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MORPHOMETRIC STUDY OF TWO INDONESIAN MANTIS SHRIMPS (*Harpiosquilla raphidea* and *Oratosquillina gravieri*) (*Studi morfometrik dua jenis udang mantis Indonesia* (*Harpiosquilla raphidea dan Oratosquillina gravieri*))

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ABSTRAK

Dua jenis udang mantis Indonesia, Harpiosquilla raphidea dan Oratosquillina gravieri, variasi karakter morfometrik [Panjang Kubo (BL), panjang capit (CL), lebar capit (CW), dan panjang penis (PL)] dikaji berdasarkan hasil tangkapan dari pantai berlumpur di Kuala Tungkal, Jambi, Sumatera. Hubungan alometri dibuat dengan kombinasi dua karakter morfometrik, dimana BL dijadikan sebagai faktor tetap pada sumbu x; hasilnya memperlihatkan bahwa nilai CL, CW, dan PL meningkat secara linear seiring peningkatan nilai BL. Hail analisis kovarians mengindikasikan bahwa panjang capit jantan H.raphidea lebih panjang daripada panjang capit jantan O.gravieri. Karakter ini mungkin merupakan faktor dibalik superioritas kemampuan kompetisi H. raphidea terhadap O. gravieri ketika keduanya hidup berdampingan.

Kata kunci: udang mantis, kajian morfometri, *Harpiosquilla raphidea, Oratosquillina gravieri*

ABSTRACT

For the two Indonesian mantis shrimps, *Harpiosquilla raphidea* and *Oratosquillina gravieri*, morphometric character variations [Kubo's length (BL), length of claw (CL), claw width (CW), and penis length (PL)] were examined based on the materials collected from mudflat in Kuala Tungkal, Jambi, and Sumatera. Some comparison of meristic characters of the two species are also presented. Allometric relationships were established between each combination of two morphometric characters for each species, in which BL was fixed on the abscissa as a reference variable; the values of CL, CW, and PL linearly increase with the BL value. The results of analysis of covariance indicate that the claw length of male *H.raphidea* is significantly longer than that of *O.gravieri*. This feature is believed to be the factor behind *H. raphidea*'s superiority in competition with *O. gravieri*.

Key words: mantis shrimp, morphometric study, *Harpiosquilla raphidea, Oratosquillina gravieri*

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INTRODUCTION

In several Asian countries mantis shrimps have long been renowned as major and commercially valuable resources of fisheries in coastal region (Colloca et al., 2003; Kodama et al., 2004; Garces et al., 2006; Lui et al., 2007; Musa & Wei, 2008). The shrimps are one of main commodities in fish market in countries like Spain, Italy, Egypt, Morocco (Abello & Martin, 1993), and Indonesia (Wardiatno, 2011; personal observation).

In ecology point of view, mantis shrimps are one of the most obvious members of the littoral and sub-littoral large-sized benthic animals living in soft sediments worldwide. These organisms burrow themselves to shelter, reproduce and feed. The spearer mantis shrimps, Harpiosquilla raphidea and Oratosquillina gravieri are common mantis shrimps inhabiting muddy bottoms in coastal waters around Indonesia (Prof. M. Kasim Moosa, 2009; personal communication). In a mudflat developed in Kuala Tungkal estuary in Sumatera Island, the two shrimps inhabit co-exist. Some biological information on the shrimps, in particular Harpiosquilla raphidea have been explored (see Wardiatno & Mashar 2010, 2011), and the distribution and co-existence pattern of the two shrimps has been shown by Mashar & Wardiatno (2011). However, there is no existing data on the morphometric relationships for these species in the area.

Morphomeric characters of crustaceans are commonly used for taxonomical studies. Most common works in taxonomical studies are to illustrate and describe morphometric usable characters displayed in adult, juvenile or larvae stage of genus or species of various organisms found in certain area [*e.g.* for thalassinidean shrimps: Rambla & Arana (1994), Rambla *et al.* (1995), Manning & Tamaki (1998), Wardiatno & Tamaki (2001); for copepods: Ho & Kim (2001), Boxshall & Ohtsuka (2001), for crabs: Sampedro *et al.* (1999), Ng & Yeo (2001); *etc.*]. For taxonomists, the features reported could be useful to establish phylogenetic relationships between species placed in monotypic genera with clear familial or ordinal placement. In addition, modern molecular methods, for instance, DNA sequences, could confirm possible evolutionary relationships between genera of certain organisms.

Comparison in morphological characters of the same genera or species among several localities would be of carcinologist' interest (*e.g.* Ohtomi & Hayashi, 1995; Clark *et al.*, 2001; Wardiatno & Tamaki, 2001). Stamhuis *et al.* (1998) gave a detailed morphology of feeding appendages of *Callianassa subterranea* to reveal the feeding mechanisms of the callianassid shrimp. In the same way, Coelho *et al.* (2000) described feeding appendages of two upogebiid shrimps, *Upogebia omissa* and *Pomatogebia operculata*, not only to show the feeding mechanisms, but also to demonstrate the differences in trophic strategies utilized by the two shrimps. Whilst Wardiatno & Tamaki (2001) studied the morphological characters of two Japanese ghost shrimps, *Nihonotrypaea japonica* and *N. harmandi* for identification.

