Society* 51: 951-952.
- Madhupratap M, Haridas P. 1992. New species of *Pseudodiaptomus* (Copepoda – Calanoida) from the salt pans of Gulf of Katch, India and comment on its speciation. *Journal of Plankton Research* 14: 555-562.
- Mauchline J. 1980. The biology of Mysids. *Advances in Marine Biology* 18: 1-369.
- McLusky DS, Heard VE. 1971. Some effects of salinity on the mysid *Praunus flexuosus*. *Journal of Marine Biological Association (United Kingdom)* 51: 709-715.
- Murano M. 1988. Mysidacea from Thailand with descriptions of two new species. *Crustaceana* 55(3): 293-305.
- Murano M. 1998. Mysidae (Crustacea-Mysidacea) collected from the Western Arabian Gulf. *Plankton Biology and Ecology* 45: 45-54.
- Mustafa S. 1995. Ecology of plankton from salt pans along the coastal environment of Bombay. Ph.D. Thesis. University of Bombay.
- Mustafa S, Nair VR, Govindan K. 1999. Zooplankton community in Bhayander and Thane salt pans around Bombay. *Indian Journal of Marine Sciences* 28: 184-191.
- Nair KB. 1939. The reproduction, oogenesis and development of *Mesopodopsis orientalis* Tattersall. *Proceedings of the Indian Academy of Sciences* 9: 175-223.
- Nouvel H. 1954. Description d'un Mysidace' nouveau de Ceylan *Mesopodopsis zeylanica* n.sp. *Zoologische Mededelingen* 33:33-39.
- Nouvel H. 1957. Mysidacés provenant de deux échantillons de "Djembret" de Java. *Zoologische Mededelingen, Leiden* 35: 315-331.

- Odum EP. 1971. Fundamentals of Ecology, pp.574. Saunders Co.
- Panampunnayil SU. 1999. Studies on Mysidacea (Crustacea) of the Indian Ocean with reference to Indian waters. Ph.D Thesis, pp.1-223. University of Mumbai.
- Panikkar NK, Aiyar RG. 1937. The brackish water fauna of Madras. Proceedings of the Indian Academy of Sciences 6: 284 -337.
- Pinkaew K, Ohtsuka S, Putchakara S, Chalermwat K, Hanamura Y, Fukuoka K. 2001. Preliminary survey of mysid fauna in the Gulf of Thailand. Proceedings of the 11th JSPS Joint Seminar on Marine Science, University of Tokyo 256–273.
- Quintero C, de Roa EZ. 1973. Notas bioecologicas sobre *Metamysidopsis insularis* Brattegard (Crustacea-Mysidacea) en una laguna litoral de Venezuela. Acta Biologica Venezuelica 8: 245-278.
- Ramamoorthy K, Thangaraj GS. 1980. In the Brine Shrimp *Artemia*. Ecology, culturing and use in aquaculture, 3: 456 G. In, Persoore, P. Sorgelous, O.A. Roeb and E. Jaspers (Eds) University Press, Western Belgium.
- Ratan P, Ansari SKR. 1982. A new source of live food for aquaculture in India. Fabrea Salina Geobios New Report 1: 67-68.
- Remane A, Schlieper C. 1958. Die Biologie des Brackwassers. Stuttgart: E. Schweizerbartsche pp. 348.
- Royan JP. 1979. Occurrence of *Artemia* sp. in the Gulf of Katch. Mahasagar 12: 271-272.
- Sarkar SK, Chowdhury A. 1986. On the occurrence and abundance of *Mesopodopsis orientalis* (W.M. Tattersall) (Crustacea– Mysidacea) from Hoogly estuary. Mahasagar 19: 203-207.
- Shirgur GA, Deshmukh SV. 1994. On ambient ecology and fisheries potentials of salt pan reservoirs around Bombay. “Advances in Fisheries” Ed. Dr. Syed Hasib Ahmed, Rajendra Agricultural University, Bihar.
- Tattersall WM. 1908. The fauna of brackish ponds at Port Canning, Lower Bengal. Pt. XI. Two new Mysidae from brackish water in the Ganges delta. Records of the Indian Museum 2: 233-239.
- Tattersall WM. 1914. Further records of Indian brackish water Mysidae with descriptions of a new genus and species. Records of the Indian Museum 10: 75-80.
- Tattersall WM. 1922. Indian Mysidacea. Records of the Indian Museum 24: 445-504.
- Turner JL, Heubach W. 1966. Ecological studies of Sacramento - San Joaquin Estuary. Distribution and concentration of *Neomysis awatschensis* in the Sacramento -San Joaquin Delta. California Fish and Game 133: 105-112.
- Whitely GC. 1948. The distribution of larger planktonic Crustacea on George Bank. Ecological Monographs 18: 233-264.

