Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(3): 1501 – 1526 (2024)
www.ejabf.journals.ekb.eg

Length-Weight Relationship and Condition Factors of the Mantis Shrimp, *Oratosquillina interrupta* (Kemp 1911), in Bone Bay, South Sulawesi, Indonesia

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ARTICLE INFO
Article History:
Received: Feb 23, 2024
Accepted: June 1st, 2024
Online: June 30, 2024

Keywords:
Oratosquillina interrupta,
Condition factor,
Growth pattern,
New moon,
Full moon

ABSTRACT

Oratosquillina interrupta is a species of mantis shrimp found in Bone Bay, along with *Harpiosquilla raphidea* and *Miyakella nepa*. The biological parameters of this species have not been previously documented. This study aimed to determine the length-weight and condition factors of *Oratosquillina interrupta* caught in Bone Bay, South Sulawesi, Indonesia. The sampling was conducted from May to October 2023 based on the new moon and full moon phases. During the study, a total of 796 mantis shrimp were collected, with 397 during the new moon phase (168 males and 229 females) and 399 during the full moon phase (173 males and 226 females). The growth type of male and female shrimp varied at each sampling time, with some exhibiting isometric growth and others hypoallometric growth. The condition factor value of the male shrimp was higher than that of the female shrimp, in both the new moon and full moon phases.

INTRODUCTION

The mantis shrimps are predatory crustaceans found in benthic ecosystems in the marine and brackish waters worldwide. According to **Van Der Wal *et al*. (2017, 2019)**, there are currently around 500 species of the mantis shrimp belonging to 120 genera, 18 families, and 7 superfamilies. In the Indonesian waters alone, over 100 species of the mantis shrimp have been identified, belonging to 54 genera, 13 families, and 6 superfamilies.

Oratosquillina interrupta is one of the mantis shrimps found in Bone Bay, South Sulawesi. The other mantis shrimp species found in this bay include *Miyakella nepa* **(Emperor, 2019)** and *Harpiosquilla raphidea* **(Prasetyo, 2022)** in Siwa waters, the northern part of Bone Bay. Additionally, *O. interrupta* was found in the waters of Mimika, Papua **(Short, 2014)**. According to **Ahyong (2001)**, *O. interrupta* is present in the Indo-West Pacific region. *Oratosquillina interrupta* is a species of the Squillidae family, belonging to the Stomatopoda order of the Malacostraca class in the Crustacea subphylum of the Animalia kingdom. It was first described by Kemp in 1911 and later classified under the *Oratosquillina* genus by Manning in 1995. According to **Ahyong (2001)**, **Ahyong *et al*. (2008)** and **Dudiya *et al*. (2022)**, this species is also known as *Squilla interrupta* Kemp, 1911; *Squilla oratoria* Gravier, 1930b; *Chloridella interrupta* Schmitt, 1931; *Squilla wood-masoni* Stephenson & McNeill, 1955; *Oratosquillina interrupta* Shanbohogue, 1969; *Oratosquilla arabica* Ahmed, 1971; *Oratosquilla interrupta* Manning, 1971b; *Oratosquilla interrupta* Blumstein, 1974; *Oratosquilla interrupta* Dutta and Ravindranath, 1975; *Oratosquilla interrupta* Dong *et al*., 1983; *Squilla interrupta* Ghosh and Manning, 1988; and *Oratosquillina interrupta* Manning, 1995.

Rahardiawan and Arifin (2013) reported that Bone Bay provides the preferred habitat for *O. interrupta* due to its substrate conditions. **Ahyong (2001)** stated that *O. interrupta* prefers sandy and muddy substrates in the intertidal areas. It is worth noting that the mantis shrimp can be a valuable source of nutrition and have high economic value as a fishery product. In Bone Bay, fishermen catch not only fish but also the blue swimmer crabs (*Portunus pelagicus*) and the mantis shrimp, although the latter is usually considered a by-catch and has not been utilized or received much attention due to its perceived lack of economic value. Some species of the mantis shrimp are considered export commodities and exotic foods. Even the members of the Harpiosquillidae and Squillidae families have high economic value **(Syafrina, 2011)**. According to **Jacoeb *et al*. (2008a)**, the mantis shrimp is classified as a commodity with a high protein and low fat. The fresh mantis shrimps have a higher protein content, as well as higher levels of vitamin A and vitamin B6, compared to the fresh shrimps, crayfish, and lobsters **(Jacoeb *et al*., 2008b)**. The mantis shrimp is a nutritious food source due to its high content of essential macrominerals, including sodium, potassium, calcium, and magnesium, as well as microminerals such as zinc, iron, and copper **(Wardiatno *et al*., 2012)**. The average meat yield of *Harpiosquilla raphidea* was 40.28± 4.03% in Jambi (Indonesia) and 39.91± 3.66% in Cirebon (Indonesia) **(Wardiatno *et al*., 2012)**. The study conducted in Visakhapatnam, India, found that the female *Harpiosquilla harpax* shrimp had a higher average meat yield of 36.96± 2.58% compared to the male shrimp with an average meat yield of 34.53± 3.04%. On the other hand, the male *Oratosquilla anomala* had a relatively similar average meat yield to that of female shrimp, with 39.56± 2.55% and 39.49± 2.55%, respectively **(Rao *et al*., 2015)**.

Several researchers have conducted studies related to the moon phase. **Ayodya *et al.* (2021)**, **Mitterwallner and Shima (2022a, 2022b)** and **Othman *et al.* (2023)** have investigated the influence of the moon cycle on the fish reproductive activity. Meanwhile, **Vergara *et al.* (2017)** have studied the influence of the moon on the catch composition. Additionally, **Libini and Khan (2012)**, **Sajeevan (2013)**, **Sajeevan and Samadi (2014a, b)** and **Pulver (2017)** have investigated the influence of the moon on catch rate.

Moreover, **Kruse *et al*. (2016)** and **Battaglia *et al*. (2022)** investigated the correlation between moon phases and fish feeding behavior. Lunar cycles also impact the migration and release of crustacean larvae in addition to molting **(Nio *et al*., 2019; Chang *et al*., 2023)**. **Maturbongs *et al*. (2020)** studied the relationship between moon phases and fish growth patterns.

There is currently no research on the biological aspects of *O. interrupta* in Indonesia. Therefore, this study aimed to investigate the length-weight relationship and condition factor of the mantis shrimp *O. interrupta*. This study served as the first reference and aimed to collect data and information about the mantis shrimp *O. interrupta* for a sustainable management in the future.

