



Seasonal availability and population structure of *Eurobowmaniella simulans* W. Tattersall, 1915 (Crustacea: Mysida) along Vizhinjam coast, Kerala, India

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Abstract

Eurobowmaniella simulans is the commonly available species of mysid along the Vizhinjam coast of Kerala. Sampling of mysids has been carried out over a period of one year from March 2014 to February 2015 to study the seasonal availability and population structure. Monthly samples of mysids consisted of individuals in various developmental stages, from juveniles to mature mysids around the year, but their percentage availability varied. The peak availability of mysids was recorded during September (2014) (avg. 48,731 numbers per haul) and their availability was lowest in July (2014) with an average of 2 individuals per haul. The availability of brooding or ovigerous females were observed throughout the year and highest and lowest percentage availability was during November (2014) and April (2014) respectively. Morphometric measurements of *E. simulans* revealed that their average size (TL) ranged from 2.35 ± 0.52 mm (juvenile) to 7.47 ± 1.75 mm (adult). Sex could be first distinguished externally when mysid attains the total length between 4.1 mm and 5 mm. Analysis of variance of different water quality parameters and mysid density comparing seasons revealed that there was significant variation of mysid availability between seasons ($P < 0.05$). Multivariate Pearson's correlation analysis of water quality parameters and mysid density showed that there was a significant relation with chlorophyll a content ($P < 0.001$) of seawater. The present study also revealed that mysids are available in harvestable quantities for aquaculture purposes from August to November.

Keywords: *Eurobowmaniella simulans*, availability, population structure, developmental stages, Vizhinjam coast

Introduction

Mysids are small crustaceans and an important zooplankton component in marine and estuarine waters. They show significant variation in their availability in different seasons and they occur in all regions of the oceans. They are grouped under macro-zooplankton since their size range from 1.5 to 25 mm in total length. They are used as live feed to rear many difficult species which feed exclusively on live feed. Mysids of different size range are found suitable as live-feed in the larval rearing of newly hatched squid and cuttlefish larvae (Domigues *et al.*, 2001; Nabhitabhata, 1996; Anil, 2003), nursery rearing of ornamental fishes, food-fishes and serve as livefeed for many other marine organisms (Beyst *et al.*, 2001), thus acting as a trophic link between primary producers and secondary consumers. Mysids are omnivorous and cannibalistic, feeding on diatoms and small crustaceans such as copepods (Odum and Herald, 1972; Mauchline, 1980).

Mysids can be cultured in laboratory by providing *Artemia*, rotifer, copepod, phytoplankton (Domigues *et al.*, 2000; Lussier *et al.*, 1988; Viherluoto, 2001) and mussel meat suspension (personal observation). *Eurobowmaniella simulans* is the common species of mysid found along the Vizhinjam coast (Biswas, 2005). Biju (2008) collected this species from the coastal waters of the Arabian Sea during monsoon (June-September).

Published works on mysid shrimps of southwest coast of Kerala are markedly lacking. Biswas (2005) conducted a short term study on the culture of new live prey organisms with focus on mysids. A number of continually changing environmental factors such as temperature, salinity, dissolved oxygen, suspended particles and currents modify the physiological performance of organisms (Vernberg and Vernberg, 1970). Chlorophyll concentration is regarded as an indicator of phytoplankton abundance and biomass in coastal and estuarine waters (Biju, 2008; Biju *et al.*, 2009). Environmental factors such as temperature, salinity, dissolved oxygen, suspended particles, and currents influence the seasonal availability, abundance and distribution of mysid species (Brandt *et al.*, 1993; Kohn, 1992; DeGreave and Reynolds, 1975; McLusky and Heard, 1979). Laboratory rearing of mysids revealed that they are highly adaptive, and can tolerate a wide range of conditions (Domigues *et al.*, 1999, 2000, 2001; Lussier *et al.*, 1988). Mysids can be used as a live feed in aquaculture especially during the months of their swarming. For the captive rearing of cephalopod hatchlings it is of importance to know about the seasonal availability of mysids, as mysids are considered as best live feed for cephalopod larval culture (Anil *et al.*, 2005; Minton *et al.*, 2001). Present study focuses on the seasonal, day time variations in availability and population structure of mysid *E. simulans* along Vizhinjam coast with special emphasis on effect of environmental parameters on its population density. This paper also elucidates the morphometric and biological features of *E. simulans* briefly.