Figure captions

Figure 1. Layout of salt pan

Figure 2. Location of stations in salt pans of Mumbai, India

Figure 3. Percentage composition of different sexual and developmental groups of *Indomysis nybini* in Thane (T) and Bhayander (B) salt pans, Mumbai. (MM- mature males, IM-immature males, SF-spent females, FED-females with eyed larvae, FEL-females with eyeless larvae, FEG-Females with eggs, IF-immature females, J-juveniles)

Figure 4. Relationship between the length of female and the brood size of *Indomysis nybini* in Thane and Bhayander salt pans, Mumbai

Figure 5. Percentage composition of different sexual and developmental groups of *Mesopodopsis orientalis* in Bhayander salt pan, Mumbai. (MM- mature males, IM-immature males, SF-spent females, FED-females with eyed larvae, FEL- females with eyeless larvae, FEG-Females with eggs, IF- immature females, J-juveniles)

Figure 6. Relationship between the length of female and the brood size of *Mesopodopsis orientalis* in Bhayander salt pan, Mumbai

Figure 7. *Mesopodopsis orientalis* W.M. Tattersall

- A. Anterior part of body, male
- B. Anterior part of body, female
- C. Fourth pleopod of male
- D. Same, tip of exopod
- E. Posterior part of body, male
- F. Same, tip enlarged

Figure 8. *Indomysis nybini* sp.nov (holotype male and allotype spent female)

- A. Anterior part of body, male
- B. Anterior part of body, female
- C. Antennule of male
- D. Antennule of female
- E. Antenna of male
- F. Antenna of female
- G. Labrum of male
- H. Palp of mandible, male
- I. Cutting edge of mandible, male
- J. Maxillule of male
- K. Maxilla of male
- L. First thoracic endopod, male

Figure 9. *Indomysis nybini* sp. nov. (holotype male and allotype spent female)

- A. Second thoracic endopod, male
- B. Third thoracic endopod, male
- C. Fourth thoracic endopod, male
- D. Same, tip enlarged
- E. Sixth thoracic endopod, male
- F. Seventh thoracic endopod, male
- G. Same, distal part
- H. Eighth thoracic endopod, male
- I. Same, distal part
- J. Third pleopod of male
- K. Fourth pleopod of male
- L. Same, endopod enlarged
- M. Same, distal part of exopod
- N. Fifth pleopod of male
- O. Fifth pleopod of female
- P. Posterior part of body, male
- Q. Distal end of telson, male
- R. Endopod of uropod, dorsal, male

Table I. Details of stations at Thane and Bhayander salt pans

	Locations	Stations	Position		Depth (m)
			Latitude (°N)	Longitude (°E)	
Thane	Creek	T1	19° 03' 42"	72° 58' 19"	1 - 2
	Reservoir	T2	19° 03' 37"	72° 57' 19"	0.9 - 1.3
	Reservoir	T3	19° 03' 36"	72° 57' 33"	0.9 - 1.3
	Condenser	T4	19° 03' 47"	72° 57' 16"	0.3 - 0.4
	Crystallizer	T5	19° 03' 42"	72° 57' 19"	0.08 - 0.12
Bhayander	Creek	B1	19° 18' 48"	72° 51' 02"	1 - 2
	Reservoir	B2	19° 17' 45"	72° 48' 49"	0.9 - 1.3
	Reservoir	B3	19° 17' 42"	72° 48' 42"	0.9 - 1.3
	Condenser	B4	19° 17' 45"	72° 48' 42"	0.3 - 0.4
	Crystallizer	B5	19° 17' 42"	72° 48' 45"	0.08 - 0.12

Table II. Distribution of *Indomysis nybini* and environmental parameters at different stations in Thane salt pan during 1991-1992.

