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Sex ratio, gonad development and fecundity of *Miyakella nepa* (Crustacea, Stomatopoda) of Pantai Remis coastal waters of Malaysia

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Abstract

The sex ratio, gonad development and fecundity of *Miyakella nepa* (Latreille, 1828), in the coastal waters of Pantai Remis, Perak, were investigated from February 2012 to January 2013. Sex identification was done by identifying stomatopod's genitalia organs, and the ovaries were dissected out and preserved for further analysis. Female stomatopods with mature or near spawning stages were used for fecundity estimation. A total of 951 specimens of *M. nepa*, with 565 females and 386 males were examined. Results showed a sex ratio of 1:1.46 (male:females). Maximum GSI was estimated to be 5.80, while lowest was 2.95. Sexual maturity for female *M. nepa* was observed at 100 mm total length. The mean fecundity of *M. nepa* was 425,657 (± 1,8701) eggs which was observed to increase with increased body length.

Key words

Miyakella nepa, Sex ratio, Fecundity, Gonad development

Introduction

Mantis shrimps, or stomatopods, are marine crustaceans belonging to the order Stomatopoda (Ahyong, 2004). In Asia, the importance of mantis shrimp as a fishery resource has long been recognized (Colloca *et al*., 2003; Lui *et al*., 2007). The small-eyed squillid mantis shrimp, *Miyakella nepa* (Latreille, 1828) (Crustacea: Stomatopoda) is readily available in the coastal waters of Pantai Remis, Perak, Malaysia. The gonad maturation stages can be used to determine the spawning season of this stomatopod species in the study area. Their spawning period has been identified as period with high gonadosomatic index (GSI), and the occurrence of higher proportions of mature and spent gonads among the samples.

Little information is available on the reproductive biology of *M. nepa,* and studies on the reproductive biology of crustaceans provide important information to understand their reproductive pattern and strategies (Kawamura *et al*., 1997). Possibly the main reason is that this species is not being used for human consumption around the world, as well as fisheries management due to their small stock size. This is in contrast to other species of stomatopods, such as *Squilla mantis* in Tunisia (Mili *et al.*, 2013), *Harpiosquilla raphidea* in Indonesia (Wardiatno and Mashar, 2010) and *Oratosquilla oratoria* in Japan (Kodama *et al.*, 2004) that have been well studied. It is important to work on the sex ratio, gonad development and fecundity of *Miyakella*, since such data might be useful for aquaculture research and development in Malaysia. Therefore, the objective of the present study was to determine the sex ratio, as well as gonad maturation process, spawning season and fecundity of *M. nepa* within the coastal waters of Malaysia.

Materials and Methods

Collection of samples : Mantis shrimp samples were collected monthly from February 2012 to January 2013. Freshly caught samples were taken from local fishermen in Pantai Remis, Perak (Fig. 1) and transported on ice to Laboratory of Biology and Aquatic Ecology, Universiti Putra Malaysia, Malaysia for further study. In laboratory, all *Miyakella* samples were sorted by sex to determine the ratio. Females were dissected monthly throughout the sampling period for the examination of ovarian maturity.

Determination of sex ratio : Sex identification of *M. nepa* was determined by the presence of a pair of petasma for male specimens, which is located at the base of the third pair of walking legs (Kubo *et.al*, 1959; Barnes, 1974; Wortham-Neal, 2002; Evans, 2005). Monthly sex ratio was calculated, and results were tested for differences from the hypothetical ratio of 1:1. A total of 951 specimens with 565 females and 386 males of *M. nepa* were examined.

