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RESEARCH ARTICLE

RESIDENT MYSIDS: COMMUNITY STRUCTURE, ABUNDANCE AND SMALL-SCALE DISTRIBUTION OF MESOPODOPSIS ORIENTALIS IN COASTAL, ESTUARINE AND SALTPAN WATERS OF MUMBAI

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ABSTRACT

Comparative study of resident mysids: community structure, abundance and small scale distributions of *Mesopodopsis orientalis* was undertaken in coastal, estuarine and saltpan waters. The study was carried out monthly basis, once in Waxing period and once in Waning period at Coastal, estuarine and Saltpan waters during May 2016 to December 2017. Monthly collection found with wide fluctuating water parameters viz., temperature, pH and salinity. *Mesopodopsis orientalis* breed throughout the year but there is a seasonal variation in the intensity of breeding. The mean body length of females with "eyed embryos" and with "eyeless embryos" is related to those of the females with "eggs". In coastal waters, estuarine waters and salt pan waters, number of male and female ratio was noticed as 1: 20.69, 1: 0.44 and 1: 0.83 respectively. Whereas, male: female length ratio in coastal waters, estuarine waters and salt pan waters was observed 1: 1, 1: 1.02 and 1: 1.05 respectively. In terms of mysid population density, a greater abundance of mysids occurred in the coastal waters and estuarine waters (35.59% and 35.67%) compared to the Saltpan waters (28.72%). As a result of its abundance, this mysid is regarded as one of the most important species of the shallow water crustacean community.

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INTRODUCTION

Mysids or opossum shrimps are component of zooplankton composition which is also used for human consumption. *Mesopodopsis orientalis* is a common mysid of the shallow coastal waters of India. It is a small, shrimp like arthropod belonging to the Order *Mysidacea* of the class *Crustacea*. The species is well represented in the plankton catch of the back waters, estuaries and even up to the inner reaches of rivers, where the water is almost fresh (Pannikar and Aiyer,1937). This is locally called as "Lepa" or "Banda Kolim" which is smaller than "Acetes" i.e."Jawla" in Maharashtra. The Indo-Australasian mysid *Mesopodopsis orientalis* (Tattersall, 1908) has been recorded throughout the south western coast of India and the Philippines. As a result of its abundance, this mysid is regarded as one of the most important species of the shallow-water crustacean community (Yukio Hanamura, Noriyuki Koizumi, Shozo Sawamoto, Ryon Siow and Phaik Ean Chee 2010). Some aspects of biology of Mysids have studied by Mauchline (1980). Mysids are an important link in the food web of coastal ecosystem (Yamada *et al.,* 2007) and pray for various fishes (Takahashi *et al.,* 1999; Baldo and Drake. 2002; Jamura, 2007) as well as for invertebrates, birds and seals (Mauchline, 1980) thereby linking primary and secondary production to higher tropic level. In India reproduction, oogenesis and development of *M. orientalis* has been studied by Nair (1939).

Salinity and temperature tolerance of *M. orientalis* from West coast has been studied by Bhattacharya and Kewalramani (1972). A laboratory investigation on salinity and temperature tolerance of the juveniles of *M. orientalis* has been carried out by Bhattacharya (1981). Breeding and fecundity in a subterranean Mysid, *Lepidomysis longiceps* has been studied by Nath and Pillai (1973). It is expected that like, several other species of mysids, *M. orientalis* must be playing a very significant role as an important species in the food chains in the coastal waters as well in the food chains in the coastal waters as well as in the estuaries and backwaters (Larkin 1948, Naoyoshi 1964, Langford 1973, Morgan1979). The importance of *M.orientalis* becomes more significant in the estuaries and backwaters, since these areas are the breeding grounds of several species of marine fishes and nursery grounds of various species of prawns. Bhattacharya and Kewalramani (1972) observed that *M. orientalis* could survive even in fresh water for considerable time after gradual acclamation. Due to their high nutritive quality, this species is suitable for aquaculture as a live feed (Biju et., 2009). *Mesopodopsis orientalis* breed throughout the year but there is a seasonal variation in the intensity of breeding. The size of mature males and females was at maximum during post-monsoon period (Biju and Panampunnayil, 2010). Although considerable literature on the occurrence and abundance of this species from different areas exist (Biju *et al.,* 2009), no published information is available on its population

composition and reproductive biology in mangrove habitat. Mauchline (1980) point out that the life history characteristics of mysid species can vary considerably from one habitat to another, hence knowledge on the biology of local population is essential for subsequent studies on related scientific field (Hanamura *et al.,* 2009). It occurs in large shoals during April and May in Back Bay, in the vicinity of the Taraporwala Marine Biological Research Station, Mumbai. The animal also occurs in January but less abundantly. Considering the ecological and economical importance, the present study on comparative frequency distribution and reproductive biology of *Mesopodopsis orientalis* in the marine environment viz, coastal waters, estuaries/mangroves and saltpans is undertaken.

MATERIALS AND METHODS

Description of study area: Mysids are collected using hand trawl made of mosquito netting during low tide period at surface water and from coastal, estuarine and saltpans regions during spring as also nip tides of every month manually during May 2016 to December 2017. The study was carried out monthly basis from: 1.0 one site from Coastal area (Girgaon Chaoupati). 2.0 three sites from mangrove estuarine areas (Juchandra, Thane and "Kandalvan" at Mauze – Mulund/ Bhandup) the Eastern suburb of Mumbai, lying along the Western bank of Thane creek. and 3.0 three sites from Saltpans (Airoli, Vasai and Naigaon) from different parts viz., reservoirs, condensers and crystallizers.

Sampling procedure and data analysis: An ordinary plankton collection net was used for the collection of samples. Monthly sampling was done regularly at all stations for 17 months from May, 2016 to December, 2017. The collections were made at least twice a month viz., once in Waxing period (New Moon to Full Moon) and once in Waning period (Full Moon to New Moon) to study the population dynamics of *Mesopodopsis orientalis*. At the same time of collection of specimen adequate water samples from surface waters also collected using a polyethylene bucket for the estimation of pH, temperature and salinity. Specimen samples were preserved in 5% buffered formalin.