Material and methods

The present study was conducted at Vizhinjam coast (Kovalam Light House beach), which is located on the west coast of Kerala, about 12.8 km south off Thiruvananthapuram at 8°22'56.13"N lat and 76°58'51.01"E long (Fig.1). Data was collected fortnightly and pooled to get monthly values, over a period of one year from March 2014 to February 2015.

Various physicochemical parameters were measured using standard techniques. Ammonia level was checked using the phenol hypochlorite method (Solorzano, 1969). Nitrate, nitrite and phosphate were checked using nitrate, nitrite and phosphate testing kits (MERCK) by adopting photometric



Fig.1. Sampling Site

method (NOVA60, Spectroquant). Temperature (Centigrade thermometer), dissolved oxygen (Winkler, 1888), pH (Compact pH meter, LAQUA twin), and salinity (Master Refractometer, ATAGO) were checked fortnightly. Chlorophyll *a* concentration was analysed with UV Visible Spectrophotometer (Evolution 201) (Strickland and Parsons, 1972).

Mysids were collected from the intertidal area by hauling a conical plankton net of 50 cm diameter, with a mesh size of 200 μ m covering a distance of 50 meters. Samples were sorted out and counted for the number of mysids per haul. Mysids were immediately transferred to plastic buckets filled with sea water taken from the sampling site and brought to the laboratory for further analysis. For morphometric and biological studies samples were preserved in 10% formalin. Mysids were sorted out and identified under a stereozoom microscope (Leica DFC 295) to find out the structure and composition of population. Individuals were classified into different developmental stages based upon their external appearance, sexual and morphometric characteristics and were grouped according to Tueanta *et al.*, 2012 as, (1) Juvenile; (2) Immature or sub-adult male; (3) Mature male (Fig. 6); (4) Immature or subadult female ; (5) Mature female (Fig. 5); (5a) Brooding or ovigerous female (marsupium with eggs or larvae); and (5b) Empty female (marsupium empty or post-nauplii were hatched out). Monthly percentage availability of mysids of different developmental stages were recorded. Day time variation in mysid availability was recorded by collecting and counting mysids at different times of the day (Morning 7.00 am, noon 12.00 pm and evening 5.00 pm). Observations were made during normal days and cloudy days.

Results

Water quality parameters recorded from March 2014 to February 2015 are presented in Figs. 2-6. The mean air and

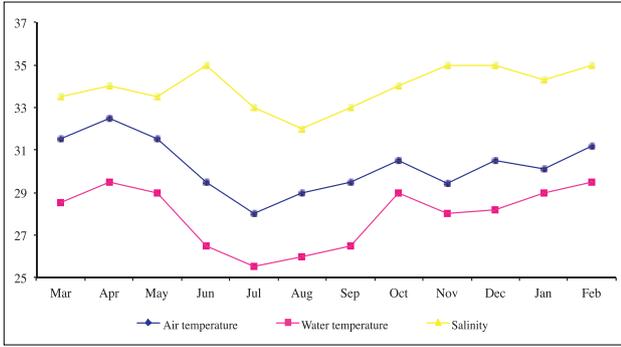


Fig.2. Air and water temperature (°C) and salinity (ppt) during the study period

water temperatures were $30.3 \pm 1.27^\circ\text{C}$ and $27.93 \pm 1.43^\circ\text{C}$ respectively during the study period. Temperature showed only a slight variation during the sampling period, water temperature ranged between 25.5°C in July and 29.5°C in February. Air temperature was 28°C during July and 31.2°C during February and May. Salinity ranged between 32ppt in August and 35ppt during the months of February, November and December. The mean annual salinity was 33.9 ± 0.98 ppt. pH ranged between 7.7 during July, August and 8.2 during November and December and the annual mean pH was 8.0 ± 0.17 . Dissolved oxygen ranged between 2.6mg/l in July and 6.1mg/l in March and the mean annual value of DO was 4.1 ± 0.79 mg/l.