MATERIALS AND METHODS

1. Period and location

The study was conducted over a six-month period from May to October 2023. Sampling of the mantis shrimp *O. interrupta* occurred every new moon and full moon in Bone Bay, East Tanete Riattang District, Bone Regency, South Sulawesi, Indonesia (Fig. 1). The time interval of approximately two weeks between each sampling was determined utilizing a purposive sampling method. Shrimp samples obtained from fishermen were brought to the Fisheries Biology Laboratory, Fisheries Department, Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, for further analysis.

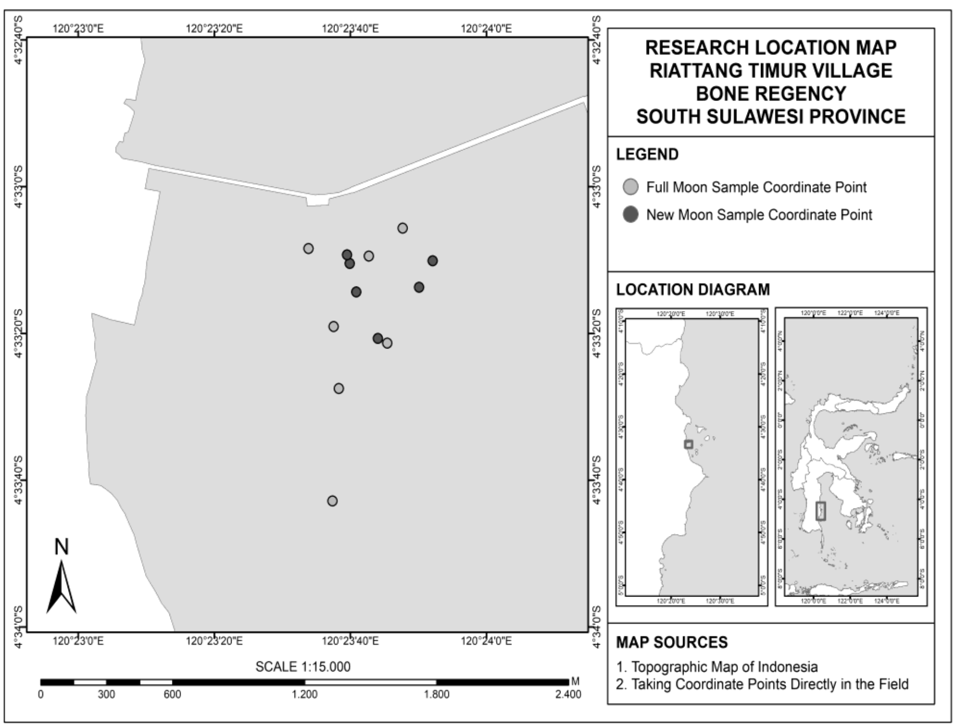

Fig. 1. The sampling location of the mantis shrimp *Oratosquillina interrupta* in Bone Bay, Bone Regency, South Sulawesi Province, Indonesia

2. Sampling and sample handling

Sampling was conducted 13 times, 7 times during full moon and 6 times at new moon. The mantis shrimp samples were obtained from fishermen bycatch using the gillnet gear with a mesh size of 3 inches, and sampling has obtained an approval through a letter of animal ethics code number 5224092057. The fishing gear was deployed in the morning and retrieved at noon. The captured mantis shrimps were then placed in a coolbox filled with ice cubes.

The mantis shrimp samples were analyzed in the Fisheries Biology Laboratory. The shrimp bodies were dried before measuring their total length and body weight. The total length was measured from the tip of the rostral plate to the tip of the telson using a ruler. The total body weight was then measured using an electric scale with an accuracy of 0.01 grams. The length and weight data were used to analyze the length-weight relationships and condition factors. Observation of the sex of the mantis shrimp was determined by the presence of a pair of petasma located at the base of the third pereiopod, corresponding to the 8th thoracic segment in males, and by the presence of the thelycum on the 6th thoracic segment sternite in females **(Sağlam *et al.*, 2018)**.

3. Data analysis

The formula used to analyze the length-weight relationship of the mantis shrimp based on sex and sampling period is W = aL^b.

To obtain a linear equation, this formula was transformed into the following logarithmic form: log W = log a + b log L. In this equation, W represents the body weight in grams, L represents the total length in millimeters, and a and b represent the intercept and slope (regression coefficient), respectively. The values of 'a' and 'b' were calculated using the least squares method **(Omar *et al.*, 2020)**.

To determine whether the value of 'b' is equal to 3 or not, a t-test was conducted at the 95% confidence level on the value of 'b' obtained from the equation above **(Zar, 2014)**.

$$t_{value} = \left|\frac{3-b}{s_b}\right|$$

Where, Sb represents the standard error of 'b', if the value of t-value is greater than t-tablel, then 'b' is different from 3. Conversely, if t-value is smaller than t-table, then 'b' is equal to 3. The growth pattern of the mantis shrimp can be determined based on the value of the regression coefficient (b) obtained. If 'b' equals 3, then the mantis shrimp exhibits an isometric growth, which means that the increase in the body length and weight is balanced. If the value of 'b' is less than 3, it shows a negative allometric growth pattern (hypoallometric), which means that the increase in the body length is faster than the increase in the body weight. Conversely, if 'b' is greater than 3, it indicates a positive allometric growth pattern (hyperallometric), which means that the body weight gain is faster than the body length gain **(Omar *et al.*, 2020)**. To determine if there is a difference in the regression coefficient 'b' between the male and female mantis shrimp, we conducted a t-test with a 95% confidence level, as recommended by **Fowler *et al.* (1998)**.

The study analyzed the condition factor or ponderal index of the mantis shrimp based on the sex and sampling period. The study found that the growth of the shrimp was isometric. To calculate the condition factor using the Fulton formula, K = 105 W/L3, the mean body weight of the shrimp in a given size class (in grams) and the mean total length of the shrimp in the same size class (in millimeters) were used. If the mantis shrimp's growth type was hypoallometric or hyperallometric, the relative condition factor formula was used as follows: Kn = W / W*, where W is the observed mass of an individual in grams, and W* is the theoretical weight of an individual of a given length. The theoretical weight was obtained from the linear regression of the length-weight relationship of the respective population sample (aLb) in grams **(Omar *et al.*, 2020)**. **Lloret-Lloret *et al.* (2022)** stated that a Kn value greater than 1 indicates the good condition for individual fish, while a Kn value less than 1 indicates the poor condition. **Salim *et al.* (2020)** classified the condition factor for the crustaceans into five groups: very thin body shape (0.01- 0.50), thin body shape (0.51- 0.99), proportional/ideal shape (1.00), fat body shape (1.01- 1.50) and very fat body shape (>1.50). Descriptive statistics and graphs were calculated using Microsoft Excel®.