The present study describes and compares some morphological characters of the two Indonesian mantis shrimps (Harpiosquilla raphidea and Oratosquillina gravieri), collected from a mudflat in Kuala Tungkal, Province Jambi, Sumatera Island. A possible effect of the differences of the morphological characters on their co-existence pattern is highlighted.

MATERIALS AND METHODS

Study Area

The present study was carried out on an intertidal soft mudflat developed at the mouth of Tungkal River, Kuala Tungkal, Province Jambi (Fig. 1). At extreme low spring tides the mudflat could be exposed for more than 1 km seaward. *Harpiosquilla raphidea* and

Oratosquillina gravieri co-occur over almost the entire mudflat. The depth of the soft sediment column could reach up to 2.0 meters. The water parameters measured were as follow: temperature ranged from 28.2 to 30.5 °C, salinity ranged from 15 to 19 psu, and oxygen concentration ranged from 6.7–7.6 ppm (Wardiatno & Mashar, 2010).

Sampling of *Harpiosquilla raphidea* and *Oratosquillina gravieri*

Mantis shrimp samples were collected from the intertidal mudflat by means of a mini-trawl like fishing gear. The total number of mantis shrimp are caught during the study was 1454 individuals. All shrimps were immediately fixed in 10% buffered seawater-Formalin.

Collected shrimps were measured to obtain some morphometrical characters, i.e. the Kubo's body length [abbreviated as BL: from the base of the rostrum to the anterior edge of the median notch of the telson (Ohtomi *et al.*, 1992; Kubo *et al.*, 1959)], length of claw [CL] (Fig. 2A), width of first leg propodus [CW] (Fig. 2B), and penis length [PL] (for males only). Measurements were made to the nearest 0.1 cm using caliper, except for the claw length where the measurements were helped by thread. Sex was determined by the presence or absence of penis located at the base of a pair of third pereiopods on the eighth thoracic segment (Kubo *et al.*, 1959), unless evident by the conspicuous presence of ovaries in females. Some differences in morphological characters are also recorded.

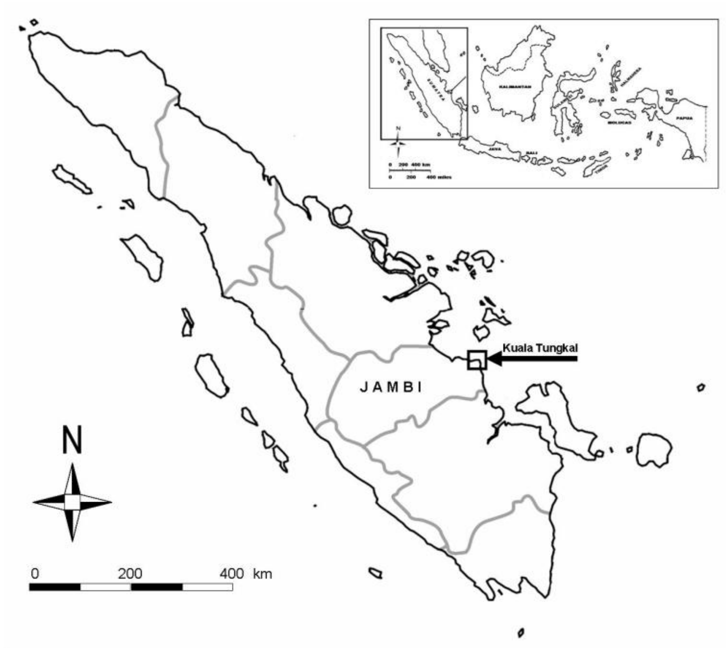


Fig. 1 Research location. Black box indicates the mudflat where the shrimps were collected (taken from Wardiatno & Mashar, 2010).

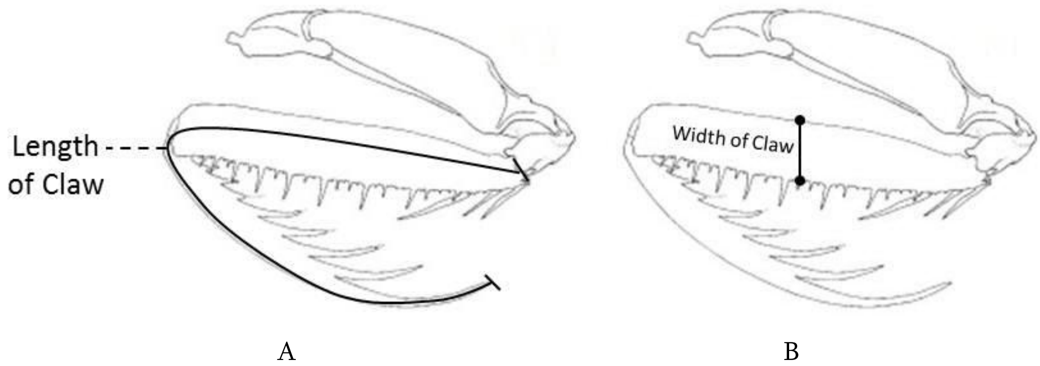


Fig. 2 Morphology measurement in: A) length of claw (CL) and B) width of first leg propodus width (CW). The measurements for CL were helped by fitting thread along the line as drawn in the figure.

