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RESEARCH ARTICLE

Factors influencing the distribution of Mysids (Crustacea: Mysida) in the Negombo lagoon, Sri Lanka

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Abstract: Mysids are minute crustaceans that occur in large numbers in estuarine waters. Their significant role as a main food source for fish populations is becoming apparent. There is currently, limited information on mysids in Sri Lankan estuarine waters. The present study investigated the distribution of mysids in the Negombo Lagoon from June 2012 to May 2013 at 18 randomly selected- sites along the lagoon. Surveys were conducted along the boundary of the lagoon, during day time, using a dip net (opening of 25 × 20 cm^2) with 500 µm mesh size. The spatial distribution survey recorded 11 mysid habitats. *Mesopodopsis zeylanica*, and a potentially new *Siriella* sp. were identified, *M. zeylanica* being the most abundant species. Survey of temporal variation in mysid abundance was also carried out at two sites for a six-month period. Mysid species did not show any temporal variation and the distribution and abundance was not affected by any single environmental factor. The spatial distribution of mysids along the lagoon boundary was found to depend mainly on the estuarine boundary conditions. Mangrove vegetation along the estuarine boundary was found to be favorable for mysids while concrete boundaries and accumulation of garbage along boundaries were found to be unsuitable.

Keywords: boundary vegetation, distribution; estuarine, mangroves, mysid species.

INTRODUCTION

Mysids are small aquatic crustaceans that have a worldwide distribution and show high abundance in estuarine waters (Scharf and Koschel, 2004; Fockedey *et al*., 2006; Suzuki *et al*., 2009, Punchihewa and Krishnarajah 2013a). Consequently, they serve as a major food source for ecologically and commercially important fish species which use estuaries as nursery grounds. Therefore, they have become an important link in estuarine food chains (Vilas *et al*., 2008; Mantiri *et al*., 2012; Punchihewa and Krishnarajah 2013b; Punchihewa, 2015) capable of energy transfer towards higher trophic levels. Mysids are also important bio indicators in brackish waters (Punchihewa *et al*., 2017). Due to their ecological significance in estuarine waters worldwide, it is important to understand the distribution and abundance of native estuarine mysid species in the most productive lagoon, the Negombo lagoon, in Sri Lanka. The Negombo lagoon is of vital importance to the fishery industry as it provides nursery, spawning and feeding grounds for juvenile fish and crustaceans (Pinto and Punchihewa, 1996) This is facilitated by the heterogeneity of habitats, such as sea grass beds, reed beds, mangroves etc. that enhance the biodiversity of the lagoon.

The distribution of mysids in estuarine waters is known to depend on several factors. In the Westerschelde estuary, Netherlands, salinity is the predominant governing factor in the spatial distribution of mysids (Rappé *et al*., 2011). Further Biju *et al*. (2009) reported that population density of mysids was influenced by temperature, chlorophyll concentration, dissolved oxygen and salinity in the Cochin estuary, India. According to Punchihewa *et al*. (2017), mysid distribution in the Bolgoda lagoon, Sri Lanka is mainly governed by stream edge conditions, where estuarine boundaries with natural vegetation provide the most suitable mysid habitats while the polluted conditions and man-made boundaries (concrete) are not suitable habitats for them.

A few studies have been carried out on the distribution of mysids in estuarine waters in Sri Lanka. The very first record of *Mesopodopsis zeylanica* Nouvel 1954 was made by Nouvel (1954) from the Bolgoda lagoon. The same species was subsequently recorded from the same location by Punchihewa *et al*. (2017). However, no published information currently available on the mysid community in the Negombo lagoon. Hence, the present study provides the first documented information on mysid species inhabiting the Negombo lagoon and their spatial and temporal distribution.

METERIALS AND METHODS

The study was conducted in the Negombo lagoon, situated on the west coast within the Wet zone of Sri Lanka (latitude: 7°09'N, longitude 79°51'E) and runs parallel to the west coast from the north to the south along the Muthurajawela marsh. The main freshwater sources, Ja Ela, Dandugam Oya and the Hamilton canal, falls at the southern tip of the lagoon and connects to the sea at its northern end through a single narrow opening.

