Sex ratio and size at first maturity of mantis shrimp (*Miyakella nepa*) in Lantebung, Makassar

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Abstract. This research was conducted from May to October 2023 in the Lantebung waters, Makassar, South Sulawesi, Indonesia. This study aimed to investigate various aspects of the reproductive biology of *Miyakella nepa*, with a specific focus on determining the sex ratio and the size of gonads at first maturity, correlating these factors with lunar phases, namely the new moon and full moon. Throughout the investigation, 838 individuals were observed, comprising 336 males and 502 females, resulting in a sex ratio of 0.67:1. Notably, the sex ratio varied based on lunar phases, with a ratio of 0.59:1 during the new moon and 0.73:1 during the full moon. The analysis of the data revealed that the size of the first mature gonads of *M. nepa* during the new moon was 125.46±1.02 mm for males, and 147.81±1.07 mm for females. A similar pattern shows that, during the full moon, the sizes were 132.53±1.02 mm for males and 149.11±1.04 mm for females. This result indicates that males tend to exhibit mature gonads earlier than females, a trend observed during both the new moon and full moon periods. In conclusion, this research provides valuable insights into the reproductive biology of *M. nepa*, highlighting the influence of lunar phases on sex ratios and gonadal maturation sizes. These findings contribute to our understanding of the species' reproductive dynamics and may have implications for broader ecological studies and resource management.
Key Words: fisheries management, lunar phase, maturity stage, reproductive biology.

Introduction. The stomatopods, a group of crustaceans commonly inhabiting shallow coral reefs and deeper shelf waters, boast a diverse array of species, with mantis shrimp alone comprising over 450 species across 17 families and 7 superfamilies (Ahyong 2001). Within Indonesian waters, literature research indicates the presence of 108 stomatopod species, with Sulawesi's waters hosting 25 species from 7 families and 4 superfamilies. Notably, the Lantebung waters of Makassar are home to *Miyakella nepa*, a species of mantis shrimp also found in Siwa waters, Bone Bay, South Sulawesi (Kaisar et al 2021).

The nomenclature of *Miyakella nepa* has undergone taxonomic refinement. Originally proposed as *Miyakea* by Manning (1995) within a monograph on Vietnamese stomatopod crustaceans, this genus included the *nepa* group of *Oratosquilla* Manning 1968, comprising *Squilla nepa* Latreille 1828 (type species) and *Squilla holoschista* Kemp 1911 (Manning 1971; Ahyong 2001; Ahyong et al 2008). However, the name *Miyakea* had previously been designated by Marumo (1933) for a genus of Lepidoptera, rendering the stomatopod genus a junior homonym. Recognizing this, Ahyong & Low (2013) proposed *Miyakella* as a replacement name. Presently, *Miyakella* Marumo 1933 is acknowledged as a valid genus with six species (Li & Li 2007). Taxonomically, *Miyakella nepa* falls within the kingdom Animalia Linnaeus 1758, phylum Arthropoda von Siebold 1848, subphylum Crustacea Brünnich 1772, class Malacostraca Latreille 1802, subclass Hoplocarida Calman 1904, order Stomatopoda Latreille 1817, suborder Unipeltata Latreille 1825, superfamily Squilloidea Latreille 1802, family Squillidae Latreille 1802, genus *Miyakella* Ahyong & Low 2013, and species *Miyakella nepa* (Latreille, in Latreille, Le Peletier, Serville & Guérin 1828) (Ahyong 2001). Synonyms for this species, as outlined by Ahyong (2001), include *Squilla nepa* Latreille 1828, *Squilla edwardsi* Giebel 1861, *Squilla laevis* Stephenson 1960, *Squilla wood-masoni* Stephenson & McNeill 1955, *Oratosquilla nepa* Manning 1968b, and *Miyakea nepa* Manning 1995. Locally in Lantebung, this particular shrimp is colloquially referred to as 'doang letta'.

Mantis shrimp, classified as stomatopod crustaceans, hold significant commercial value, with prices subject to fluctuations contingent upon location and time of purchase (Lee et al 2022b). In the waters of Sinaboi, Riau, Indonesia, mantis shrimp is priced between 90000 IDR (5.62 USD) and 170000 IDR (10.62 USD). Subsequently, this crustacean is distributed both domestically and internationally, with markets extending to Singapore, Malaysia, Hong Kong, and other countries (Syahrul et al 2022). Malaysia, in particular, exports mantis shrimp to Hong Kong, fetching a notable value of 60 USD per kg (Lee et al 2022b). The high price of mantis shrimp is attributed to its nutritional richness. *M. nepa* in Mumbai contains 12.61% crude protein and 0.27% fat (Sawant et al 2019). Mantis shrimp muscles have a dense distribution of collagen fibers. The collagen content of freeze-dried *M. nepa* is 0.478±0.06% (Hiransuchalert et al 2021). Despite the commercial appeal and nutritional benefits, it is noteworthy that consumption of mantis shrimp remains relatively uncommon in several regions of Indonesia.

The majority of people in Lantebung work as fishermen whose main catches are shrimp (*Fenneropenaeus merguiensis* and *Penaeus monodon*) and crabs (*Portunus pelagicus* and *Scylla serrata*). *M. nepa* is a bycatch species with a significant catch volume. Unfortunately, once brought ashore and sorted, mantis shrimp from Lantebung often face disposal without being repurposed, sold locally, consumed, reintroduced into their habitat, or exported. This practice stems from the absence of culinary traditions associated with this commodity. This neglectful disposal of mantis shrimp results in economic losses for both the national and regional fisheries sectors. Despite the current lack of interest and utilization, there remains the potential for increased consumer demand in the future. However, the ongoing issue of intensive fishing, characterized by inadequate selectivity due to large bag openings or targeting inappropriate species, exacerbates the problem of bycatch and discards (Yang & Herrmann 2022). These challenges, in turn, contribute to the reduction of mantis shrimp stocks, emphasizing the need for more sustainable fishing practices and resource management.

The lunar phase plays a pivotal role in shaping environmental variations and influencing the evolution of fundamental strategies in marine systems (Shima et al 2020). Numerous fish species utilize environmental cues, such as lunar phases, to regulate various aspects of their behavior, including reproductive activity, spawning patterns, and migration (Takemura et al 2010; Ikegami et al 2014; Kruse et al 2016; Shima et al 2020). Additionally, lunar phases are influential in determining abundance (Mili et al 2013; Kruse et al 2016), moulting patterns (Hernáez et al 2011), as well as the delivery and dispersal of resources through tidal movements. Furthermore, lunar phases play a crucial role in shaping foraging behaviors and influencing predator-prey interactions within marine ecosystems (Shima et al 2020). Recognizing the significance of lunar phases for various species, we have employed this aspect as a comparative factor in our research. This approach allows for a nuanced exploration of how lunar phases may impact the reproductive biology of *M. nepa*, contributing to a broader understanding of the intricate relationships between environmental cues and specific behaviors.

Limited information exists on the reproductive aspects of *M. nepa*. Existing literature reveals that studies focusing on the reproductive biology of *M. nepa* have been conducted solely in Malaysia (Zamri et al 2016) and India (Kishor et al 2023). Notably, research on the reproductive biology of crustaceans is crucial for unraveling essential information pertaining to their reproductive patterns and survival strategies (Zamri et al 2016). However, the scant attention to *M. nepa*'s reproductive dynamics can be attributed to several factors. Primarily, this species is infrequently consumed globally due to its low meat content and the difficulty in extracting flesh from its shell (Sawant et al 2019). Moreover, *M. nepa* tends to spend a significant portion of its life concealed within burrows and holes (Samphan & Ratanamusik 2018), further complicating research efforts. Additionally, the species exhibits a relatively small stock size (Zamri et al 2016). Given these challenges, the present study was initiated to provide preliminary insights into the sex ratio and first mature gonad size of *M. nepa* in Indonesian waters, with a particular emphasis on the influence of lunar phases (new moon and full moon). This research aims to contribute foundational knowledge to the underexplored field of *M. nepa* reproductive biology, addressing the current gap in comprehensive understanding and fostering future investigations into this intriguing species.