Examination of ovaries : A total of 30 *M. nepa* were dissected monthly to obtain the ovaries. Both body weight before dissection and ovarian weight were measured to the nearest milligram using an electronic digital balance. The ovaries were removed after measuring the body weight and then preserved in 5% formalin for later examination. The maturity stages of the ovaries from each female were recorded and determined based on the four developmental stages according to Wu and Cheng (1957) and updated by Vila *et al*. (2013) : as Stage I (immature ovaries), Stage II (mature ovaries), Stage III (near spawning ovaries), Stage IV (spent ovaries),

Meanwhile, 30 *M. nepa* females were examined every month for the estimation of ovarian condition and gonadosomatic index (GSI). GSI was later determined using the following equation (Oh and Jeong 2003),

$$\text{Percentage GSI} = \frac{\text{Ovary weight}}{\text{Female body weight}} \times 100$$

Relative condition factors (K_n) for each sample was calculated by the formula (Le Cren 1951), $K_n = W/aL^b$

Where, W is the observed bodyweight in milligrams (mg), L is the total length in millimeters (mm) and a, b are the parameters of length weight relationship

Estimation of fecundity : Female samples with matured and fully mature ovarian stages were used for estimating fecundity. Each preserved ovary was dissected from three positions (fore, middle and rear) of the ovary (Amin *et al*., 2009), and sample was weighed to the nearest 0.01 mg. The oocytes were counted under a compound microscope. The number of ova with mature ovaries was counted from 30 individuals of sexually matured *M. nepa* females. Fecundity was estimated by the following equation (Kodama *et al.,* 2004):

$$F = Fs \times \frac{GW}{Gws}$$

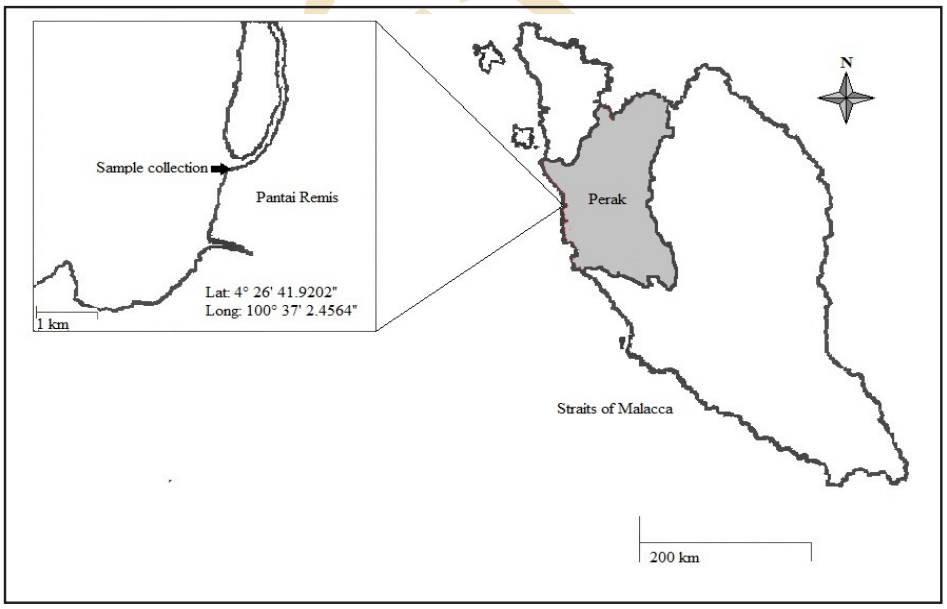

Fig. 1 : Geographical location of sampling station in Pantai Remis, Perak, Malaysia

Where, F represents the estimated fecundity of an individual sample, Fs is the number of oocytes in a sample, GW is the total weight of the ovary and GWs is weight of the ovary.

Results and Discussion

The results indicated that the overall ratio of male and female *M. nepa* was 1:1.46. Monthly proportion of males and females are shown in Fig. 2. With the exception of May and September, there was predominance of females throughout the study period. Highest number of females was recorded in the month of January 2013, while lowest in September 2012. Although the sex ratio varied each month, the ratio by class size in total length (TL) showed dominance of males in the lower class size (< 120 mm). In contrast, the number of females increased in the larger class size (> 120 mm) as shown in Fig. 3. No male individuals were observed with a total length less than 70 mm.

