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Life history and reproductive biology of four estuarine mysid species in Sri Lanka

Neetha Nandanie Punchihewa
Department of Zoology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka

Abstract
Mysids were collected at nine estuarine waters (Negombo, Chilaw, Bolgoda, Mundal, Puttalam, Kalpitiya, Arippuwa, Achchankulam and Mannar) during March 2012 to July 2013. Three common species, *Mesopodopsis orientalis*, *Mesopodopsis zeylanica* and *Sirella srilankensis*, and one rare species, *Anisomysis srilankensis* were studied. The common species were studied in detail. Their females predominated over males and breeding occurred throughout the year. A significant positive correlation existed in relation to the abundance of *M. orientalis*, brooding females with salinity, temperature, pH, and adult females with rainfall while males only had a positive correlation with salinity. The larger species, *M. orientalis* showed higher brood size and higher egg diameters than smaller species. *Mesopodopsis zeylanica* possessed more broods in low salinity than in hyper saline conditions. The opposite was true for *M. orientalis* and *S. srilankensis*. The smaller species, *M. zeylanica* had the longest incubation time compared to the larger species, *M. orientalis* and *S. srilankensis*. Maximum brood sizes recorded for *M. zeylanica*, *M. orientalis*, *S. srilankensis* and *A. srilankensis* were 13, 16, 15 and 7 respectively. Males were found to reach maturity at a smaller size than females. The longest incubation time of 7–8 days was shown by the smaller species *M. zeylanica*, while the larger species, *M. orientalis* and *S. srilankensis* it was 5–6 days and 6 days respectively. All species produced overlapping generations. *S. srilankensis* was able to produce 7–10 successive broods within its lifetime with a life span of nearly 3–4 months. *M. zeylanica*, and *M. orientalis* were able to produce five and six successive broods within their life span respectively, and they lived ≈ 3–4 months and ≈ 4–5 months respectively. Growth rate of *S. srilankensis* was found to be the highest in juvenile and sub-adult stages. Site specific differences of brood size for a particular species was mainly dependent on the salinity of the water body.

Keywords: brood size, development, generations, growth, mysids

Introduction

Mysids play a significant ecological role in estuarine food chains because they are consumed by many juvenile fish (Punchihewa and Krishnarajah, 2013; Mantiri *et al*., 2012; Punchihewa and Silva, 2019) [14, 8, 17]. In Sri Lanka, limited studies have been carried out on mysids. However, the first estuarine mysid species to be recorded in Sri Lanka, *Mesopodopsis zeylanica* (Nouvel, 1954) [10], was studied in the Cochin backwaters of India (Biju and Panampunnayil, 2010) [1] and it was found that their reproduction was continuous. Similar studies in India showed that *Mesopodopsis orientalis* breeds throughout the year (Biju and Panampunnayil, 2011) [3]. The same species in Penang Island, Malaysia (Hanamura *et al*., 2009) [5], also showed breeding occurring continuously throughout the year.

Studying the reproductive biology, brood size, incubation period are also important aspects to investigate further. There is evidence that brood size varies among different species as well as the same species inhabiting separate locations. In Indian estuarine waters, it was reported that the brood size for *M. orientalis* varies with the site; it was 8 from Mebok estuary (Hanamura *et al*., 2008) [4], 8–10 from a tropical mangrove estuary (Nair, 1939) and it was 6–18 from Versova mangrove (Biju and Panampunnayil, 2011) [3]. In the coastal waters of Mumbai, *M. orientalis* showed higher brood size (6–29) (Panampunnayil, 1999) [2] than estuarine waters in Malaysia (24) (Hanamura *et al*., 2009) [5]. Although *M. zeylanica* and *M. orientalis* were recorded from several countries, the length of their incubation period and complete life history were not extensively studied.

Due to lack of mysid studies in Sri Lanka, it is important to identify their ecology and biology. There are only some distributional studies that were investigated in Sri Lanka (Nouvel, 1954; Punchihewa *et al*., 2017; Punchihewa and Krishnarajah, 2019; Punchihewa, 2020, Punchihewa, 2021) [10, 16, 17, 12, 13]. Furthermore, the importance of mysid contribution to the estuarine food web was also studied by Punchihewa and Silva (2019) [17] in Sri Lanka. The object of the present study was to describe the life history and reproduction of Sri Lankan mysids and was also the first quantitative account of larval development of *M. zeylanica* and *M. orientalis*. More detailed field and laboratory studies were conducted to identify the reproductive biology and life history of common mysid species in Sri Lanka.