The present study examines two aspects related to mysids: a spatial distribution survey around the lagoon and

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a temporal distribution survey over a six-month period from July 2012 to December 2012, at two sites, Liyanagemulla and Kadolkele. These two sites were selected following initial reconnaissance surveys, during which relatively high numbers of mysids were recorded. Liyanagemulla which has a patchy distribution of mangroves, is situated in between the lower and mid estuary. All mangroves adjoining this site were cleared along the water front for landfill for highway developments. Kadolkele is situated closer to the upper estuary and has an extensive mangrove belt. The survey to determine the spatial distribution was conducted on different occasions; from June 2012 to May 2013 at 18 randomly selected sites, to cover a considerable area of the lagoon (Figure. 1, Table 1). At each site, four transects (each of 10 m length, 10 m apart) were established along an 80 m stretch of the estuarine bank along the boundary of the lagoon. Hence, four replicate samples were taken (10 m length x 4).

Mysid surveys were conducted along the boundary of the lagoon during the day time (≈9.0-11.30am) and samples were obtained using a dip net of circumference of 25 × 20 cm^2 and 500 µm mesh size. Samples were preserved in 70 % ethyl alcohol. Water parameters; salinity, pH, dissolved oxygen (DO), water temperature were measured at each sampling event, using WTW 400i Multi-Parameter Water Quality Field Meter, Geotech Environmental Equipment, USA. Boundary conditions such as, man-made concrete boundary, presence of mangrove vegetation, *Eichhornia crassipes*, and garbage at each sampling site and water level were also recorded. Morphological characteristics were analyzed in the laboratory to identify the mysid species.

STATISTICAL ANALYSES

The mean and standard deviation of abundance values (temporal distribution) were calculated. The variations among them were inferred through a series of one-way Analysis of Variance (ANOVA) tests considering the site, month and species separately as factors. The mean separation was done using Tukey's Honestly Significant Difference (HSD). The factors that affect the distribution of mysid species and their abundance were determined using Pearson correlation Coefficient.

RESULTS

Spatial Distribution Survey

Of the 18 sites surveyed, mysids were present only in 11 sites (Table 2). Only two mysid species, *Mesopodopsis zeylanica* Nouvel 1954, and a potentially new *Siriella* sp. were identified. *Mesopodopsis zeylanica*, inhabited seven sites as a single species and, both species were found sympatrically in another three sites. *Sirella* sp. was found as a single species only in one sites. Of the two species recorded *M. zeylanica* was the widely distributed and the dominant species found in the Negombo lagoon (Table 2 & 3). The sites where mysids were recorded, had patchily or widely distributed mangrove boundaries, whereas sites where mysids were absent had man-made concrete edges, areas with household pollutants and prevalence of *Eichhornia crassipes* (Mart.) Solms.

Table 1: Qualitative description of sampling sites, Negombo Lagoon.

Study site	Location (GPS)	Ecological profile of the stream	Presence of garbage
Duwa 1	7°202390'N, 79°829416'E	Boundary filled with large stones	Yes
Duwa 2	7°206902'N, 79°826206'E	Boundary filled with large stones	Yes
Munnakare	7°192295'N, 79°832819'E	Mangrove belt	No
Kadolkele	7°196494′N, 79°850328'E	Mangrove belt, Sea grasses	No
Kurana 1	7°191848'N, 79°853654'E	Mangroves- patchy distribution	No
Kurana 2	7°189213'N, 79°854432'E	Mangroves- patchy distribution	No
Katunayake 1	7°175243'N, 79°862196'E	Man-made concrete edges	Yes
Katunayake 2	7°166215'N, 79°866507'E	Mangroves- patchy distribution	No
Katunayake 3	7°159265'N, 79°867986'E	Man-made concrete edges	Yes
Liyanagemulla	7°148420′ N,79°867000'E	Mangrove belt, Sea grasses	No
Seeduwa 1	7°135855'N, 79°869136'E	*Eichornia crassipes*	No
Seeduwa 2	7°119979'N, 79°862560'E	*Eichornia crassipes*	No
Kepumgoda	7°121210'N, 79°845380'E	Mangroves- patchy distribution	No
Rajawatta	7°135180'N, 79°838510'E	Mangrove belt	No
Dunagalpitiya	7°147127'N, 79°837018'E	Man-made concrete edges	Yes
Talahena	7°158350'N, 79°832150'E	Mangrove belt	No
Basiyawatta	7°175390'N, 79°825050'E	Mangrove belt	No
Pitipana	7°195890'N, 79°827170'E	Mangroves	No