The peak GSI values for female *M. nepa* were recorded during March-April, between June and September and November-December during the study period (Fig. 4). Maximum GSI value of 5.8 was observed in the month of July 2012. On the other hand, minimum GSI value of 2.95 was observed in February of 2012 (Fig. 4). The annual mean variation of GSI showed the existence of three spawning peaks at different months (April, July and December) between February 2012 and January 2013 in the study area (Fig. 4).

The monthly distribution of different maturity stages of the ovaries indicated a seasonal variation pattern as shown in Fig. 5. Immature ovarian phase (Stage I) occurred nearly every month with exception in September and December. The mature and near to spawning stages (Stage II and III) occurred in each month (> 50%) with the highest percentage of the near spawning stage (Stage III) in July (82.14%), demonstrating most spawning occurred during this month. The mature and near spawning stages (Stage II and III) occurred more than 50% in each month, and reached the highest percentage of the near spawning stage in the months of April, July and December. This was in accordance with GSI variations and occurrence of matured ovaries, which showed same indications (Fig. 4). No females with spent ovaries were observed in the month of July and September during the study period.

Table 1 : Fecundity of *M. nepa* from the coastal waters of Pantai Remis, Perak, Malaysia (n = 30)

	Total length (mm)	Total weight (mg)	Gonad weight (mg)	Fecundity
Mean	136.37	333.52	16.69	42562.46
SE	1.45	11.77	0.84	1871.71
Minimum	123.57	208.80	7.60	22040.00
Maximum	152.23	458.70	28.70	58843.00

Relative condition factor (K_n) was calculated monthly and observed for both sexes (Fig. 6). Highest value of K_n for male was 1.05 in February and lowest (1.00) in October. Relative condition factor (K_n) for females was highest (1.02) in February and lowest (1.00) in July (Fig. 6).

The estimation of length at first maturity was done by examining the percentage composition of females at each ovarian maturity stage according to their total length as shown in Fig. 7. Stage II and Stage III first appeared more than 50% at a total length of 100 mm. The maturity percentage of females increased with total length. The percentage of matured females gradually increased after reaching a size of 100 mm (Fig. 7). The results indicated that the sexual maturity size for female *M. nepa* was observed at 100 mm total length.

The mean fecundity for 30 individuals of female *M. nepa* was 425,657 (± 18,701) eggs. Individual fecundity ranged from 221,413 to 588,433 in females with a total length (TL) ranging from 123.57 – 152.23 mm (Table 1).

A linear regression model was used to analyze the relationship between fecundity (F) and total length (TL), which is shown in Fig. 8:

$$Y = -82490 + 916.99X \ (R^2 = 0.51, n = 30)$$

Analysis of the relation between fecundity (F) and body weight (BW) is shown in Fig. 9:

$$Y = 5999.4 + 109.63X \ (R^2 = 0.48, n = 30)$$

A linear regression between fecundity (F) and gonad weight (GW) is presented in Fig. 10:

$$Y = 9469 + 1982.4X \ (R^2 = 0.79, n = 30)$$

A linear regression between fecundity (F) and gonadosomatic index (GSI) is shown in Fig. 11:

$$Y = 9578.7 + 6601.2X \ (R^2 = 0.37, n = 30)$$

The sex ratio of *M. nepa* was determined to obtain a better understanding of whether the ratio is balanced as seen in many other crustacean populations or it is biased towards a

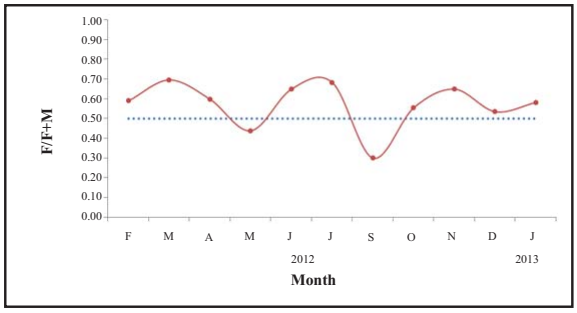

Fig. 2 : Temporal variations in sex ratio of *M. nepa* in the coastal waters of Pantai Remis, Perak, Malaysia. Dotted line indicates a ratio of 1:1 (female:male)