	Mysid density (inds./ m ³)					Water temperature (°C)					Salinity (‰)					DO (mg/l)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
May'91	-	-	-	-	-	34	36.5	36.5	42	42	36	74	89.5	221	324	5.9	5.5	6.2	4.5	1.4
June	-	-	-	-	-	30	28.5	28.5	28.4	29	20	27.2	29.6	32.5	34.1	3.3	6.1	4.4	2.3	5.1
July	-	17	-	42	-	25	24	24.5	25	26	16	16.1	3.3	5	3.3	3.2	2.2	7.3	6.3	6
Aug	-	-	11	-	20	29	30	29.5	29.5	30	13	9.9	11.2	10.1	10.5	4.7	6.9	6.9	7.2	7.2
Sep	6	-	138	-	425	29	27.5	28.2	27.5	27	29	23.3	24.2	22.6	26.6	5.7	4.1	5.2	4.4	4.6
Oct	54	-	-	-	-	31	33.5	33	32.5	33	35	41.6	45.1	50.7	52.6	3.6	10	9.5	12	9.6
Nov	55	-	-	-	-	29	33	34	36.5	33	36	64.4	48.6	55.5	51.1	5	11	4.6	4.6	2.2
Dec	-	4	7	-	-	30	31	30	29.2	32	35	42.9	73.3	89.1	87	3.2	4.9	4.4	1.9	3.9
Jan'92	-	21	-	-	-	22	20	20.1	21.5	22	35	70.7	74.5	189	345	3.8	4.1	2.5	3.2	2.8
Feb	-	160	75	-	-	28	26	24.5	29	30	36	80.3	63.2	193	278	6	4.7	7.3	3.5	4.7
Mar	-	28	-	-	-	30	32	36.5	35	39	36	54.8	163	99	323	5.3	8.7	7.8	5.9	3.7
Apr	-	-	-	-	-	31	32	34.5	32	37	33	70.9	183	149	321	3.4	7.7	4	3.4	3.7
May	-	-	-	-	-	34	38	37	38	43	38	99.9	98.1	172	329	6.2	4	4	4.4	1.6
June	-	-	-	-	-	29	37.5	37	38	42	31	68.9	58.7	170	290	6.2	6.8	9.6	1.6	2.5
July	-	-	-	-	-	30	30	29.5	28	29	11	7.5	11.2	14.8	14.7	6.2	9.3	8.7	9.3	9.3

- absent

Table III. Distribution of mysids and environmental parameters at different stations in Bhayander salt pan during 1991-1992.