Table 2: Distribution and of mysid species in different study sites.

Sites where mysids were recorded	Mysid species		Sites where mysids were not recorded
	M. zeylanica,	*Siriella sp.*	
Munnakare	P		Duwa 1
Kadolkele	P	P	Duwa 2
Kurana 1	P		Katunayake 1
Kurana 2	P		Katunayake 3
Katunayake 2	P		Seeduwa 1
Liyanagemulla	P	P	Seeduwa 2
Kepumgoda	P		Dunagalpitiya
Rajawatta	P		
Talahena	P	P	
Basiyawatta	P		
Pitipana		P	

P = presence of mysids

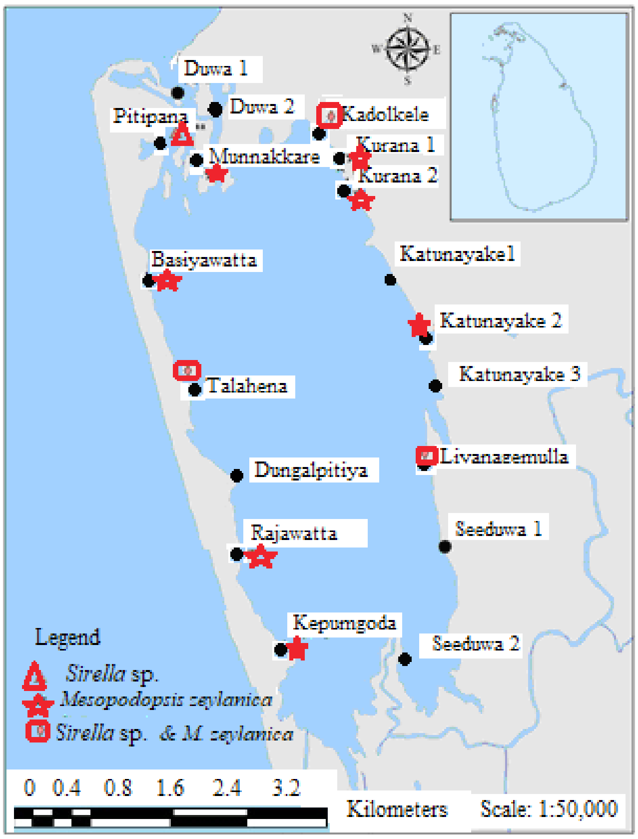

Figure 1: Distribution of mysid habitats, Negombo Lagoon.

Table 3: Number of individuals of *M. zeylanica* and *Sirella sp.* collected from different study sites (Except temporal distribution survey).