Material and Method

Research time and location. This research was conducted in Lantebung, Makassar, South Sulawesi, Indonesia. The location of the fishing area is 119°26'44.77''E to 119°27'51.33''E and 5°4'21.54''S to 5°5'9.11''S. Data collection in this research was carried out every new moon and full moon for six months, spanning from May to October 2023. The time interval between successive sample collections was approximately two weeks. 13 sampling points were selected (Figure 1). The collection process involved capturing 40 mantis shrimp samples utilizing the "dragon trap" fishing gear. Each dragon trap employed in the study was 9 m in length, featuring a mesh size of 2.82 cm. The fishing operation took place between 11:00 AM and 4:00 PM, adjusted according to sea tide times, and was conducted without the use of bait. The fishing gear was subsequently retrieved at 5:00 AM the following day. All collected samples underwent analysis at the Fisheries Biology Laboratory, Fisheries Department, Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia.

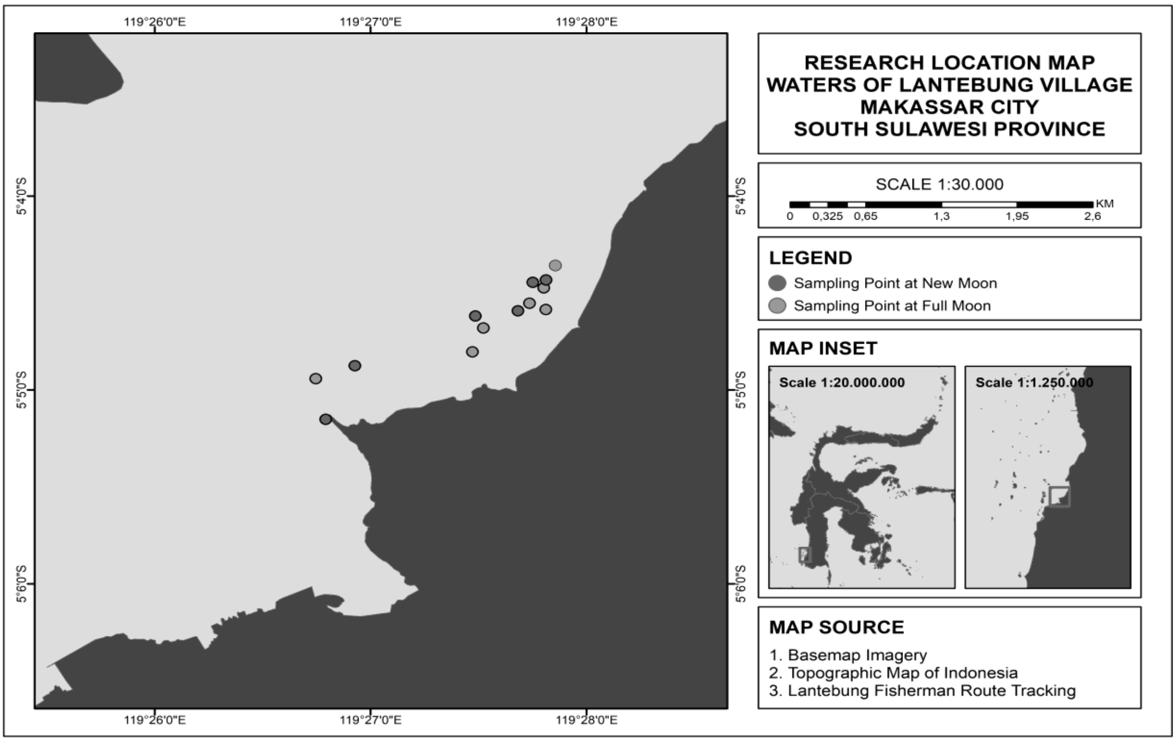

Figure 1. Location of catching *Miyakella nepa* during new moon and full moon.

Sample observation procedure. *M. nepa* obtained from fishermen's catches was organized based on sex. Sex identification of *M. nepa* is determined based on the presence of their genitals. Male shrimp have a pair of petasma located at the base of the third walking leg or the eighth thoracic segment (Figure 2a), whereas female genitals (thelicum) are situated in the middle of the first walking leg in the sixth thoracic segment and are flat in appearance (Figure 2b). Subsequently, the total length of each sample was measured using a measuring board equipped with a ruler, with an accuracy of 1 mm. The body weight of each specimen was determined using a digital scale with an accuracy of 0.01 g. The total length of the mantis shrimp was determined from the deepest tip of the rostral plate to the tip of the outermost telson, in accordance with Manning (1998). After organizing the mantis shrimp samples by sex, measuring their total length, and weighing, the specimens were dissected to observe the development of their gonads. The progression of gonad development was categorized into four stages, following the criteria outlined by Vila et al (2013) and Mulyono et al (2017).

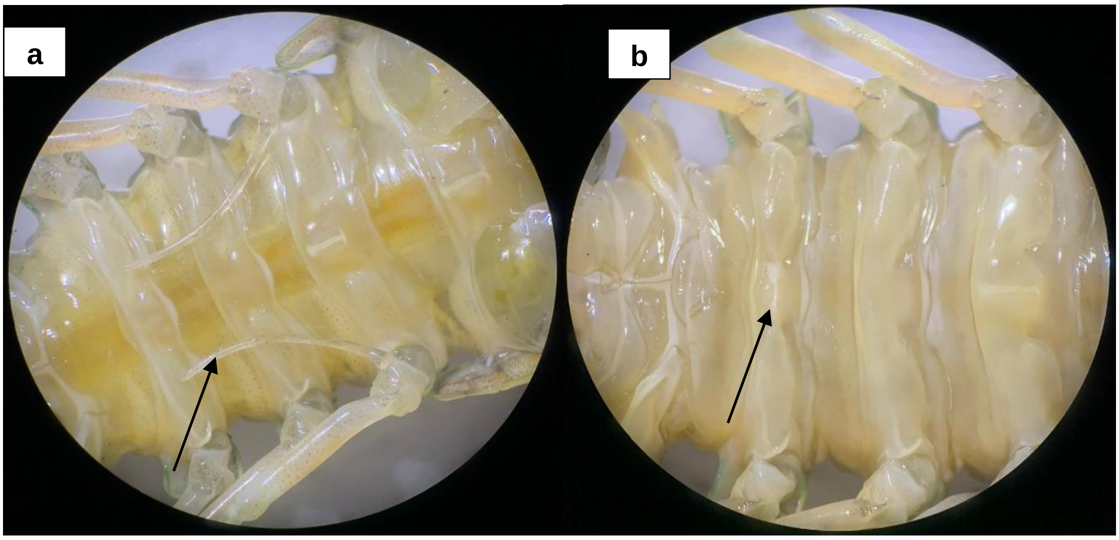

Figure 2. Location and morphology of *Miyakella nepa* genitals: a) male genitals (petasma); b) female genitals (thelicum).