	Mysid density (inds./ m ³)					Water temperature (°C)					Salinity (‰)					DO (mg/l)				
	B1	B2	B3	B4	B5	B1	B2	B3	B4	B5	B1	B2	B3	B4	B5	B1	B2	B3	B4	B5
May'91	224	-	-	-	-	37	39	39.5	43	45	34	58.2	51.6	108	335	5.2	8.6	6.8	2.2	2.2
June	-	-	-	67	-	29	27.7	27.8	28	29	35	40.6	42.4	44	84.1	4.4	4.6	4	4.4	2.3
July	-	-	-	18	6	28	27	26.7	26.8	27	4	8	11.4	20.1	19	4.4	5.4	5.4	3.5	5.7
Aug	2	4	-	3875	323	28	28.5	27.8	28	29	1.2	7.2	7.2	9	8.5	6	6.3	5.3	5.3	5.3
Sep	-	-	-	-	-	29	31	31.5	31	33	28	11.4	11.4	17	16.3	4.4	1.7	4.6	3.2	2.1
Oct	155	-	-	-	-	29	24.5	25.5	26	26	27	36.3	33.2	49.1	82.6	3.2	1.9	5.8	6	2.4
Nov	15	-	-	3	-	25	27	24.2	24.9	25	27	32.3	40.2	45.8	43	5.8	3.5	4.6	4.6	4.4
Dec	70	-	-	-	-	24	23.2	24	28.9	29	31	35.4	29.8	153	122	3.5	5	5.5	3.6	1.6
Jan'92	-	-	-	2	-	24	26.8	26.9	28	28	28	71.5	59.5	90.2	99.2	6.9	7.3	6.3	5.7	2.8
Feb	6	*21	*13	-	*15	27	30.5	27.5	31	32	30	58.6	62.2	107	85.7	6.3	9.5	6.3	5.7	6
Mar	147	-	*33	*137	-	28	25.5	26.5	29.5	30	36	52.2	51.3	129	189	5.3	6.8	5.6	2.5	2.2
Apr	16	-	-	*2	-	31	30.9	31.5	36	38	30	44.3	71.8	81.5	187	5.5	5.2	2.2	3.7	6.2
May	190	-	-	-	*5	34	31	33	34	44	29	54.8	32.7	147	343	4.4	4.7	2.5	1.9	6
June	-	43	40	-	-	34	32.5	34	36	39	33	47.7	63.6	179	361	5.6	4.7	5.9	3.4	1.6
July	-	*392	-	-	-	29	28	28	28	28	0.9	15	13.9	22.9	24	6.2	8.7	6.8	7.7	6.5

- absent, **Indomysis nybini*, Remaining: *Mesopodopsis orientalis*

Table IV. Variation in length (mm) of different sexual and developmental groups of *Indomysis nybini* and *Mesopodopsis orientalis* in Thane and Bhayander salt pans in different months. (AM-adult males, IM-immature males, AF-adult females (spent females, females with eyed larvae, females with eyeless larvae and females with eggs), IF- immature females, J- juveniles)

	<i>Indomysis nybini</i>										<i>Mesopodopsis orientalis</i>				
	Thane					Bhayander					Bhayander				
	AM	IM	AF	IF	J	AM	IM	AF	IF	J	AM	IM	AF	IF	J
May'91	-	-	-	-	-	-	-	-	-	-	5.5-6.6	4.5-5.2	6.3-6.9	5.7	2.4-2.9
June	-	-	-	-	-	-	-	-	-	-	5-6.2	4-4.8	6.3-7	4.5-5.2	1.6-3
July	4.5-5.7	3.6	5.2-6.7	3.9-4.5	1.8-3	-	-	-	-	-	5.2-6.6	4.2-5	6.3-7.4	4.5-5	2.3-3.5
Aug	5-5.6	3.8-4.4	5.1-6	3.6-3.9	2.3-2.7	-	-	-	-	-	5.7-6.6	4.7	6-7.9	4.8-5.4	2-4
Sep	4.8-5.6	3.5-4.1	5-6.1	4-5.3	2.5-3.5	-	-	-	-	-	-	-	-	-	-
Oct	4.2-5.4	3.8-4.5	5.5-6.3	3.6-4.8	2-3.2	-	-	-	-	-	6.4-8.6	-	7.6-9.8	-	2.3-4
Nov	4.2-5.6	3.2-4.6	5.4-7.2	3.6-4.2	3.5	-	-	-	-	-	6.6-7.2	5-6	7.9-8.8	5-6	1.3-2
Dec	4.5-4.8	-	5-5.6	-	2-3.5	-	-	-	-	-	6.5-7	5-5.4	6.8-7.6	5.1-6	3.1-4
Jan'92	5.4-5.6	4.2-4.5	5.3-6	3.8-4.8	2.4-3	-	-	-	-	-	-	-	6-6.6	-	-
Feb	5-5.7	3.2-3.6	5.1-7	3.6-4.3	1.8-2.5	4.7-5.9	3.4-4	5.1-7.2	4-4.5	2.3-3	6.2-8.1	-	6.8-8.2	-	-
Mar	4.6-5.4	3.8-4.2	5.5-5.8	3.9-5	2.3-2.9	5.1-5.6	4-4.2	6.0-6.9	4-4.4	1.9-2.5	6-6.5	4.2-5.2	6.8-7.2	4.8-6.5	1.5-3
Apr	-	-	-	-	-	5.2-5.4	-	5.2	-	-	-	-	6.5-7.2	-	-
May	-	-	-	-	-	5.1	-	5.6	-	-	6.3-6.8	4-5.7	6-6.7	5-5.5	1.3-3.5
June	-	-	-	-	-	-	-	-	-	-	5.5-6.2	4-5	6.5-7.2	5	1.5-3
July	-	-	-	-	-	4.4-5.7	3.1-3.4	4.5-6.5	3.8-4.4	1.3-2.9	-	-	-	-	-

