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Comparison of day and night mysid assemblages in a seagrass bed by using emergence traps, with key to species occurring at Pulau Tinggi, Malaysia

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Abstract—A study of the mysid assemblage was carried out at the seagrass bed of Pulau Tinggi, Johor, east coast of Peninsular Malaysia. Two seagrass species, namely *Cymodocea serrulata* and *Halophila ovalis*, were dominant from this area. The aim of the study was to investigate the diversity and abundance of mysids between day and night by using emergence trap (0.25 m^2). Day and night samples were taken at 5 stations. Two traps were deployed randomly at each sampling period. A total of 16,544 mysid individuals were enumerated throughout the sampling period. Eleven species belonging to three subfamilies of the family Mysidae were identified. These species, which were found to be new records from this study area were: *Acanthomysis platycauda* (Pillai 1961), *Acanthomysis quadrispinosa* (Nouvel 1965), *Acanthomysis longispina* (Fukuoka and Murano 2002), *Anisomysis aikawai* (Ii 1964), *Erythrops minuta* (Hansen 1910), *Lycomysis spinicauda* (Hansen 1910) and *Prionomysis aspera* (Ii 1937) belonging to the subfamily Mysinae; *Anchialina dentata* (Pillai 1964), *Haplostylus bengalensis* (Hansen 1910) and *Pseudanchialina inermis* (Illig 1906) from the subfamily Gastrosaccinae; and *Siriella vulgaris* from the subfamily Siriellinae. Analyses of variance (ANOVA) showed that the effect of sampling period to be highly significant for total density but not significant for species richness, diversity index and evenness index. The majority of mysids (94%) were captured at night with the remaining 6% captured during the day. *A. quadrispinosa* was the most abundant species which comprised 99.5% of the total sample. The distribution and abundance of this species influence the diversity and evenness of the mysid community at each station. In this paper, the key of mysid species from the study area is also provided.

Key words: mysid assemblage, day and night, emergence trap, seagrass bed, Pulau Tinggi, Malaysia

Introduction

Mysids are shrimp-like peracaridean crustaceans which belong to the order Mysida. Almost 95% of the species are marine while some live in brackish water and a few species live in freshwater environments. The distribution of marine mysids is mainly regulated by salinity, temperature, oxygen concentration and the depth of the water column (Salemaa et al. 1986). Most of the marine mysids occur in coastal waters and to a lesser extent in the open ocean (Mauchline 1980). They are commonly hyperbenthic, living on or just above the sediment surface part of the time, and normally migrating into the water column at night (McConnaughey 1978). This is a common form of migration in shelf and littoral species (Rudstam et al. 1989).

One of the factors that control the vertical distribution of mysids is light intensity (Viherluoto 2001). The photosensitive species would remain near the bottom during the day, rise to the water column at dusk and descend again at dawn. Apart from that, the vertical migration pattern is also probably due to antipredation and feeding responses. Mysids stay at the bottom during day time to avoid being preyed by visual daytime predators such as planktivorous fish (Alldredge and King 1980), while the nocturnal movement into the water column allows them to utilize planktonic food sources (Porter and Porter 1977).

Mysids play an important role in the marine ecosystem as they link the primary and secondary producers to higher trophic levels (Hostens and Mees 1999). This is because they are preyed by many larger predators such as invertebrates, fish, birds and marine mammals (Mauchline 1980). They also provide an energy link between the pelagic and benthic environments by utilising both pelagic and benthic food

sources (Viherluoto 2001).

Mysids are an important component of the fauna associated with seagrass. They generally swim in the water column within the seagrass bed (Yamada et al. 2007). Seagrass provides living space and shelter for mysids. They face lower predation risk at the center of the seagrass bed compared with the edge of the bed (Bullard and Hay 2002). Furthermore, epiphytes which are attached to the seagrass provide refuge for mysids and reduce the predation pressure on mysids as epiphytes contribute as an alternative food for many other epifauna (Morgan 1980).