Site	Boundary vegetation	No of individuals	
		M. zeylanica	***Sirella sp.***
Munnakkare	Mangrove	16	
Talahena	Mangrove	36	07
Kurana 1	Mangrove	27	
Kurana 2	Mangrove	35	
Kepumgoda	Mangrove	14	
Basiyawatta	Mangrove	14	
Katunayake	Mangrove	19	
Rajawatta	Mangrove	20	
Pitipana	Mangrove	-	10

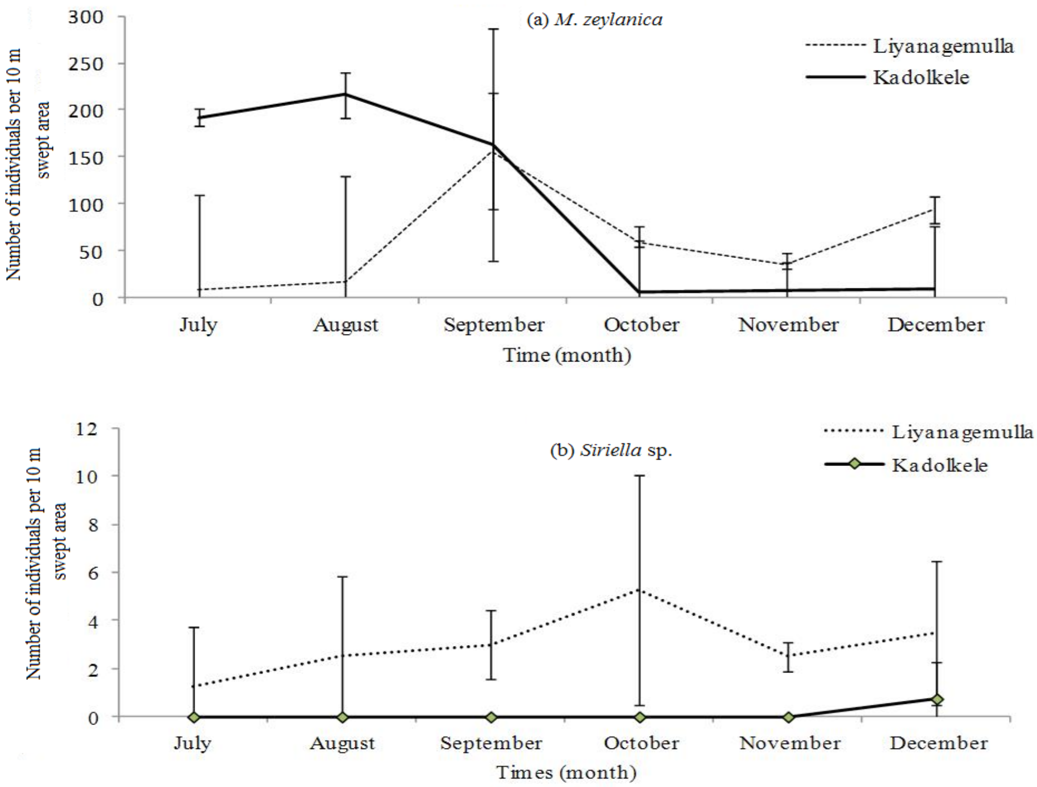

Figure 2: Monthly variation of mean (± SD) abundance (n = 4) of mysid species, (a) *M. zeylanica* (b) *Siriella* sp. in Negombo lagoon.

Temporal Distribution Survey

Both *M. zeylanica* and *Siriella* sp. were encountered at Kadolkele and Liyanagemulla sites. *Mesopodopsis zeylanica* was the most common mysid species found at both sites over the six months of the survey period at these two locations (Figure 2). *Siriella* sp. was recorded only once (in December) at the Kadolkele site and only three individuals were collected, whereas at Liyanagemulla this species was recorded in each of the six months (Figure 2). A total of 72 individuals of *Siriella* sp. were collected from Liyanagemulla during July to December with the abundance being low at all times (Figure 2).

A total of 2371 *M. zeylanica* individuals were collected over a six month period at Kadolkele site. A major peak in the density of this species was apparent in August while the numbers continued to decline to reach low values during October to December (Figure 2). A total of 1473 *M. zeylanica* were collected from Liyanagemulla. The number of individuals was initially low and subsequently fluctuated markedly over the monitoring period; peaks in September and December (Figure 2), although no clear, recurring temporal trend is apparent.