RESULTS

During the sampling period from May to October 2023 in Bone Bay, a total of 796 mantis shrimps were caught. The sampling was conducted during both the new moon and full moon phases, with 397 mantis shrimps caught during the new moon phase and 399 mantis shrimps caught during the full moon phase. Of these, 341 were males and 455 were females. The male to female ratio was similar in both phases, with 168 males and 229 females caught during the new moon phase and 173 males and 226 females caught during the full moon phase. The study analyzed the frequency distribution of the total body length and body weight of the male and female mantis shrimp during the new moon and full moon phases. The results showed that there were 8 classes of the total body length and body weight of the mantis shrimp with varying frequencies (Figs. 2, 3). The data revealed that the female mantis shrimp were more prevalent in the 100- 109mm interval class, even surpassing the male shrimp in the >130mm interval class. Moreover, the study found that the number of the mantis shrimp was higher in the body weight interval of 10.01- 13.00g during the new moon phase and in the interval of 13.01- 16.00g during the full moon phase. The male shrimps were not found in the interval class >22.01g during the new moon phase and >25.01g during the full moon phase (Figs. 2, 3).

Tables (1, 2) show the range, average total length, and body weight of the male and female mantis shrimps at each sampling time. It is worth noting that the average total length and body weight of the female mantis shrimps were greater than those of the males in both the new moon and full moon phases. The study found that the average total length of the male and female shrimps caught during the full moon phase was greater than during the new moon phase. Additionally, the average body weight of the female shrimps was greater during the full moon phase, while the average body weight of the male shrimps was relatively similar between the two phases. Statistical tests revealed a significant difference (*P*< 0.05) in the total length of male and female shrimp between the two moon phases. The total length of the male and female shrimp differed significantly (*P*< 0.05) during the full moon phase. Similarly, the statistical tests showed significant differences (*P*< 0.05) in body weight between the male and female shrimp during both the new and full moon phases.

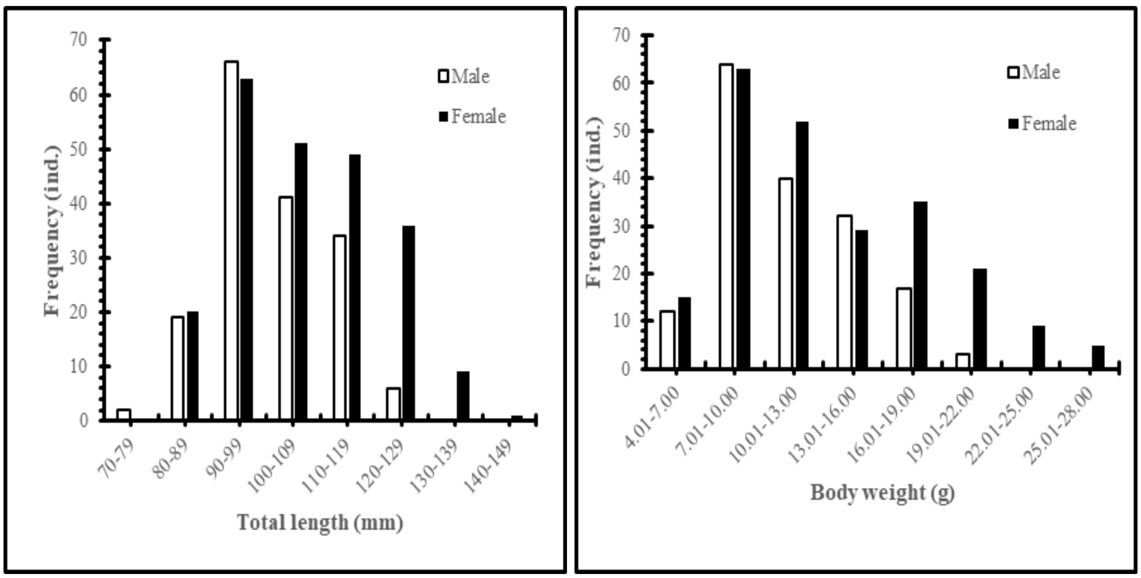

Fig. 2. Total length (left) and body weight (right) frequency distribution for both sexes of *Oratosquillina interrupta* collected on the new moon

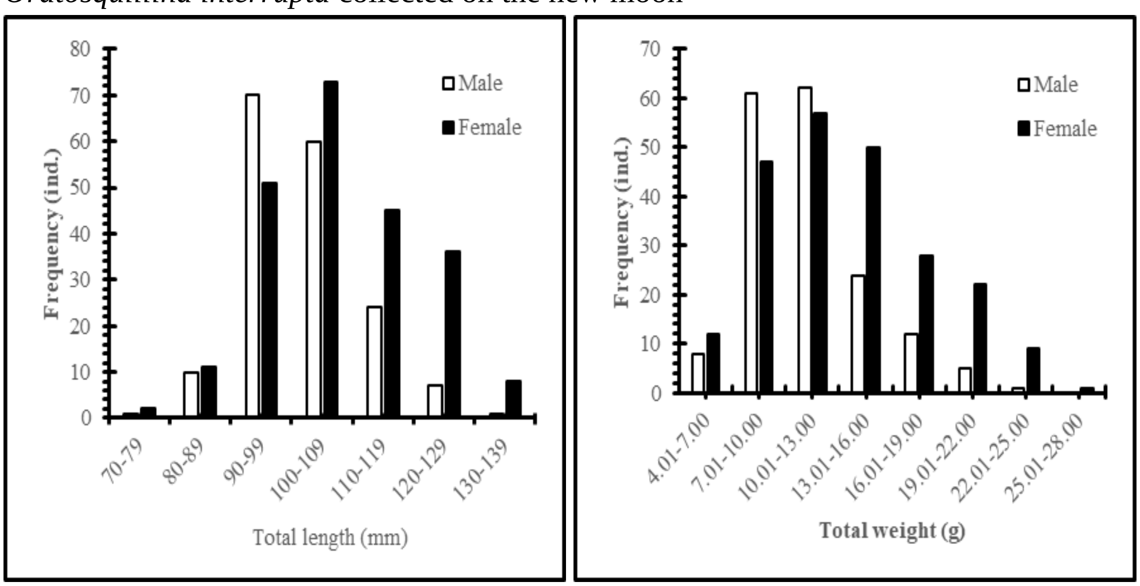

Fig. 3. Total length (left) and body weight (right) frequency distribution for both sexes of *Oratosquillina interrupta* collected on the full moon

1. Length-weight relationship

The relationship between total body length and body weight was shown through regression equations for the male and female mantis shrimp in both new moon and full moon phases. For males in the new moon phase, the equation was $W = 0.00002\ L^{2.8885}$, while for full moon it was $W = 0.00004\ L^{2.7331}$. Additionally, for females in the new moon phase, the equation was $W = 0.00001\ L^{2.9492}$, and for full moon it was $W = 0.00003\ L^{2.8014}$. The statistical analysis of the value of 'b' using the t-test indicates that the male and female mantis shrimp exhibit an isometric growth type ($b = 3$) during the new moon phase, while both exhibit a hypoallometric or negative allometric growth type ($b< 3$) during the full moon phase. The growth pattern of the mantis shrimp can be either isometric or negative allometric (hypoallometric). In the former, the total length gain and body weight were balanced, while in the latter, the total length gain was faster than the body weight gain.