The main aim of this study is to extend the field of mysid research in Malaysia. This is generally intended to contribute to basic information and knowledge on mysids in Malaysian waters as well as the Southeast Asian region. At present, there is a definite dearth of basic information in this field of research. Thus, the objective of this research is to investigate the diversity and abundance of mysids between day and night by using emergence traps.

Materials and Methods

Study Area

The field work was carried out at Pulau Tinggi in Johor, on the east coast of Peninsular Malaysia from 14th to 19th July, 2007. The sampling was conducted at a seagrass area of Kampung Pasir Panjang (2°17′33″N and 104°6′1″E), where the depth ranged from 3 to 5 metres. During the sampling, weather and sea conditions were fine. The sampling coincided with the new phase of the moon.

Azman et al. (2008) reported two species of seagrass, *Cymodocea serrulata* and *Halophila ovalis* from this study area. Mysids were collected at five sampling stations (Figure 1), namely, Stations A (2°17′34.7″N and 104°6′3.2″E), B (2°17′34.8″N and 104°6′3.3″E), C (2°17′34.7″N and 104°6′3.4″E), D (2°17′34.8″N and 104°6′4.5″E) and E (2°17′33.6″N and 104°6′4.5″E). In general, these stations were located in the 1,770 m^2 of seagrass area that consists of mostly sandy substrate (Azman et al. 2008). Two replicates were obtained for each period of time at each station.

Field method

Mysids were collected by using emergence traps. Each trap consists of a 1.5 m high cone with a 140 μm mesh net, attached to the 0.25 m^2 metal frame. The cone is topped with a 500 ml polyethylene sample bottle. A funnel is used to connect the polyethylene sample bottle and net. The funnel extends two-thirds of the way up into the sample bottle to prevent the mysids from swimming back into the net. The sample bottle contains a small amount of air to keep the system upright. A float is tied with a rope at one end of the frame to indicate the location of the emergence trap during sampling (Figure 2).

Two emergence traps were placed randomly at the sampling site. Sampling was conducted for two periods within one day (24 hours). The traps were deployed from the boat by holding the ropes attached to one end of the metal fame and the float and letting them sink slowly to the bottom till the frame is properly rested on the seagrass bed. The mouth of the metal frame was kept vertical to minimize sampling contamination from the water column. After 12 hours, the traps were retrieved by pulling up the ropes and again making sure that the mouth of the metal frame was in vertical position to

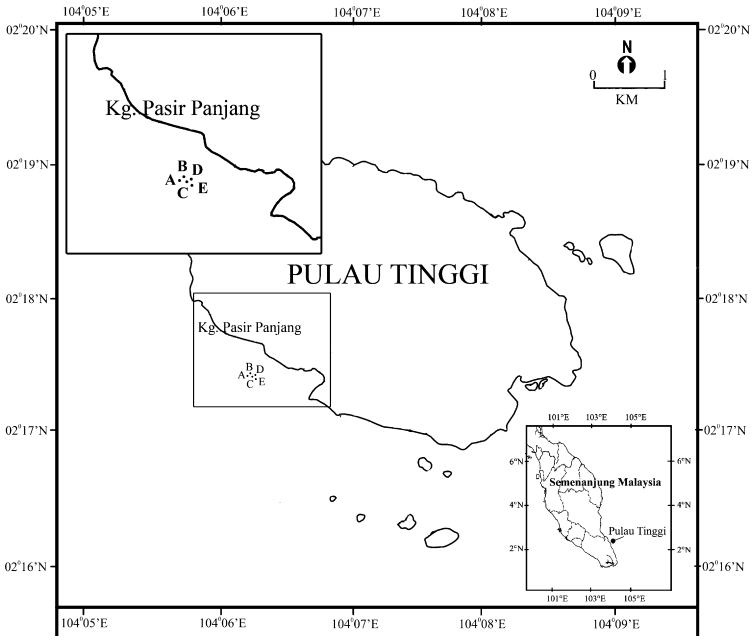

Fig. 1. Sampling location.