There was a significant temporal vairation in the mean abundance of *M. zeylanica* over the six months period at both Kadolkele and Liyanagemulla (Table 4). Tukey test

Table 4: Synopsis of significance/non-significance in variation of mysid numbers among months and between sites.

Species	Site	F value	Df	Significance/non-significance
All mysids	Kadolkele	9.21	05	s
	Liyanagemulla	2.71	05	s
	Both sites	1.51	01	ns
M. zeylanica	Liyanagemulla	2.76	05	s
	Kadolkele	9.23	05	s
Siriella sp.	Liyanagemulla	0.83	05	ns
	Kadolkele	1.00	05	ns

ns = not significant, s = significant at $P \leq 0.05$, Df = degrees of freedom.

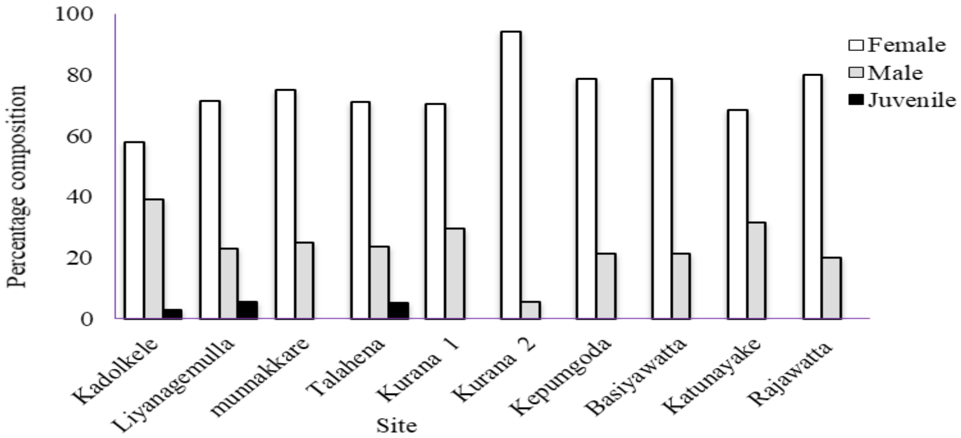

Figure 3: Percentage composition of male, female and juveniles in each site.

Table 5: Pearson correlation coefficients (r) of bivariate analysis of the environmental parameters, stream edge condition, and .presence of garbage on mysid availability

	pH	Do	Salinity	Water temperature	Air temperature	Pollution	Boundary condition
Mysid availability	0.303	0.471	0.269	0.031	-0.144	-0.789	0.976
Significance	ns	ns	ns	ns	ns	s**	s**

** significant at $P \leq 0.01$, ns = not significant, s = significant, Do = dissolved oxygen

confirmed that the mean abundance values of *M. zeylanica* over July to September being significantly higher than that recorded from October to December at Kadolkele while the abundance in September and December was significantly higher than that in July and August at Liyanagemulla.

Data from both sites showed that there was no significant temporal variation in mean abundance of *Siriella* sp. across months (Table 4). But taking individual locations, considering the abundance of all mysids, the temporal differences were significant at both locations ($P \leq 0.05$) (Table 4).

Percentage composition of male, female and juveniles collected from each site (Figure 3) has shown that female composition was always higher than males.

The environmental parameters recorded during the monthly survey is given in Figure 4. During the monitoring period, water temperature fluctuated between 26 °C and 34 °C. Dissolved oxygen levels were generally between 6.0 mg L^{-1} and 8.4 mg L^{-1} at all sites. The pH values varied throughout the sampling period at all sites, generally ranging from 6.4 to 7.8. Salinity recorded at Liyanagemulla consistently lower than at Kadolkle.