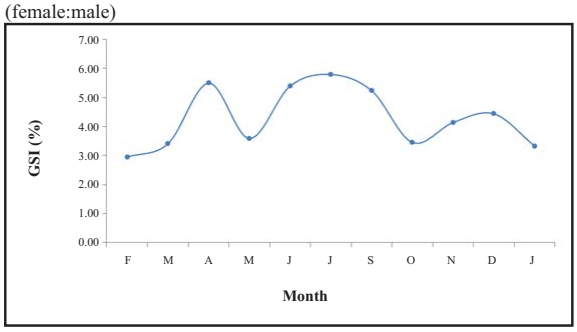

Fig. 4 : Monthly variations in gonadosomatic index (GSI) of female *M. nepa* during February 2012 to January 2013

certain sex. The annual sex ratio of *M. nepa* population of the coastal waters of Pantai Remis, Perak was found to be 1:1.46 (males:females). Other studies on the biological or ecological aspects of different stomatopod species were performed on *O. oratoria* (Hamano and Matsuura, 1984, 1987; Torisawa *et al*., 1998; Kodama *et al*., 2004, 2005, 2006a, 2006b), *O. interrupta* (Yousuf, 2003) and *S. empusa* (Wortham-Neal, 2002) but only a few have discussed the sex ratio. Lui (2005) stated that the population of *M. nepa* throughout the study period in Hong Kong water was female biased with a ratio of 1:1.285 (males:females) for overall eastern and western waters. As such, female dominance in terms of number was also observed in *M. nepa* in South Kanara coast, India with the ratio of 1:1.362 (males:females) (Sukumaran, 1987).

Like most studies on decapod crustaceans, the sex ratio of an entire population of *M. nepa* is biased towards female stomatopods. As such, similar results were also obtained in several other stomatopods (Reddy and Shanbhogue, 1994; Wardiatno and Mashar, 2010). Wortham-Neal (2002) stated that the sex ratio is yearly-biased towards the female population as well, but an unusual male-biased ratio was found in *S. mantis* (Mili *et al.,* 2011) and *Erugosquilla massavensis* (Sallam, 2005). This particular case of skewed

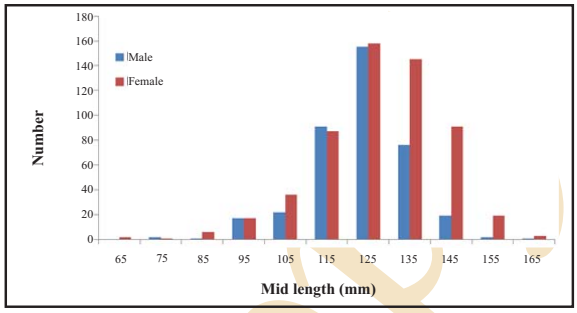

Fig. 3 : Variations in sex ratio of *M. nepa* in relation to size (TL) in the coastal waters of Pantai Remis, Perak, Malaysia

sex ratio towards females can be caused by different mortalities between sexes and different behavioural characteristics such as agonistic and territorial behaviours (Dingle and Caldwell, 1969; Wardiatno and Mashar, 2010). Caldwell (1991) also stated that a skewed sex ratio from the usual 1:1 ratio was observed in gonodactylids due to increased mortalities among the males, since the laborious activities of searching for a new cavity/shelter every time they breed increased their chances to predation.

Gonadosomatic index (GSI) and ovarian maturity were used in order to determine the spawning season of *M. nepa*, and the results showed that they breed continuously throughout the year with peaks in the month of April, July and December. A similar result was also obtained from the coastal waters of South Kanara (Reddy and Shanbhogue, 1994) with a peak intensity in June (Sukumaran, 1987).

The condition factor, which reflects the overall well-being of the mantis shrimp, showed highest peak in both males (1.05) and females (1.02), at in February. However, the lowest relative condition factor (K_n) value for males was 1.00 in October and lowest for females was 1.00 in July during the whole year of study. The seemingly unchanged relative condition factor (Kn) for *M. nepa* is in agreement with results of Rajeswary (1996). The condition factor of different populations of the same species may indicate food availability, timing and duration of breeding process. However, these factors were not confirmed in this study.