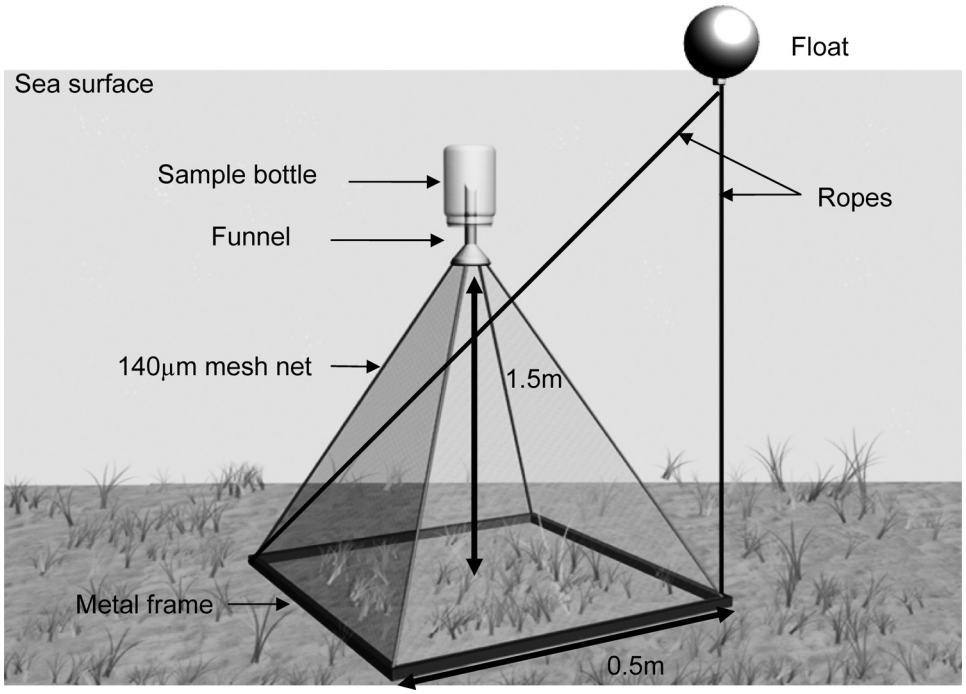

Fig. 2. A set of emergent trap placed on seagrass bed

minimize contamination from the water column.

Before bringing up the emergence trap to the boat, the net is washed to ensure all biota is collected in the sample bottle. The sample bottles were removed and replaced with another new bottle for the next sampling. Samples collected in the bottles were then preserved with 10% formalin in seawater. Samples that were obtained between 6.30 am and collected at 6.30 pm were known as day samples; while the night samples were represented by the samples left overnight, from 6.30 pm to 6.30 am.

Analysis of data

In the laboratory, mysids were sorted, dissected, identified and enumerated for further numerical analyses. Ecological parameters such as species richness, diversity and evenness indices, were calculated.

A two-way analyses of variance (ANOVA) were used to determine the effect of time (day and night) and station (A, B, C, D and E) on mysid abundance, species richness, diversity and evenness indices. All statistical analyses were performed using the Minitab 14 package.

Results

A total of 16,544 mysid individuals belonging to 11 species from three subfamilies of the family Mysidae were enumerated. The species identified were *Acanthomysis platycauda* (Pillai 1961), *A. quadrispinosa* (Nouvel 1965), *A. longispina* (Fukuoka and Murano 2002), *Anisomysis aikawai* (Ii 1964), *Erythrops minuta* (Hansen 1910), *Lycomysis spinicauda* (Hansen 1910) and *Prionomysis aspera* (Ii 1937) belonging to the subfamily Mysinae; *Anchialina dentata* (Pillai 1964), *Haplostylus bengalensis* (Hansen 1910) and *Pseudanchialina inermis* (Illig 1906) from the subfamily Gastrosaccinae; and *Siriella vulgaris* (Hansen 1910) from the subfamily Siriellinae.