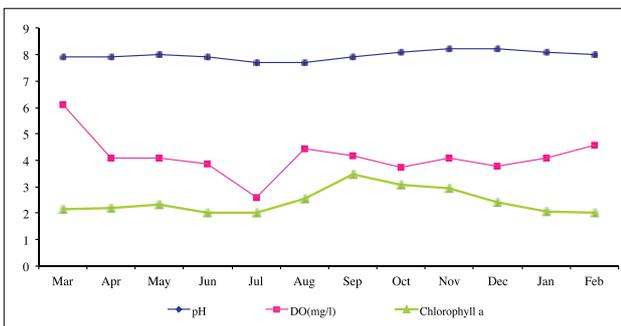


Fig.3. Seasonal values of pH, dissolved oxygen (mg/L) and Chlorophyll a (mg m^{-3}) during the study period

The mean concentrations of other parameters recorded were, nitrate (NO_3^-), 0.058 ± 0.006 mg/l; nitrite (NO_2^-), 0.044 ± 0.009 mg/l; ammonia (NH_4^+), 0.066 ± 0.021 mg/l; phosphate (PO_4^-), 0.103 ± 0.039 mg/l and showed only slight variations throughout the year. Chlorophyll a values showed significant increase during the last phase of monsoon and initial phase of post monsoon season. The concentration ranged between 2.011 mg m^{-3} during July to 3.451 mg m^{-3} during September with an average annual concentration of $2.437 \pm 0.476 \text{ mg m}^{-3}$.

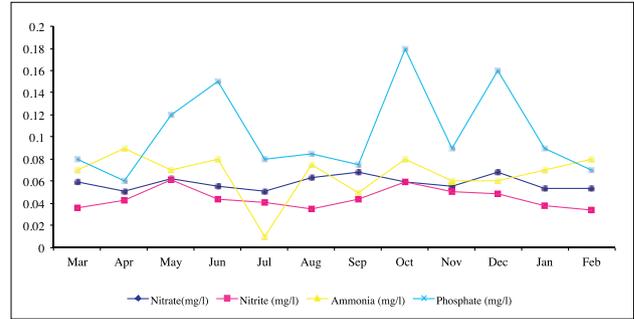


Fig.4. Seasonal variation of Nitrate, Nitrite, Ammonia and Phosphate (mg/L) during the study period

Eurobowmaniella simulans was found to occur along Vizhinjam coast throughout the year in varying intensities. Male and female can be easily distinguished by the presence of brood pouch in females (Fig. 5) and the peculiarity of extended third pleopods and penis in males (Fig. 6). Fertilized eggs develop inside the brood pouch and hatch out as a miniature adult. About 20-35 nauplii (eyed larvae) were recorded in female brood pouch. After the incubation period they are released from the brood pouch as miniature mysids of 1.6-1.8 mm of total length.



Fig.5. *E. simulans*, female with brood pouch carrying eggs



Fig.6. *E. simulans* male

The average size (TL) of *E. simulans* ranged between 2.35 ± 0.52 mm (Juvenile) to 7.47 ± 1.75 mm (adult). The average total length of mysids at different developmental stages were (1) juvenile (TL- 2.35 ± 0.52 mm); (2) immature or sub-adult male (TL- 3.89 ± 0.35 mm); (3) mature male (TL- 6.55 ± 1.68 mm); (4) immature or sub adult female (TL- 3.60 ± 0.28 mm); (5) mature female (TL- 7.47 ± 1.75 mm); (5a) brooding or ovigerous female (TL- 7.47 ± 1.75 mm); and (5b) empty females (TL- 6.55 ± 2.05 mm). Sex could be first distinguished externally when mysid attains the total length between 4.1-5 mm. Females were observed to attain sexual maturity from a total length of 5.7 mm, in males it was from 4.9 mm. Monthly samples of mysids from Vizhinjam coast consisted individuals in all developmental stages, from juveniles to oldest mature mysids, but their percentage availability varied (Fig.8). The peak availability of mysids was recorded during September (avg. 48731 ind. per haul) and least availability was in July with an average number of 2 ind. per haul (Fig.7).