The size at sexual maturity for female *M. nepa* was observed to be 100 mm in total length and the percentage of mature females increased with increasing total length. Similar results were demonstrated by previous studies in South Kanara coast, India (Sukumaran, 1987; Reddy and Shanbhogue, 1994) with 95 mm total length for sexual maturity of female *M. nepa*. In an another study, Sallam

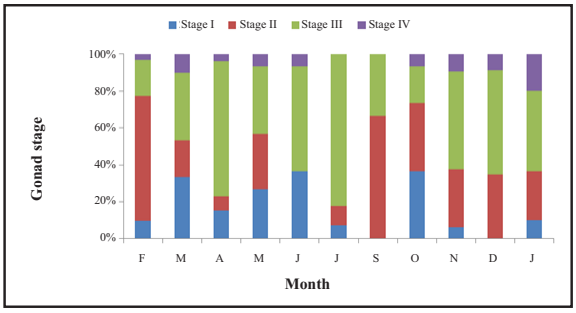

Fig. 5 : Percentage occurrence of each ovarian maturity stage of female *M. nepa* during February 2012 to January 2013 in the coastal waters of Pantai Remis, Perak, Malaysia

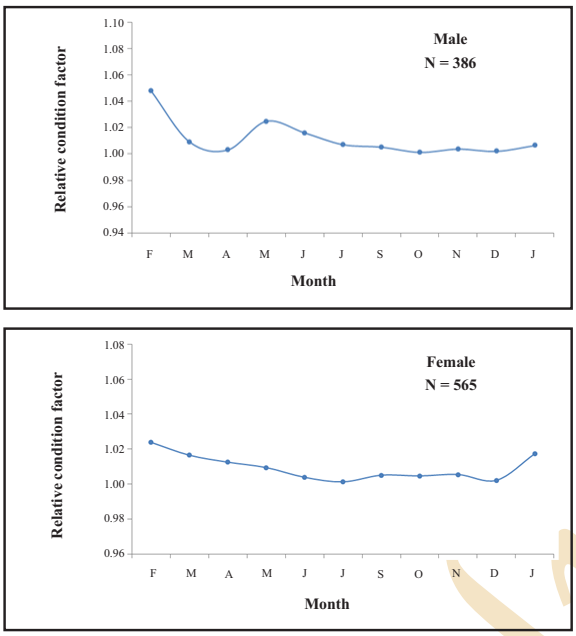

Fig. 6 : Monthly variations in relative condition factor (Kn) of male and female *M. nepa* during February 2012 to January 2013

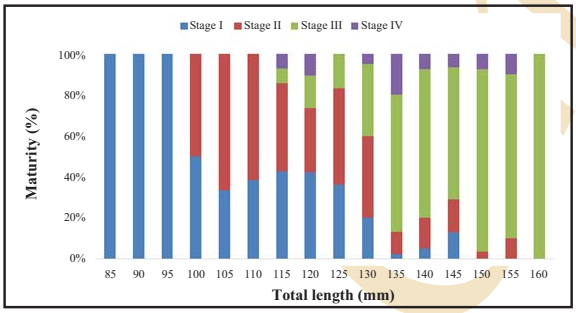

Fig. 7 : Percentage occurrence of each ovarian maturity stage against total length (TL) for female *M. nepa* in the coastal waters of Pantai Remis, Perak, Malaysia

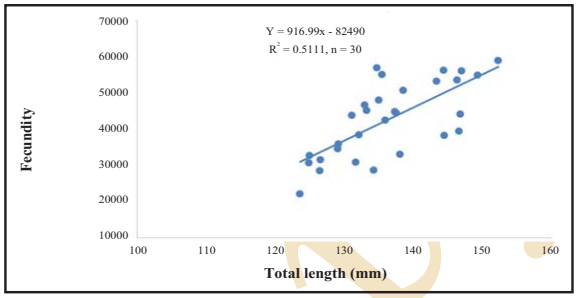

Fig. 8 : Linear relationship between number of fecundity and total length of M. nepa from coastal waters of Pantai Remis, Perak, Malaysia. n is the number of stomatopods in this study