Table 1 shows the abundance of mysids by species, station and replicate. The number of individuals at any one trap for each species sampled throughout the study ranged from 0 to 3,426 individuals and the number of individuals per trap ranged from 0 to 3,438 individuals/0.25 m^2. Mysids obtained at Station C recorded the highest in terms of abundance, with 4,945 individuals compared with other stations. Station E, with 712 individuals, recorded the least number of individuals.

Of the total number of individuals sampled throughout the entire study, *A. quadrispinosa* was the most dominant and ubiquitous species where 16,458 individuals were enumerated. This species contributed 99.48% of the total mysids collected. This species was present at all stations and periods except in one of the day time samplings at Station A. The other 10 species combined made up 0.52% of the total number. *Acanthomysis platycauda*, *Anisomysis aikawai* and *L. spinicauda* were only present at two stations. *Erythrops minuta* was very rare with only one individual obtained during the sampling.

Throughout the entire sampling period, the majority of mysids were captured during the night time (Figure 3). This comprised of 94% of the total density, compared with the 6%

Table 1. Number, densities, species richness, diversity and evenness indices of mysid species recorded in each replicate trap, and total number and percentage of each species.

Species	Station																				Total	Percentage (%)
	A				B				C				D				E					
	Night		Day		Night		Day		Night		Day		Night		Day		Night		Day			
Replicate no.	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2		
Family Mysidae																						
Subfamily Gastrosaccinae																						
Anchalina dentata	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	4	0.02
Haplostylus bengalensis	2	2	1	0	2	3	0	0	1	0	0	0	0	2	0	0	0	0	0	1	14	0.08
Pseudanchialina inermis	0	0	3	0	2	1	0	0	0	0	0	0	0	4	0	0	1	2	0	0	13	0.08
Subfamily Mysinae																						
Tribe Erythropini																						
Erythrops minuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.01
Tribe Leptomysini																						
Prionomysis aspera	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	1	6	0.04
Tribe Mysini																						
Acanthomysis longispina	3	0	0	0	0	0	0	3	4	0	0	1	1	0	0	0	0	2	0	0	14	0.08
Acanthomysis platycauda	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0	0	0	5	0.03
Acanthomysis quadrispinosa	3426	728	32	0	282	2270	77	97	3135	1531	97	175	602	3087	27	190	80	386	218	18	16458	99.48
Anisomysis aikawai	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0.02
Lycomysis spinicauda	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	4	0.02
Subfamily Siriellinae																						
Tribe Siriellini																						
Siriella vulgaris	4	0	7	0	0	0	1	4	0	1	0	0	0	4	0	1	0	0	0	0	22	0.13
Density (ind/ 0.25m^2)	3438	731	45	0	286	2275	79	105	3140	1532	97	176	603	3103	28	194	82	392	218	20	16544	100.00
Species richness	6	3	6	0	3	4	3	4	3	2	1	2	2	8	2	4	3	5	1	3		
Diversity Index	0.0285	0.0293	0.9662	0.0000	0.0833	0.0177	0.1356	0.3436	0.0126	0.0054	0.0000	0.0350	0.0123	0.0415	0.1541	0.1219	0.1316	0.0995	0.0000	0.3944		
Evenness Index	0.0119	0.0122	0.4029	0.0000	0.0347	0.0074	0.0566	0.1433	0.0053	0.0023	0.0000	0.0146	0.0051	0.0173	0.0643	0.0508	0.0549	0.0415	0.0000	0.1645		

captured during the day time. The ANOVA for total density shows a significant effect (Table 2) of sampling period ($p<0.01$). The night time sampling period recorded a mean of 1,558 individuals/0.25 m^2 compared with the day time sampling period with a mean of 96 individuals/0.25 m^2 (Figure 3).