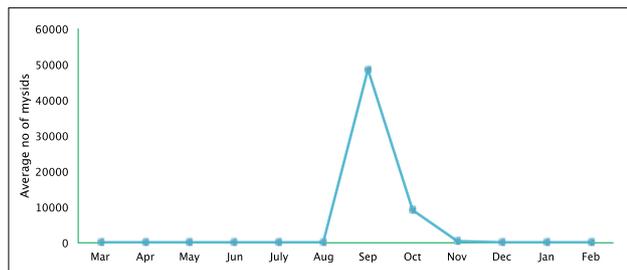


Fig.7. Month-wise distribution of mysids per haul

Mature individuals were observed throughout the study period, peak availability of mature male mysids (80%) was recorded in February and peak availability of mature females (76.67%) during May. The availability of mature males was lowest during December (10%) whereas, mature females was lowest (20%) during February. The maximum availability of juveniles was recorded during December. Maximum availability of sub-adult males was observed in April (26.7%). During December, 20% of sub-adult females were obtained. Mature females consisted of ovigerous or brooding and empty females. The maximum number of ovigerous females were recorded during November (94.74%) and minimum number

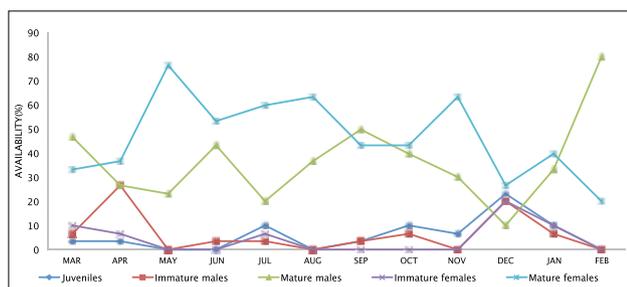


Fig.8. Monthly percentage availability of mysids in different stages

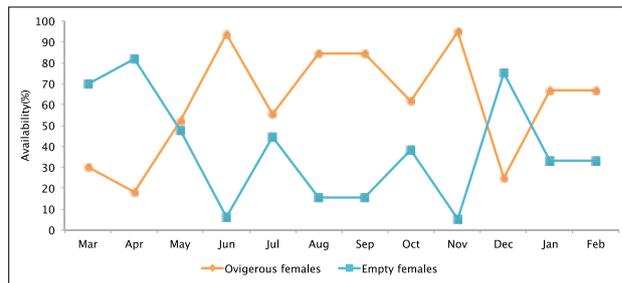


Fig.9. Percentage of ovigerous and empty females during the study period

during April (18.18%) (Fig. 9).

Availability of mysids during sunny days in the intertidal and surf zones, at different times of the day (7.00 am, 12.00 pm and 5.00 pm) showed significant variations (Fig.10). Number of mysids were maximum during morning hours with an average of 25.55 ± 21.14 numbers per haul, minimum during noon with an average of 8.95 ± 9.02 numbers per haul since the mysids got buried in sand or moved to deeper waters as the temperature and light intensity increases. Their number was moderate during evening with an average of 16.45 ± 17.59 numbers per haul. During cloudy days good collection could be made, even during noon hours (23.85 ± 15.84 numbers per haul). Low or medium tides were found to be more conducive for mysid collection.

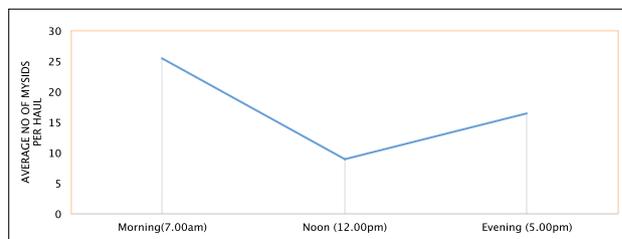


Fig.10. Day time variation in the availability of mysids

Analysis of variance (One Way ANOVA) and Multivariate Pearson's correlation analysis of different water quality parameters and mysid density in various seasons are represented in Table 1 and 2.

Discussion

The present study unveiled the seasonal availability and population structure of mysid *E. simulans* along Vizhinjam coast. *E. simulans* can be seen at all times throughout the year but their monthly availability and density varied. ANOVA of different water quality parameters and mysid density against seasons revealed that there was significant variation ($P < 0.05$) of mysid availability between seasons (Table 1). During the pre-monsoon period (February-May) mysids occurred with an average density of 21.2 ± 16.2

Table 1. Analysis of variance (One Way ANOVA) of different water quality parameters and mysid density comparing seasons.