Data analysis. The sex ratio is determined based on the number of female and male mantis shrimp samples acquired at each sampling time and is calculated using the following formula (Omar 2013):

$$SR = \frac{\sum F}{\sum M}$$

Where: SR – sex ratio; Σ F – number of female shrimp (ind); Σ M - number of male shrimp (ind).

The uniformity of the distribution of sex ratios was analyzed using the chi-square test, which was prepared in the form of a contingency table (Omar 2013):

$$X^2 = \sum_{i=1}^{k} \frac{(Oi - Ei)^2}{Ei}$$

Where: χ^2 - chi-square value; O - observed frequency of male or female shrimp; E - expected frequency of male or female shrimp.

$$Ei = \frac{(n_{io} \times n_{oj})}{n}$$

Where: E_{ij} - expected theoretical frequency; n_{io} - number of rows to-i; n_{oj} - number of rows to-j; n - the number of frequencies acquired from the observation values.

The level of gonad maturity was determined by visual observation of gonad morphology. The characteristics observed were adjusted to the characteristics of the maturity level. Gonad maturity stage (GMS) is divided into four phases, namely: GMS I (immature), GMS II (development), GMS III (mature) and GMS IV (post-mature) following Vila et al (2013) and Mulyono et al (2017).

The average size of mantis shrimp when the gonads were at first maturity was estimated using the Spearman-Karber method (Udupa 1986), using the equation:

$$\log m = X_k + \frac{x}{2} - (X \sum Pi)$$

The minimum and maximum sizes of gonads at first maturity (significance level α=0.05, confidence level = 95%) were calculated using the formula (Udupa 1986):

$$M = antilog\left[m \pm 1{,}96\sqrt{X^2\sum\frac{(p_1 - q_1)}{(n_1 - 1)}}\right]$$

Where: M - the average length of mantis shrimp when they first reach gonad maturity; m - logarithm of shrimp length when the gonads are at first maturity; Xk - logarithm of the mean value of the length class when the gonads first mature; X - the difference in the logarithm of the middle values; p_i - proportion of gonad mature shrimp in class i (pi=ri/ni); ri - number of gonad mature shrimp in the class i; ni - number of shrimp with mature gonads in the class i; qi=1–pi.

Results

Size distribution. The number of mantis shrimp samples obtained during research in Lantebung waters was 838 shrimps. At new moon, 347 samples were obtained, consisting of 129 males and 218 females. On the other hand, at full moon, 491 shrimps were caught, consisting of 207 males and 284 females. The range and average total length of males in new moon were 89-145 mm and 117.18±0.98 mm (mean±SE), while for females they were 79-169 mm and 126.37±0.9 mm. Male shrimp had a body weight range of 6.70-34.92 g, with an average of 19.58±0.46 g, while females had 6.06-49.46 g and 23.79±0.48 g, respectively. At full moon, the range and average total length of males were 77-151 mm and 120.19±0.94 mm, while for females they were 74-168 mm and 127.42±0.96 mm, respectively. The range and average body weight of males were 5.20-39.30 g and 22.02±0.48 g, while for females they were 4.49-51.75 g and 25.55±0.52 g, respectively.

Figure 3 shows the distribution of size, total length and body weight of male and female shrimp caught during research in Lantebung waters, both during the new moon and full moon. In the new moon, more females were caught with a total length of >111 mm and a body weight of >16 g. Likewise, at full moon, female shrimp were more numerous than males, with a total length of >131 mm and body weight >28 g.

Sex ratio. Overall, 838 samples of *M. nepa* caught during the study consisted of 336 males and 502 females. Based on the chi-square test, the total sex ratio was 0.67:1 male to female, which was significantly different from the expected 1:1 ($p<0.05$). Sex ratios were found to vary according to GMS, month, and lunar phase, which are presented in Tables 1, 2, and 3. Based on the chi-square test for GMS, month, and lunar phase, the average results showed significant differences except for GMS II (Table 1) and the month of August (Table 2). Each observation shows that females are more dominant than males, both in the GMS, month and lunar phase.

Maturity of gonads stage. Mantis shrimp in GMS I and II are considered to have immature gonads, while those in GMS III and IV have mature gonads. The number of *M. nepa* with mature gonads, both males and females, in the new moon and full moon, was only one third of the total samples caught (Figure 4). Male and female shrimp that had immature gonads in the new moon were 66.67% and 66.05%, while in the full moon they were 66.18% and 67.96%.

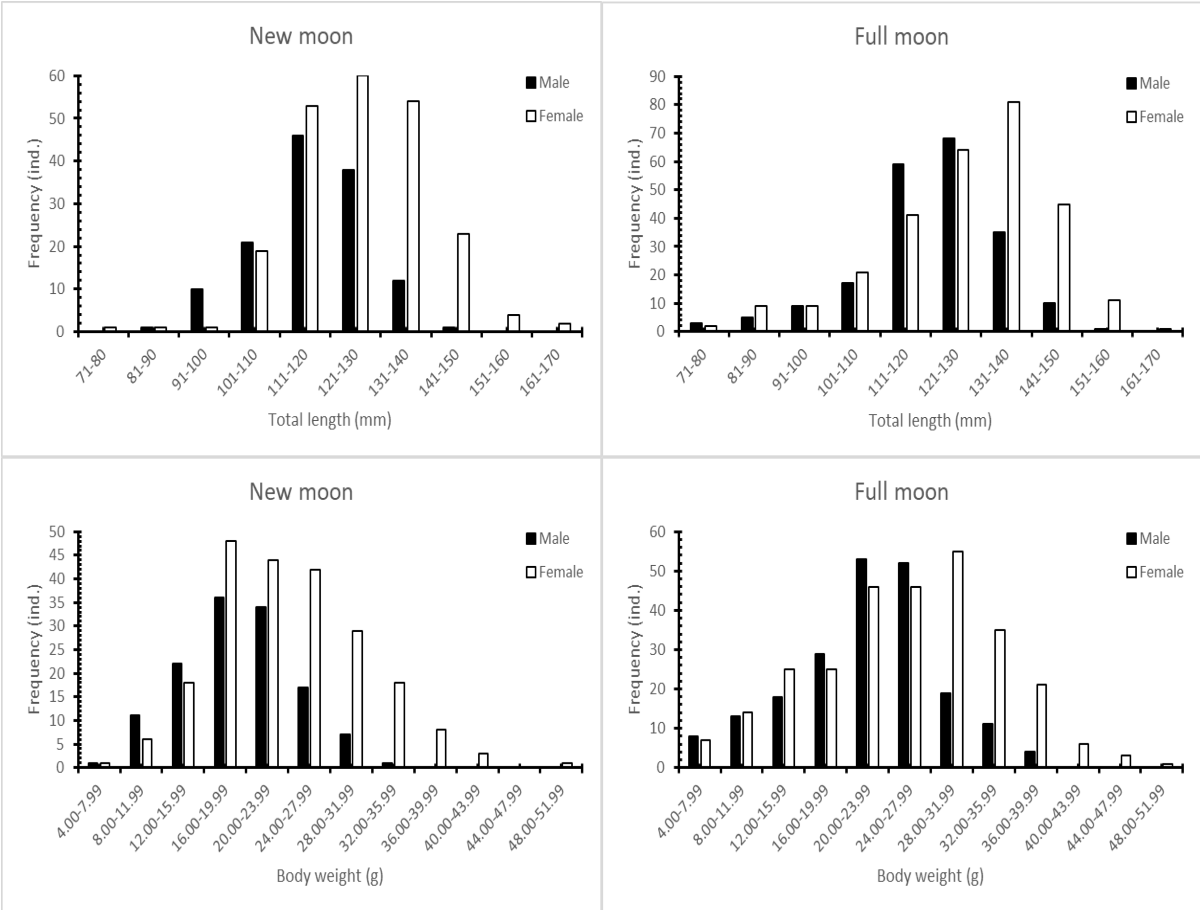

Figure 3. Total length and body weight distribution of *Miyakella nepa* at new moon and full moon.