- absent

Figure 1

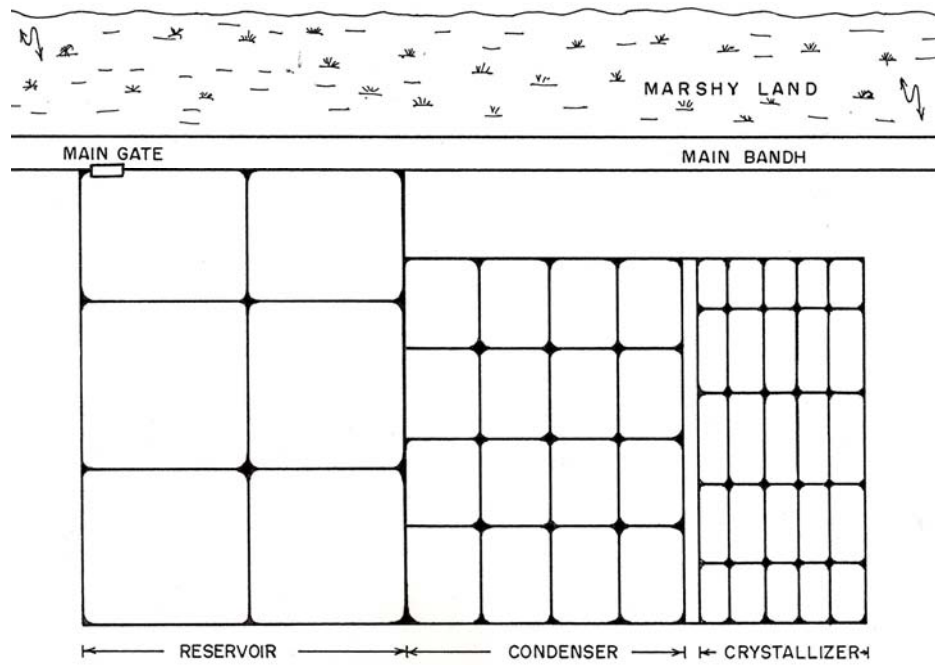


Figure 2

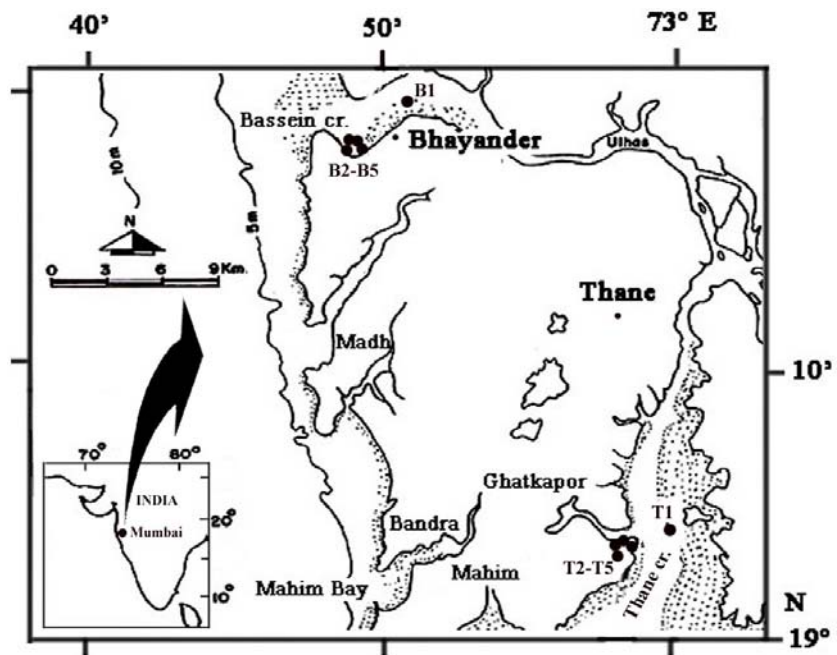