Laboratory work: In the laboratory, on sorting of the sample mysids are counted under a stereomicroscope. Mysids are then classified into different groups based on the degree of development of secondary sexual characteristics. Sexes can be distinguished by the presence of an extended fourth pleopod in males and the brood pouch in females (Mauchline, 1980). Immature individuals were distinguished from juveniles by the presence of rudimentary oostegites in females and a large fourth pleopod in male. The total body length of the each individual was measured, from the tip of the rostrum to the posterior end of the telson, including setae. The number of individuals within the population has been studied under various categories, such as 1.0 Mature male: when the secondary sexual characters are fully developed and the animals are provided with penes. Exopods of fourth pleopod are specially modified. 2.0 Mature/Gravid females with "eggs" present in the brood pouch. 3.0 Mature/Gravid females with "eyeless embryos" present in the brood pouch.4.0 Mature/Gravid females with "eyed embryos" present in the brood pouch. 5.0 Mature/Spent females: females with empty brood pouches from which the youngs have emerged. 6.0 Mature/Empty females: Mature but Unfertilized females with empty brood pouch; more than 4 mm in size. 7.0 Immature Male (juveniles): less than 4 mm in size provided with large and slender annular peduncle with hirsute lobe but secondary sexual characters absent. 8.0 Immature Female: less than 4 mm in size and brood pouch is not developed. The developmental stages of eggs/embryos were classified according to Hanuamura *et al.* (2008a) viz., spherical egg like embryo, eyeless embryo and eyed embryo. The diameter of the egg like embryo was measured along the longest axis. Eyeless embryo and eyed embryos were measured along the distance between the anterior end at ventral side and the posterior end of the uropod without stretching the body. Monthly observations on total length of each population category was analysed of *M.orientalis* from the coastal, estuarine as also from salt pan waters.

RESULTS AND DISCUSSION

Size Frequency: The numbers and total length of all male and females mysids was measured from well preserved individuals. It was found that, in coastal waters, when there was average no. 3339 of the population with the range of 59-10437 nos. and range of percentage was 0.12-20.84% the average length was 7.02 mm. the range of which was 2.72-12.72 mm. In estuarine waters, when there was average no.1643.62 of the population with the range of 51.33-4263 nos and range of percentage was 0.25-24.77%, the average length was 4.81 mm. the range of which was 2.72-6.88 mm. In saltpan waters, when there was average no. 777.58 of the population with the range of 53.33-4649 nos and range of percentage was 0.84-38.80% the average length was 5.06 mm. the range of which was 2.05-7.14 mm (Fig: 1). During the collection of specimens, water parameters viz., temperature, pH and salinity also was noted down. It was found that, in coastal waters, when there was population with the range of 59-10437 nos.; water temperature was 24.90-31^{0}C, pH was 7.30-8.50 and salinity was observed at 27.62-36.76 ppt. In estuarine waters, when there was population with the range of 51.33-4263 nos.; water temperature was 25.03-33.80^{0}C, pH was 77.07-8.77 and salinity was observed at 7.28-60.71 ppt. In saltpan waters, when there was population with the range of 53.33-4649 nos.; water temperature was 23.00-36.67^{0}C, pH was 5.33-8.30 and salinity was observed at 6.37-48.50ppt (Fig. 2). The body length of the animals in the population during the waning period and in waxing period was also observed. During the Waning period in coastal waters, the average body length of 24319 no. of animals was 9.83 mm with the range of 8.25-13.13mm; in estuarine waters the average body length of 15281 no. of animals was 6.60 mm with the range of 1.43-8.76 mm; whereas, in salt pan waters, the average body length of 21838 no. of animals was 7.15 mm with the range of 3.20-8.76 mm. During the Waxing period in coastal waters, the average body length of 25761 no. of animals was 9.88 mm with the range of 8.71-12.22 mm; in estuarine waters the average body length of 34906 no. of animals was 7.25 mm with the range of 3.88-9.30 mm; whereas, in salt pan waters, the average body length of 18577 no. of animals was 6.65 mm with the range of 5.40-9.30mm (Fig: 3). In Coastal waters and Estuarine mysids were present year-round and exhibited marked monthly variations in abundance, with maximum length during Waxing period than Waning, whereas in saltpans waters maximum quantity as also maximum length was found during Waning period. The maximum and minimum average population density of gravid females as also total length was analysed. In Coastal waters, Gravid / Ovigerous females in mysids were

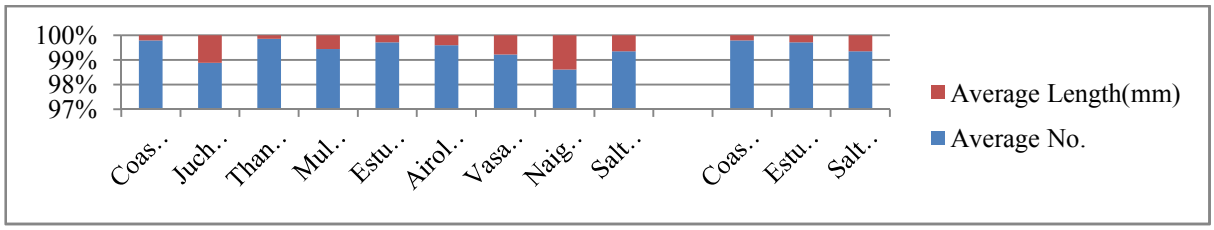

Fig. 1Month wise population of mysids of Coastal, Estuarine and Saltpan water in relation with in relation to the total length of mysids from May,2016 to December, 2017

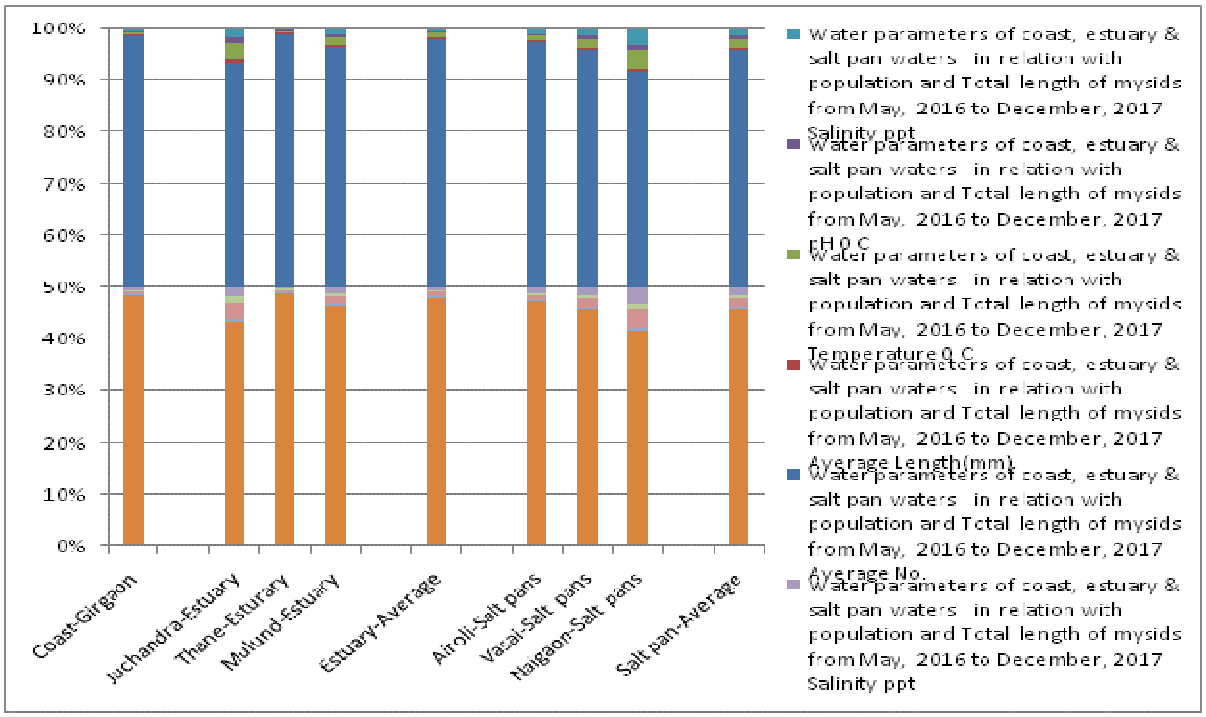

Fig. 2. Water parameters of coast, estuary and salt pan waters in relation with population and Total length of mysids from May, 2016 to December, 2017