Materials and Methods

Mysid samples which were collected monthly during July to December 2012, from Negombo, Chilaw, and Puttalam lagoons. Continuous spatial distributional surveys from nine estuarine waters (Negombo, Chilaw, Bolgoda, Mundal, Puttalam, Kalpitiya, Arippuwa, Achchankulam and Mannar) were also collected during March 2012 to May 2013 (Punchihewa *et al*., 2017; Punchihewa and Krishnarajah, 2019) [16]. These studies were considered for the reproductive biology and life history studies. The data, such as body length, sex, reproductive state of each mysid and brood size of gravid females was gathered. The reproductive states of the mysids were further classified as juveniles, immature males and females, adult males and females, gravid females and post-spawned females based on

Punchihewa (2018) [11]. The number of larvae, and their development stages such as stage I (egg), stage II and stage III within the marsupium were also noted.

Mysids samples were collected for culture experiments to observe the development stages, during August 2012, from two main sites (Chilaw and Puttalam). Collected mysids were safely transferred to plastic buckets containing water from the collection site. They were taken to the laboratory and kept in aerated containers with water from the collection site for a day to recover from sampling stress, at room temperature of 27±1 °C. Intra-marsupial development period (incubation time) was studied for *M. zeylanica*, *S. srilankensis* and *M. orientalis* under the laboratory conditions, at 27±1°C (room temperature) and salinity 23 ‰.

Gravid females collected from the sampling sites were examined under the light microscope to determine the status of larvae within the brood. For all experiments, three replicate glass beakers (1000 ml) were used and were filled with 800 ml water with a continuous aeration. Water collected from the sampling site was used throughout the experiment. Culture beakers were maintained at 27±1°C in a temperature-controlled water bath. Water parameters: pH, dissolved oxygen, temperature, and salinity were monitored using WTW 3400i Multi-Parameter Water Quality Field Meter (Geotech Environmental Equipment, USA). Each day ammonia levels were monitored using an Ammonia Test Kit.

In each beaker, six mature females (gravid females & post-spawned females) and four males were held at 27±1°C for six weeks. To observe the intra-marsupial development from the initial egg stage, males were also kept in the beaker to allow for reproduction to obtain fresh eggs. Mysid stocking density and suitable sources of food were decided based on the preliminary investigations (Punchihewa, 2018) [11].

To distinguish the individual female mysids over the experimental period, mysids with different lengths were selected for each replicate beaker. Brooded females were examined under the light microscope daily to observe the stage of larval development in the marsupium. The number of days the larvae spent in each of the three developmental stages were recorded. Dead mysids were removed and replaced with new ones of known size (from the original sample). Mysids were fed with newly hatched Artemia. Approximately one third of the water was renewed daily and it was completely renewed every fourth day. Faeces and possible moults were removed daily.

Considering the lower survival rates of *M. zeylanica* and *M. orientalis* in repeated surveys and the high survival rate of *S. srilankensis* in the preliminary survey, the growth analysis of juvenile mysids (up to maturation) was undertaken only for *S. srilankensis.* Based on a preliminary survey, non-lethal stocking density of juvenile mysids was determined to be 15 juveniles per culture beaker (1000 ml). Juveniles released within 24 hours were selected at random for each replicate and their lengths were measured. Three replicate culture beakers were maintained at 27°C, salinity 23 ‰, each containing 15 juvenile mysids. Every four days, the total body length of each mysid was measured using a Sedgwick rafter cell, under the light microscope fitted with an eye piece micrometer. Experimental conditions were maintained as the above experiment.

Results

Sex ratio

The sex ratio was determined for the mysids which were collected during monthly survey, *S. srilankensis M. zeylanica*, and *M. orientalis*, based on their secondary sexual characteristics (Fig. 1a, 1b). Higher female dominance over males were observed. Similar results were observed within the *Anisomysis srilankensis* population collected during the distributional survey from Kalpitiya lagoon.

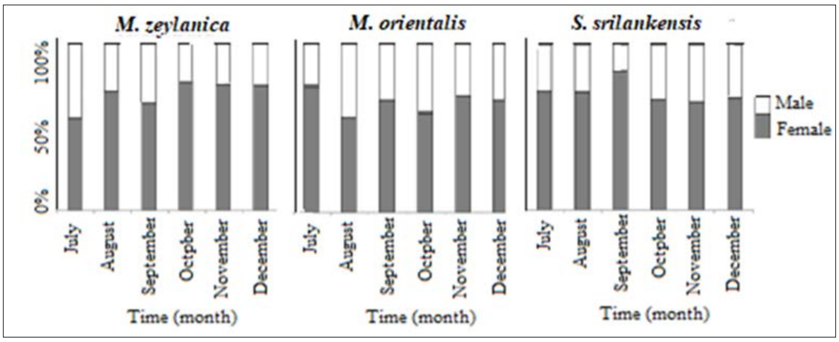

Fig 1a: Sex ratio of mysids collected over six months.