Parameter	Season	Mean	+ SD	F value
Air Temperature	Pre-monsoon	31.675	0.568	19.830**
	Monsoon	29.000	0.707	
	Post-monsoon	30.125	0.519	
Water Temperature	Pre-monsoon	29.125	0.479	41.392**
	Monsoon	26.125	0.479	
	Post-monsoon	28.550	0.526	
pH	Pre-monsoon	7.950	0.058	18.500**
	Monsoon	7.800	0.116	
	Post-monsoon	8.150	0.058	
Salinity	Pre-monsoon	34.000	0.707	2.265
	Monsoon	33.250	1.258	
	Post-monsoon	34.575	0.506	
Dissolved Oxygen	Pre-monsoon	4.713	0.949	1.905
	Monsoon	3.770	0.813	
	Post-monsoon	3.933	0.195	
Nitrate	Pre-monsoon	0.057	0.005	0.224
	Monsoon	0.059	0.008	
	Post-monsoon	0.059	0.006	
Nitrite	Pre-monsoon	0.044	0.012	0.881
	Monsoon	0.041	0.004	
	Post-monsoon	0.049	0.009	
Ammonia	Pre-monsoon	0.078	0.010	1.415
	Monsoon	0.054	0.032	
	Post-monsoon	0.068	0.010	
Phosphate	Pre-monsoon	0.083	0.026	1.712
	Monsoon	0.098	0.035	
	Post-monsoon	0.130	0.047	
Chlorophyll <i>a</i>	Pre-monsoon	2.176	0.128	0.933
	Monsoon	2.515	0.672	
	Post-monsoon	2.618	0.467	
Mysids	Pre-monsoon	21.225	16.195	3.045*
	Monsoon	12187.000	4362.667	
	Post-monsoon	2382.700	509.707	

* P < 0.05; ** P < 0.001

Table 2. Multivariate Pearson's correlation analysis of water quality parameters and mysid density.

Parameters	Air Temperature	Water Temperature	pH	Salinity	Dissolved Oxygen	Nitrate	Nitrite	Ammonia	Phosphate	Chlorophyll <i>a</i>	Mysids
Air Temperature	1										
Water Temperature	0.863**	1									
pH	0.321	0.633*	1								
Salinity	0.279	0.501	0.754**	1							
Dissolved Oxygen	0.531	0.371	0.056	-0.04	1						
Nitrate	-0.04	-0.17	0.155	-0.26	0.195	1					
Nitrite	0.139	0.231	0.491	0.178	-0.34	0.255	1				
Ammonia	0.689*	0.627*	0.288	0.301	0.522	-0.01	0.035	1			
Phosphate	-0.05	0.052	0.446	0.341	-0.26	0.335	0.646*	0.163	1		
Chlorophyll <i>a</i>	-0.2	-0.15	0.237	-0.21	-0.04	0.585*	0.435	-0.06	0.173	1	
Mysids	-0.18	-0.27	-0.08	-0.3	-0.02	0.522	0.077	-0.21	-0.11	0.751**	1

* P < 0.05; ** P < 0.001

ind. per haul, during monsoon (June – September) it was 12187 ± 4362.7 ind. per haul and 2382.7 ± 509.7 ind. per haul during post-monsoon (October–January). Other parameters which showed significant seasonal variations ($P < 0.001$) include air temperature, water temperature and pH (Table 1).

During the last phase of monsoon and post-monsoon seasons a significantly higher availability of this species was recorded, which may be due to nutrient enrichment and subsequent higher primary production in the coastal waters. Multivariate Pearson's correlation analysis (Table 2) of water quality parameters and mysid density showed that there was a significant relation with chlorophyll a content ($P < 0.001$) of seawater. Chlorophyll concentration is regarded as an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. Biju *et al.*, 2009 reported that chlorophyll values were very high in monsoon period compared to pre-monsoon and post-monsoon periods in Cochin backwaters. A rise in chlorophyll a (3.451 mg m^{-3}) was observed during September, the peak season of mysids. According to Hanamura *et al.* (2009) food availability is one of the vital factor which regulate the mysid abundance. Pillai (1957) reported the availability of *E. simulans* along the intertidal areas of Kerala coast during March to October and their peak availability during June and July. Biju (2008) reported that this species was fairly common along the Kerala coast during March to October. The present study showed a peak availability of *E. simulans* during September and October and least availability during July.