Data Analysis

Allometric relationships were established between each combination of two morphometric characters for each species, in which BL is fixed on the abscissa as a reference variable; for the claw and penis of males, data from both sides of a specimen were plotted against the same BL value.

A total of 402 specimens for Oratosquillina gravieri (98 males and 300 females) and 1066 specimens for Harpiosquilla raphidea (466 males and 590 females) were used. All statistical tests were performed with a statistical package. Firstly, the linear regression equations between each of all claw characters and penis versus BL were established for each species, and the significance of the differences between the two species (concerning slopes and intercepts) was tested by analysis of covariance (ANCOVA).

Spearman rank correlation is performed to show the correlation between the two species using the abundance of each species. If the correlation is negative, it can be said that the presence of one species will exclude the other one, and vice versa. Data on the abundance of the two species were summarized from Mashar & Wardiatno (2011).

RESULTS AND DISCUSSION

Of the studies on morphometric character variations for crustaceans, it has very rare been done for stomatopod shrimps. However, there some studies for callianassid shrimps. For example, Felder & Lovett (1989) used morphometric characters (*i.e.* carapace length, chela width, and chela height) to estimate maturation size of male and female *Lepidophthalmus louisianensis* (originally as *Callianassa louisianensis*). Labadie & Palmer (1996) conducted a morphometric analysis of cheliped size and shape variation in the strikingly heterochelous, north-eastern Pacific ghost shrimp, *Neotrypaea californiensis* to obtain a better understanding of the cheliped function and ontogeny. Dworschak (1998) made some morphometric character comparisons between sexes of *Callianassa tyrrhena* and *C. candida* collected from tidal flats in the northern Adriatic Sea. His biometric analysis showed a sexual dimorphism in both species, especially in the size of the propodus of the major cheliped. Wardiatno & Tamaki (2001) studied relationships between carapace length and ratio of cornea width and eyestalk width in *Nihonotrypaea japonica* and *N. harmandi*. They established bivariate discriminant formula to separate the two species.

Relationships of some morphometric characters to carapace or total length are often included in morphometric studies of decapod crustaceans (*e.g.* Phinney, 1975; Haefner, 1990; Oh & Hartnoll, 1999; Sampedro *et al.*, 1999; Conan *et al.*, 2001; Wardiatno & Tamaki, 2001). Allometric relationships have been used widely to quantify relative growth of body parts expressing secondary sexual characters in crustaceans (Hartnoll, 1978, 1982). According to White & Gould (1965), the slope of the allometric relationship undergoes a sudden change at the molt before maturity.

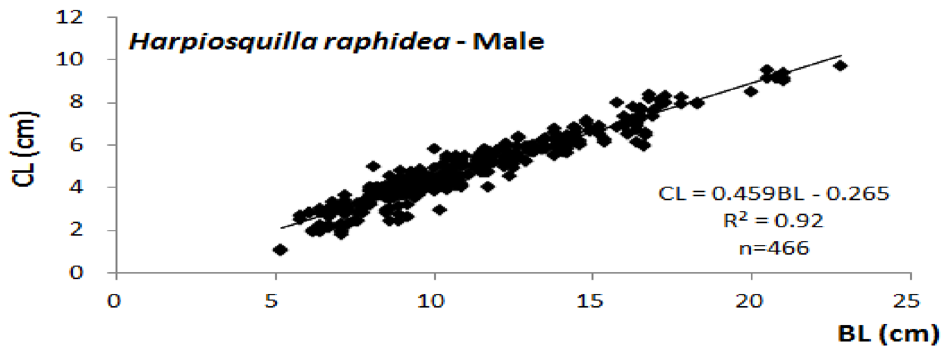
In this study, the scatter plots for each pair of three variables in the two species, in which BL is fixed on the abscissa, are shown in Fig. 3 (for CL), Fig. 4 (for CW), and Fig. 5 (for PL). The ranges of BL were 2.8-22.8 cm for *Harpiosquilla raphidea* and 2.9-15.0 cm for *Oratosquillina gravieri*; the much larger body size is attained in *H. raphidea*. The minimum mature body sizes of *H. raphidea* (for female) were at around a 22.4–cm BL (Wardiatno; unpublished data) but it may attain 38.2-cm BL (for both sexes) (Wardiatno & Mashar, 2011), whereas those of *O. gravieri* were seems to be smaller. Thus, the specimens used for the two species spanned from immature to full-grown individuals. For all cases in Figs. 3-5, the values of the ordinate variables linearly increase with the BL value, and their linear regression equations are summarized in Table 1. The results of ANCOVA for each pair of two variables between the two species and between sexes of the same species are also summarized in Table 1 and 2. The slopes of the linear regression lines (vs. BL) are regarded as non-parallel for all morphometric characters, except for CL between male species and between sexes in *H. raphidea*. In the case of CL, in general male *H. raphidea* has significantly longer CL than male *O. gravieri*, while by comparing sex, CL of both male and female *H. raphidea* is the same within the same BL size. For CW in male, with the increase in BL, CW becomes larger in *O. gravieri* beyond the cross 3.74-mm BL and 0.11 cm-CW, meaning the wider claw for *O. gravieri* with body growth. However, although the line slope in the BL vs. CW relationship is greater for female *O. gravieri*, the difference is not so clearly visible at least for the overlapped BL values. The condition is the similar with BL vs. CL relationship in female, as well as with BL vs. PL in male.