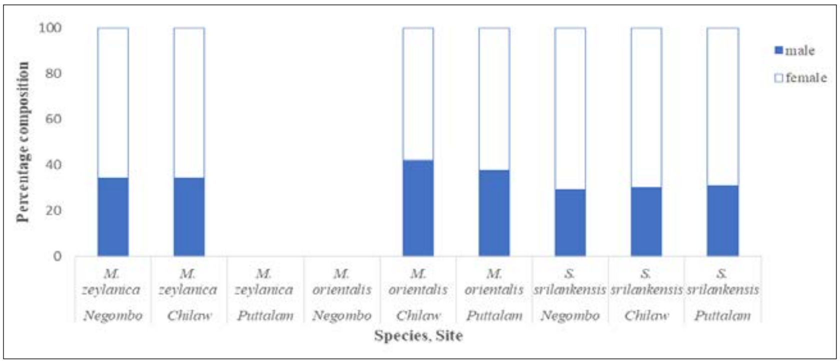

Fig 1b: Sex ratios for different species for different lagoons.

Population structure

It was observed that over the six-month period, the major proportion of the populations in all species were represented by the gravid females. In each population, the juvenile and sub-adult proportion was always lower than that of the adult populations (Figs. 2a, 2b).

In addition to the monthly sampling in all three species, gravid females were recorded from different lagoon sites (Bolgoda, Negombo, Puttalam, Chillaw, Kalpitiya, Mannar, Mundal, Achchanulam and Arippuwa), during March to June 2012, and January to May 2013. In consideration of pooled data, it is evident that in each species, gravid females were recorded throughout the survey period (Table 1).

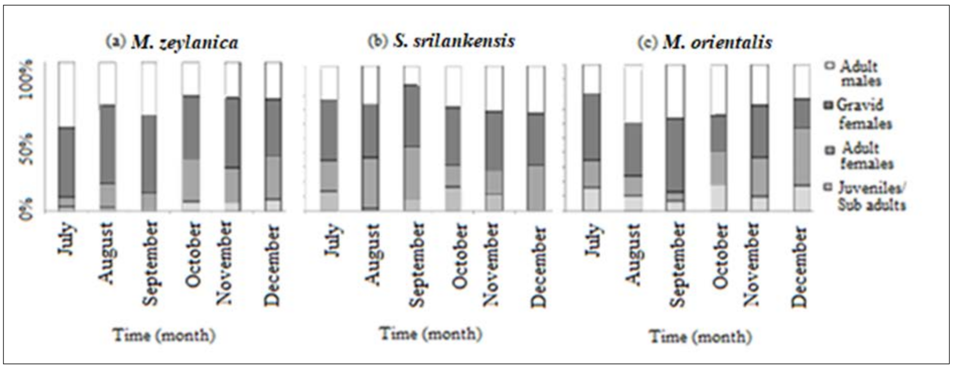

Fig 2a: Proportional population structure of mysids collected over six months.

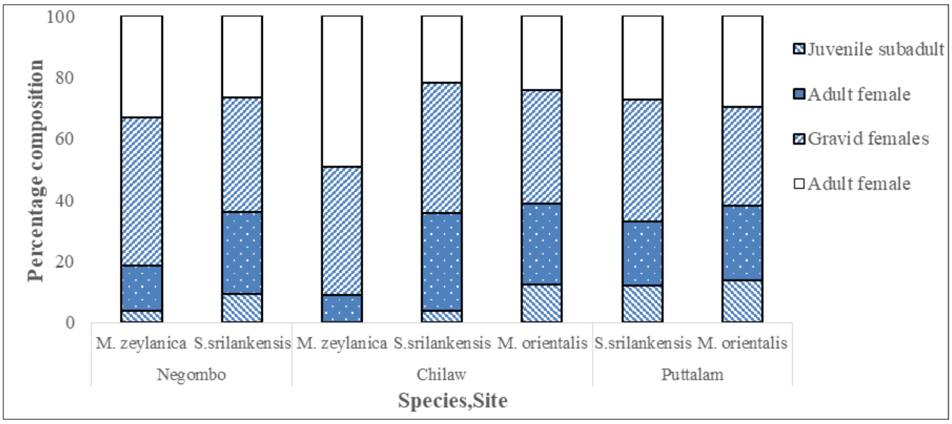

Fig 2b: Proportional population structure of mysids collected from different lagoons

Table 1: Number of gravid females recorded in each month (pooled data).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M. zeylanica	120	178	61	387	614	318	371	488	661	119	221	149
M. orientalis	36	33	50	242	60	242	56	37	60	33	41	38
S. srilankensis	23	36	12	46	19	20	25	20	13	20	26	09

The correlation of environmental parameters and the number of individuals from different life stages indicated that *M. orientalis* numbers are highly dependent on salinity, pH, temperature and rainfall ($p \leq 0.05$). The gravid female numbers increased with increasing salinity, temperature and pH, while male numbers increased with only increasing salinity.