Figure 3

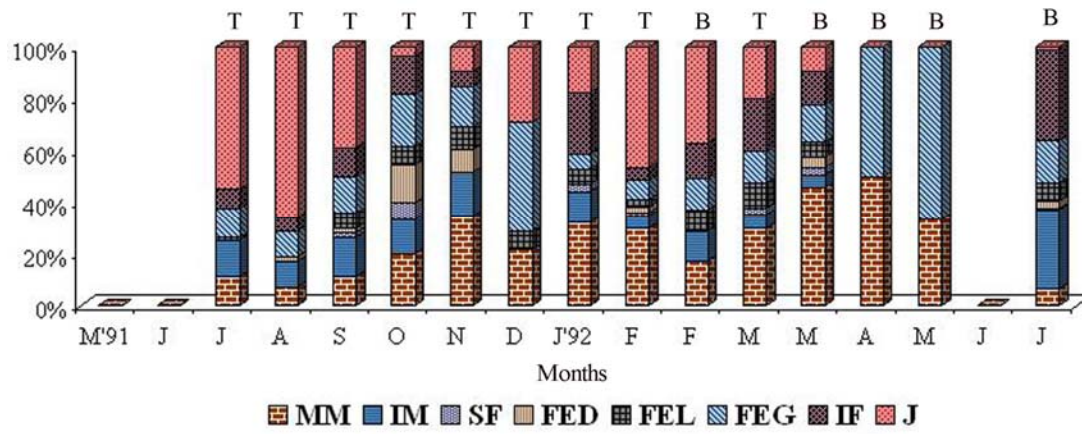


Figure 4

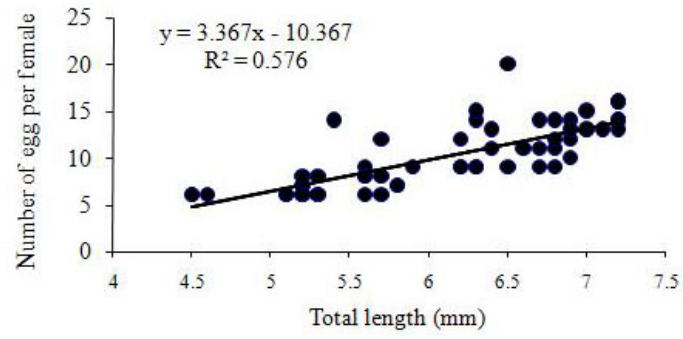


