Preliminary observation of mantis shrimp breeding success in captivity

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Abstract

Mantis shrimps (Crustacea: Stomatopoda) are potential aquaculture species as they are constantly fished from the wild to satisfy demands of the seafood industry. Breeding capacity of mantis shrimps in captivity is scarce and implies a gap in this area to achieve successful aquaculture practices for this species. A preliminary observation was conducted with locally obtained mantis shrimps *Miyakella nepa* (n=42) and *Oratosquillina interrupta* (n=22) to elucidate their breeding behaviour in laboratory settings. The ratio of female to male were kept to 1:1 and females kept together are either all mature or immature. Mature females were selected based on the ovary development and males from similar size group were selected to respective females for the breeding observation. The mantis shrimps were placed in either group comprising of 6 females and 6 males, 3 females and 3 males or 1 female paired to 1 male in an aquarium. The observation was conducted for 2 months and daily observation of spawning, egg brooding, mortality, moulting occurence were recorded. For *M. nepa* within the group breeding, a total of 2 spawning activities occurred, however all egg clutches were unfertilized. Breeding of pairs was more successful comparatively, with the fertilization rate of 66.7% (n=6) for *M. nepa*. More studies are needed for *O. interrupta* as results obtained were insufficient, with only 2 spawning and only 1 fertilized egg mass for both group and pair breeding. High mortality rate was the main cause of unsuccessful breeding within the group breeding as aggression and cannibalistic behaviour was displayed among conspecifics even though ample artificial shelters were provided in the tanks. This preliminary observation indicated that pair settings is more favourable compared to group settings for successful mantis shrimps breeding.

Keywords: Aquaculture, Crustacean breeding, Mantis shrimp, Stomatopoda

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Introduction

The spearer mantis shrimps (Crustacea: Stomatopoda) are a potential aquaculture species as they are constantly fished from the ocean to satisfy demands of the seafood industry. The commercially fished species are the *Oratosquilla oratoria* (Japan), *Squilla mantis* (Mediterranean countries), *Oratosquilla nepa* (India), and *Oratosquilla stephensoni* (Australia) (Ahyong, 2001, Hernáez *et al.*, 2011). In Malaysia, *Harpiosquilla harpax* are commercially fished at Pantai Remis, Perak and exploitation levels are reaching optimum levels (Arshad *et al*., 2015).

Aquaculture is the avenue to increase mantis shrimp stocks for the purpose of seafood availability locally and internationally. However, biological information, culture conditions and breeding capacity of mantis shrimps in captivity is scarce and implies a gap in this area to achieve successful aquaculture practices for this species. Hence, a preliminary observation was conducted with locally obtained mantis shrimps *Miyakella nepa* (n=42) and *Oratosquillina interrupta* (n=22) to elucidate their breeding behaviour in laboratory settings. Furthermore, mantis shrimps are aggressive and territorial which makes it challenging to raise them in a group setting (Christy and Salmon, 1991; Wortham-Neal, 2002a). To ascertain the success of stomatopod best aquaculture practices, development should not only include growth and survivability, but also consider reproductive measures. This seeks to determine suitable method used to ensure the breeding success of mantis shrimps.

Materials and mehtods

Animal acquisition and acclimatization

Mantis shrimps were sourced from a trawler fishermen located at Bayan Lepas, Penang. The mantis shrimps were then transported to the Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM) and were acclimatized in a 1-tonne tank filled with filtered seawater. Polyvinyl chloride (PVC) pipes were provided as artificial burrows for the mantis shrimp. Mortality and moulting occurrencee were noted throughout the 24-hour acclimatization period.

Formalin treatment

A 150 parts per million (ppm) formalin bath was performed to remove ectoparasites. The treatment was carried out for 30 minutes following the dosage recommended by Mohamed *et al*. (2000). Vigorous aeration was provided throughout the treatment and all mantis shrimps were closely monitored. After treatment, the mantis shrimps were placed into individual tanks (44 x 20 x 31 cm).

Biological measurements, sex and species identification

All mantis shrimps were weighed and measured for total body length (BL) and carapace length (CL). The BL is measured from the tip of the rostral plate to the tip of the submedian teeth of the telson using a digital caliper. The

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carapace length (CL) was taken as this is potentially an indicator of the mantis shrimps maturity stage. Female and male mantis shrimps can be differentiated by observing the reproductive organs located ventrally at the 6th and 8th thoracic somites (TS), respectively. Males have petasma while the females have the thelicum (Zamri *et al*., 2016). Species identification was based on identification keys provided by Manning (Zamri *et al*., 2016; Manning, 1998) and Ahyong (Ahyong, 2012).

Experimental set-up

Reproductive capabilities were observed in two different experimental set-ups. Mantis shrimps were either placed in groups (6 and 12 animals, with 1:1 Male:Female) or in pairs (1:1 Male:Female). Females with body length of 10 cm or more, and males of similar body length were paired to the respective female. Matured females (presence of developed eggs fully fused at the telson) with their respective pairs were grouped together, forming groups of 6 individuals (*M. nepa*: group 1, 2, and *O. interrupta*: group 1). Unmatured females were group in either groups of 6 (*M. nepa*: group 3) or 12 individuals (*M. nepa*: group 4).