Furthermore, juveniles and adult female numbers increased with the monthly rainfall ($p \leq 0.05$). Among the three mysid species, *M. zeylanica* is an exception and did not correlate with any of the environmental parameters whereas juvenile and sub adult populations of *S. srilankensis* numbers increased at high temperatures (Table 2).

Table 2: Correlation coefficients (r) of bivariate analysis of pooled environmental parameters on different life stages

		pH	DO mg L^{-1}	Salinity ‰	Tempe °C	Rainfall mm
M. orientalis	Juvenile/sub adult	0.068	-0.35	0.118	-0.04	0.516*
	Gravid females	0.588*	-0.204	0.547*	0.464*	0.098
	Adult females	0.024	-0.372	0.135	0.022	0.569*
	Male	0.270	-0.176	0.442*	0.196	0.429
M. zeylanica	Juvenile/sub adults	-0.085	-0.039	-0.203	-0.432	-0.042
	Gravid females	-0.186	-0.075	0.035	-0.306	-0.254
	Adult females	-0.217	-0.244	-0.272	-0.235	0.034
	Male	-0.019	-0.001	0.125	-0.332	-0.302
S. srilankensis	Juvenile/sub adults	0.217	-0.329	0.308	0.562**	0.158
	Gravid females	0.253	-0.347	0.134	0.275	0.125
	Adult females	0.242	-0.337	0.343	0.194	-0.237
	Male	0.231	-0.299	-0.110	0.097	0.227

* Significant at $P \leq 0.05$ level,** Significant at $P \leq 0.01$ level, Do=Dissolved oxygen Tempe=temperature

Brood size

Considering the four species recorded from different locations, *M. orientalis* was the largest mysid species (9.9 mm) recorded herein and it had the highest brood size while *A. srilankensis* was recorded as the smallest (4.0 mm) with the lowest brood size (Table 3).

There are site specific differences observed in the brood size for all three species in local populations (Table 3). The highest brood numbers for *M. zeylanica* were recorded from Achchankulam and Arippuwa (13). The decreasing order of brood size was recorded in Bolgoda (11), Chilaw (10), Negombo (10), Puttalam (9) and Kalpitiya (9) respectively. *M. orientalis* and *S. srilankensis* recorded the highest brood numbers from Puttalam lagoon (Table 3).

Table 3: Maximum length and the brood sizes of each species recorded from respective estuarine areas

	Minimum and Maximum brood size								
Site Salinity	Bolgoda 0–9 ‰	Negombo 0–28 ‰	Puttalam 23–56 ‰	Chillaw 0–33 ‰	Kalpitiya 10–55 ‰	Mannar 10–55 ‰	Mundal 10–53 ‰	Achchanulam 20–30 ‰	Arippuwa 30–35 ‰
Maximum length (mm)									
M. zeylanica 7.7 (M), 8.00 (F)	2–11	3–10	4–9	3–10	2–9	3–11		4–13	4–13
M. orientalis 9.5 (M), 9.9 (F)			6–16	3–11	7–15	3–12	5–13	5–10	4–11
S. srilankensis 8.3 (M), 9.0 (F)		5–12	5–15	3–12	6–10	6–11		5–10	
A. *srilankensis* 4.4 (M), 4.0 (F)					2–7				

M=male, F=female

Intra-marsupial development

The recorded lengths of the larvae (stage I–III) from field collected broods of *A. srilankensis*, *M. zeylanica*, *M. orientalis* and *S. srilankensis* are given in Table 4. The smallest mysid species, *A. srilankensis* recorded the smallest larvae. Similar egg size is shown by *S. srilankensis* and *M. orientalis*. However, stage II and III larvae of *S. srilankensis* are larger than that of *M. orientalis*.

Table 4: Total body lengths of stage I–III larvae recorded for each mysid species

Species	Stage I length (mm)	n	Stage II length (mm)	n	Stage III length (mm) n	
A. srilankensis	0.29–0.30	90	0.43–0.71	128	1.07–1.21	72
M. zeylanica	0.31–0.43	109	0.64–1.14	112	1.29–1.43	103
M. orientalis	0.36–0.46	130	0.71–1.29	128	1.43–1.57	88
S. srilankensis	0.36–0.46	127	0.79–1.36	138	1.69–1.86	71

n = number of individuals

The longest incubation period at 27°C and salinity 23 ‰ was recorded for *M. zeylanica* (7–8 days). *M. orientalis* (5–6 days) and *S. srilankensis* (6 days) showed similar development time. Each mysid species identified a significant difference in the mean incubation period (Table 5, Fig. 3). One-way ANOVA showed that the incubation periods of these three mysid species were significantly different (F value–15.50, DF=2, $P \leq 0.05$).