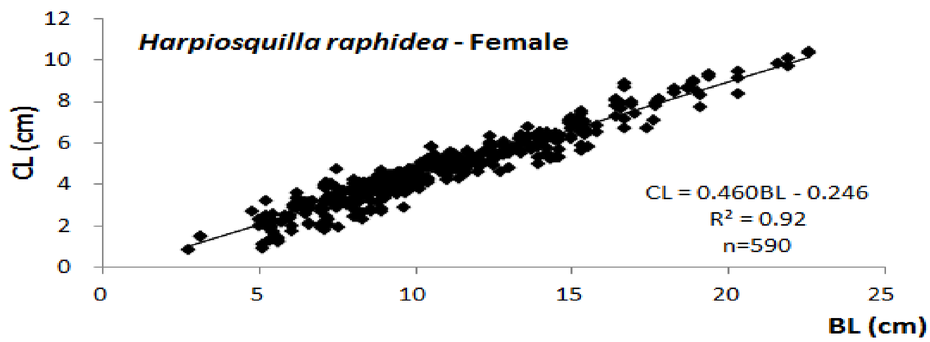
Table 1 Linear regression equations between four morphometric variables (BL is the reference variable) in *Harpiosquilla raphidea* and *Oratosquillina gravieri*, with the ANCOVA results for the difference between the two species.

Relation Between	Species	y = ax + b		R^2	ANCOVA Results: Slopes	ANCOVA Results: b-value/ Crossing-point
Male						
BL vs. CL	*H. raphidea*	CL = 0.459 BL – 0.265	($p < 0.001$)	0.92	Parallel	b1≠b2
	O. gravieri	CL = 0.429 BL – 0.769	($p < 0.05$)	0.58		
BL vs. CW	*H. raphidea*	CW = 0.039 BL – 0.037	($p < 0.001$)	0.88	non-parallel	at 3.74 cm-BL
	O. gravieri	CW = 0.054 BL – 0.095	($p < 0.05$)	0.68		
BL vs. PL	*H. raphidea*	PL = 0.108 BL – 0.402	($p < 0.001$)	0.92	non-parallel	at 17.30 cm-BL
	O. gravieri	PL = 0.095 BL – 0.169	($p < 0.05$)	0.64		
Female						
BL vs. CL	*H. raphidea*	CL = 0.460 BL – 0.246	($p < 0.001$)	0.92	non-parallel	at 14.60 cm-BL
	O. gravieri	CL = 0.533 BL – 1.314	($p < 0.001$)	0.86		
BL vs. CW	*H. raphidea*	CW = 0.037 BL – 0.027	($p < 0.001$)	0.88	non-parallel	at 48.20 cm-BL
	O. gravieri	CW = 0.036 BL + 0.029	($p < 0.05$)	0.72		

Table 2 Linear regression equations between three morphometric variables (BL is the reference variable) in *Harpiosquilla raphidea* and *Oratosquillina gravieri.*, with the ANCOVA results for the difference between female and male in the same species.

Relation Between	Sex	y = ax + b		R^2	ANCOVA Results: Slopes	ANCOVA Results: b-value/ Crossing-point
H. raphidea						
BL vs. CL	Male	CL = 0.459 BL – 0.265	($p < 0.001$)	0.92	parallel	b1=b2
	Female	CL = 0.460 BL – 0.246	($p < 0.001$)	0.92		
BL vs. CW	Male	CW = 0.039 BL – 0.037	($p < 0.001$)	0.88	non-parallel	at 3.75 cm-BL
	Female	CW = 0.037 BL – 0.027	($p < 0.001$)	0.88		
O. gravieri						
BL vs. CL	Male	CL = 0.429 BL – 0.769	($p < 0.05$)	0.58	non-parallel	at 5.20 cm-BL
	Female	CL = 0.533 BL – 1.314	($p < 0.001$)	0.86		
BL vs. CW	Male	CW = 0.054 BL – 0.095	($p < 0.05$)	0.68	non-parallel	at 6.80 cm-BL
	Female	CW = 0.036 BL + 0.029	($p < 0.05$)	0.72		