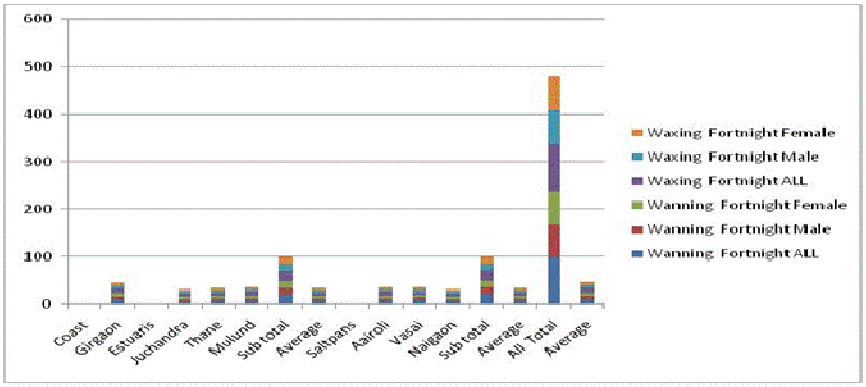

Fig. 3. Average Length of *M.orientalis* in different fortnights (Waning and Waxing) from May, 2016 to December, 2017 (mm)

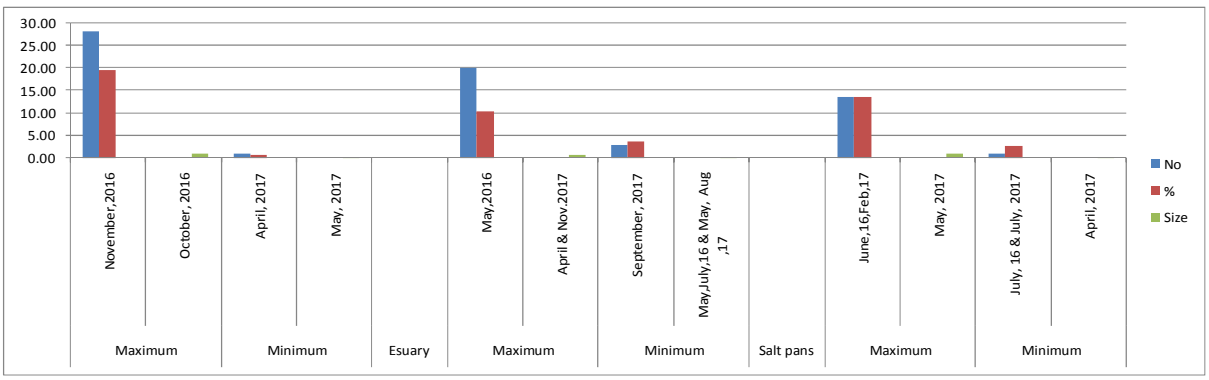

Fig. 4. Month wise maximum and minimum number and size of broods per brood pouch (mm)

found in minimum body size of 5.88 mm (5.58%) with the range 3.84-7.84mm but they occurred in minimum number (39 no.0.12.%) of the population in February, 2017 when the average size of which was 6.13 mm with the range of 3.44-7.04mm. However, they were found maximum number (6729 No, 20.03%) in November, 2016, when the average size of which was 6.83 mm with the range of 4.96-9.12mm. Whereas maximum body size of 12.06 mm (11.45%) with the range of 5.28-12.72mm. was found in December, 2016. In Estuarine waters, minimum body size of Gravid/Oviparous female mysids were found 8.09mm (12.59 %) with the range of 1.92-6.08 mm. in March, August and November, 2017, but they occurred in minimum number (25 no. 0.04%) of the population in April, Aug and Nov.17. However, they were found maximum number (2903 No, 24.76%) in February, May and November, 2017, whereas maximum body size 5.89 mm (9.55%) with the range of 4.72-6.88mm was found in July, September and November, 2017. In Salt pan waters, minimum body size of Gravid/Oviparous female mysids were found 4.10mm (4.98%) with the range of 2.24-5.84mm. in March, August and September, 2017, but they occurred in minimum number (25 no. 0.04%) of the population in April, Aug and Nov.17. However, they were found maximum number (25No, 0.04%) in April, August and November, 2017, whereas maximum body size 5.83 mm (6.98%) with the range of 3.04-7.84 mm. was found in May,2016, June and July, 2017 (Table 1)

The females were divided into three groups, 1.0 Females carrying "Eggs", 2.0 "Eyeless embryos" and 3.0 "Eyed embryos" in their brood pouches. The month wise maximum and minimum number and size of broods per brood pouch of mysids was also analysed. The size variation of the broods indicates that the population of *Mesopodopsis orientalis* can be divided into two groups, the summer (Pre-monsoon) generation and winter (Post-monsoon) generation. In coastal waters, maximum number of broods was 28.30 no.(19.51%) in the month of November, 2016 but maximum size of broods was 0.80mm with the range of 0.40-1.36mm. in October, 2016. Whereas, minimum number of broods was 1.07 no.(0.74%) in the month of April, 2017, but minimum size of broods was 0.06mm with the range of 0.06-0.06mm.was found in May, 2017. In estuarine waters, maximum number of broods was 20no.(10.38%) in the month of May, 2016(Pre-monsoon) but maximum size of broods was 0.64mm with the range of 0.64-0.64mm. in April (Pre-monsoon) and November, 2017(Post-monsoon). Whereas, minimum number of broods was 3 no.(3.81%) in the month of September, 2017(monsoon), but minimum size of broods was 0.16mm with the range of 0.16-0.16mm.in the month of August, 2017 (monsoon). In Saltpan waters, maximum number of broods was 13.63no (13.61%) in the month of June, 2016 (monsoon) and February, 2017, but maximum size of broods was 0.70mm with the range of 0.64-0.80mm. in May, 2017. Whereas, minimum number of broods was 1no.(2.83%) in the month of June, 2016 and July, 2017, but minimum size of broods was 0.16mm with the range of 0.16-0.16mm.in the month of April, 2017 (Fig 4). The mean body length of the females in each group was determined and it was observed that the mean length of females with "eyed embryos" and with "eyeless embryos" is related to those of the females with "eggs". An average increase in the total length of females carrying the different stages of embryos was observed. Data from Coastal waters indicates an average increase in body length of the parent animals is 0.66 mm between the "eggs" and the "eyeless embryos" and 0.2 mm between Eyeless to Eyed embryos. Whereas, a growth in body length of about 0.86 mm takes place during the entire period of embryonic development i.e. up to the stages of "Eyed embryos". In Estuarine waters, an average increase in body length of the parent animals is 2.21mm between the "eggs" and the "eyeless embryos" and 0.12 mm between Eyeless to Eyed embryos. Whereas, a growth in body length of about 2.33 mm takes place during the entire period of embryonic development i.e. up to the stages of "Eyed embryos". In Salt pan waters, an average increase in body length of the parent animals is 0.24mm between the "eggs" and the "eyeless embryos" and 0.55 mm between Eyeless to Eyed embryos. Whereas, a growth in body length of about 0.79 mm takes place during the entire period of embryonic development i.e. up to the stages of "Eyed embryos". (Table: 2). Mysids, euphasiids and most macruran decapods probably have this capacity to increase the body length in the inter moult period to occur at times, such as when females are carrying youngs without consequent restriction of growth in the body size. (Mauchline, 1980).