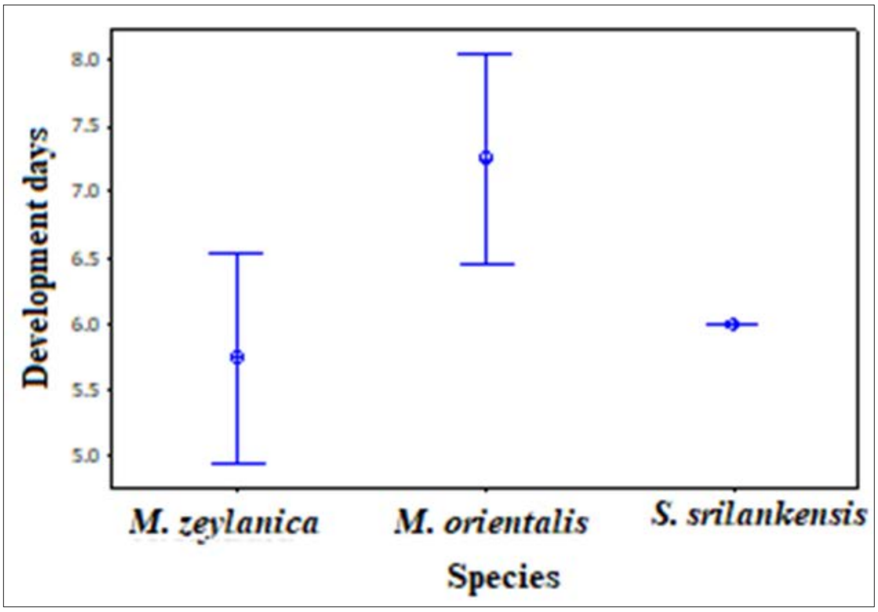

Fig 3: Intra-marsupial development time of *M. zeylanica*, *M. orientalis* and *S. srilankensis*, at 27°C and salinity 23 ‰.

Table 5: Mean intra-marsupial development time and the mean time taken for each stage (I–III) in *S. srilankensis*, *M. orientalis* and *M. zeylanica* at 27°C and salinity 23 ‰.

Species	Stage I	Stage II	Stage III	Incubation time
	Mean time(day) ±SE			
S. srilankensis	02.00±0.00	02.00±0.00	02.00±0.00	06.00±0.00
M. orientalis	01.75±0.25	02.00±0.00	02.00±0.00	05.75±0.25
M. zeylanica	02.00±0.00	02.75±0.25	02.50±0.29	07.25±0.25

(SE-standard error) Incubation time

Post-marsupial development

In each species fresh juveniles which were released from the marsupium (free swimming) were measured (Table 6). The lengths of these juveniles were different among each species. The smallest juveniles belong to *A. srilankensis* and the largest belong to *S. srilankensis.* From field samples, it was observed that the length at which the secondary sexual characteristics appeared and the length at which sexual maturity was attained differed between the species (Table 6).

In all four species, the males reached maturity at a smaller size than the females (Table 6).

Table 6: Early growth stages of *A. srilankensis*, *M. zeylanica*, *M. orientalis* and *S. srilankensis*

		A. srilankensis	***M. zeylanica***	***M. orientalis***	***S. srilankensis***
Sex	Event	Length (mm)			
	Juvenile released from the marsupium	1.3−1.5	1.5−1.8	1.6−2.1	2.07−2.36
Male	Maturing stage- (secondary sexual characteristics start to develop)	2.5−2.7	4.2−4.4	4.3−4.6	5.00−5.29
	Fully matured- (attain maturity)	2.9−3.2	4.5−4.9	4.9−5.3	5.36–5.71
Female	Maturing stage Fully matured	2.6−2.8 3.1−3.5	4.3−4.5 4.6−5.0	4.6−4.9 5.0−5.6	5.71–6.0 6.04–6.36

The lengths of *S. srilankensis* juveniles released from the marsupium ranged from 2.07–2.36 mm. Further measurement of growth was taken from these juveniles up to their mature stage (post-marsupial development). It was observed that the males reached maturity in a shorter time (24–29 days) and at a smaller size (5.36–5.71 mm) than the females (29–31days; 6.0–6.36 mm). Matured females laid eggs at lengths of 6.29–6.57mm (29–36 days≈ weeks 5) and the first-generation juveniles were released at lengths of 6.64–6.79 mm (35–43 days≈ weeks 6). (Table 7). The growth rate of *S. srilankensis* increased during the early stages (juvenile/sub adult), up to a length of 4.14–5.00 mm, and then decreased at larger sizes before maturation (Fig. 4). However, after maturation, growth rate increased approximately up to 42–45 days (≈7.10–7.25 mm) and then gradually decreased.