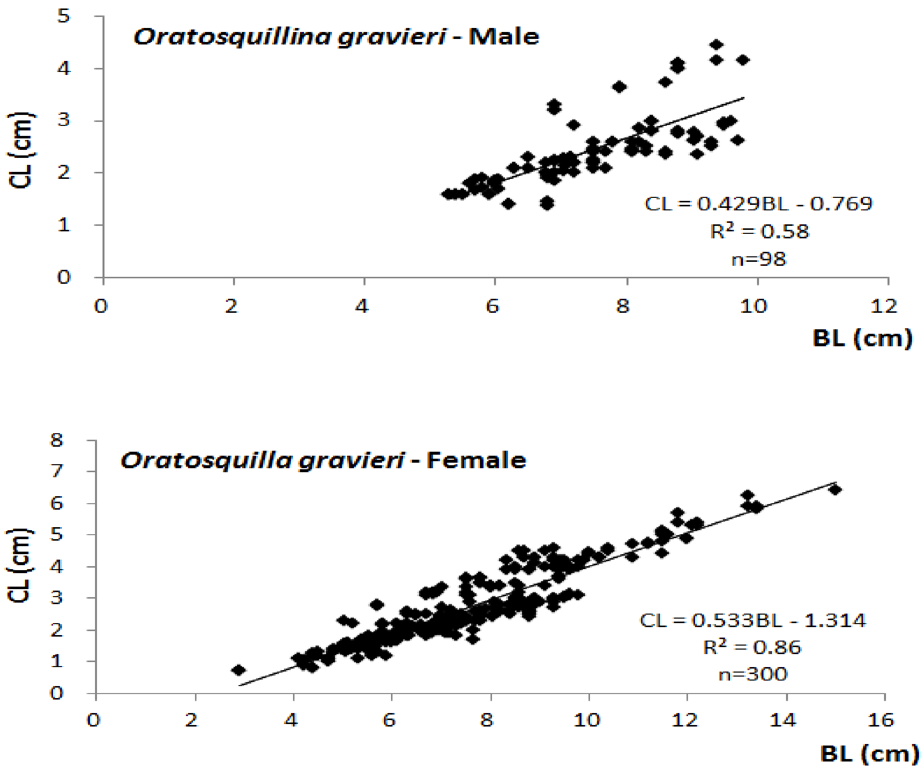
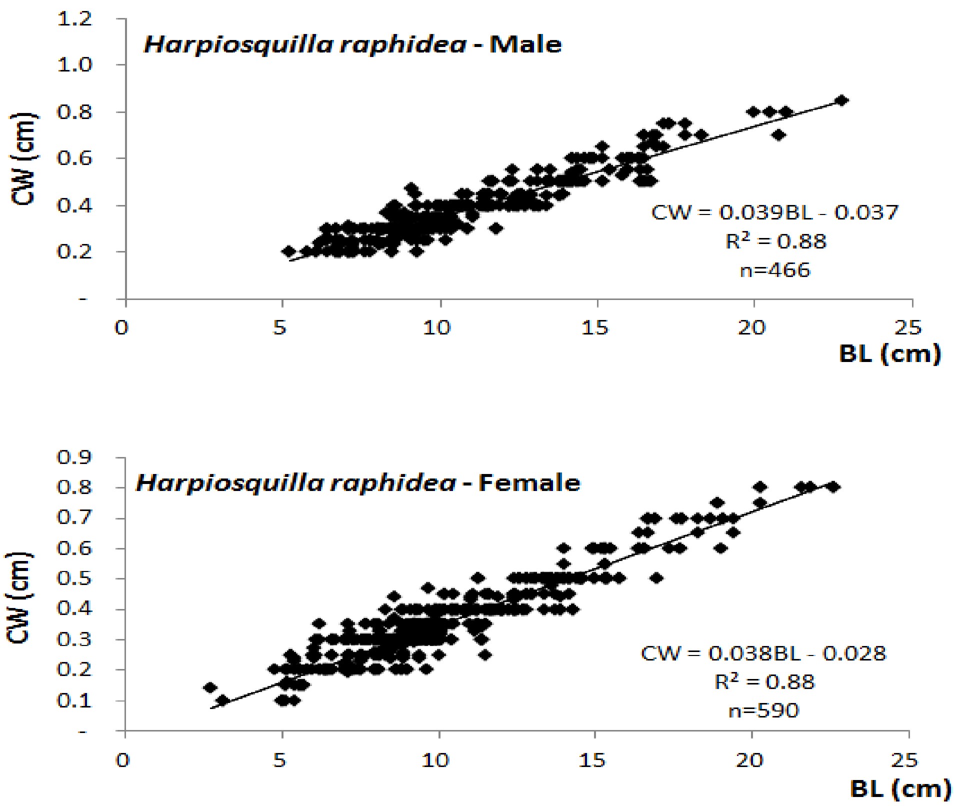