Figure 5

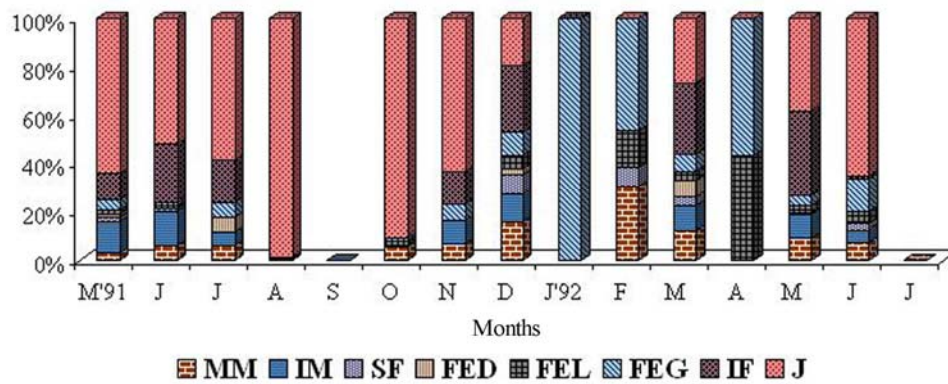


Figure 6

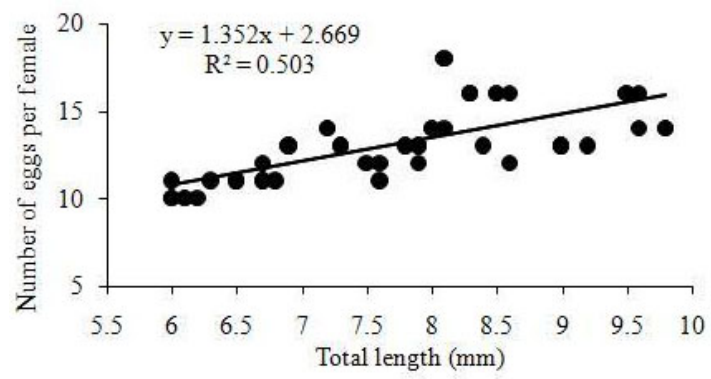