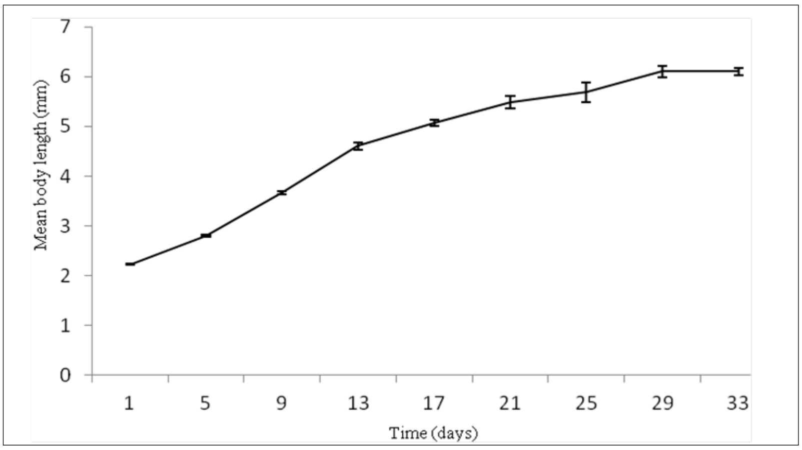

Fig 4: Mean growth (±SE) of *S. srilankensis* during the post-marsupial development.

Table 7: Early growth stages of *S. srilankensis* reared in the laboratory.

Event	Juvenile length (mm)	Male length (mm)	No of days	Female length (mm)	No of days
1. Juveniles released from the marsupium	2.07–2.36				
2. Maturing stage		5.00–5.29	21–23	5.71–6.0	24–27
3. Fully matured mysid		5.36–5.71	24–29	6.04–6.36	29–31
4. Egg laying stage				6.07–6.57	29–32
5. 1st generation Juveniles released				6.64–6.79	35–38

Salinity: 23, PH: 6.7–6.8. Temperature: 27 °C

Life history and generations

Based on the developmental periods, length classes of gravid females and recorded maximum length of each species, field collected adult females can be grouped into generations (Table 8) and used this data to calculate the life span. Data shows that *M. zeylanica*, *M. orientalis* and *S.*

srilankensis produced successive broods, within their life span, specifically five, six and seven respectively (Table 9). Hence, *M. zeylanica* and *M. orientalis* live ≈ 3–4 months and ≈ 4–5 months, respectively.
However, during laboratory experiments at 27°C and salinity of 23 ‰, *S. srilankensis* produced continuous broods immediately after the previous brood, which resulted in six overlapping generations (Fig. 5).
These generations can be explained as follows. In this study the abbreviations G, E, and J represent the terms generation, egg and juveniles respectively.

Table 8: Monthly collected adult mysids, with their potential production of generations and the condition of their marsupium

	Generation1	Generation 2	Generation 3	Generation 4	Generation 5	Generation 6	Generation 7
M. zeylanica	4.3-5.0 (M) 4.4-5.4 (L)	5.2-5.8 (M) 5.3-6.1 (L)	5.9-6.4 (M) 6.1-6.9 (L)	6.5-7.1 (M) 7.0-7.6 (L)	7.2-7.9 (M) 7.6-8.0 (L)		
M. orientalis	5.0-5.9 (M) 5.1-6.2 (L)	6.0-6.7 (M) 6.3-7.0 (L)	6.8-7.5 (M) 7.1-7.8 (L)	7.4-7.7 (M) 7.4-7.9 (L)	7.8-8.3 (M) 8.1-8.8 (L)	8.4-9.0 (M) 8.9-9.9 (L)	
S. srilankensis	5.4-5.8 (M) 5.8-6.2 (L)	6.4-6.9 (M) 6.5-6.9 (L)	7.1-7.3 (M) 7.1-7.5 (L)	7.4-7.7 (M) 7.4-7.8 (L)	7.6-7.9 (M) 7.6-8.1 (L)	8.0-8.3 (M) 8.3-8.6 (L)	8.4-8.8 (M) 8.5-9.0 (L)

(*M – marsupium without larvae; L – Stage I-Stage III larvae present).