The relationship between the length of brood pouch, No. and length of broods and the total length of females was also studied. In coastal waters, average no. of "eggs" was 10.29, when the length of gravid female was 6.36mm.whereas, diameter of eggs was 0.16mm and size of brood pouch was 0.85 mm. As regards to "eyeless embryos carrying females", average no. of "eyeless embryos" was 7.25, when the length of gravid female was 7.02 mm. whereas, length of "eyeless embryos" was 0.32mm and size of brood pouch was 1.07 mm. In case of "eyed embryos carrying females", average no. of "eyed embryos" was 11.94, when the length of gravid female was 7.22 mm. whereas, length of "eyed embryos" was 0.65mm and size of brood pouch was 1.0 mm. In estuarine waters, average no. of "eggs" was 5.25, when the length of gravid female was 3.45mm.whereas, diameter of eggs was 0.14mm and size of brood pouch was 0.46 mm. As regards to "eyeless embryos carrying females", average no. of "eyeless embryos" was 9.75, when the length of gravid female was 6.64 mm. whereas, length of "eyeless embryos" was 0.51mm and size of brood pouch was 0.78 mm. In case of "eyed embryos carrying females", average no. of "eyed embryos" was 6.96, when the length of gravid female was 5.47 mm. whereas, length of "eyed embryos" was 0.57mm and size of brood pouch was 0.72 mm. In saltpan waters, average no. of "eggs" was 6.42, when the length of gravid female was 5.12mm.whereas, diameter of eggs was 0.20mm and size of brood pouch was 0.65 mm. As regards to "eyeless embryos carrying females", average no. of "eyeless embryos" was 6.68, when the length of gravid female was 5.38 mm. whereas, length of "eyeless embryos" was 0.44mm and size of brood pouch was 0.70 mm. In case of "eyed embryos carrying females", average no. of "eyed embryos" was 7.32, when the length of gravid female was 5.28 mm. whereas, length of "eyed embryos" was 0.59mm and size of brood pouch was 0.69 mm. (Table: 3). In view of the above, it was observed that the length of the brood pouch is not related to that of the body length of oviparous females carrying embryos with different stages in their brood pouches Further, an average increase of 0.75.mm of length of the brood pouch was noticed during the successive embryonic stages when an average increase of 0.66 mm of total length of oviparous females was found in Coastal waters. Whereas in Estuarine waters and Saltpan waters an average increase of 0.11mm and 0.02mm of length of the brood pouch was noticed during the successive embryonic stages respectively and an

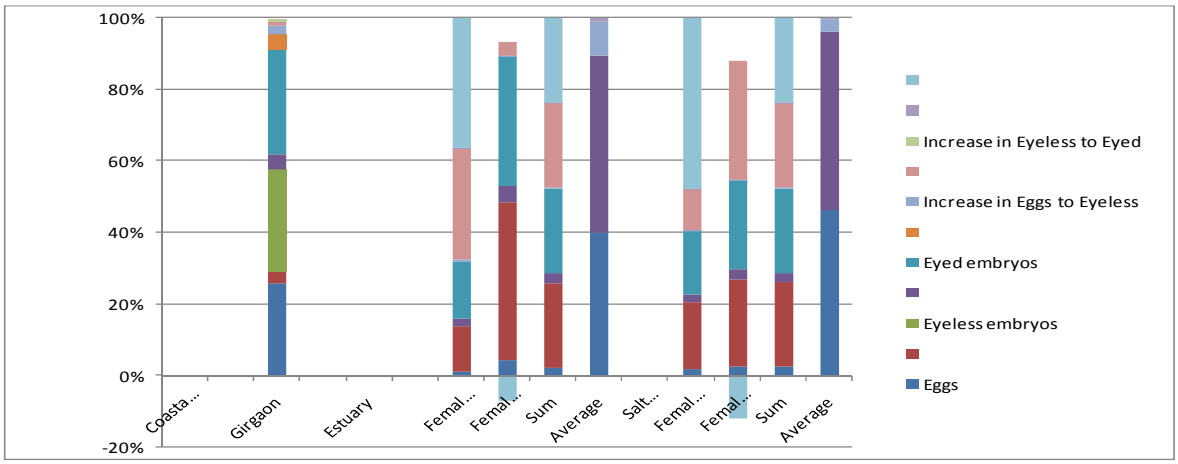

Fig. 5. Relation of total length of gravid females carrying embryos in different stages in brood pouches and average increase of length of the brood pouch (mm)

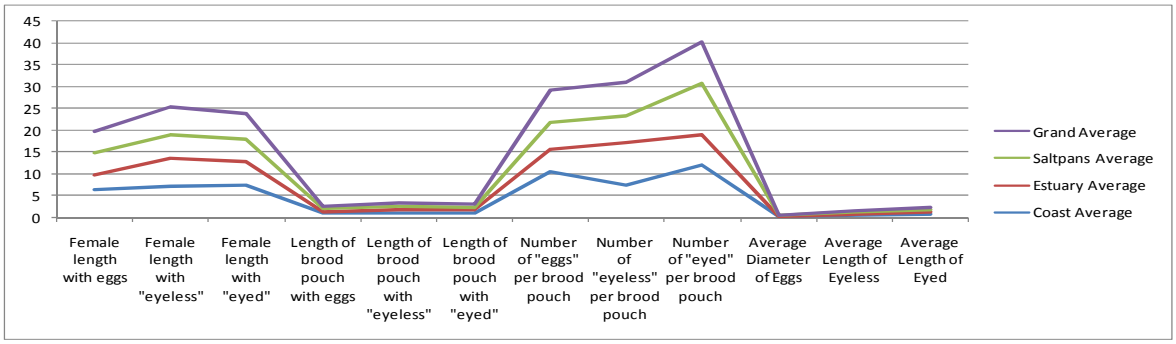

Fig. 6. Month wise average number of Embryos per brood pouch in relation to the average size of embryos and total length of the female(mm)