Figure 3 shows the mean number of mysid individuals obtained during the two different periods for each station. All stations recorded higher number of mysids captured during night time. Station C is the most abundant night sampling station, followed by Stations A, D, B and E, respectively (Table 1). The mean number of mysids captured during day time at each station did not exceed 150 individuals/0.25 m^2 (Figure 3). However, the effect of station and the interaction between sampling period and station were not significant ($p>0.05$).

Figure 4 shows the pooled mean abundance of mysid species obtained during the day and night. All the species were present during the day and night, except for the single sample of *E. minuta*, which was obtained at night. The number of individuals for each species captured were higher in the night time samples compared with day time, except for *L. spinicauda* and *S. vulgaris*. Except for the dominant species *A. quadrispinosa*, the pooled value for all of the other species did not exceed 10 individuals/0.25 m^2.

Acanthomysis quadrispinosa collected during the night was higher than that during the day (Figure 4). The ANOVA for density of *A. quadrispinosa* (Table 2) shows a highly significant effect of time of sampling ($p<0.01$). The mean number of this species captured during the day and night were 93 and 1,554 individuals/0.25 m^2, respectively. *A. quadrispinosa* contributed more than 99% of the total mysid density in this study, thus it strongly influences the analyses results. The effect of station and the interaction were not significant ($p>0.05$).

The ANOVA for species richness (Table 2) showed no significant effects of sampling period, station and the interaction between the two ($p>0.05$). Generally, night sampling captured a higher number of species than day time sampling, with the exception of Station B.

The ANOVA for diversity index (H') and evenness index (J') (Table 2) both gave no significant effects of sampling period, station and the interaction ($p>0.05$). Generally, the diversity and evenness indices of the entire sampling were definitely affected by the dominant species, *A. quadrispinosa*. However, the diversity index (H') is quite variable (Table 1). This may be due to the differences in relative abundance of the species. The highest species diversity index ($H'=0.9662$) was in the day sample at Station A which is due primarily to an even distribution of individuals among the 6 species present ($J'=0.4029$).

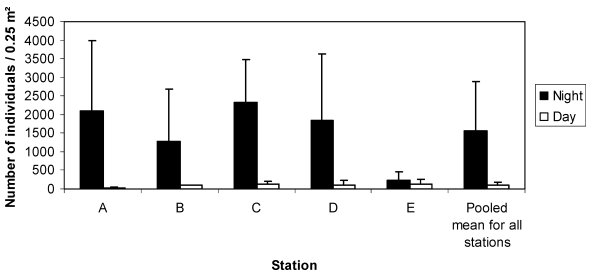

Fig. 3. Mean day and night mysid densities (ind/0.25 m^2) at each station.

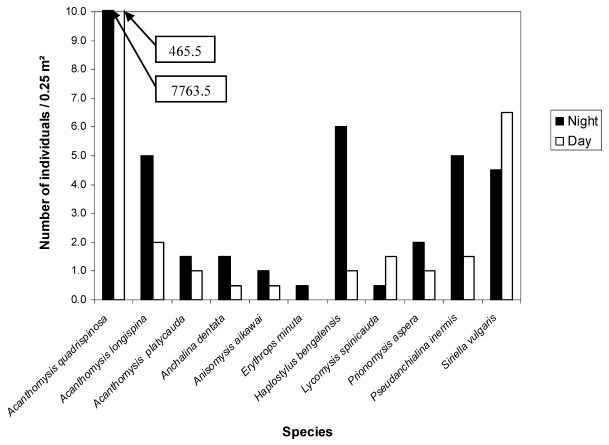

Fig. 4. Pooled day and night densities (ind/0.25 m^2) of each mysid species.

Table 2. Analyses of variance for the effects of sampling period, station and the interaction between sampling period and station on total density, density of *A. quadrispinosa*, species richness, diversity index (H') and evenness index (J').