Table 1

The sex ratio of *Miyakella nepa* based on gonad maturity stage

Gonad maturity stage	*Number of mantis shrimp*				*Sex ratio*	χ^2_{value}	*Significant or not at 5% level*
	Male		*Female*				
	n	*%*	*n*	*%*			
I	125	37.20	228	45.42	0.55:1.00	30.05	S
II	98	29.17	109	21.71	0.90:1.00	0.58	NS
III	106	31.55	106	21.12	1.00:1.00	0.00	S
IV	7	2.08	59	11.75	0.12:1.00	40.97	S
Total	336	100	502	100	0.67:1.00	32.88	S

Note: degrees of freedom: 1 in all cases; S - significant; NS - not significant.

Table 2

The sex ratio of *Miyakella nepa* based on the sampling time

Months	*Number of mantis shrimp*				*Sex ratio*	χ^2_{value}	*Significant or not at 5% level*
	Male		*Female*				
	n	*%*	*n*	*%*			
May	56	16.67	80	15.94	0.70:1.00	4.24	S
June	50	14.88	73	14.54	0.69:1.00	4.30	S
July	49	14.58	71	14.14	0.69:1.00	4.03	S
August	94	27.98	112	22.31	0.84:1.00	1.57	NS
September	36	10.71	82	16.33	0.44:1.00	17.93	S
October	51	15.18	84	16.73	0.61:1.00	8.07	S
Total	336	100	502	100	0.67:1.00	32.88	S

Note: degrees of freedom: 1 in all cases; S - significant; NS - not significant.

Table 3

The sex ratio of *Miyakella nepa* based on lunar phase

Lunar phase	*Number of mantis shrimp*				*Sex ratio*	χ^2_{value}	*Significant or not at 5% level*
	Male		*Female*				
	n	*%*	*n*	*%*			
New moon	129	38.39	218	43.43	0.59:1.00	22.83	S
Full moon	207	61.61	284	56.57	0.73:1.00	12.08	S
Total	336	100	502	100	0.67:1.00	32.88	S

Note: degrees of freedom: 1 in all cases; S - significant.

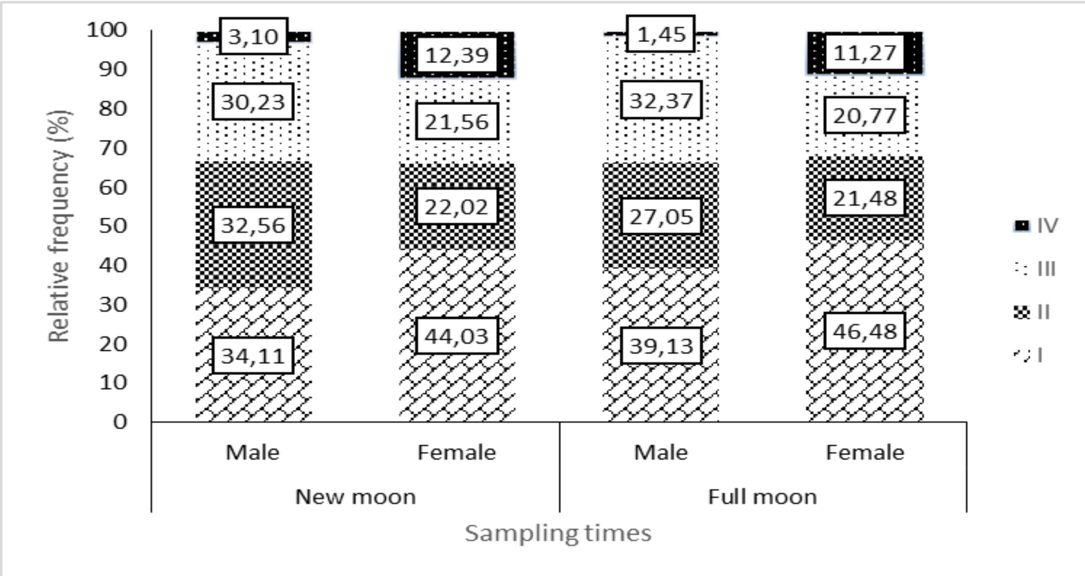

Figure 4. Percentage of gonad maturity stage of *Miyakella nepa* at new moon and full moon.

Length at first maturity. Based on total body length, the size of the first mature gonads in *M. nepa* indicates that male mantis shrimp develop mature gonads earlier than females, both in new moon and full moon periods (Table 4).

Table 4

Length at first maturity of *Miyakella nepa* based on total length and body weight at new moon and full moon

Parameter	*Sex*	*New moon*		*Full moon*	
		Ind	*Mean ± SE*	*Ind*	*Mean ± SE*
Total length (mm)	Male	129	125.46±1.02	207	132.53±1.02
	Female	218	147.81±1.07	284	149.11±1.04

Discussion. During the research conducted in Lantebung waters, it was observed that female *M. nepa* exhibited greater total length and body weight compared to their male counterparts, both during the new moon and the full moon. Moreover, mantis shrimp captured during the fusll moon had larger and heavier bodies than those caught during the new moon, as indicated by their higher average total length and body weight. Similar findings were reported by Kaisar et al (2021) in Bone Bay, South Sulawesi, where male *M. nepa* ranged from 70 to 148 mm in total length, and females ranged from 77 to 158 mm. Comparable total length ranges were documented by Manning (1995) for *M. nepa* from Vietnam (66-155 mm for males and 55-156 mm for females). In Madras, India, James & Thirumilu (1993) reported total length ranges of 46-100 mm for male *Oratosquilla nepa* and 46-110 mm for females. Ahyong (2001) provided size estimates for *M. nepa*, indicating a range of 69-144 mm for males and 68-150 mm for females. Abdurahiman et al (2004) found *O. nepa* in Karnataka, India, with total length and body weight ranges of 40-112 mm and 1.0-15.5 g for males, and 60-114 mm and 2.3-15.3 g for females, respectively. The latest data from Kishor et al (2023) on the Mangalore coast, Karnataka, India, reported total length ranges of 24-112 mm for male *M. nepa* and 34-126 mm for females. Comparatively, the body length range of *M. nepa* from Vietnam and Australia aligns relatively closely with the results of our study. However, the body size of the same species from Indian waters appears to be smaller when compared to our findings. This discrepancy in body size is attributed to the geographic locations where the shrimp were caught and the varying levels of fishing exploitation present in each location.

In addition to body size indicators such as total length and body weight, it was observed that the number of male and female *M. nepa* captured during the full moon was relatively greater than during the new moon, as illustrated in Table 3. This observation aligns with findings from the study conducted by Mili et al (2013), which reported a lunar phase influence on catches of *Squilla mantis*. Specifically, they noted higher catches during the full moon (with an average catch of 1.9 kg $hour^{-1}$), while the catch per unit effort (CPUE) decreased significantly during moonless periods, with an average catch of less than 0.5 kg $hour^{-1}$. Similarly, research on *Penaeus plebejus* revealed peak catches occurring during the full moon, approximately ±3 days from the full moon (Courtney et al 1996). These results suggest that lunar phases play a significant role in influencing the abundance and catch rates of crustacean species, including *M. nepa*. Furthermore, it is important to consider factors such as female spawning behavior, habitat preferences, social interactions, and seasonal movements, as these aspects can collectively contribute to variations in the sex ratio within each species (Maturbongs et al 2020). The interplay of these factors underscores the intricate relationship between lunar phases and the reproductive ecology and behavior of mantis shrimp.