The statistical analysis of the regression coefficients between the male and female mantis shrimp during the new moon phase showed no significant difference ($P> 0.05$). This suggested that, in general, the male and female mantis shrimp were similar in terms of length and weight gain. As a result, the data were combined, and a combined regression equation of $W = 0.00002\ L^{2.8956}$ was obtained, indicating a hypoallometric or negative allometric growth. The statistical analysis showed that the male and female mantis shrimp regression coefficients did not differ significantly ($P> 0.05$) during the full moon phase. Therefore, the data were combined, and a combined regression equation of $W = 0.00003\ L^{2.7816}$ was obtained, indicating a hypoallometric or negative allometric growth type.

Based on the results of the statistical tests on the regression coefficients of the male and female *O. interrupta* in Bone Bay waters, it was found that they generally exhibit an isometric growth type during the new moon phase, while they generally exhibit a hypoallometric growth type during the full moon phase. Specifically, the male shrimp showed a hypoallometric growth during the June and October samplings in the new moon phase, while the female shrimp showed a hypoallometric growth during the September sampling.

The correlation coefficients for the male mantis shrimps were 0.9227 on the new moon and 0.9187 on the full moon (Fig. 4). For the female mantis shrimps, the correlation coefficients were 0.9565 on the new moon and 0.9583 on the full moon (Fig. 5). Overall, the correlation coefficient values for the male and female mantis shrimp were 0.9460 on the new moon and 0.9487 on the full moon (Fig. 6). The correlation coefficient of the male and female mantis shrimps ($r> 0.90$) indicates a very strong relationship between the total length and body weight, both in the new moon and full moon phases.

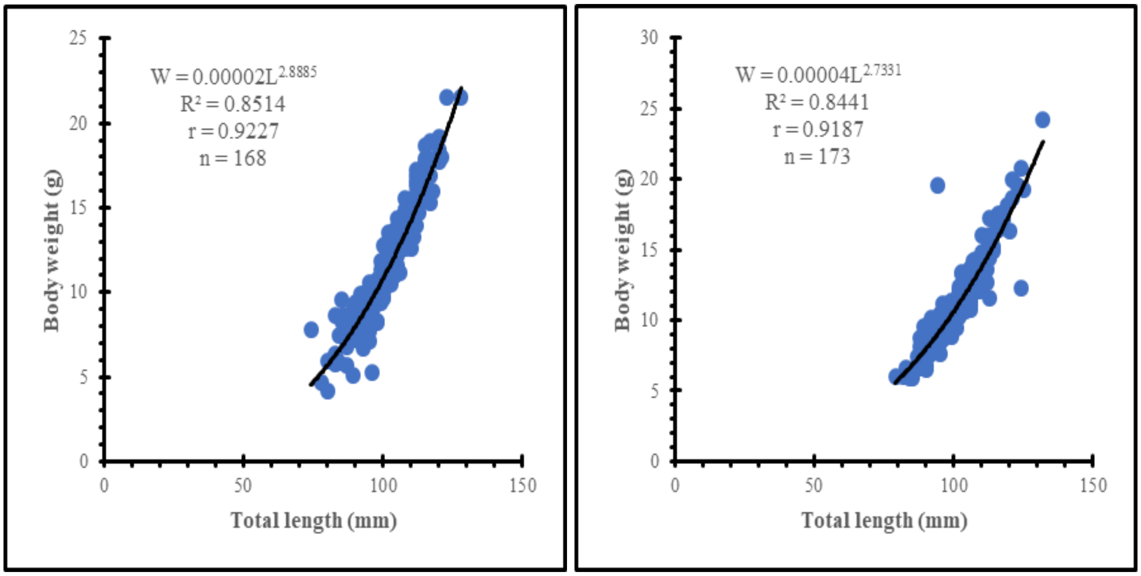

Fig. 4. Relationship between total length and body weight for the male of *Oratosquillina interrupta* on the new moon (left) and full moon (right)

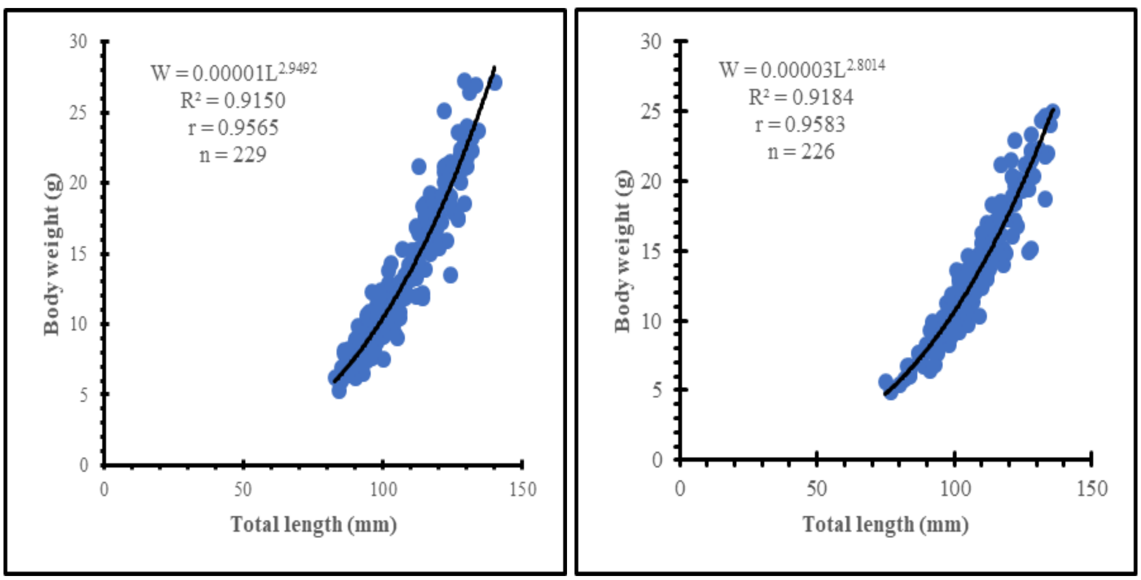

Fig. 5. Relationship between total length and body weight for the female of *Oratosquillina interrupta* on the new moon (left) and full moon (right)