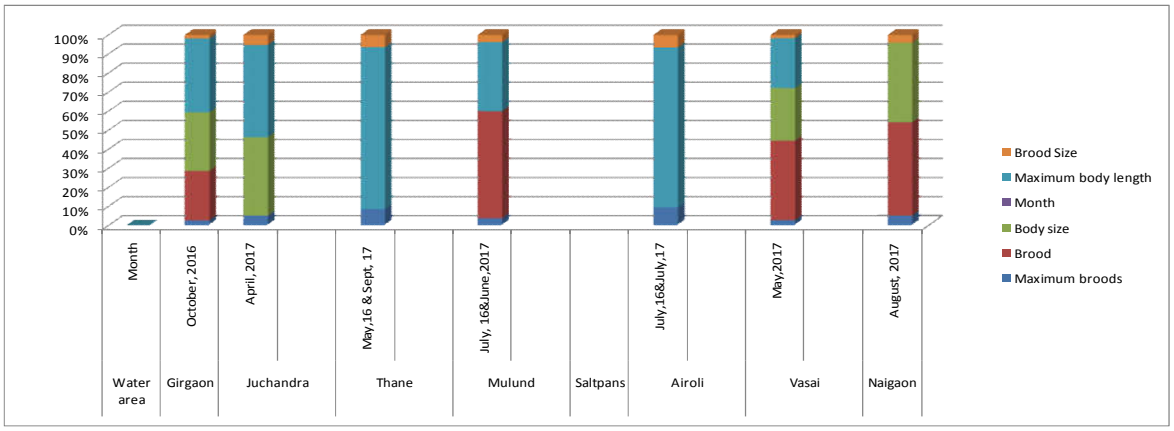

Fig. 7. Month wise maximum no. and size of brood and total length of gravid female

average increase of 1.17 mm and 0.40 mm of total length of oviparous females was found respectively. All oviparous females with embryos present in their brood pouches were also examined in all the collections. It was observed that the number of embryos contained in the brood pouch of a female depends upon the size of the individual embryo, season and size of the brood pouch. Similar observations were made in Anchialina agilis by Mauchline (1968, 1973). The average number of embryos per brood pouch of oviparous females of different sizes was determined. The average number of embryos per brood pouch of oviparous females of different sizes from 6.36 mm to 7.22 mm found in all the collections throughout the period of investigation in Coastal waters. The largest broods were produced during November, 2016 (Winter). The average number of embryos per brood pouch of oviparous females of different sizes from 3.80 mm to 6.13 mm determined in all the collections throughout the period of investigation in Estuarine waters of Juchandra, Thane and Mulund. The largest broods were produced during May, 2016 (Summer) and February, 2017 (Winter), during May, 2016 (Winter) and February, 2017.Whereas, the average number of embryos per brood pouch of oviparous females of different sizes from 5.12 mm to 5.90 mm determined in all the collections throughout the period of investigation in Saltpan waters of Aairoli, Vasai and Naigaon. The largest broods were produced during June, 2017, June, 2016 and February, 2017 (Winter) and May, 2016 and June, 2017 respectively (Fig: 5).

Breeding females and broods: The embryonic development of mysids takes place entirely within the brood pouch, Nair (1939). All the embryos within a single brood pouch were found at the same stage of development. The development of embryos within the brood pouch is usually divided into three distinct stages as "eggs", "eyeless embryos" and "eyed embryos".

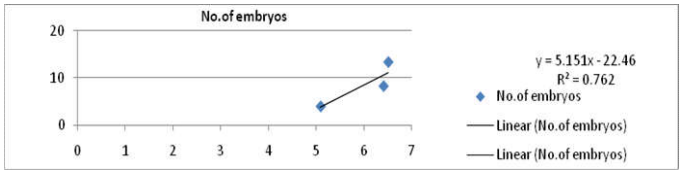

Fig. 8.1. Total length of gravid females in relation with no. of embryos

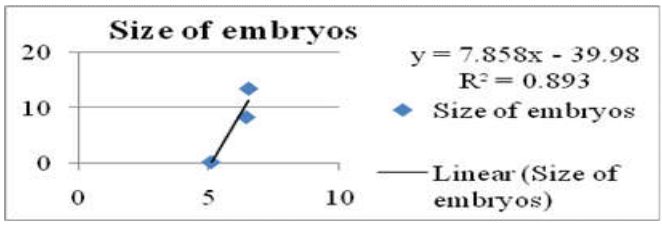

Fig. 8.2. Total length of gravid females in relation in relation with of length of embryos

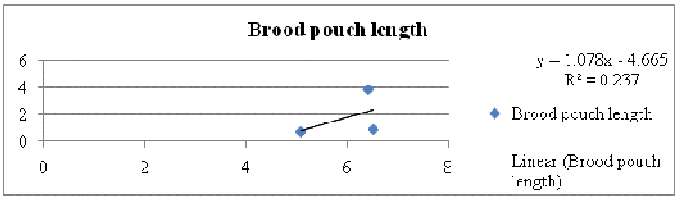

Fig. 8.3. Total length of gravid females in relation with length of brood pouch

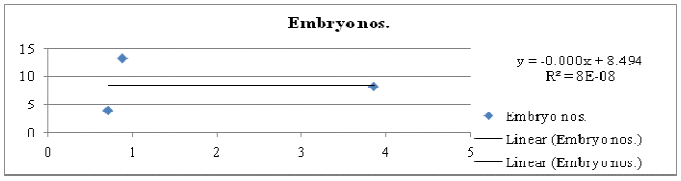

Fig. 8.4. Length of brood pouch in relation with no. of embryos

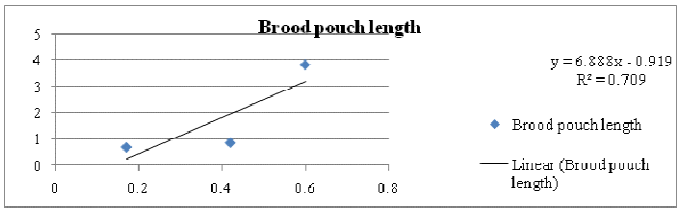

Fig.8.5. Length of embryos in relation with length of brood pouch

Fig. 8. Total length of gravid females in relation to the embryos in different stages in brood pouch (Figure 8.1 to 8.5)