Source of variation	d.f.	Mean squares				
		Total density	Density of *A. quadrispinosa*	Species richness	Diversity index	Evenness index
Sampling period	1	10687220**	10666762**	8.45	0.1426	0.0248
Station	4	683824	683248	2.50	0.0327	0.0057
Interaction	4	715861	717261	0.70	0.0296	0.0052
Error	10	1014572	1004662	4.85	0.0570	0.0099

** ($p<0.01$)

Discussion

Emergence trap was originally designed to collect the fauna that emerged from the substrate or near bottom habitat (Porter and Porter 1977). This method is advantageous to collect the integrated sample of animals that emerge from the bottom and near bottom habitat at a given area of the water column, while information about vertical and horizontal extent of their migrations were difficult to obtain. In particular, most mysids are well known to show the large extent diel horizontal migration as well as vertical migration (Mauchline 1980). Remarkable increase of mysid (*Acanthomysis*) abundance at night observed in this study would be partly explained by their nocturnal horizontal migration at near bottom habitat from outside of the sampling site especially during the replacement of trap between day and night sampling cycle. Nevertheless, we consider that results in this study represent a general pattern of vertical migration of mysid fauna in the seagrass bed in terms of diel cycle.

The present study is strongly affected by diel migration behaviour of mysids. Mysid migrations ordinarily exhibit variation with time, temperature, intensity and vertical extent, seasonality, nightly differences and tidal cycles. Light intensity might be the main controlling factor of vertical migrations of many mysids (Gal et al. 1999). This phenomenon was proved to exist by Kouassi et al. (2006). In their study, they discovered that moonlight affected the density of mysids in the water column. The greater number of mysids captured at night in the present study might be caused by the total absence or a weak amount of moonlight as the phase of the moon was new and waxing crescent during the sampling period.

Prey searching behavior may be another reason. Some studies showed that mysids migrate into the water column at night to feed upon zooplankton as the zooplankton densities are higher in the water column during night time, while they stay at the bottom during day time to utilize the detritus near the bottom (Rudstam et al. 1989, Kouassi et al. 2006). In addition, the mysids remaining at the bottom during day time to avoid from being detected by predators such as planktivorous fish probably contribute to the extremely low number of mysids captured in day time samplings (Alldredge and King 1980).

Mysids have well-developed eyes which help them to locate members of the same species and swim in swarms to find suitable habitats (Nilsson and Modlin 1994). Their good vision may help them in forming very organised swarms during the day near the rocks on sandy bottoms or edge of corals (Ohtsuka et al. 1995), suggesting that the distribution range may be patchy during the day, possibly resulting in low number of catch with high variability. On the other hand, the swarms would be loose at night and extended to seagrass bed, resulting in high number of catch at night. However, they would keep certain aggregation even at night. Zalina and Othman (1994) stated that the mysids collected by emergence traps were often composed of only a single species with a large number of individuals. In addition, their developed eyes might allow them to avoid traps during the day causing the low number of daytime capture.

In this study, juveniles, immature and mature individuals of this species were found in the samples, including females with eggs and larvae. The occurrence of mixed age group within swarms of this species might aid in protecting the individuals and populations against predators as well as maintaining the population (Mauchline 1980). The maintenance of the population number could be achieved by the presence of gravid females in swarms by immediate release of the young from the marsupium.

The number of species obtained in the present study was higher in comparison with the other studies. For instance, Barberá-Cebrián et al. (2002) recorded 7 species in fragmented seagrass habitats on the Mediterranean coast. Their study covered four different habitats which included the meadows of *Posidonia oceanica* and *Cymodocea nodosa*, the edge of *P. oceanica* meadow and sandy substrates. Ledoyer (1962) cited only four species of mysids on shallow bottoms with seagrass and algae in the French Mediterranean while Maj and Taramelli (1989) cited eight species found in the Italian *Posidonia* meadows. Zalina and Othman (1994) obtained 24 species by using the emergence trap in the fringing reef area at Cape Rachado, west coast of Peninsular Malaysia. However, the samples were taken with a wider mouth area (1 m^2) and a smaller mesh size (40 μm). The large variation in species richness and abundance of mysids obtained in these studies were probably influenced by different seagrass coverage and composition as well as the efficiency of various mysid capture methods. In addition, the mysid species also show different degrees of relationship with the substratum (Wittmann 1977).