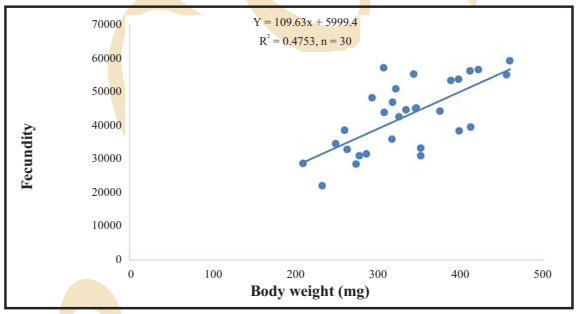

Fig. 9 : Dispersion and linear regression between fecundity and body weight of *M. nepa* from the coastal waters of Pantai Remis, Perak, Malaysia. n denotes the number of samples investigated

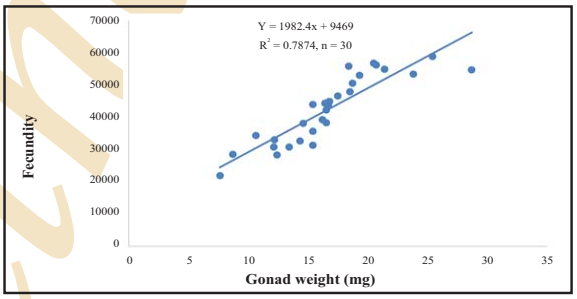

Fig. 10 : Dispersion and linear regression between fecundity and gonad weight of *M. nepa* from the coastal waters of Pantai Remis, Perak, Malaysia. n denotes the number of samples investigated

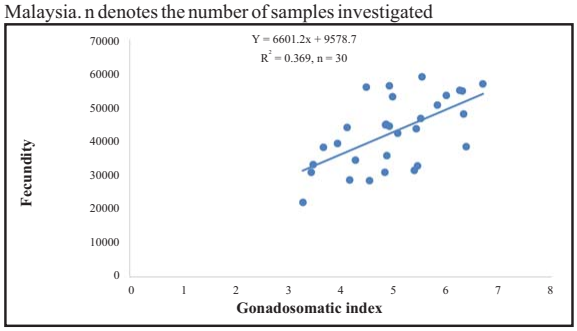

Fig. 11 : Dispersion and linear regression of *M. nepa* for its fecundity and gonadosomatic index from the coastal waters of Pantai Remis, Perak, Malaysia. n is the number of samples investigated

(2005) stated that mantis shrimp would mature earlier due to high fishing mortality, thus likely explaining the reason of slightly increased total length of *M. nepa* in the coastal waters of Pantai Remis, Perak as opposed to the other studies.

The mean fecundity of 30 matured *M. nepa* females was 42,562 eggs. The estimated maximum numbers of ova of *M. nepa* in the study was 58,843, while the minimum numbers of ova was 22,040 in females with total length within the range between 123.57 and 152.23 mm total length. The finding is similar to the previous study of Rajeswary (1996), in which the fecundity of *M. nepa* varied from 10,300 to 85,5429 in the range of total length from 59 mm to 116 mm. Lyla *et al.* (1999) stated that *M. nepa* produced less eggs as compared to different stomatopod species, namely *H. melanoura* due to different size groups. Fecundity of *H. melanoura* females was found to be significantly more having the range values between 5,24,963 and 10,04,523 eggs within the range of total length from 153 to 220 mm.

The overall sex ratio for both males and females of M. nepa was 1:1.46 (males:females). Throughout the study period, the estimated GSI of *M. nepa* showed that the species continuously breeds throughout the year. Relative condition factor (K_n) for male and female *M. nepa* was relatively unchanged. Size at sexual maturity for female *M. nepa* in the coastal waters of Pantai Remis, Perak was observed at 100 mm of total length, and fecundity increased with the increasing of total length and body weight of *M. nepa*.

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