The correlation among the environmental parameters, condition of the boundary, and presence of garbage with the availability of mysids is shown in Table 5. It shows that the occurrence of *M. zeylanica* is strongly and positively correlated with the boundary condition ($P \leq 0.01$) and negatively correlated with presence of garbage ($P \leq 0.01$). There was no direct correlation of the availability of mysids with any of the tested environmental parameters. Here boundary condition was assessed through the presence of natural boundary vegetation (mainly mangroves) and the absence of *Eichhornia crassipes* or garbage, and lack of a concrete boundary. It was observed that mysid habitats were found mainly within the vicinity of mangrove

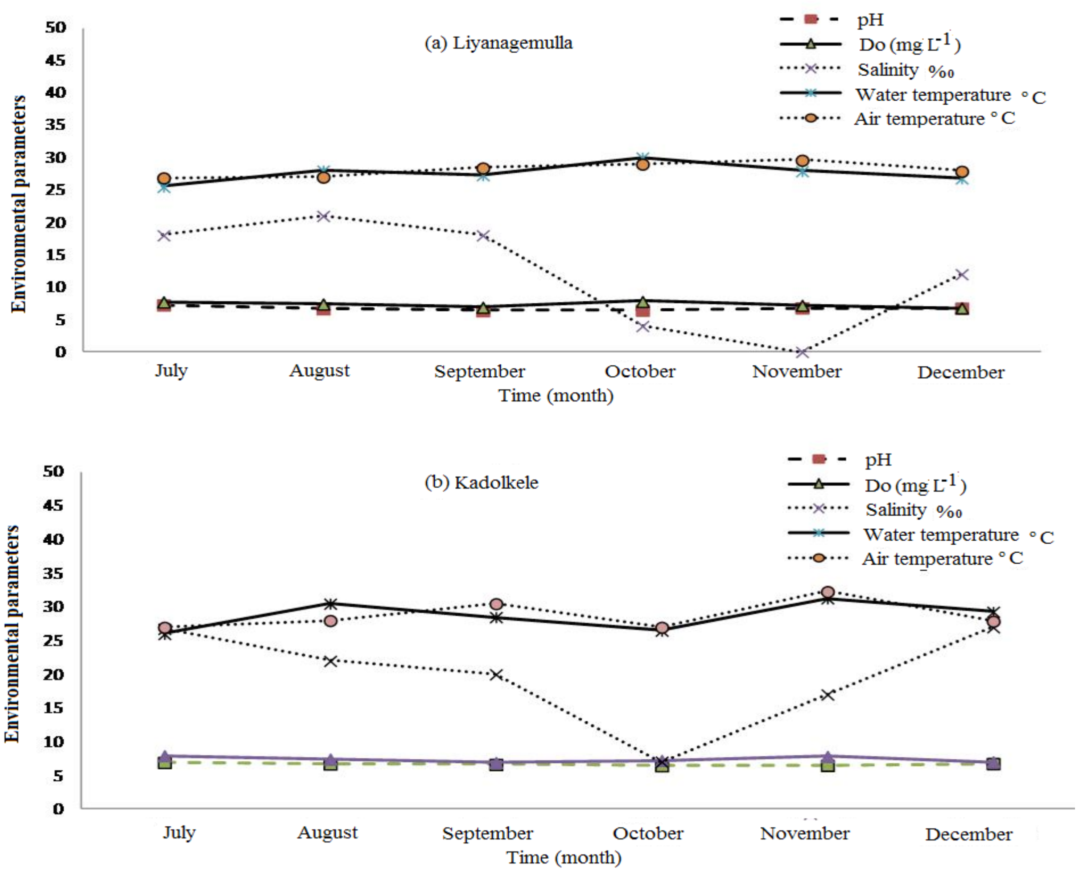

Figure 4: Monthly variation of environmental parameters, in study sites, (a) Liyanagemulla (b) Kadolkele.

Table 6: Pearsons correlation coefficients (r) between mysid abundance and environmental Parameters.

	pH	Do	Salinity	Water temperature	Air temperature	Water level
Mysid abundance	-0.042	-0.069	0.202	-0.163	-0.023	-0.449
Significance	ns	ns	ns	ns	ns	s*

*significant at $P \leq 0.05$, Do = dissolved oxygen, ns = not significant, s = significant

vgetation and none with the other areas.