Fig. 3 BL (Kubo's length) vs. CL (length of claw) relationships in males and females of both *Harpiosquilla raphidea* and *Oratosquillina gravieri.*



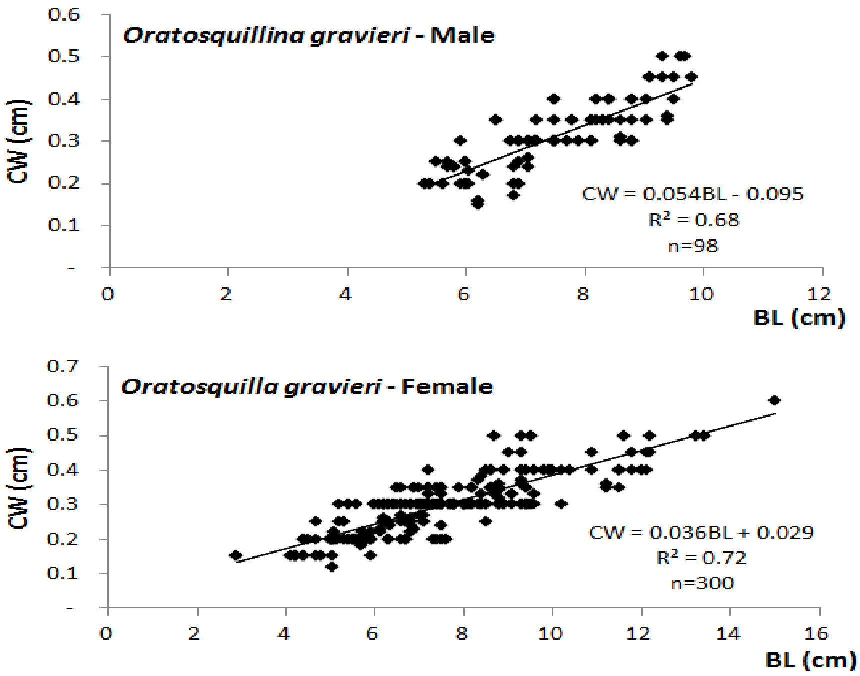


Fig. 4 BL (Kubo's length) vs. CW (claw width) relationships in males and females of both *Harpiosquilla raphidea* and *Oratosquillina gravieri.*

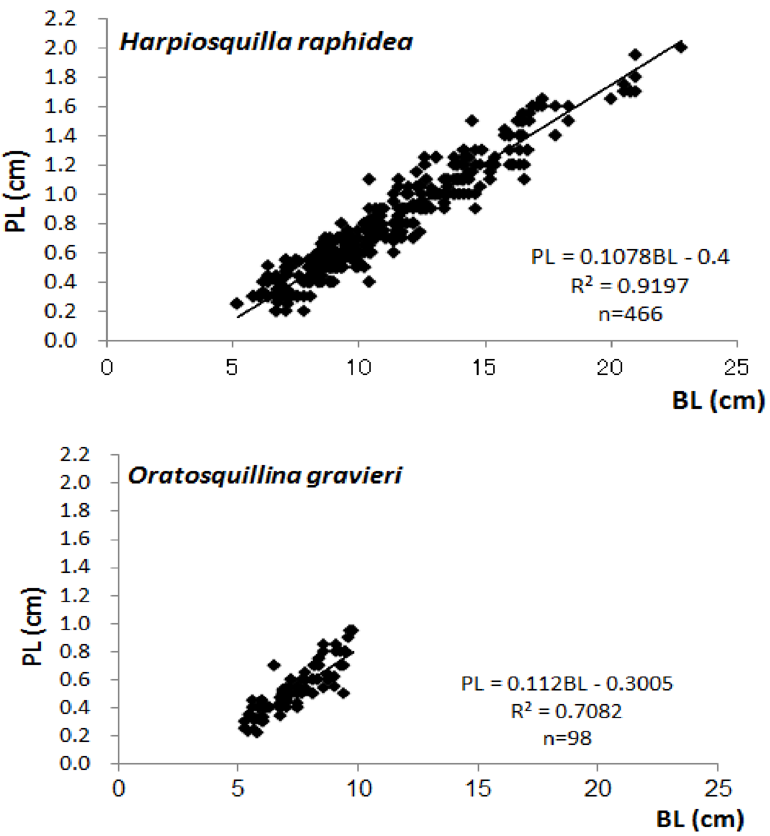


Fig. 5 BL (Kubo's length) vs. PL (length of penis) relationships in male *Harpiosquilla raphidea* and *Oratosquillina gravieri.*