In pairs, females selected were only with matured ovaries. All females were allowed to have contact with the male partner until eggs were produced. Artificial burrows were given and fresh clams were fed daily. Daily observations recorded were mortality, moulting and spawning or brooding behaviour.

Brooding behaviour

Female mantis shrimps brood its' egg mass inside its' burrow, aerating it regularly using its maxillipeds (Hamano and Matsuura, 1984) . Once brooding behaviour was observed, the female was carefully removed and placed in an individual tank covered with dark canvas. Brooding stops at day 3-4 if the egg mass was unfertilized. Development will be observed under a dissecting microscope. Fertilized eggs were brooded for about 9-11 days and the female will stop attending the egg mass a day before hatching occurs.

Resuts and discussion

According to research done on the *Oratosquilla oratoria* of the same Squillidae family, male reached the body length of 7 cm and female of 10 cm are sexually matured for breeding. Moreover, the occurrence of copulation highly depends on the sexual receptivity of the females (Kodama *et al*., 2009).

Species composition

A total of 3 species were bought on early December 2020, around Bayan Lepas waters. *Miyakella nepa* (*n*=43), *Oratosquillina interrupta* (*n*=35) and *Chloridopsis scorpio* (*n*=3) were collected. No female specimens were obtained for *C. scorpio* and were therefore excluded from the breeding study. Species found in Penang waters were relatively similar to the species found in Perak. Arshad *et al*. (2015) and Zamri *et al*. (2016) reported that *M. nepa* and *Harpiosquilla harpax* can be found in coastal waters of Pantai Remis while

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Ng (2013) reported that *M. nepa* (Latreille, 1828), *O. perpensa* (Kemp. 1911), *H. raphidea* and *C. scorpio* (Latreille, 1828) were found in Matang waters.

Male to female ratio were 1:0.95, 1:0.94 and 1:0, for each respective species obtained in this study. This showed that all species were slightly male-biased which were reported differently from other research. *Miyakella nepa* have an overall female-biased population with a sex ratio of 1:1.46 (Zamri *et al*., 2016), 1:1.29 (Lui, 2005) and 1:1.36 (Sukumaran, 1987). However, Zamri *et al*. (2016) reported that the *M. nepa* population was male-biased for the month May and September which were close to the spawning or breeding seasons (April, July and December). There are 2 mating system reported for the spearing mantis shrimp where monogamy or polygamy relationship are form (Caldwell, 1991). Mantis shrimps either mate briefly at the females' burrow entrance or form lifetime partners [5]. Hence, *M. nepa* most likely forms monogamous relationships and males were out looking for mating partners, which in turn leads to a relatively higher male numbers obtained reported.

Similar case happened to *O. interrupta* as well where sex ratio of male to female is slightly higher. However, *O. interrupta* was reported to have spawning seasons during October and January where female population was low. Seasonal factors influence their spawning behaviour as mated females were low in numbers during winter (Taylor and Haddy, 2007). Hence, breeding season of *O. interrupta* in tropical countries may differ.

No female *Chloridopsis scorpio* were sampled from this study. This was like the *C. scorpio* found in Perak where its' population was male-biased. The numbers obtained was also very low (3 individuals only) as this species was an inshore species, thriving in shallow waters (Ng, 2013). This male-biased population of *C. scorpio* also occurs in the population of mantis *Squilla mantis* and *Erugosquilla massavensis* (Zamri *et al.*, 2016).

Breeding of Miyakella nepa

No spawning activity was observed in groups 1 and 2 throughout the 2-month experimental observation period. Increased aggressive behaviours were detected with cannibalism and fights in these groups (Table 1). As sex ratio and past findings showed that December should be a breeding season of the mantis, thus aggressive and territorial behaviour may be the reason for the unsuccessful breeding (Zamri *et al.*, 2016). *Miyakella nepa* mating may occurs briefly only at the females' burrow entrance and females may injure the males to secure its' burrow (Caldwell, 1991). Moreover, spawning leaves the female in a vulnerable state, where the mantis hides in its' burrow and spawned in a supine posture (Hamano and Matsuura, 1984). The PVC tube burrows were with 2 openings. Hence, the females may feel insecure and eggs were not spawned.

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Table 1: Spawning and egg fertility of *Miyakella nepa* cultured in groups (± Standard error of mean).

Group	Sex	*n*	Mean body length (mm)	Mean carapace length (mm)	Observations
1[a]	Male	3	124.0 ± 1.5	26.4 ± 0.3	No spawning 2 being eaten after moulting
	Female	3	140.7 ± 1.0	28.9 ± 0.4	3 injured (punctured carapace), which always died later
2[a]	Male	3	113.4 ± 2.0	24.3 ± 0.3	No spawning 1 injured
	Female	3	121.6 ± 1.4	24.8 ± 0.2	3 being eaten (1 after moulting)
3	Male	3	108.0 ± 0.3	22.5 ± 0.3	1 unfertilized egg mass spawned
	Female	3	111.9 ± 0.6	23.4 ± 0.2	5 being eaten after moulting
4	Male	6	117.9 ± 0.8	24.7 ± 0.2	1 unfertilized egg mass spawned 1 injured 2 being eaten
	Female	6	128.3 ± 1.2	26.5 ± 0.3	7 being eaten after moulting 1 died of moulting failure

[a] indicates matured females.