(Nair, 1939, Matsudaira *et al.,* 1952, Jesen, 1964, Davis, 1966, Mauchline, 1973). 1). "Eggs": Eggs do not occur in the brood pouch since they are fertilized immediately, they are extruded from the oviducts. The early embryos, however, are spherical or sub-spherical and the size of this egg-like developmental stage of *M.orientalis* has been found to be 0.16mm.to.0.24mm, 0.11 mm to 0.26 mm and 0.12 mm to 0.25 mm in diameter in coastal, estuarine and saltpan waters respectively. 2) "Eyeless embryo" found with a size of 0.06mm to 0.56 mm, 0.30mm to 0.50 mm and 0.36mm to 0.49 mm having developing eyes and antennae in coastal, estuarine and saltpan waters respectively. 3) "Eyed embryo" found with a size of 0.54 mm to 0.88 mm, 0.46 mm to 0.64 and 0.45 mm to 1.78 mm having fully developed stalked eyes and developing thoracic appendages in coastal, estuarine and saltpan waters respectively. The relationship between the body size of the oviparous female and the number of embryos with different developmental stages, and between the increase in size of the brood pouch and the increase in number of embryos was examined. In coastal waters, it was found that 1.07 No to 28.30 Nos. of developing embryos with 0.75 mm to 2.53 mm of length and 0.06 mm to 0.88 mm of diameter of brood pouch in 3.34 mm to 12.06 mm body length of oviparous females. In Estuarine it was found that 1.0 No to 11.0 Nos. developing embryos in the brood pouch measuring 0.00 mm to 0.91 mm in length and 0.00 mm to 0.64 mm in diameter with a body length of 0.00.mm to 6.26 mm of the oviparous females. In Salt pan waters, it was found that 1.0 No to 13.63 Nos. developing embryos in the brood pouch measuring 0.40 mm to 0.89 mm in length and 0.05 mm to 0.65 mm in diameter with a body length of 4.24.mm to 6.40 mm of the oviparous females. (Fig 6). Casanova (1977) found that *Eucopia unjiculata* had 8 to 23 embryos in the brood pouch but the number was not related to the size of the female. The size of the individual embryo in the brood pouch was also found to vary seasonally. In coastal waters, larger sized, fully developed embryo of 0.88 mm were obtained in October, 2016 when body size was 9.56 mm and 8.06 number of embryos, but, larger body size 12.06mm was found in December, 2016, when 14 number of embryos and 0.56 mm was the embryo size. In Estuarine waters of Juchandra, Thane and Mulund, larger sized fully developed embryo of 0.64mm, 0.64 mm and 0.63 mm were obtained in April, 2017,May, 2016 and Sept, 2017 and July, 2016 and June, 2017 and 14.25 and 20.00, 9.17 and 9.57 was the no of embryos, when body size was 5.04, 5.74 and 5.68 mm and 5.67 mm and 5.67 mm respectively. But larger body size was found 5.92 mm, 6.26 and 5.90 mm in Nov, 2017 and Nov.2017 and July, 2017, but, during the same months, size of fully developed embryos was 0.64 mm, 0.47 mm and 0.61 mm respectively. In Salt pan waters of Aairoli, Vasai and Naigaon, larger sized fully developed embryos of 0.65mm and 0.65 mm, 0.70 mm and 0.64 mm were obtained in July, 2016 and June, 2017, May, 2017 and Aug, 2017 and 6.04 and 7.50, 10.00 and 6.00 was the no of embryos, when body size was found 5.34mm and 5.48 mm, 5.65 mm and 5.12 mm respectively. But larger body size was found 5.72 mm, 6.28 and 6.24mm and 6.24 mm in July, 2017 and June, 2017, January, 2017 and July, 2016 and June, 2017 but, during the same months, size of fully developed embryos was found 0.44 mm, 0.39 mm and 0.49 mm and 0.00 mm respectively. (Fig: 7).

However, it was found that *Mesopodopsis orientalis* had the number of embryos present in the brood pouch are closely correlated with total length of gravid female as per the regression equation obtained: y: 5.15x – 22.46; R^2 = 0.762. But, not related to the length of the brood pouch and length of gravid females was also found not related to the length of the brood pouch. Further, surprisingly it was found that, length of embryos are correlated to the length of brood pouch as per the regression equation: y: 6.888x – 0.919; R^2 = 0.709 and the regression equation indicates (y : 7.858x – 39.98, R^2 : 0.893) that total length of gravid females are also found correlated to the length of embryos (Fig 8.1 to 8.5). Apart from this, allometric relationship between the length of telson, embryos in females and penis and 4th pleopod in males (in mm) and the total length was also measured. The relationship between the length of telson and the total length was also measured. It was found that, size of telson was not directly correlated to the Total length mysids from all the waters viz., coast, estuary and salt pans also as per the regression equations : y = 0.767x + 0.935; R^2 = 0.170, y = 0.755x + 0.785; R2 = 0.149 and y = 0.997x + 0.285; $R^2$0.223 respectively (Fig 9).