The sex ratio of *M. nepa* in Lantebung, Makassar, indicates favorable population conditions, as evidenced by the predominance of female individuals across various parameters, including GMS, sampling time, and lunar phase (Tables 1, 2, 3). In the context of population survival, it is generally desired to maintain a balanced or, ideally, a higher number of female individuals (Mulyono et al 2017; Pratama et al 2019; Ekalaturrahmah et al 2020; Hasibuan & Khairul 2021). A balanced sex ratio (1:1) or a higher proportion of females increases the likelihood of successful spawning, consequently enhancing the prospects for population sustainability (Ambarsari 2016). The dominance of female mantis shrimp in nature has been observed and explained by Wardiatno & Mashar (2010), Mulyono et al (2017), and Dimenta et al (2019). These studies elucidate that, in natural settings, female mantis shrimp tend to exhibit dominance. This is attributed to the combative behavior of males, who, upon reaching maturity, engage in aggressive encounters to secure mating opportunities with females (combatant behavior). Unfortunately, this aggression among males can lead to fatalities, impacting male abundance within the population over time.

Several previous studies on mantis shrimp have consistently indicated that female individuals are generally more abundant than male individuals, as summarized in Table 5.

Table 5

Sex ratio of several mantis shrimp

Species	*Location*	*Number of individuals*		*Sex ratio*	*References*
		Male	*Female*	*Male:Female*	
Cloridopsis scorpio	Belawan, North Sumatera (Indonesia)	249	370	0.67:1.00	Dimenta et al (2019)
Erugosquilla massavensis	Port Said (Egypt)	1023	974	1.05:1.00	Sallam (2005)
Harpiosquilla harpax	Antalya Bay (Turkey)	138	133	1.04:1.00	Gökoğlu et al (2008)
	Visakhapatnam (India)	224	361	0.62:1.00	Rao et al (2015)
	Banten Bay (Indonesia)	119	112	1.06:1.00	Mulyono et al (2016)
Harpiosquilla raphidea	South of Madura Island (Indonesia)	347	343	1.01:1.00	Ekalaturrahmah et al (2020)
	Tungkal River, Jambi (Indonesia)	152	223	0.68:1.00	Wardiatno & Mashar (2010)
	Kuala Tungkal, Jambi (Indonesia)	466	590	0.79:1.00	Wardiatno & Mashar (2013)
	Banten Bay (Indonesia)	186	146	1.27:1.00	Mulyono et al (2016)
	Labuhanbatu, North Sumatera (Indonesia)	65	98	0.66:1.00	Hasibuan & Dimenta (2022)
Harpiosquilla spp	Andaman Sea (Thailand)	265	172	1.54:1.00	Samphan & Ratanamusik (2018)
Miyakea nepa	Banten Bay (Indonesia)	283	324	0.87:1.00	Mulyono et al (2016)
Miyakella nepa	Bone Bay, South Sulawesi (Indonesia)	533	467	1.14:1.00	Kaisar et al (2021)
	Mangalore coast, Karnataka (India)	250	650	0.38:1.00	Kishor et al (2023)
	Pantai Remis (Malaysia)	386	565	0.68:1.00	Zamri et al (2016)
	Lantebung, Makassar (Indonesia)				
	- New moon	129	218	0.59:1.00	This study
	- Full moon	207	284	0.73:1.00	This study
Oratosquilla anomala	Visakhapatnam (India)	370	333	1.11:1.00	Rao et al (2015)
Oratosquilla nepa	Madras (India)	187	288	0.65:1.00	James & Thirumilu (1993)
	Karnataka (India)	107	109	0.98:1.00	Abdurahiman et al (2004)
Oratosquilla oratoria	Cilacap, Central Java (Indonesia)	200	256	0.78:1.00	Djuwito et al (2013)
	Tongyeong (Korea)	1241	1380	0.90:1.00	Kim et al (2017)
	Coastal area of Goheung, Korea	1521	1676	0.91:1.00	Ha-Kyong (2022)
Oratosquillina gravieri	Kuala Tungkal, Jambi (Indonesia)	98	300	0.33:1.00	Wardiatno & Mashar (2013)
	Palabuhanratu, West Java (Indonesia)	588	921	0.64:1.00	Ambarsari (2016)
Oratosquillina sp	South of Madura Island (Indonesia)	182	230	0.79:1.00	Ekalaturrahmah et al (2020)
Squilla mantis	Gulf of Gabes (Tunisia)	8770	7799	1.12:1.00	Mili et al (2008)
	Gulf of Hammamet (Tunisia)	1620	1404	1.15:1.00	Mili et al (2008)
	Gulf of Tunis (Tunisia)	1726	1564	1.10:1.00	Mili et al (2008)
	Southern coast of Sicily (Italy)	207	277	0.75:1.00	Ragonese et al (2012)
	Izmir Bay, Aegean Sea (Turkey)	387	549	0.70:1.00	Sağlam et al (2017)
	Lagos Lagoon (Nigeria)	169	65	2.60:1.00	Akinwunmi et al (2021)
	Mediterranean Sea-Western Basin	422	490	0.86:1.00	Kennouche & Kacimi (2021)
	Edremit Bay, Aegean Sea (Turkey)	223	404	0.55:1.00	Torcu Koç et al (2023)

However, certain research results deviate from this trend, reporting instances where male shrimp outnumber their female counterparts. For instance, in *Erugosquilla massavensis* in Antalya Bay, Turkey, a male-to-female sex ratio of 1.04:1 was observed (Gökoğlu et al 2008). Similarly, in the Gulf of Tunis, Gulf of Gabes, and Gulf of Hammamet, Turkey, *S. mantis* exhibited ratios of 1.1:1, 1.12:1, and 1.15:1, respectively (Mili et al 2008). Other examples include a ratio of 1.54:1 for *Harpiosquilla* spp. in the Andaman Sea (Samphan & Ratanamusik 2018), 1.01:1 for *Harpiosquilla harpax* on Madura Island, Indonesia (Ekalaturrahmah et al 2020), and a notably higher ratio of 2.6:1 for *S. mantis* in Lagos Lagoon, Nigeria (Akinwunmi et al 2021). This variability in sex ratios is attributed to the unique reproductive behaviors of mantis shrimp. Female mantis shrimp are known to remain in their burrows without feeding for extended periods, often more than two months, to care for their eggs (Vila et al 2013; Lee et al 2022a). This behavior could contribute to the lower number of female mantis shrimp captured during sampling. Comprehensive insights into sex ratios across various mantis shrimp species are presented in Table 5.

Figure 4 illustrates the relative frequency of *M. nepa* immature gonads (GMS I and II) and mature gonads (GMS III and IV), during both the new moon and the full moon. There are relatively more female shrimp in Lantebung waters with mature gonads in the new moon than in the full moon, while there are relatively more male *M. nepa* in the full moon compared to the new moon. This observation aligns with several studies indicating that gonad maturity often occurs during the new lunar phase. For instance, research on *P. monodon* demonstrated moulting during the new moon (Rusaini & Owens 2019), a process closely linked to reproductive function facilitating fertilization and gonad maturity (Lemos & Weissman 2020). In the context of other marine species, Palinuridae were reported to emerge from their nests for feeding during the full moon, with an increased activity in the number of individuals engaging in feeding and foraging immediately after the full moon. The peak of *P. ornatus* moulting activity was observed approximately one week after the full moon (Skewes et al 1994). It is noteworthy that, as emphasized by Shima et al (2020), only a few studies have explored the broader implications of variations in the nighttime light cycle, which have the potential to affect individual growth and survival.