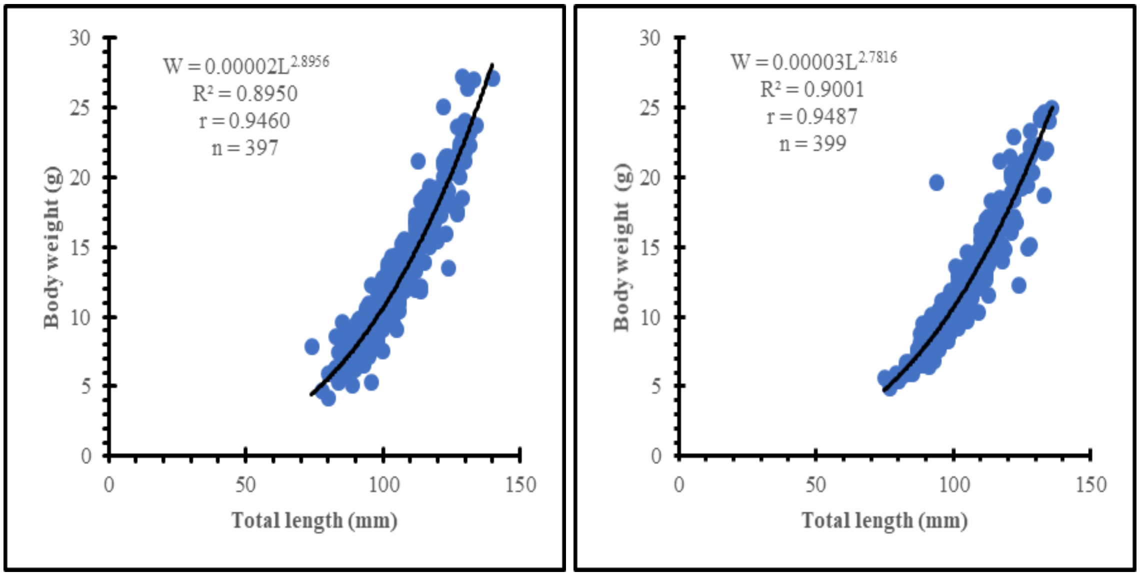

Fig. 6. Relationship between total length and body weight for combined sexes of *Oratosquillina interrupta* on the new moon (left) and full moon (right)

Table (1) shows that, in general, the mantis shrimps in Bone Bay during the new moon phase exhibited isometric growth patterns. However, the male mantis shrimps showed hypoallometric or negative allometric growth patterns in June and October, and the female mantis shrimps showed the same in September. During the full moon phase, the mantis shrimp generally exhibited hypoallometric growth patterns. However, the male mantis shrimps in July and October and the female mantis shrimps in July and August showed isometric growth patterns (Table 2).

2. Condition factor

The mantis shrimp condition factors were differentiated by sex at each sampling time, both in the new moon phase and in the full moon phase, as listed in Table (3). The female shrimp condition factor values were greater than those of the male shrimps in August, September, and October sampling times of the new moon phase and in July, August, and September of the full moon phase. The opposite occurred at other sampling times. Overall, Table (3) reveals that the mean condition factor values of the male mantis shrimps were greater than those of the female shrimps in both the new moon phase (1.0895 for males vs. 1.0487 for females) and the full moon phase (1.0062 for males vs. 1.0047 for females). The statistical tests showed that the condition factor of the male and female mantis shrimp in the new moon phase was significantly different (P< 0.05), while in the full moon phase it was not significantly different (P> 0.05).

Tabel 1. The range and mean values for total length and body weight, as well as the total length-body weight relationship parameters of the male and female mantis shrimp *Oratosquillina interrupta* during the new moon phase

Sex	Month	n	Total length (mm)		Body weight (g)		Length-weight regression parameters			Growth type
			Range	Mean±SE	Range	Mean±SE	a	b	R^2	
Male	May	20	80-116	97.30±2.19	5.78-17.94	9.99±0.74	0.00002	2.8629	0.8721	Isometric
	Jun	19	74-117	101.84±2.71	7.82-18.95	13.24±0.80	0.0004	2.2259	0.9173	Hypoallometric
	Jul	16	84-128	110.81±2.70	5.82-21.53	14.55±1.00	0.000004	3.1958	0.9574	Isometric
	Aug	42	80-123	103.34±1.57	4.16-21.51	12.31±0.60	0.000004	3.2408	0.8547	Isometric
	Sep	47	78-114	95.98±1.13	4.67-17.02	9.50±0.37	0.000009	3.0416	0.8542	Isometric
	Oct	24	83-113	97.96±1.46	8.24-14.69	10.49±0.39	0.0011	2.0024	0.7004	Hypoallometric
	Total	168	74-128	100.34±0.79	4.16-21.53	11.31±0.28	0.00002	2.8885	0.8514	Isometric
Female	May	24	85-132	112.71±2.19	6.05-22.30	14.65±0.82	0.000008	3.0383	0.9332	Isometric
	Jun	25	86-132	109.80±3.12	6.54-27.26	16.12±1.28	0.00002	2.8584	0.9351	Isometric
	Jul	33	84-134	111.67±2.65	5.30-23.73	14.97±1.00	0.000009	3.0301	0.9780	Isometric
	Aug	40	83-140	111.52±2.10	6.23-27.17	15.78±0.86	0.00001	3.0233	0.9391	Isometric
	Sep	68	85-129	100.96±1.35	6.22-18.79	10.43±0.40	0.00008	2.5569	0.8790	Hypoallometric
	Oct	39	88-116	101.62±1.28	6.46-18.31	11.58±0.48	0.000008	3.0566	0.8538	Isometric
	Total	229	83-140	106.65±0.87	5.30-27.26	13.28±0.34	0.00001	2.9492	0.9150	Isometric

Note: n = number of mantis shrimps (ind.), SE = standard error of mean, a = intercept, b = slope (regression coefficient), R^2 = coefficient of determination.