Figure 7

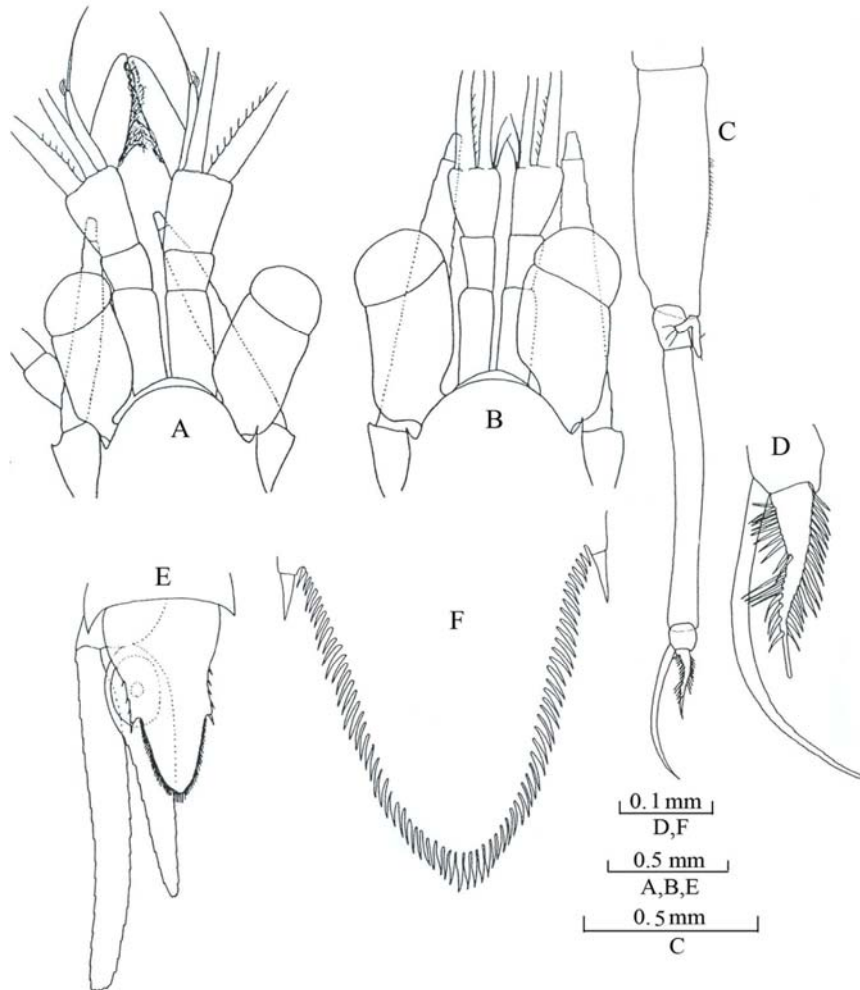


Figure 8

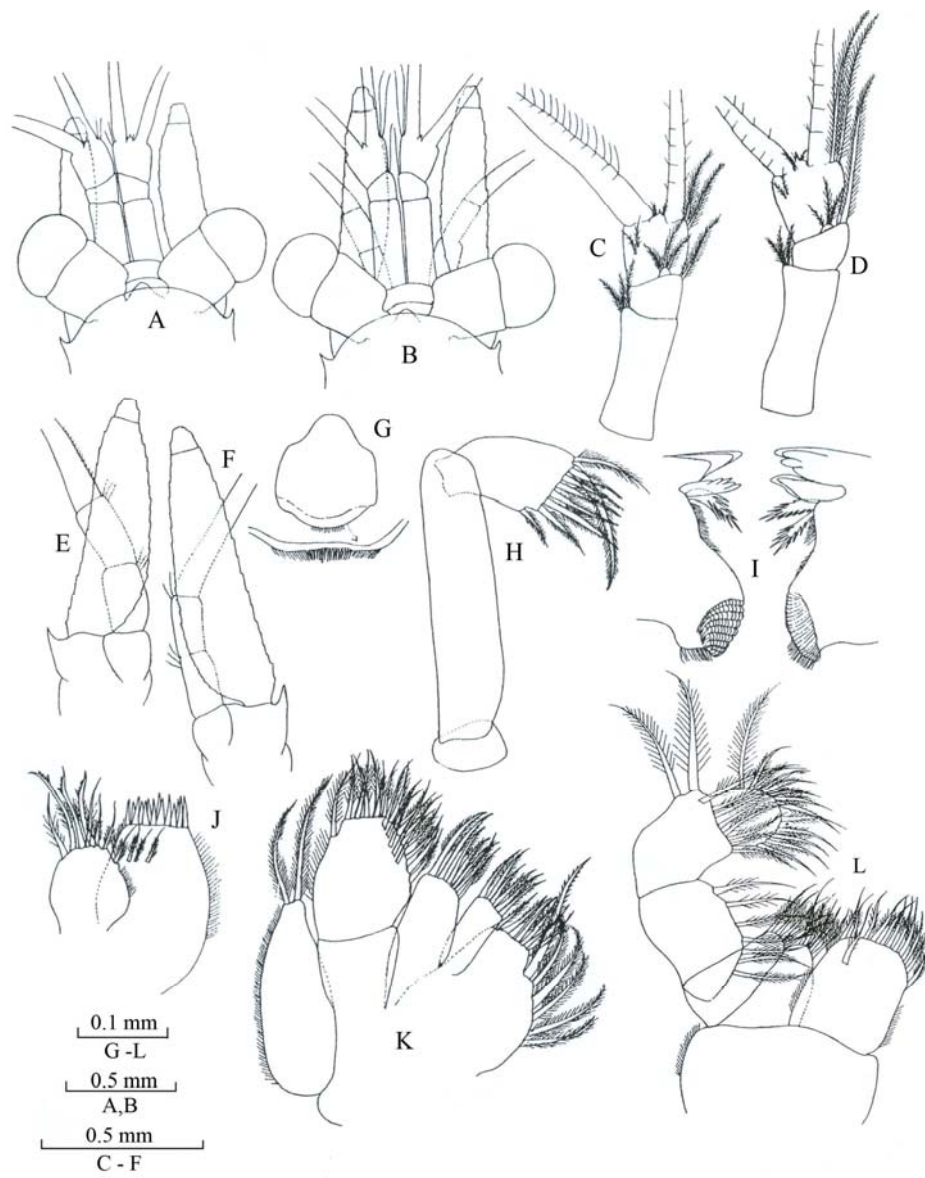


Figure 9