The predominant catch location for fishermen in Lantebung is in the vicinity of the mangroves, primarily targeting crustaceans such as shrimp and crabs. Consequently, there is a notable abundance of mantis shrimp with immature gonads (GMS I and II) in the catch, reflecting the utilization of the mangrove area by mantis shrimp as a crucial nursery and feeding ground. This aligns with the findings of Ramdhani et al (2023), who identified a distance of 0 to 4 miles from the coast as an optimal zone for small mantis shrimp, serving as both a nursery and feeding ground.

The mantis shrimp caught in Lantebung waters are considered a bycatch and are frequently captured by local fishermen in significant quantities. Despite the abundance of this catch, the entire mantis shrimp catch is not fully utilized by the fishermen and their families. Figure 4 illustrates that the majority of the captured mantis shrimp, ranging from 66.05% to 67.96%, exhibit immature gonads (GMS I and II). This observation raises concerns as it contradicts the principles of responsible shrimp fishing aimed at ensuring sustainable fisheries. The current state of mantis shrimp harvesting in Lantebung, poses a potential threat to the population stock of *M. nepa* in the future if not properly controlled.

The first size of gonad maturity, defined as the range of lengths under the condition that 50% of a population has mature gonads (Zamri et al 2016), serves as a crucial indicator of maturity and spawning readiness in individuals (Aswady et al 2019). This size is commonly used as a threshold for determining the minimum allowable catch size (Hasan et al 2021). In the research conducted in Lantebung waters, the average first mature gonad size for males *M. nepa* during the new moon was 125.46±1.02 mm and during the full moon it was 132.53±1.02 mm. For female shrimp, the average first mature gonad size during the new moon was 147.81±1.07 mm, and during the full moon it was 149.11±1.04 mm. These findings indicate that male mantis shrimp reach gonad maturity earlier than their female counterparts, both during the new moon and the full moon.

Manangkalangi et al (2022) suggested that the faster sexual maturity observed in male individuals is linked to maximizing energy early on for reproduction. In contrast, female individuals are believed to require a greater energy allocation to reach maturity, resulting in larger size or older age. Similar results were reported by Kishor et al (2023) on *M. nepa* found on the Mangalore coast, India, namely 85 mm for male shrimp and 90 mm for female shrimp. Previously, Sukumaran (1987) reported that the average first maturity size of female *O. nepa* shrimp originating from the South Kanara coast, India, was 95 mm in total length, while James & Thirumilu (1993) reported that for female *O. nepa* shrimp originating from Madras, India, gonads matured first at a total length of 73.2 mm. Furthermore, Zamri et al (2016) reported that female *M. nepa* in Pantai Remis, Malaysia, had on average first maturity at a total length of 100 mm. These results imply that *M. nepa* mantis shrimp from Lantebung waters mature more slowly than their counterparts from Indian and Malaysian waters. This difference is attributed to variations in geographic location and the aquatic environment. Further insights into the average first maturity size for other mantis shrimp species are presented in Table 6.

Table 6

Size at first maturity of several mantis shrimp

Species	*Location*	*Size at first maturity (mm)*		*References*
		Male	*Female*	
Cloridopsis scorpio	Belawan, North Sumatera (Indonesia)	205.5	186	Dimenta et al (2020)
Erugosquilla massavensis	Port Said (Egypt)	-	125.1	Sallam (2005)
Harpiosquilla raphidea	Banten Bay (Indonesia)	230	199	Mulyono et al (2017)
	Labuhanbatu, North Sumatera (Indonesia)	198.8	187.5	Hasibuan & Dimenta (2022)
Miyakea nepa	Mangalore coast, Karnataka (India)	85	90	Kishor et al (2023)
Miyakella nepa	Pantai Remis (Malaysia)	-	100	Zamri et al (2016)
	Lantebung, Makassar (Indonesia) – new moon	125.46	147.81	This study
	Lantebung, Makassar (Indonesia) – full moon	132.53	149.11	This study
Oratosquilla nepa	Madras (India)		73.2	James & Thirumilu (1993)
Oratosquilla oratoria	Tokyo Bay (Japan)	40-50	≥ 70	Kodama et al (2009)
	Tongyeong (Korea)	-	96,5	Kim et al (2017)
Squilla mantis	Gulf of Gabes (Tunisia)	-	147.19	Mili et al (2011)

Conclusions. Observations on the sex ratio and first mature gonad size of *M. nepa* during lunar phases, specifically in the new moon and full moon, were conducted in Lantebung, South Sulawesi. This study represents the first of its kind in examining mantis shrimp at this location. The research findings reveal significant differences in the population dynamics of *M. nepa* in Lantebung, particularly in terms of the number of males and females during the new moon compared to the full moon. Traditionally, fishermen using "dragon traps" predominantly catch immature mantis shrimp. This prevalence of immature individuals poses a potential threat to the continuity of the *M. nepa* population stock in Lantebung. Addressing the observed sex ratio variations and the high incidence of immature mantis shrimp in the catch is crucial for the sustainable management of *M. nepa* in this region. Further research and conservation efforts are warranted to ensure the long-term viability of the population in Lantebung.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

Abdurahiman K. P., Harishnayak T., Zacharia P. U., Mohamed K. S., 2004 Length-weight relationship of commercially important marine fishes and shellfishes of the southern coast of the Karnataka, India. NAGA 27(1&2):9-14.

Ahyong S. T., 2001 Revision of the Australian stomatopod crustacea. Records of the Australian Museum 26:1-326.

Ahyong S. T., Chan T. Y., Liao Y. C., 2008 A catalog of the mantis shrimp (Stomatopoda) of Taiwan. National Taiwan Ocean University, Keelung, Taiwan, 190 p.

Ahyong S. T., Low M. E. Y., 2013 *Miyakella* nom. nov., a replacement name for *Miyakea* Manning, 1995, (Crustacea: Stomatopoda: Squillidae), preoccupied by *Miyakea* Marumo, 1933 (Insecta: Lepidoptera: Crambidae). Zootaxa 3616(1):99-100.

Akinwunmi M. F., Bello-Olusoji O. A., Egwu H. E., 2021 Bionomics of *Squilla mantis* (Linnaeus, 1758) from Maroko area of the Lagos Lagoon, Nigeria. Advances in Food Sciences 43(2):81-91.

Ambarsari N., 2016 [Mantis shrimps (*Oratosquillina gravieri* Manning, 1978) resources management in Palabuhanratu bay, Sukabumi, West Java]. Thesis, IPB University, Bogor, Indonesia, 76 p. [In Indonesian].

Aswady T. U., Asriyana., Halili, 2019 [Sex ratio and size at first maturity of parrot fish (*Scarus rivulatus* Valenciennes, 1840) in the waters of Tanjung Tiram Village, North Moramo District, South Konawe Regency]. Jurnal Manajemen Sumberdaya Perairan 4(2):183-190. [In Indonesian].

Courtney A. J., Die D. J., McGilvray J. G., 1996 Lunar periodicity in catch rate and reproductive condition of adult eastern king prawns, *Penaeus plebejus*, in coastal waters of south-eastern Queensland, Australia. Marine and Freshwater Research 47(1):67-76.