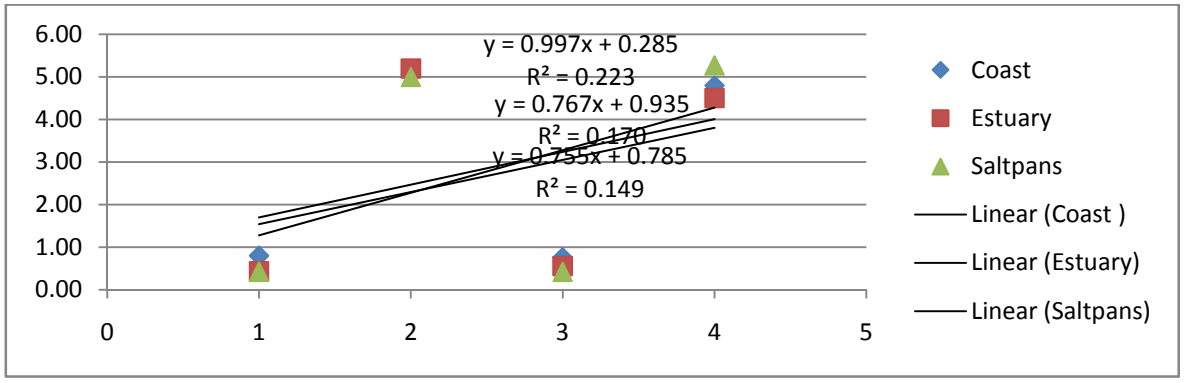

Fig. 9. Average Length of Telson in relation of Body length of mysids

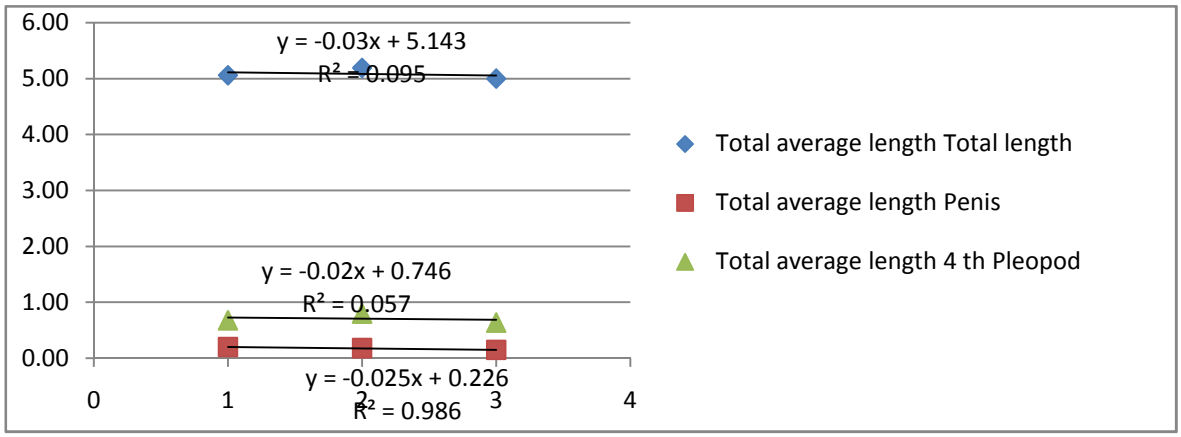

Fig. 10. Length of penis and 4th pleopod in relation to Total length of male mysids

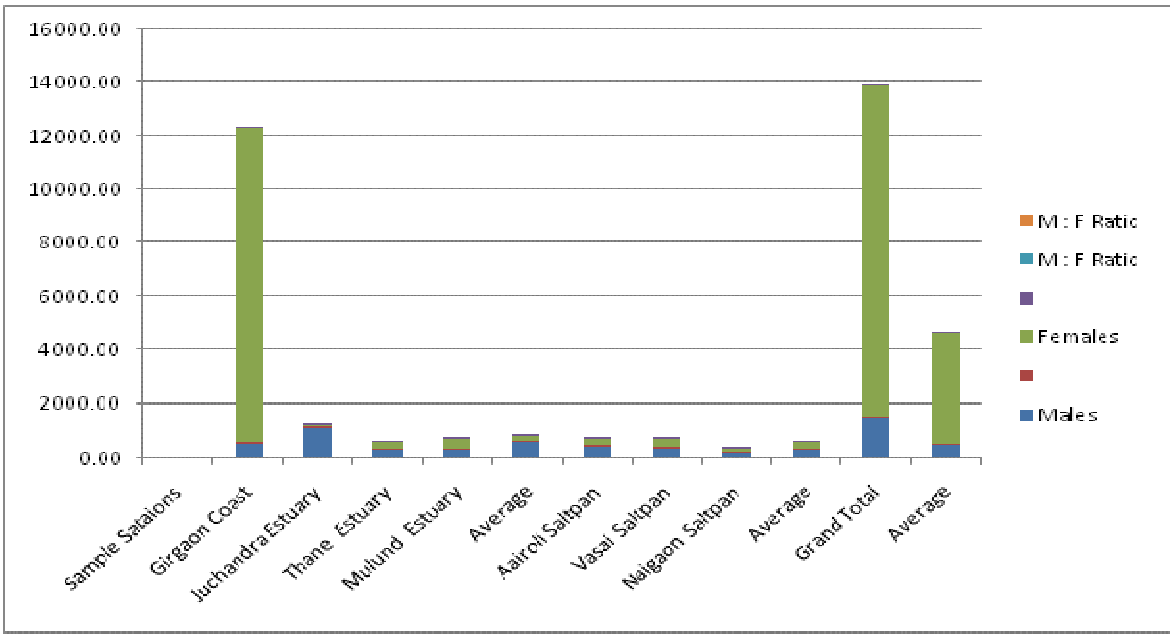

Fig. 11. Number and Length of Mature Male Female Ratio

In the case of males, size of penis and 4th pleopod (in mm) and the total length was also measured. It was found that, size of penis was directly correlated to the Total length of male mysids but size of 4th pleopod was found not related to the Total length of male mysid as per regression equations: y =0.02 x + 0.746; R^2 + 0.056 and y = 0.025 x + 0.226; R^2 = 0.986 respectively (Fig. 10). The average sex ratio of number as also length of mature male and females was calculated for complete data (male: female). In coastal waters, estuarine waters and salt pan waters, number of male and female ratio was noticed as 1: 20.69, 1: 0.44 and 1: 0.83 respectively.

Whereas, male: female length ratio in coastal waters, estuarine waters and salt pan waters was observed 1: 1, 1 : 1.02 and 1 : 1.05 respectively (Fig 11). The number of individuals in the population was found fluctuating seasonally. 35.59% of Total mysids found in Oceanic waters followed by 35.67% in Estuarine waters and 28.72% in Saltpan waters. In Waxing period 56.32% collection was found whereas 43.67% found in Waning period. In Estuarine waters 69.55% specimen obtained in Waxing period followed by 51% in Oceanic waters and 45.96% in Saltwaters. Whereas in Waning period, 54.03% obtained from Saltpan waters followed by 49% mysids obtained

Table 1. Month wise maximum and minimum population in relation to the Total Length of gravid females (mm)

Month wise maximum and minimum population in relation to the Total Length of gravid mysid females (mm)								
		Month	No	%	Month	Length(mm)	%	Range
Water areas								
Girgaon coast	Maximum	Nov,16	6729	20.03	Dec,16	12.06	11.45	5.28-12.72
	Minimum	Febr,17	39	0.12	July,2016	5.88	5.58	3.84-7.84
Estuary Average	Maximum	Feb,May &Sept,17	2903	24.76	July.Sept.&Nov,17	5.89	9.55	4.72-6.88
	Minimum	April,Aug &Nov.17	25.00	0.04	March,Aug.&Nov,17	8.09	12.59	1.92-6.08
Saltpan Average	Maximum	May,16,June &July,17	2565.3	38.61	May,Dec,16&July,17	5.83	6.98	3.04-7.84
	Minimum	Nov,16 and June, 17	29.67	0.71	March,Aug.&Sept,17	4.10	4.98	2.24-5.84

Table 2. Average increase in total length of gravid female with different stages of embryos(mm)

Increase in total length of gravid females with different stages of embryos						
	Body length with			Increase in length		
	Eggs	Eyeless	Eyed	Eggs to EL	EL to ED	Eggs to ED
Coast	mm	mm	mm	mm	mm	mm
Girgaon	6.36	7.02	7.22	0.66	0.20	0.86
Estuary	3.80	6.01	6.13	2.21	0.12	2.33
Saltpans	5.12	5.36	5.90	0.24	0.55	0.79