The juveniles which were released from the marsupium, grew, and took nearly one month to lay eggs (length: 6.04–6.20 mm). In 35–38 days (length: 6.64–6.79 mm), 1st generation juveniles (G_1J) were released and immediately after emptying the marsupium on the same day, eggs were laid for the 2nd generation (G_2E). Then 41–44 days (length: 7.14–7.23 mm) 2nd generation juveniles (G_2J) released and on the same day eggs were laid for the 3rd generation (G_3E). In the 47–50 days (length: 7.43–7.55 mm) 3rd generation juveniles (G_3J) were released, and eggs were laid for the 4th generation (G_4E) on the same day. In the 54–57 days (length: 7.71–7.85 mm) eggs were laid for the 5th generation (G_5E) and juveniles were released (G_5J) on the 60th day. At this point only one individual survived. Eggs were laid for the 6th generation on the same day (G_6E) and Juveniles were released (G_6J) on the 67th day at a length of 7.81 mm. On the 70th day, at a length of 7.86 mm, death occurred due to an unknown reason (Fig. 6). However, according to growth calculations, the above mentioned 7.86 mm individual needs another 70 days to reach recorded maximum size (9.0 mm). Accordingly, the life span is 140 days (4.6 months ≈ 4–5 months).

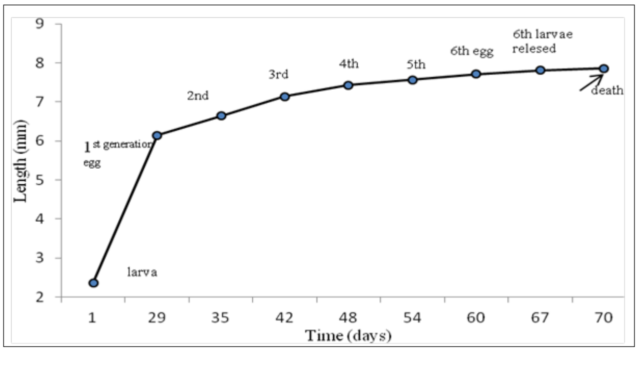

Fig 5: Post-marsupial development and successive generations of *S. srilankensis*.

The female *S. srilankensis* (C_1-cohort one) produced juveniles in several continuous generations. Similarly, these juveniles from G_1J– G_6J also matured and released their juveniles (G_1, J_1). Therefore G_1J– G_6J, the first cohort juveniles have a possibility to synchronize with G_1J_1– G_6J_1. Likewise, generations are always overlapping, and continuous breeding occurs.
Considering the six days of intra-marsupial development and the 29 days of post-marsupial development of *S. srilankensis*, the generation time can be calculated as 35 days. Generation time can be explained as the time taken to develop an egg up to a mature mysid.

Discussion
Highest female numbers were observed in all three species, *M. zeylanica*, *M. orientalis*, *S. srilankensis*, and *A. srilankensis.* Similar patterns were also reported for *M. orientalis* from Malaysia (Hanamura *et al*., 2009) [5], India (Biju and Panampunnayil, 2011) [3] and with the temperate mysids, *Tenagomysis chiltoni* and *T. novaezealandiae* in New Zealand (Punchihewa, 2018) [11]. The juvenile and sub-adult population numbers were always lower than adult numbers. This may be due to predation or fast growth rate of mysids in the immature stage (Punchihewa, 2020) [12].
Over the six-month sampling period, domination of gravid females was recorded for *M. zeylanica*, *M. orientalis*, *S. srilankensis*. Similarly, throughout the spatial distribution survey in different locations, all three populations recorded gravid females in each month. This indicated that in each population, breeding takes place throughout the year at any site. This is supported by *M. orientalis* populations in India (Biju and Panampunnayil, 2011) [3], Malaysia (Hanamura *et al*., 2009) [5] and *M. zeylanica* populations in India (Biju and Panampunnayil, 2010) [1], *Acanthomysis thailandica* in Malaysia (Ramarn *et al*., 2012) [18].
The largest mysid species, *M. orientalis* had the largest brood size (16), and the smallest, *A. srilankensis* recorded the smallest brood size (7), showing that brood size coincided with body size. Looking at the larval lengths, smallest to longer larval lengths were recorded for *A. srilankensis*, *M. zeylanica*, *M. orientalis* and *S. srilankensis* respectively. However, the largest body size was recorded for *M. orientalis* followed by *S. srilankensis*, *M. zeylanica* and *A. srilankensis* as the smallest. In these four species, there was no relationship found between larval lengths and body size. However, in the same genus, *Mesopodopsis* showed a relationship where the larvae of larger species (*M. orientalis*) was larger than the larvae of smaller species (*M. zeylanica*). New Zealand mysids also recorded that the larger mysid species (same genus), *T. chiltoni* had larger brood size and larger larval lengths than the smaller *T. novaezealandiae* (Punchihewa, 2018) [11].
There are differences in brood size for same species in local populations. *M. zeylanica* recorded more broods in areas where salinity ranged from 20–35‰ (moderate salinity conditions). The lower salinity or hyper saline conditions recorded less broods. In contrast, *M. orientalis* and *S.*

srilankensis were observed to be successfully inhabiting the Puttalam and Kalpitiya lagoons, tolerating the high salinity conditions and having more broods than in lower salinity areas. Accordingly, this study exposed the fact that the site-specific differences of brood size for a particular species depends mainly on the salinity of the water body.