Dimenta R. H., Machrizal R., Khairul, 2019 [Information reproductive morphology and sex ratio of mantis shrimp *Cloridopsis scorpio* (Latreile, 1828) in Belawan's aquatic ecosystem mangrove]. Jurnal Pembelajaran dan Biologi Nukleus 5(2):24-33. [In Indonesian].

Dimenta R. H., Machrizal R., Khairul., Hasibuan R., Manurung A. Q., Ihsan M., 2020 [Reproductive biology of the mantis shrimp *Cloridopsis scorpio* in the Belawan mangrove ecosystem, North Sumatera]. Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan 9(2):227-234. [In Indonesian].

Djuwito, Saputra S. W., Widyaningtiwi W. A., 2013 [Several biological aspects of mantis shrimp (*Oratosquilla oratoria* De Haan, 1844) in Cilacap waters, Central Java]. Journal of Management of Aquatic Resources 2(3):56-64. [In Indonesian].

Ekalaturrahmah Y. A. C., Zairion, Wardiatno Y., 2020 Population dynamics of mantis shrimp *Harpiosquilla harpax* and *Oratosquillina* sp. in the waters south of Madura Island, Indonesia. Biodoversitas 21(4):1458-1466.

Gökoğlu M., Kaya Y., Deval M. C., Tosunoğlu Z., 2008 Some biological parameters of the Erythrean mantis shrimp, *Erugosquilla Massavensis* (Kossmann, 1880) (Stomatopoda, Squillidae) in the northeastern Mediterranean (Turkish waters). Crustaceana 81(1):35-42.

Ha-Kyong C., 2022 Population dynamics of the Japanese mantis shrimp, *Oratosquilla oratoria* (De Haan, 1844) in the coastal area of Goheung, Korea. Dissertation, Master of Engineering, Pukyong National University, 60 p.

Hasan M. R., Hossain M. Y., Mawa Z., Tanjin S., Rahman M. A., Sarkar U. K., Ohtomi J., 2021 Evaluating the size at sexual maturity for 20 fish species (Actinopterygii) in wetland (Gajner Beel) ecosystem, north-western Bangladesh through multi-model approach: A key for sound management. Acta Ichthyologica et Piscatoria 51(1):29-36.

Hasibuan M. Z., Khairul, 2021 [Biological aspects of blacktip sea catfish (*Plicofillis dussumieri* Valenciennes, 1840)]. Jurnal Pendidikan Biologi dan Sains 4(1):18-24. [In Indonesian].

Hasibuan S. A. D., Dimenta R. H., 2022 [Reproductive aspects of the mantis shrimp *Harpiosquilla raphidea* in Labuhanbatu Regency mangrove ecosystem, North Sumatera]. Jurnal Biolokus: Jurnal Penelitian Pendidikan Biologi dan Biologi 5(1):24-34. [In Indonesian].
Hernáez P., McLellan-Clarke T., Benavides-Varela C., Villalobos-Rojas F., Nívia-Ruiz J., Wehrtmann I., 2011 Population demography and spatial distribution of the mantis shrimp *Squilla biformis* (Stomatopoda, Squillidae) from Pacific Costa Rica. Marine Ecology Progress Series 424:157-168.
Hiransuchalert R., Oonwiset N., Imarom Y., Chindudsadeegul P., Laongmanee P., Arnupapboon S., 2021 Extraction and characterization of pepsin-soluble collagen from different mantis shrimp species. Fisheries and Aquatic Sciences 24(12):406-414.
Ikegami T., Takeuchi Y., Hur S. P., Takemura A., 2014 Impacts of moonlight on fish reproduction. Marine Genomics 14:59-66.
James D. B., Thirumilu P., 1993 Population dynamics of *Oratosquilla nepa* in the trawling grounds off Madras. Journal of Marine Biological Association of India 35(1&2):135-140.
Kaisar, Nadiarti, Umar M. T., Nafie Y. A. L., Priosambodo D., Irmawati, Tresnati J., Suwarni, 2021 Population dynamics of mantis shrimp (*Miyakea nepa* Fabricius, 1781) in Siwa, Bone Bay, South Sulawesi, Indonesia. IOP Conference Series: Earth and Environmental Science 763:012037.
Kennouche H., Kacimi A., 2021 Growth estimation and length-weight relationships of spottail mantis shrimp (*Squilla mantis* Linneaus, 1758) in the Algiers region (south-west of Mediterranean Sea). Applied Ecology and Environmental Research 19(6):5083-5101.
Kim S. E., Kim H., Bae H., Kim H. G., Oh C. W., 2017 Growth and reproduction of the Japanese mantis shrimp, *Oratosquilla oratoria* (De Haan 1844) in the coastal area of Tongyeong, Korea. Ocean Science Journal 52(2):257-265.
Kishor C., Venkatappa, Nataraju O. R., Somashekar S. R., Puneeth R., 2023 Studies on length weight relationship and reproductive biology of *Miyakea nepa* (Latreille, 1828) from the trawl bycatches of Mangalore coast, Karnataka. Journal of Experimental Zoology India 26:1597-1602.
Kodama K., Shiraishi H., Morita M., Horiguchi T., 2009 Reproductive biology of the Japanese mantis shrimp *Oratosquilla oratoria* (Crustacea Stomatopoda): Annual cycle of gonadal development and copulation. Marine Biology Research 5(5):415-426.
Kruse M., Taylor M., Muhando C. A., Reuter H., 2016 Lunar, diel, and tidal changes in fish assemblages in an East African marine reserve. Regional Studies in Marine Science 3:49-57.
Lee L. Y., Nilamani M., Wong S. C., Woo S. P., Shu-Chien A. C., Jaya-Ram A., 2022a Preliminary observation of mantis shrimp breeding success in captivity. Journal of Survey in Fisheries Sciences 9(1):1-9.
Lee L. Y., Normaiyudin N. A., Wong S. C., Shu-Chien A. C., Rahmah S., Jaya-Ram A., 2022b First description of mantis shrimp, *Miyakella nepa* (Latreille, 1828), feeding preference behaviour in captive conditions. Aquaculture Reports 22:100969.
Lemos D., Weissman D., 2020 Moulting in the grow-out of farmed shrimp: a review. Reviews in Aquaculture 13(1):5-17.
Li W. C., Li H. H., 2007 A study of the genus *Miyakea* Marumo (Lepidoptera, Crambidae, Crambinae) from China, with description of one new species. Acta Zootaxonomica Sinica 32(3):546-567.
Manangkalangi E., Syafei L. S., Lapadi I., Lefaan P. T., Widiastuti N., Rahardjo M. F., 2022 [Reproductive biology of the spotted scat, *Scatophagus argus* (Linnaeus, 1766) in Pabean Bay, Indramayu]. Jurnal Sumberdaya Akuatik Indopasifik 6(3):215-226. [In Indonesian].
Manning R. B., 1971 Keys to the species of *Oratosquilla* (Crustacea, Stomatopoda), with descriptions of two new species. Smithsonian Contributions to Zoology 71:1-16.