Table 2. The range and mean values for total length and body weight, as well as the total length-body weight relationship parameters of the male and female mantis shrimp *Oratosquillina interrupta* during the full moon phase

Sex	Month	n	Total length (mm)		Body weight (g)		Length-weight regression parameters			Growth type
			Range	Mean±SE	Range	Mean±SE	a	b	R^2	
Male	May	19	93-116	100.79±0.65	10.57-17.50	11.69±0.65	0.0007	2.1156	0.3135	Hypoallometric
	Jun	11	79-124	103.73±3.51	5.97-15.26	11.68±0.81	0.0011	1.9985	0.7686	Hypoallometric
	Jul	19	82-132	104.74±2.92	5.91-24.18	12.06±4.38	0.00002	2.8392	0.9572	isometric
	Aug	47	83-125	102.09±1.76	6.56-20.83	12.00±0.59	0.00004	2.7323	0.9389	Hypoallometric
	Sep	47	85-113	97.57±0.95	5.93-14.40	9.42±0.26	0.0001	2.6018	0.8537	Hypoallometric
	Oct	30	95-121	102.63±0.95	8.61-19.94	12.08±0.41	0.000005	3.1516	0.8621	isometric
	Total	173	79-132	101.21±0.71	5.91-24.18	11.27±0.25	0.00004	2.7331	0.8441	Hypoallometric
Female	May	19	96-126	114.21±1.73	9.35-21.14	15.32±0.68	0.00002	2.8217	0.8798	Hypoallometric
	Jun	19	75-127	105.05±3.87	4.94-20.11	12.79±1.14	0.00006	2.6254	0.9477	Hypoallometric
	Jul	39	83-134	109.44±2.26	6.06-22.17	14.06±0.79	0.00002	2.8502	0.9602	Isometric
	Aug	62	84-136	106.46±1.73	6.40-12.02	13.83±0.67	0.00001	2.9332	0.9493	Isometric
	Sep	39	84-135	103.59±1.90	6.09-24.08	11.11±0.65	0.00003	2.7230	0.9238	Hypoallometric
	Oct	48	92-128	106.77±1.16	8.34-20.26	13.50±0.31	0.0002	2.4334	0.8061	Hypoallometric
	Total	226	75-136	107.09±0.83	4.94-25.02	13.36±0.30	0.00003	2.8014	0.9184	Hypoallometric

Note: n = number of mantis shrimps (ind.), SE = standard error of mean, a = intercept, b = slope (regression coefficient), R^2 = coefficient of determination.

Table 3. Condition factor values of the male and female mantis shrimp *Oratosquillina interrupta* measured at new moon and full moon sampling times

Sex	Month	n	New moon		n	Full moon	
			Range	Mean±SE		Range	Mean±SE
Male	May	20	0.8342-1.3631	1.0562±0.0267	19	0.9772-2.3610	1.1436±0.0690
	Jun	19	0.9540-1.9298	1.2441±0.0413	11	0.7477-1.1585	1.0073±0.0371
	Jul	16	0.8765-1.1802	1.0385±0.0187	19	0.7991-1.1344	1.0127±0.0170
	Aug	42	0.5990-1.3564	1.0798±0.0199	47	0.7987-1.1950	1.0032±0.0118
	Sep	47	0.6919-1.2301	1.0049±0.0144	47	0.8790-1.2641	1.0021±0.0098
	Oct	24	0.7928-1.2281	1.0045±0.0199	30	0.9133-1.2247	1.1071±0.0123
	Total	168	0.5990-1.9298	1.0895±0.0107	173	0.6417-2.1865	1.0062±0.0095
Female	May	24	0.8577-1.2050	0.9973±0.0166	19	0.8818-1.2216	1.0178±0.0170
	Jun	25	0.8131-1.3823	1.1610±0.0242	19	0.7485-1.1686	1.0051±0.0231
	Jul	33	0.8499-1.1471	1.0198±0.0055	39	0.8533-1.2086	1.0313±0.0130
	Aug	40	0.8573-1.4672	1.0942±0.0164	62	0.8493-1.3239	1.0968±0.0120
	Sep	68	0.7660-1.2808	1.0052±0.0124	39	0.8360-1.2381	1.0035±0.0135
	Oct	39	0.8579-1.3891	1.0836±0.0175	48	0.7330-1.1494	1.0037±0.0096
	Total	229	0.7081-1.4672	1.0487±0.0077	226	0.7144-1.2829	1.0047±0.0064

Note: n = number of mantis shrimps (ind.), SE = standard error mean.

DISCUSSION

The study obtained a greater number of the female mantis shrimp *O. interrupta* during both the new moon and full moon phases. This finding is consistent with the research of **Yousuf (2003)** on the mantis shrimp *O. interrupta* in the Northern Arabian Sea, Karachi, Pakistan. Several studies conducted in the Indonesian waters have shown that the female mantis shrimp are caught more frequently than males. For instance, **Muzammil (2010)** studied *Oratosquilla gravieri* in Kuala Tungkal, Jambi; **Djuwito *et al*. (2013)** studied *Oratosquilla oratoria* in Cilacap, Central Java, and **Ekalaturrahmah *et al*. (2020)** studied the *Oratosquillina* sp, in Madura, East Java. The difference in the abundance between the male and female shrimp is attributed to the high mortality rate of the male shrimp during their search for new breeding holes. The females of *O. interrupta* caught in Bone Bay waters were found to have a greater range, average total length, and body weight than the male mantis shrimps, both during the new moon and full moon phases (Tables 1, 2). The results obtained are not different from the findings of **Ahyong (2001)**, **Yousuf (2003)** and **Dudiya *et al.* (2022)**. Table (4) displays the total length of various species of the mantis shrimp belonging to the genus *Oratosquillina*. The data in Table (4) indicates that *O. interrupta* from Bone Bay has a larger body size than those from Vietnam, Pakistan, Taiwan, and India. Differences in the location where the shrimp were caught and the level of exploitation of the catch in each location are believed to be the primary factors that cause variations in the shrimp body size.

The study analyzed the growth of the *O. interrupta* mantis shrimp caught in Bone Bay waters using length-weight relationships. The regression coefficient 'b' in the length-weight relationship equation was used to determine the growth type of the mantis shrimp.

Separate calculations were conducted for the male and female mantis shrimp, as well as for different sampling times and moon phases. During the new moon phase, the male and female mantis shrimps exhibit an isometric growth, while during the full moon phase they exhibit a hypoallometric or negative allometric growth. Additionally, based on the sampling time, the male and female mantis shrimps generally exhibit an isometric growth during the new moon phase and a hypoallometric growth during the full moon phase (Tables 1, 2).

No studies have been conducted on the length-weight relationship in *O. interrupta*. Therefore, a comparison was made with other mantis shrimp species. The study reported isometric and hypoallometric growth types, which have been observed in other mantis shrimp species from different waters. Table (5) shows that most studies on the length-weight relationship of the mantis shrimp found hypoallometric and isometric growth types, **Mili *et al.* (2011)** reported on *Squilla mantis* in the Gulf of Gabes, Tunisia, which found hyperallometric or positive allometric growth types. According to **Wardiatno and Mashar (2011)**, the hypoallometric growth in the mantis shrimp is generally caused by overfishing, competition between the mantis shrimp populations, and competition between the mantis shrimp and other captured organisms in the same habitat. **Ekalaturrahmah *et al*. (2020)** also noted that the trophic potential can affect the value of the 'b' coefficient in addition to overfishing and competition. The study was conducted in the waters of Bone Bay, a fishing ground for various fish species. The mantis shrimp, although not the primary target, are incidentally caught by fishermen in this area.