Mashar & Wardiatno (2011) studied the distribution and coexistence of the two species in the study site. Their finding is summarized in Table 3. Spearman Rank correlation showed that there is a significantly negative correlation between the abundance of the two species in the study site (two tailed-test; R= -0,522; p < 0,05). The correlation might indicate that the occurrence of one of the two species would diminish the other one. By seeing Table 4, it seems that the high abundance of *H. raphidea* would prevent the occurrence of *O. gravieri,* and *H. raphidea* could be categorized as superior competitor in the study site. This phenomenon might be related to the morphometric characters of the two species. As seen in Table 2, the length of claw in male *H. raphidea* is longer with the same body length. Antagonistic behavior, especially in male of burrowing crustaceans is common. Male *H. raphidea* is probably get advantage from their length of claw to spatially compete with *O. gravieri.* Wardiatno & Tamaki (2003) studied the same object with *Nihonotrypaea japonica* and *N. harmandi*. They found the first species as superior competitor due to its bioturbation ability. Such asymmetrical competition via bioturbation has been assumed to explain the segregated zonation patterns for *Neotrypaea californiensis* (superior competitor) and *Upogebia pugettensis* (Swinbanks & Luternauer, 1987), and *Glypturus acanthochirus* (superior competitor) and *Neocallichirus grandimana* (Dworschak & Ott, 1993).

Table 3 The mean abundance (ind.m^{-2}) of *Harpiosquilla raphidea* and *Oratosquillina gravieri* collected from the study site (Summarized from Mashar & Wardiatno, 2011).

Distance from the shoreline (m)	*Harpiosquilla raphidea*	*Oratosquillina gravieri*
970-1170	7	5
1270-1470	10	3
1570-1870	12	3
2560-2760	13	5
2860-3060	18	4
3160-3460	16	4
618	40	34
793	43	13
930	39	11
1181	47	40
1321	48	9
1359	29	4
1384	36	4
1669	51	3
1321	9	3
1460	2	1

CONCLUSIONS

Male *H. raphidea* has longer claw than male *O. gravieri*, and this feature might be the factor behind their successful to be the superior competitor in the study site.

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REFERENCES

Boxshall GA, S Ohtsuka. 2001. Two new families of copepods (Copepoda: Siphonostomatoida) parasitic on echinoderms. *Journal of Crustacean Biology* . 21: 96-105.

Clark PF, M Neale, P S Rainbow. 2001. A morphometric analysis of regional variation in *Carcinus* Leah, 1814 (Brachyura: Portunidae: Carcininae) with particular reference to the status of the two species *C. maenas* (Linnaeus, 1758) and *C. aestuarii* Nardo, 1847. *Journal of Crustacean Biology* . 21: 288-303.

Coelho VR, AB Williams, S de A Rodrigues. 2000. Trophic strategies and functional morphology of feeding appendages, with emphasis on setae, of *Upogebia omissa* and *Pomatogebia operculata* (Decapoda: Thalassinidea: Upogebiidae). *Zoological Journal of the Linnaean Society.* 130: 567-602.

Colloca F, M Cardinale, A Belluscio, G Ardizzone. 2003. Pattern of distribution and diversity of demersal assemblages in the central Mediterranean Sea. *Estuarine, Coastal and Shelf Science.* 56: 469-480.

Conan GY, M Comeau, M Moriyasu. 2001. Are morphometrical approaches appropriate to establish size at maturity for male American lobster, *Homarus americanus*? *Journal of Crustacean Biology.* 21: 937-947.

Dworschak PC. 1998. Observations on the biology of the burrowing mud shrimps *Callianassa tyrrhena* and *C. candida* (Decapoda: Thalassinidea). *Journal of Natural History.* 32: 1535-1548.

Dworschak PC, JA Ott. 1993. Decapod burrows in mangrove-channel and back-reef environments at the Atlantic Barrier Reef, Belize. *Ichnos.* 2: 277-290.

Felder DL, DL Lovett. 1989. Relative growth and sexual maturation in the estuarine ghost shrimp *Callianassa louisianensis* Schmitt, 1935. *Journal of Crustacean Biology.* 9: 540-553.

Garces LR *et al.* 2006. Spatial structure of demersal fish assemblages in South and Southeast Asia and implications for fisheries management. *Fisheries Research.* 78: 143-157.

Haefner PA Jr. 1990. Morphometry and size at maturity of *Callinectes ornatus* (Brachyura, Portunidae) in Bermuda. *Bulletin of Marine Science.* 46: 274-286.

Ho J, I Kim. 2001. New species of *Doridicola* (Copepoda, Rhynchomolgidae) from Thailand, with a cladistic analysis of genus. *Journal of Crustacean Biology.* 21: 78-89.

Kodama K *et al.* 2004. Reproductive biology of the female Japanese mantis shrimp *Oratosquilla oratoria* (Stomatopoda) in relation to changes in the seasonal pattern of larval occurrence in Tokyo Bay, Japan. *Fisheries Science.* 70: 734-745.