The correlation among the environmental parameters on mysid abundance is given in Table 6. None of the environmental parameters had significant correlation with mysid abundance and the distribution ($P > 0.05$). A negative correlation ($P \leq 0.05$) between mysid abundance and the water level indicating that lower water levels are more favourable for mysids.

DISCUSSION

The occurrence of mysids in the Negombo lagoon was associated with the presence of extensive mangrove forests along the banks of the estuary indicating that these habitats are favourable. The Kadolkele site which supported the highest numbers of mysids has a relatively healthy mangrove forest. Of the two mysid species recorded *M. zeylanica* was the dominant species in this lagoon. This may be due to its high environmental suitability or fulfilment of its niche requirements within the lagoon. However, both species occurred sympatrically at three of the sampled sites. This study recorded the potentially new *Sirella* sp. for the first time in Sri Lankan estuarine waters.

Nouvel (1954) reported the presence of *M. zeylanica* in the Bolgoda lagoon and Punchihewa *et al*. (2017) recorded this species in the same lagoon after a lapse of 58 years, most likely because no surveys had targeted this taxonomic group. Although this species was originally reported from Sri Lanka, it was subsequently identified from similar habitats in India (Biju & Panampunnayil, 2010; Verlecar *et al*., 2012).

Although temporal variations in species abundance were not evident at both Kadolkele and Liyanagemulla in the Negambo lagoon, in Cochin backwater in India, mysid abundance was associated with the monsoon period (Biju *et al*., 2009). Another study carried out in the Hooghly estuary in India, found that mysid abundance weakly correlated with the monsoon seasons (Sarkar & Choudhury 1986). However, the present study is consistent with that of Hanamura *et al*. (2009) which showed that stable water temperature reduced the seasonality of mysids in tropical shallow-waters. Also, it is possible that short duration of the present study has not shown a temporal variation of mysid abundance in Negombo lagoon where water quality exhibits drastic variations (Gammanpila *et al.,* 2019).

In the present study it was clear that the mysid distribution in the Negombo lagoon was not governed by any single environmental factor. However, Biju *et al*. (2009) reported that the population density of mysids in the Cochin estuary, India was influenced by several factors including temperature, chlorophyll concentration, Do and salinity. In the present study, it was clearly shown that low water levels directly influenced the abundance of mysids which agrees with the findings for *Neomysis integer* (Hampel *et al*., 2003) in an intertidal salt marsh creek, Netherlands. Mysids become concentrated at the water's edge at low tide and the populations become dispersed again throughout the intertidal area on the following high tide (Connell, 1974). The present analysis has shown that mysid distribution mainly depends on the estuarine boundary condition and this is supported by the study in Bolgoda lagoon in Sri Lanka (Punchihewa *et al*., 2017). Low water levels and natural vegetation (mainly mangroves) of the estuarine boundary provide suitable conditions for the occurrence of mysids, while polluted or concrete banks are unsuitable.

Although Sri Lanka has a rich biodiversity, the Sri Lankan mysid species have not been listed under crustaceans, mostly likely due to the lack of knowledge on these taxa. The findings of the present study would therefore provide much needed information towards conservation of the mysid species.

The clearance of mangroves was apparent in Liyanagemulla due to the landfills for highway development projects. The exposed estuarine boundary is subjected to considerable erosion from strong currents as well as a result of tidal impacts. Therefore, to conserve the biodiversity of the lagoon, and also can perhaps be enhanced through replanting of mangroves along the boundary, mainly where heavy destruction of mangroves has occurred.

CONCLUSION

Present study recorded two mysid species, *Mesopodopsis zeylanica*, and a potentially new *Sirella* sp. Among the two species, *M. zeylanica* was the dominant species in this lagoon. Distribution of mysids in Negombo Lagoon depends on the estuarine boundary condition and tidal amplitude. The natural vegetation (mainly mangroves) of the estuarine boundary provides suitable conditions for the occurrence of mysids, while polluted or concrete banks are unsuitable.

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