Manning R. B., 1995 Stomatopod Crustacea of Vietnam: the legacy of Raoul Serène. Crustacean Research 4(1-8):1-339.
Manning R. B., 1998 Stomatopods. In: The living marine resources of the Western Central Pacific, Vol. 2: Cephalopods, crustaceans, holothurians and sharks. Carpenter K., Niem V. (eds), Food and Agriculture Organization of the United Nations (FAO), Italy, pp. 828-849.
Marumo N., 1933 [Studies on rice borers. I. Classification of the subfamily Crambinae in Japan]. Nojikairyoshiryo, Department of Agriculture, Ministry of Agriculture and Forestry, Tokyo, pp. 1-6. [In Japanese].
Maturbongs M. R., Elviana S., Lesik M. M. N. N., Rani C., Burhanuddin A. I., 2020 Growth patterns, sex ratio and size structure of nurseryfish (*Kurtus gulliveri* Castelnau, 1878) according to the lunar phase in Maro River, Merauke. AACL Bioflux 13(2):539-552.
Mili S., Bouriga N., Missaoui H., Jarboui O., 2011 Morphometric, reproductive parameters and seasonal variations in fatty acid composition of the mantis shrimp *Squilla mantis* (Crustacea: Stomatopoda) in the Gulf of Gabes (Tunisia). Journal of Life Sciences 5:1058-1071.
Mili S., Ennouri R., Jarboui O., Missaoui H., 2013 Distribution and abundance of the mantis shrimp *Squilla mantis* (Crustacea: Stomatopoda) in Tunisian waters: Gulfs of Tunis, Hammamet and Gabes. Greener Journal of Life Sciences 1(1):1-13.
Mili S., Jarboui O., Missaoui H., 2008 Caracteres biometriques de la squille *Squilla mantis* dans les eaux Tunisiennes [Biometric characteristics of the *Squilla mantis* squill in Tunisian waters]. Bulletin Institut National des Sciences et Technologies la Mer de Salammbô 35:1-14. [In French].
Mulyono M., Patria M. P., Abinawanto, Affandi R., Mardiyono, 2017 The development of gonad mantis shrimp *Harpiosquilla raphidea* Fabricius, 1798 in Banten Bay, Indonesia. International Journal of Aquatic Science 8(1):26-33.
Mulyono M., Patria M. P., Abinawanto., Affandi R., Heriyansyah F. A., 2016 Growth aspects of giant mantis shrimp *Harpiosquilla raphidea* Fabricius, 1798 in Banten Bay waters, Banten Province. International Journal of Marine Science 6(32):1-14.
Omar S. B. A., 2013 [Fishery biology]. Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, 153 p. [In Indonesian].
Pratama C., Hartati R., Redjeki S., 2019 [Biological aspects of *Rastrelliger* sp., (Actinopterygii: Scombridae) in terms of length, weight, and gonad somatic index in Semarang waters]. Journal of Marine Research 8(2):189-196. [In Indonesian].
Ragonese S., Morara U., Canali E., Pagliarino E., Bianchini M. L., 2012 Abundance and biological traits of the spottail mantis shrimp, *Squilla mantis* (L., 1758) (Crustacea: Stomatopoda), off the southern coast of Sicily. Cahiers de Biologie Marine 53:485-493.
Ramdhani F., Heltria S., Gelis E. R. E., Nofrizal, Jhonnerie R., Zidni I., 2023 Spatial distribution of mantis shrimp (*Harpiosquilla raphidea*) in small-scale gillnet fishery: a case study in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi. Jurnal Kelautan Tropis 26(1):85-94.
Rao P. Y., Prasad D. R., Sirisha I. R., Rao M. S., Teja G., 2015 Meat yield studies in *Harpiosquilla harpax* (de Haan, 1844) and *Oratosquilla anomala* (Tweedie, 1935) (Crustacea: Stomatopoda) represented in the shrimp trawl net by-catches off Visakhapatnam, east coast of India. European Journal of Experimental Biology 5(5):6-11.
Rusaini, Owens L., 2019 The effect of viral infection on the relationship between the LOS cells and moulting stages of the black tiger prawn (*Penaeus monodon*). AACL Bioflux 12(4):1087-1101.
Sağlam N. E., Sağlam Y. D., Sağlam C., 2017 A study on some population parameters of mantis shrimp (*Squilla mantis* L., 1758) in Izmir Bay (Aegean Sea). Journal of the Marine Biological Association of the United Kingdom 98(4):721-726.
Sallam W. S., 2005 Reproductive biology of the mantis shrimp *Erugosquilla massavensis* from Port Said, Egypt. Egyptian Journal of Aquatic Biology and Fisheries 9(1):171-183.

Samphan P., Ratanamusik A., 2018 The length-weight relationship factor and sex-ratio of mantis shrimp (*Harpiosquilla* spp) in Andaman Sea of Satun Province, Thailand. International Journal of Agricultural Technology 14(1):61-71.
Sawant A. A., Iburahim S. A., Kesavan S., Patil S., Xavier K. A., 2019 Proximate composition of mantis shrimp resources available along Mumbai Waters. Journal of Aquaculture in the Tropics 34(3-4):251-258.
Shima J. S., Osenberg C. W., Alonzo S. H., Noonburg E. G., Mitterwallner P., Swearer S. E., 2020 Reproductive phenology across the lunar cycle: parental decisions, offspring responses, and consequences for reef fish. Ecology 101(8):e03086.
Skewes T. D., Pitcher C. R., Trendal J. T., 1994 Changes in the size structure, sex ratio and molting activity of a population of ornate rock lobsters, *Panulirus ornatus,* caused by an annual maturation molt and migration. Bulletin of Marine Science 54(1):38-48.
Sukumaran K. K., 1987 Study on the fishery and biology of the mantis shrimp *Oratosquilla nepa* (Latreille) of South Kanara Coast during 1979-83. Indian Journal of Fisheries 34(3):292-305.
Syahrul, Jonny Z., Bustari, 2022 Technical and financial study of capture business mantis shrimp (*Harpiosquilla raphidea*) using base nets driven in Kepenghuluan Sinaboi, Sinaboi District, Rokan Hilir Regency, Riau Province. Journal of Coastal and Ocean Sciences 3(3):201-208.
Takemura A., Rahman M. S., Park Y. J., 2010 External and internal controls of lunar-related reproductive rhythms in fishes. Journal of Fish Biology 76(1):7-26.
Torcu Koç H., Erdoğan Z., Sarıgöl C., 2023 A study on some population parameters of spot-tail mantis shrimp (*Squilla mantis* L.) (Crustacea: Stomatopoda) in Edremit Bay (Northern Aegean Sea). Acta Biologica Turcica 36(2):1-9.
Udupa K. S., 1986 Statistical method of estimating the size at first maturity in fishes. Fishbyte 4(2):8-10.
Vila Y., Sobrino I., Jimenez M. P., 2013 Fishery and life history of spot-tail mantis shrimp, *Squilla mantis* (Crustacea: Stomatopoda), in the Gulf of Cadiz (eastern central Atlantic). Scientia Marina 77(1):137-148.
Wardiatno Y., Mashar A., 2010 Biological information on the mantis shrimp, *Harpiosquilla raphidea* (Fabricius 1798) (Stomatopoda, Crustacea) in Indonesia with a highlight of its reproductive aspects. Journal of Tropical Biology and Conservation 7:65-73.
Wardiatno Y., Mashar A., 2013 Morphometric study of two Indonesian mantis shrimps (*Harpiosquilla raphidea* and *Oratosquillina gravieri*). Buletin PSP 21(1):19-30.
Yang B., Herrmann B., 2022 Simple and effective: T90 codends improve size selectivity and catch efficiency compared with diamond-mesh codends for mantis shrimp (*Oratosquilla oratoria*) in demersal trawl fishery of the South China Sea. Frontiers in Marine Science 9:939269.
Zamri Z., Arshad A., Amin S. M. N., Rahman M. A., Khayat J. A. A., 2016 Sex ratio, gonad development and fecundity of *Miyakella nepa* (Crustacea, Stomatopoda) of Pantai Remis Coastal Waters of Malaysia. Journal of Environmental Biology 37(4):677-683.

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