Kubo I *et al.* 1959. A biological study on a Japanese edible mantis-shrimp, *Squilla oratoria* de Haan. *Journal of the Tokyo University of Fisheries.* 45: 1-25.

Labadie LV, AR Palmer. 1996. Pronounced heterochely in the ghost shrimp, *Neotrypaea californiensis* (Decapoda: Thalassinidea: Callianassidae): allometry, inferred function and development. *Journal of Zoology, London.* 240: 659-675.

Lui KKY, JSSNg, KMY Leung. 2007. Spatio-temporal variations in the diversity and abundance of commercially important decapoda and stomatopoda in subtropical Hong Kong waters. *Estuarine, Coastal and Shelf Science.* 72 : 635-647.

Manning RB, A Tamaki. 1998. A new genus of ghost shrimp from Japan (Crustacea: Decapoda: Callianassidae). *Proceedings of the Biological Society of Washington.* 111: 889-892.

Mashar A, Y Wardiatno. 2011. Distribusi spasial udang mantis, *Harpiosquilla raphidea* dan *Oratosquillina gravieri* di Kuala Tungkal, Kabupaten Tanjung Jabung Barat, Provinsi Jambi. *Jurnal Ilmiah Pertanian dan Perikanan.* 1: 41-46.

Musa N, LS Wei. 2008. Outbreak of vibriosis in mantis shrimp (*Squilla* sp.). *World Journal of Agricultural Science.* 4(2): 137-139.

Ng PKL, DCJ Yeo. 2001. A revision of the genus *Tiwaripotamon* Bott, 1970 (Decapoda: Brachyura: Potamidae), with a description of a new species. *Journal of Crustacean Biology.* 21: 275-287.

Oh CW, RG Hartnoll. 1999. Size at sexual maturity, reproductive output, and seasonal reproduction of *Philocheras trispinosus* (Decapoda) in Port Erin Bay, Isle of Man. *Journal of Crustacean Biology.* 19: 252-259.

Ohtomi J, K Hayashi. 1995. Some morphological characters of the deep-water shrimp *Plesionika semilaevis* from Kagoshima Bay, southern Japan (Crustacea, Decapoda, Caridea). *Fisheries Science.* 61: 1035-1036.

Ohtomi J, N Nakata, M Shimizu. 1992. Discarding of the Japanese mantis shrimp *Oratosquilla oratoria* by small-scale trawlers in Tokyo Bay. *Nippon Suisan Gakkaishi.* 58: 665-670.

Phinney DE. 1975. Length-width-weight relationships for mature male snow crab, *Chionocoetes bairdi*. *Fisheries Bulletin.* 75: 870-871.

Rambla JPB, IL Arana. 1994. New records and new species of ghost shrimps (Crustacea: Thalassinidea) from Venezuela. *Bulletin of Marine Science.* 55: 16-29.

Rambla JPB, IL Arana, LB Lares M. 1995. A new callianassid (Decapoda: Thalassinidea) from the southern Carribean Sea. *Proceedings of the Biological Society of Washington.* 108: 102-106.

Sampedro MP *et al.* 1999. Morphometry and sexual maturity in the spider crab *Maja squinado* (Decapoda: Majidae) in Galicia, Spain. *Journal of Crustacean Biology.* 19: 578-592.

Stamhuis EJ, B Dauwe, JJ Videler. 1998. How to bite the dust: morphology, motion pattern and function of the feeding appendages of the deposit-feeding thalassinid shrimp *Callianassa subterranea*. *Marine Biology.* 132: 43-48.

Swinbanks DD, JL Luternauer. 1987. Burrow distribution of thalassinidean shrimp on a Fraser Delta tidal flat, British Columbia. *Journal of Palaeontology.* 61: 315-332.

Wardiatno Y, A Mashar. 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 and Conservation.* 7: 63-73.

Wardiatno Y, A Mashar. 2011. Population dynamics of the Indonesian mantis shrimp, *Harpiosquilla raphidea* (Fabricius 1798) (Crustacea: Stomatopoda) collected from a mud flat in Kuala Tungkal, Jambi Province, Sumatera Island. *Ilmu Kelautan.* 16: 111-118.

Wardiatno Y, A Tamaki. 2001. Bivariate discriminant analysis for the identification of *Nihonotrypaea japonica* and *N. harmadi* (Decapoda: Thalassinidea:Callianassidae). *Journal of Crustacean Biology.* 21: 1042-1048

Wardiatno Y, A Tamaki. 2003. Zonation of congeneric callianassid shrimps, *Nihonotrypaea harmandi* (Bouvier, 1901) and *N. japonica* (Ortmann, 1891) (Decapoda: Thalassinidea), on intertidal sandflats in the Ariake-Sound estuarine system, Kyushu, Japan. *Benthos Research.* 58: 51-73.

White JF, SJ Gould. 1965. Interpretation of the coefficient in the allometric equation. *American Naturalist.* 99: 5-18.