The maximum brood size of *M. orientalis* recorded from this study was 16, in hyper saline waters while in the Mebok estuary in India it was 8 (Hanamura *et al*., 2008) [4], in a tropical estuary 8–10 (Nair, 1939) and in Mumbai it was 6–18 (Biju and Panampunnayil, 2011) [3]. However, *M. orientalis* was observed to inhabit all coastal waters (high salinity) and had higher brood size than the above-mentioned estuarine populations. In the coastal regions of Mumbai (Panampunnayil, l999a) [2], the brood size was 6–29 and in a tropical sandy beach in Malaysia it was 24 (Hanamura *et al*., 2009) [5]. This study also indicated that the highest brood size of *M. orientalis* was recorded from hyper saline waters.

A correlation was clearly established in relation to the abundance of *M. orientalis*, where the gravid females had a positive correlation with increased salinity, temperature, pH and the adult females with rainfall while males only had a positive correlation with salinity. Furthermore, temperature influenced the abundance of juveniles of *S. srilankensis*.

The longest incubation time of 7–8 days is shown by the smaller species, *M. zeylanica*, while the larger species, *M. orientalis* and *S. srilankensis* take 5–6 days and 6 days respectively. The opposite is true for New Zealand species, with the larger species, *T. chiltoni* having the longest intra-marsupial development time compared to the smaller species, *T. novaezealandiae* (Punchihewa, 2018) [11]. Considering these facts among tropical and temperate mysids, there seems to be no relationship between body size and incubation period.

Similar to shorter development time in present mysids, another tropical mysid, *Metamysidopsis insularis*, recorded a development time of 5.5 days at 32.5°C (Wittmann, 1984) [20]. However, temperate mysids tend to have longer development time than tropical mysids. The development time recorded for temperate mysids *Tenagomysis chiltoni* was 19–20 days and for *T. novaezealandiae* it was 17–18 days at 15°C (Punchihewa, 2018) [11] and *Anisomysis mixta australis*, *Tenagomysis tasmaniae* and *Paramesopodopsis rufa* recorded 15, 15, and 20-days development time at 17°C, respectively (Johnston *et al*., 1997) [6].

In all four species, females are lengthier than males and males reached maturity at a smaller size than the females. These two significant observations are useful for the life history study of mysids. The length at which the secondary sexual characteristics appear and the length at which the mysids attain sexual maturity differs between the species. After sexual maturation, the growth of each species occurs continuously up to their maximum lengths. The growth rate of *S. srilankensis* increased during the immature stages and decreased steadily at larger sizes before maturation. Similar observations were recorded from *T. chiltoni* and *T. novaezealandiae* in New Zealand (Punchihewa, 2020) [12].

The laboratory experiments revealed that *S. srilankensis* produced six successive broods or generations within the period of two and half months at 27 °C, and a salinity of 23 ‰, up to the length of 7.86 mm and died. However, the maximum lengths of brooding females collected during sampling were ranged between 8.3–9.00 mm. All the 9.00 mm females had broods, indicating their capability of carrying eggs/larvae at this length. Culturing experiments showed that within 20 days (34–54 day), the length increment was nearly 1.00 mm (growth rate 0.05mm^{-1} day) and produced four generations. It was observed that one female died of unknown reasons at a length of 7.86 mm after producing 6 consecutive broods. However, *S. srilankensis* had the ability to produce more broods (1–4) within the next 1.00 mm length (7.86+1 mm), but the time duration might be dependent on their age also. Therefore, it can be concluded that *S. srilankensis* is able to produce 7–10 {6 + (1 to 4)} successive broods. According to the gathered data, their life span is between 4–5 months.

The two other mysid species, *M. zeylanica*, and *M. orientalis* are able to produce five and six successive broods within their life span respectively and they live ≈ 3–4 months and ≈ 4–5 months respectively. However, it seems apparent that temperate mysids produced less broods within their lifetime compared to tropical mysids. The *Rhopalophthalmus terranatalis* in a temperate estuary produced three generations annually (Wooldridge, 1985), *Acanthomysis robusta* in Japan produced four broods within their lifetime (Sudo, 2003) and *T. chiltoni* and *T. novaezealandiae* in New Zealand produced four broods in a lifetime (Punchihewa, 2018) [11].

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