Immature females (group 3 and 4) developed "fused" eggs at telson after 2-3 weeks when the experiment started. After about a week, an unfertilized egg mass was found outside the burrow from each group. Both groups focused on growth rather than breeding as moulting occurs to the majority of the mantis prior to the unfertilized eggs being spawned. As *M. nepa* were aggressive, this leads to cannibalism. With lesser number of males in the tank, the success of mating may be reduced as spearers relies more on physical contacts for interactions between individuals (Wortham-Neal, 2002a).

Using pair breeding methods, more successful spawning occurs (Table 2). Four females spawned fertilized egg mass at 1-2 weeks after pairing up while 1 pair spawned an unfertilized egg mass and another did not spawn at all. Cannibalism greatly reduce as the mantis were in contact with their partners only when the females were matured. Fighting behaviour occurs lesser as well with males usually being injured by the females. This further proves that mating occurs briefly only, and male will be attacked if it lingers after mating (Caldwell, 1991). Pair breeding methods have a relatively lower mortality rate (50%) and higher fertilization rate (66.67%) than breeding mantis in group settings (86.67% mortality and 0% fertilization rates, respectively). Planning a tighter monitoring schedule may helped to further lower the mortality rate and reduce production loss in an aquaculture system.

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Table 2: Spawning and egg fertility of *Miyakella nepa* cultured in pairs.

Pair	Sex	*n*	Body length (mm)	Carapace length (mm)	Observations
1[a]	Male	1	104.4	22.0	1 fertilized egg mass spawned
	Female	1	106.7	21.0	
2[a]	Male	1	113.8	24.0	1 fertilized egg mass spawned Male being injured by female
	Female	1	111.8	23.0	
3[a]	Male	1	113.1	24.0	1 unfertilized egg mass spawned
	Female	1	113.7	24.0	
4[a]	Male	1	120.6	26.0	1 fertilized egg mass spawned Male being injured by female
	Female	1	119.5	26.0	
5[a]	Male	1	103.3	22.0	1 fertilized egg mass spawned
	Female	1	102.5	22.0	
6[a]	Male	1	117.8	25.0	No spawning Male being injured by female
	Female	1	112.9	24.0	

[a] indicates matured females.

Breeding of Oratosquillina interrupta

Majority of the *O. interrupta* obtained were lesser than 7cm or 10cm. Therefore, only 1 group breeding observation was carried out in this study (Table 3).

Table 3: Spawning and egg fertility of *Oratosquillina interrupta* cultured in groups (± Standard error of mean).

Group	Sex	*n*	Mean body length (mm)	Mean carapace length (mm)	Observations
1[a]	Male	3	103.8 ± 1.6	21.8 ± 0.5	1 unfertilized egg mass spawned 1 fertilized egg mass spawned All males being eaten after moulting
	Female	3	114.5 ± 1.0	24.6 ± 0.3	

[a] indicates matured females.

Aggressive behaviour was also displayed by this species, indicating that the mating system are most likely similar to *M. nepa*. Although the sample size was small, all males were eaten after moulting and the female survived was due to the immediate separation after moulting and for spawning purposes. Aggressiveness of the female was also seen in the pair breeding method.

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Breeding success for this species were unclear as both methods showed that 1 fertilized and 1 unfertilized egg mass was spawned from each method (Table 4). Mortality rate were the same as *M. nepa*, where higher mortality rate was observed in group breeding method. A 50% mortality rate was observed in group breeding while a 12.5% mortality rate occurs in pair breeding.

Table 4: Spawning and egg fertility of *Oratosquillina interrupta* cultured in pairs.

Pair	Gender	*n*	Body length (mm)	Carapace length (mm)	Observations
1[a]	Male	1	101.3	20.0	1 fertilized egg mass spawned Male being injured by female
	Female	1	99.8	22.0	
2[a]	Male	1	114.3	25.0	No spawning
	Female	1	111.8	23.0	
3[a]	Male	1	115.5	25.0	No spawning
	Female	1	114.3	25.0	
4[a]	Male	1	109.4	24.0	1 unfertilized egg mass spawned
	Female	1	109.0	23.6	

[a] indicates matured females.

Conclusion

Overall, group breeding has high mortality rate and low fertilization rate but some research have showed that no cannibalism occurs if food was sufficient [15]. Hence, a more intense feeding schedule may be needed for mantis shrimp aquaculture in the perspective of group breeding set-up. Group breeding was also carried out by (Wortham-Neal, 2002b) but the methods on how to breed mantis shrimps were not discussed. More research and reproductive information (e.g. monthly population dynamic assessments, lower male to female ratio, tighter monitoring schedule, single opening burrows and etc.) will be needed to fine tune the methods used for breeding mantis shrimp in captivity so that production loss were reduced while supplies are increased.

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