According to Kohn (1992), DeGreave and Reynolds (1975) and McLusky and Heard (1979) the distribution, survival and behaviour of mysids were strongly influenced by salinity, temperature and oxygen concentration. Augmented temperature shown to increase the movement and feeding rate of mysids upto a definite limit, after which their mortality starts to increase (DeGreave and Reynolds, 1975; Chipps, 1998). Temperature play an important role in the larval development time in mysids (Mauchline, 1980). Wittman (1981) reported that incubation time is related to water temperature. In the present study a minimum availability was noticed at higher temperatures (noontime during sunny days).

The recorded mean annual pH was 8.0 ± 0.17 , pH above or below the range of tolerance can cause a drastic decline in population density of mysids. Variation in pH can have major impact on the distribution of organisms (Peter Stiling, 2011). In culture experiments, decrease of pH is the main reason for the rapid decline of mysid production (Domigues *et al.* 1998). Only a slight variation of pH was

recorded during the study. The salinity ranged between 32-35 ppt. *E. simulans* was found to be a euryhaline organism, and comparatively higher abundance of mysids (edge effect) were recorded in certain sites where small streams conjoins with the sea. The effect of salinity on mysid availability and distribution were well documented for some species by Baldo *et al.* (2001), Bhattacharya (1982), Bhattacharya and Kewalremani (1972), Biju and Panampunnayil (2010) in their studies. Bhattacharya (1982) opined that the mysid, *Mesopodopsis orientalis* can tolerate from near freshwater condition to 60 ppt. salinity if the animals are properly acclimatized.

Biju (2008) reported that the amount of dissolved oxygen in natural water depends up on temperature, salinity, turbulence of water and atmospheric pressure and the low oxygen may also be the result of decomposition of organic matter present in the bottom. Concentration of oxygen was found to play significant influence on the survival, distribution and behaviour of mysids, they seem to avoid areas where oxygen concentration is low (Ackefors, 1969; Salemaa *et al.*, 1986). Low concentration of DO is also an indication of nutrient richness. Johannassen and Dahl (1996) have reported a decline in dissolved oxygen as a result of increased nutrient load. DO did not show significant variations throughout the study period and the mean annual concentration of DO was 4.1 ± 0.79 mg/l. Low oxygen concentration was recorded during the month of July and in the same month lowest availability of mysids was recorded; which may be due to the migration of mysids away from the oxygen deficient areas. Low oxygen in surface waters is a phenomenon associated with upwelling during the south west monsoon period along the south west coast of India.

During the present study, nitrate, nitrite, ammonia and phosphate showed only slight variations and did not show much influence on availability of mysids. According to Brandt *et al.* (1993) high concentration of ammonia, nitrate, phosphate together with low dissolved oxygen decrease mysid availability. Biju and Panampunnayil (2010) reported a higher productivity in Cochin backwaters during monsoon due to nitrogenous input due to monsoon river flow and a subsequent variation in abundance and distribution of mysid *Mesopodopsis zeylanica*. Spotte (1979) proposed that the limits for nitrogenous waste levels for most marine animals should follow: < 0.10 mg/l ammonia, < 0.10 mg/l nitrite and < 20.00 mg/l nitrate. The tolerance limits for some species were above these values (Boletzky and Hanlon, 1983).

The effect of temperature, pH, salinity, nitrite, nitrate,

ammonia, phosphate and dissolved oxygen did not show significant correlation with mysid availability in the present study as compared to previous studies which may be due to the insignificant variations in the above parameters during the study period.

During sunny days, the availability of mysids was maximum at morning hours, minimum at noon and their number was moderate at evening. During cloudy days with weak light and temperature a large number of mysids were collected even during noon hours. Mauchline (1980) studied the influence of light on distribution and behavior of mysids. In general mysids are attracted to weak sources of light but avoid bright light. Bright light often inhibits the swimming activity (Mauchline, 1980) and swarming behavior (Steven, 1961). This may be the reason for their low availability at noon during sunny days. In Vizhinjam waters, the study of seasonal availability of *E. simulans* revealed seasonal variations during the study period. Throughout the year the mysid population consisted of individuals in all developmental stages (different age groups), which indicate its reproduction throughout the year. Availability of mysid varied at different times of the day, which was found to be due to the influence of varying intensity of light and temperature. The present study also revealed that mysids are available in harvestable quantities for aquaculture purposes from August to November along Vizhinjam coast.

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