Tabel 4. Total body length (mm) of some species of *Oratosquillina*

Species	Total length (mm)		Reference
	Male	Female	
O. asiatica	81.5-93.0	97	Manning (1978)
	73-114	71-131	Ahyong *et al.* (2008)
O. berentsae	-	73-100	Ahyong (2001)
O. gonypetes	39-55	26-47	Manning (1978)
O. gravieri	92	-	Manning (1978)
	92-99	94-110	Manning (1995)
	36-113	33-118	Ahyong (2001)
	-	97-108	Ahyong *et al.* (2008)
O. inortata	91	39	Manning (1978)
	48-80	39-112	Ahyong (2001)
	63-107	64-97	Ahyong *et al.* (2008)
	69±12 (C)		Huang *et al.* (2009)
O. interrupta	89	86-88	Manning (1995)
	38-155	66-160	Ahyong (2001)
	56-89	58-95	Yousuf (2003)
	65-135	67-137	Ahyong *et al.* (2008)
	76±23 (C)		Huang *et al.* (2009)
	71.10-108.00	75.39-112.36	Dudiya *et al.* (2022)
	74-132	75-140	This study
O. manningi	39-87	79-90	Ahyong (2001)
	87	79-90	Ahyong *et al.* (2008)
O. nordica	44-118	47-124	Ahyong *et al.* (2008)
O. perpensa	64-93	63-97.5	Manning (1978)
	30-112	31-119	Ahyong *et al.* (2008)
O. quinquedentata	59-140	119	Manning (1978)
	30-148	55-155	Ahyong (2001)
O. stephensoni	93-144	109.5-149	Manning (1978)
	43-150	63-157	Ahyong (2001)

Note: C = combined sexes (male and female).

The regression coefficient 'b' values listed in Table (5) not only exhibit variation between one species and another but also for the same species but from different waters. Many factors can cause differences in 'b' values, including sex, diet, stomach fullness, biota health conditions, habitat conditions, gonad maturity stage, spawning season, growth rate, sampling time, differences in the observed length ranges of the caught specimen, and even preservation techniques **(Ekalaturrahmah *et al*., 2020; Omar *et al.*, 2020; Baker & Mehanna, 2024)**. In addition, the variation of the 'b' coefficient value also depends on the number and size range of the observed biota **(Kharat *et al*., 2008; Asadi *et al*., 2017)**.

The coefficient of determination (R^2) of the female mantis shrimp obtained during the study in Bone Bay was higher than that of the males, namely 0.9150 in the new moon phase and 0.9184 in the full moon phase, while males were 0.8154 and 0.8441 in the new moon and full moon phases, respectively (Tables 1, 2). These values are similar to those reported in other studies on the mantis shrimp, as listed in Table (5). An ideal fish growth has an R^2 coefficient value ranging between 0.9 and 1.0 **(Hanif *et al*., 2020)**.

The condition factor (K) is a crucial indicator of the environment's ability to support an organism's life. It can be used to evaluate an organism's physiological and health status **(Zakzok *et al*., 2022)**. The environmental factors, both biotic and abiotic, can influence the condition factors. Therefore, it can serve as an index that reflects the status of the aquatic ecosystem in which the organism resides **(Omar *et al*., 2020)**. If only the body length and weight are measured, the condition factor can estimate the spawning season of aquatic organisms **(Arshad *et al*., 2015)**. The study conducted in Bone Bay found that the highest mean condition factor values for male and female *O. interrupta* occurred in June during the new moon phase, with values of 1.2441 and 1.1610, respectively. This suggests that the spawning season for *O. interrupta* in Bone Bay is likely to occur in June. Throughout the study, the average condition factor value for *O. interrupta* in Bone Bay remained above 1 (Kn>1.0). According to **Lloret-Lloret *et al*. (2022)**, the mantis shrimp specimens were found to be in good condition. The average condition factor values for the male mantis shrimps ranged from 1.0021 to 1.2441, while for the female shrimps, the values ranged from 0.9973 to 1.1610. This shows that male shrimps are included in the ideal shape to the fat body shape group, while the female shrimps are included in the thin body shape to the fat body shape group **(Salim *et al*., 2020)**. In general, the condition factor values of *O. interrupta* obtained during the study in Bone Bay did not differ from the condition factor values of the other mantis shrimp species from various waters, as shown in Table (6).

Table 5. Length-weight relationship coefficients and growth pattern of the mantis shrimps

Species	Location	Sex	n	Regression parameters			Growth type	Reference
				a	B	R^2		
Erugosquilla massavensis	Antalya Bay, Turkey	M	138	0.000128	2.478	0.823	Hypoallometric	Gökoğlu *et al.* (2008)
		F	133	0.000062	2.628	0.868	Hypoallometric	
		C	271	0.000091	2.546	0.852	Hypoallometric	
	Port Said, Egypt	M	610	0.0245	2.716	0.878	Hypoallometric	Zakzok *et al.* (2020)
		F	702	0.023	2.716	0.897	Hypoallometric	
		C	1312	0.0231	2.726	0.884	Hypoallometric	
Gonodactylus chiragra	Batukalasi, Indonesia	M	46	0.000985	2.0870	0.8103	Hypoallometric	Asriani (2022)
		F	23	0.000384	2.3044	0.8877	Hypoallometric	
Harpiosquilla harpax	Madura, Indonesia	M	347	0.0210	2.3057	0.8713	Hypoallometric	Ekalaturrahmah *et al.* (2020)
		F	343	0.0163	2.4302	0.8251	Hypoallometric	
	Pantai Remis, Malaysia	M	439	0.023	2.698	0,715	Hypoallometric	Arshad *et al.* (2015)
		F	365	0.014	2.884	0.899	Hypoallometric	
		C	804	0.015	2,852	0.841	Hypoallometric	
	Visakhapatnam, India	M	344	0.000079	2.5650	0.4416	Hypoallometric	Prasad and Rao (2015)
		F	551	0.000048	2.6622	0.7257	Hypoallometric	
		C	895	0.000066	2.6015	0.6524	Hypoallometric	
	Palabuhanratu, Indonesia	M	13	0.0152	2.8644	0.9869	Hypoallometric	Iftitah *et al.* (2017)
		F	19	0.0366	2.5454	0.8965	Hypoallometric	
		C	32	0.0244	2.6870	0.9549	Hypoallometric	
	Sakuala Island, Indonesia	M	148	0.0019	1.9492	0.7550	Hypoallometric	Arifandi (2022)
		F	172	0.0006	2.1979	0.7235	Hypoallometric	
		C	320	0.0008	2.1355	0.8217	Hypoallometric	
Harpiosquilla raphidea	Tarakan, Indonesia	M	131	0.0070	2.8343	0.9706	Hypoallometric	Salim *et al.* (2020)
		F	83	0.0067	2.8573	0.9085	Hypoallometric	