Table 3. Total length of female mysids in relation of length of Brood pouch number and length of Eggs, Eyeless & Eyed embryos

Total length of female mysids in relation of length of Brood pouch, number and length of Eggs, Eyeless & Eyed embryos												
	Eggs				Eyeless embryos				Eyed embryos			
		Total average length				Total average length				Total average length		
	No.	Total length	Diameter	Brood pouch	No.	Total length	Length	Brood pouch	No.	Total length	Length	Brood pouch
Coast	10.29	6.36	0.18	0.85	7.25	7.02	0.32	1.07	11.94	7.22	0.65	1.00
Estuary	5.25	3.45	0.14	0.46	9.75	6.64	0.51	0.78	6.96	5.47	0.57	0.72
Saltpans	6.42	5.12	0.20	0.65	6.68	5.36	0.44	0.70	7.32	5.28	0.59	0.69

in oceanic waters and 30.44% from Estuarine waters. *Mesopodopsis orientalis* breed throughout the year but there is a seasonal variation in the intensity of breeding. The species produced more than one generation per year and the number of embryos carried by a single female ranged from 5 – 25. In coastal waters, they found breed profusely in November, 2016 (10437nos) out of Total Nos.50080. In estuarine waters of Juchandra, Thane and Mulund, they found breed profusely in February (1101 nos.), September (8253 nos.), and May, 2017 (3454 nos.) respectively out of Total Nos.50187. In saltpan waters of Aairoli, Vasai and Naigaon, they found breed profusely in June (2910), July (7392), and April, 2017 (3645) respectively out of Total Nos.40415. The mean body length of the females in each group was determined and it was observed that the mean length of females with "eyed embryos" and with "eyeless embryos" is related to those of the females with "eggs". It was also observed that the length of the brood pouch is not related to that of the body length of oviparous females carrying embryos with different stages in their brood pouches and an average increase of 0.08.mm of length of the brood pouch was noticed during the successive embryonic stages when an average increase of 0.66 mm of total length of oviparous females was found in Coastal waters. Whereas in Estuarine waters and Saltpan waters an average increase of 0.11mm and 0.02mm of length of the brood pouch was noticed during the successive embryonic stages respectively and an average increase of 1.17 mm and 0.40mm of total length of oviparous females was found respectively. The result of calculation of sex ratio of male: female indicates that numbers of females are much more found in coastal waters than estuarine as also salt pan waters. As regards to the length of females was found equal to the length of male in coastal waters but less than mature males in estuarine as also in salt pan waters. The study area in the Coastal, Estuarine and Saltpan waters ecosystem does have a moderate potential for mysids. The density variation did not show fully synchronous pattern between the sampling sites. Bhattacharya (1982) studied salinity tolerance in the laboratory and reveal that *M.orientalis* of Indian coastal waters could survive under an extremely wide range of salinity conditions, even though it tends towards a low salinity preference, particularly in the early life stages; this ability ensures its wide distribution from sea water to near fresh water conditions. McLusky and Heard (1971) reported that euryhaline species are well adapted to live in changes in their internal environment by maintain their bold hyper/hypo-osmotic to the medium. *Mesopodopsis orientalis* breed throughout the year but there is a seasonal variation in the intensity of breeding. The species produced more than one generation per year and the number of embryos carried by a single female ranged from 5 – 25. The number of females exceeds the number of males in most of the samples, a pattern also reported for *M.orientalis* collected from sandy beach, Malaysia (Hanamura *et al.,* 2009) and other species of mysids (e.g. *Neomysis Americana* (Pessack and Corey, 1979); *Metamysidopsis neritica* (Catil and Borzone, 2008). The sizes of relatively isolated population of Coastal species were estimated seasonally in various regions of the West coast of Scotland between latitudes 55 0 30 0 and 58 0 N by Mauchline (1976). Clarke (1962) measured various parts of the body in four species of *Gnathophausia*. Mauchline (1965, 1971) has observed that the late summer and autumn breeding females are usually smaller in body size than those breeding in the early summer. In present study, monthly collection of *Mesopodopsis orientalis* found occurred in wide fluctuating

water parameters viz., temperature, pH and salinity. In the coastal waters, the mysids found with the range of 59-10437 nos, when temperature was 24.90-31.00 ^{0}C, pH was 7.30-8.50 and salinity was 27.60-36.76 ppt. In estuarine waters, month wise collection ranged from 51.33-4263 nos. when temperature was 25.03-33.80, pH was 7.07-8.77 and salinity was 7.28-60.71 whereas in salt pan waters, 53.33-4649 nos were collected, when temperature was recorded at 23-36.67, pH was 5.33-8.30, and salinity was found at 6.37-48.50 ppt. This species has also been recorded from highly fluctuating saline conditions (eg. Cochin backwaters (0-34.25) and Bhayander salt pan (1.2-63.6) (Biju *et al.,* 2009; Biju and Pannampunnayil, 2010). Bhattacharya (1982) studied salinity tolerance in the laboratory and reveal that *M.orientalis* of Indian coastal waters could survive under an extremely wide range of salinity conditions, even though it tends towards a low sea water to near fresh water conditions. McLusky and Heard (1971) reported that euryhaline species are well adapted to live in an environment with a wide fluctuation in salinity through their capacity to prevent excessive changes in their internal environment by maintain their blood hyper/hypo-osmotic to the medium. *M.orientalis* shows variation in their seasonality in abundance with respect to different population. For example, in Cochin backwaters, abundance of this species associated with monsoon period (Biju *et al.,* 2009) while in Hooghly estuary, the periodicity in abundance of *M.orientalis* weakly correlated with the monsoon season (Sarkar and Choudhary, 1986). Hanumura *et al.* (2009) reported that there is no evidence of periodicity in the abundance of *M.orientalis* in the Malaysian sandy beach. These observations suggest that the intensity of breeding varies different population of the same species. The water temperature significantly affects the periodicity and reproductive biology of mysids (Mauchline, 1980; Johnston *et al.,* 2001). Hanamura *et al.* (2009) state that stable water temperature reduces the seasonality of mysids in tropical shallow waters. Females found predominated over males in the entire population, and brooding females were present at every monthly sample, indicating that reproduction is continuous year round. It was also observed that the numbers of males are usually more in the population in post-mosoon period. It may be therefore presumed that males may live in different habitats from that of females. Similar observations were made by Wigley and Burns (1971) in *Mysis mixta*.

Conclusion

The mysids are important in marine food chains since they occur in large numbers in inshore waters and estuaries. They have commercial importance in the aquarium pet industry and as food for penaeid shrimp and fish larvae in aquaculture. In addition, mysids are harvested for human consumption in India, Indonesia and Thailand. With these views, more morphometric analysis are required to clarify the difference in life history feature within different population of the same species which will enable to help culturing of mysids.

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