All of the 11 species obtained from the samplings are new records for Pulau Tinggi, east coast of Peninsular Malaysia. However, some of the species had been previously recorded in the west coast of Peninsular Malaysia. Tattersall (1965) had identified 18 species from samples of plankton collected in the northern region of the Malacca Strait. Four species found in the present study, namely *S. vulgaris*, *H. bengalensis*, *Anchialina dentata* and *E. minuta*, had previously been recorded by Tattersall (1965). Of the species collected by Zalina and Othman (1994), *H. bengalensis*, *E. minuta* and *A. platycauda* were also present at Pulau Tinggi. Mysids from the subfamily Rhapalopthalminae, which were obtained by both Tattersall (1965) and Zalina and Othman (1994), were not found in the present study.

Key to the mysid species from Pulau Tinggi

As all of the mysid species are new records for Pulau Tinggi, a key to the mysid species of this study area is prepared for future reference.

1a. Exopod of uropod 2 segment (Subfamily: Siriellinae) .....*Siriella vulgaris* (Hansen 1910)
1b. Exopod of uropod unjointed 2
2a. Exopod of uropod with outer margin armed with spines (Subfamily: Gastrosaccinae) 3
2b. Exopod of uropod with outer margin armed with setae (Subfamily: Mysinae) 5
3a. Postero-lateral part of carapace expended into large rounded lobe .....*Haplostylus bengalensis* (Hansen 1910)
3b. Posterior margin of carapace straight or feebly emarginate..... 4
4a. Exopod of uropod with many spines along outer margin .....*Anchialina dentata* (Pillai 1964)
4b. Exopod of uropod with single distal spine at distrolateral corner .....*Pseudanchialina inermis* (Illig 1906)
5a. Antennal scale with outer margin non-setose and serrate with denticles.....*Erythrops minuta* (Hansen 1910)
5b. Antennal scale with setose outer margin.....6
6a. Four posterior pairs of male pleopods usually well developed and biramous.....*Prionomysis aspera* (Ii 1937)
6b. At least second pair of male pleopods rudimentary and uniramous, exopod of the fourth male pleopod elongate and modified.....7
7a. Telson with cleft .....*Anisomysis aikawai* (Ii 1964)
7b. Telson without cleft.....8
8a. Second segment of mandibular palp without dentation .....*Acanthomysis platycauda* (Pillai 1961)
8b. Second segment of mandibular palp with dentate 9
9a. Apex of telson with 3 pairs of long spines ....*Acanthomysis longispina* (Fukuoka and Murano 2002)
9b. Apex of telson with 2 pairs of long spines.....10
10a. Long and short spines on dorsal and along lateral margin of telson .....*Lycomysis spinicauda* (Hansen 1910)
10b. Long and short spines along the lateral margin of telson .....*Acanthomysis quadrispinosa* (Nouvel 1965)

Conclusion

Eleven species of mysids were captured in this study and all of them were new records from Pulau Tinggi, Johor. The study showed significantly higher numbers of mysids captured during the night than the day which may be due to diel vertical migration. This phenomenon was observed at all the stations sampled. *Acanthomysis quadrispinosa* was the most dominant species. The distribution and abundance of this species highly influenced diversity and evenness at each station. This species also showed significant difference between day and night samplings, being more abundant during night time. The overwhelming abundance of this species is probably due to swarming behavior. Consequently, this study shows that mysids are an important component as emerging fauna from bottom to water column at night. Further investigations into their vertical and horizontal migration patterns in relation to their life history, feeding and predator, would reveal their role in the ecosystems.

Acknowledgements

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