	Kuala Tungkal, Jambi, Indonesia (intertidal area)	M	331	0.00003	2.743	0.876	Hypoallometric	Wardiatno and Mashar (2011)
		F	484	0.00004	2.687	0.885	Hypoallometric	
	Kuala Tungkal, Jambi, Indonesia (subtidal area)	M	549	0.0003	2.356	0.896	Hypoallometric	Wardiatno and Mashar (2011)
		F	745	0.0002	2.413	0.779	Hypoallometric	
Harpiosquilla sp	Andaman Sea, Thailand	M	265	0.0257	2.7425	0.8377	Hypoallometric	Samphan and Ratanamusik (2018)
		F	172	0.0610	2.4810	0.7239	Hypoallometric	
		C	437	0.0341	2.6564	0.8129	Hypoallometric	
Miyakella nepa	Sakuala Island, Indonesia	M	54	0.0067	1.6785	0.7766	Hypoallometric	Arifandi (2022)
		F	143	0.0004	2.2956	0.8282	Hypoallometric	
		C	197	0.001	2.0920	0.8208	Hypoallometric	
Oratosquilla anomala	Visakhapatnam, India	M	573	0.00337	1.7336	0.4784	Hypoallometric	Prasad and Rao (2015)
		F	743	0.00278	1.7801	0.5609	Hypoallometric	
		C	1316	0.00293	1.7801	0.5316	Hypoallometric	
Oratosquilla gravieri	Kuala Tungkal, Jambi, Indonesia	M	77	0.0150	2.7995	0.8720	Hypoallometric	Muzammil (2010)
		F	146	0.0123	2.8920	0.9296	Hypoallometric	
Oratosquilla nepa	Madras, India	M	187	0.009466	1.5088		Hypoallometric	James and Thiramilu (1993)
		F	288	0.005931	1.6236		Hypoallometric	
	Karnataka, India	M	107	0.017	2.786	0.94	Hypoallometric	Abdurahiman *et al.* (2004)
		F	109	0.014	2.884	0.94	Hypoallometric	
Oratosquilla oratoria	Cilacap, Indonesia	M	200	0.0097	2.189	0.7117	Hypoallometric	Djuwito *et al.* (2013)
		F	256	0.013	2.086	0.6052	Hypoallometric	
	Tongyeong, Korea	M	1116	0.000027	2.8727	0.9092	Hypoallometric	Kim *et al.* (2017)
		F	1328	0.000029	2.8498	0.9170	Hypoallometric	
Oratosquillina sp	Madura, Indonesia	M	182	0.0405	2.3090	0.8428	Hypoallometric	Ekalaturrahmah *et al.* (2020)

		F	230	0.0365	2.4970	0.8725	Hypoallometric	
Oratosquillina interrupta	Bone Bay, Indonesia (new moon)	M	168	0.00002	2.8885	0.8514	Isometric	This study
		F	229	0.00001	2.9492	0.9120	Isometric	
		C	397	0.00002	2.8956	0.8950	Hypoallometric	
	Bone Bay, Indonesia (full moon)	M	173	0.00004	2.7331	0.8441	Hypoallometric	This study
		F	226	0.00003	2.8014	0.9184	Hypoallometric	
		C	399	0.00003	2.7816	0.9001	Hypoallometric	
Squilla mantis	Gulf of Gabes, Tunisia	M	8770	0.000004	3.2097	0.96	Hyperalometric	Mili *et al.* (2011)

Note: n = number of mantis shrimp (ind), F = female, M = male, C = combined sexes (male and female).

Tabel 6. Condition factor of the mantis shrimps

Species	Region	Sex	Condition factor	Reference
Erugosquilla massavensis	Port Said, Egypt	M	2.576	Zakzok *et al.* (2020)
		F	2.424	
		C	2.43	
Gonodactylus chiragra	Batukalasi, Indonesia	M	0.6870-1.5065	Asriani (2022)
		F	0.8039-1.2441	
Harpiosquilla harpax	Pantai Remis, Malaysia	M	1.002-1.021	Arshad *et al.* (2015)
		F	1.010-1.025	
	Palabuhanratu, Indonesia	M	1.06	Iftitah *et al.* (2017)
		F	1.01	
		C	1.03	
	Cirebon, Indonesia	M	1.07	Iftitah *et al.* (2017)
		F	1.00	
		C	1.04	
	Sakuala Island, Indonesia	M	0.6792-2.5174	Arifandi (2022)
		F	0.6666-2.2599	
Harpiosquilla raphidea	Tarakan, Indonesia	M	0.30-0.60	Salim *et al.* (2020)
		F	0.30-0.70	
Miyakella nepa	Sakuala Island, Pangkep, Indonesia	M	0.7906-1.3523	Arifandi (2022)
		F	0.7920-1.4507	
	Karnataka, India	M	0.6183-0.7339	Kishor *et al.* (2023)
		F	0.6103-0.7227	
Oratosquilla oratoria	Cilacap, Central Java (Indonesia)	M	1.052	Djuwito *et al.* (2013)
		F	1.097	
Oratosquillina interrupta	Bone Bay, Indonesia	M	0.5990-2.3610	This study
		F	0.7330-1.4672	
Squilla mantis	Izmir Bay, Aegean Sea, Turkey	M	1.00	Sağlam *et al.* (2017)
		F	1.04	
		C	1.02	
	Edremit Gulf, Aegean Sea, Turkey	M	0.88-0.95	Sarigöl (2019)
		F	0.89-0.94	
		C	0.88-0.95	
	Lagos Lagoon, Nigeria	M	0.9-1.1	Akinwunmi *et al.* (2021)
		F	1.1-1.5	

Note: F = female, M = male, C = combined sexes (male and female).

CONCLUSION

During both new and full moon phases in Bone Bay, the female mantis shrimps were predominant among *O. interrupta* catches. Both the male and female mantis shrimps exhibited isometric (b=3) and hypoallometric (b<3) growth patterns. The mean condition factor values for the male and female shrimps during the new and full moons indicate that the mantis shrimp population in Bone Bay is generally in good health.

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