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Carapace Length–Weight, Carapace Width–Weight Relationships and Relative Condition Factor of Four Portunid Crab Species of the Gulf of Mannar, Southeast Coast of India

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Portunid crabs, CLWR, CWWR, Condition factor, Gulf of Mannar

ABSTRACT

Carapace Length–Weight (CLW) and Carapace Width–Weight (CWW) relationships by sex, combined with Relative Condition Factor (Kn) are presented for four commercially important portunid crab species *viz.*, *Portunus pelagicus* (Linnaeus, 1758), *Portunus sanguinolentus* (Herbst, 1783), *Portunus gladiator* Fabricius, 1798 and *Charybdis natator* (Herbst, 1794) collected from the Gulf of Mannar, Southeast coast of India. A total of 1,391 specimens were collected and measured from January to June 2022. All CLW and CWW relationships were linear (R^2 >0.95 and R^2 >0.91 respectively). The slope (*b*) of the CLWR ranged between 2.8210 and 3.2862 whereas the same was between 2.0099 and 3.1033 for CWWR for these four species. The relationship for the above two parameters were also established with regression coefficient of corelation and the 99% confident interval using ANOVA (MS Excel version 2016). The relationship of the studied two parameters namely carapace CLW and CWW were found to be significant between all the selected species at 1% level (P > 0.01). The Relative Condition factor (Kn) showed wide variations among these four species between CLWR and CWWR. This study presents the first reference on CLWR and CWWR for these species from the Gulf of Mannar. In addition, it also reports CLWR and CWWR for *P. gladiator* for the first time and for *C. natator* for which only limited information is available.

INTRODUCTION

Among crustacean brachyuran crabs are most diversified group (Rajaraman *et al*., 2015). There are 990 species of marine brachyuran crabs in Indian waters, which are divided into 281 genera and 36 families (Myla Chakravarty *et al*., 2015). 404 species of crabs from 26 families and 152 genera can be found along the coast of Tamil Nadu (Kathirvel, 2008). The dominant Portunid crabs along Gulf of mannar are *Calappa, Scylla, Portunus, Charybdis,* Thalamita (Vidya *et al*., 2017). *Portunus pelagicus* and *P. sanguinolentus* together constitute 90% of the crab landings in the Indian coast (Sukumaran and Neelakantan, 1997). *Charybdis natator* contributes to crab fishery in India and it is believed that it can reduce the subsequent entry of *P. pelagicus* in a trap due to agonistic interaction (Sumpton, 1990). *P. gladiator* also contribute to a major part of crab fishery along Gulf of Mannar (Vidya *et al*., 2017).

According to (Dulcic and Kraljevic, 1996; Ikhwanuddin et al., 2010), the length-weight relationship is the most reliable method for estimating fish and crustacean populations in the area. Length weight relationships reveal taxonomic differences and life history events in fishes and crustaceans (Jaiswar and Kulkarni, 2002) and thought to be helpful in calculating biomass, condition indices, and various other population dynamics aspects (Atar and Secer, 2003). Additionally, it is used to determine whether the species have isometric or allometric somatic growth conditions (LeCren, 1951; Ricker, 1975). Any change in this relationship indicates a change in the animal's physiology, habitat ecology, or both (Jaiswar and Kulkarni, 2002).

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There have been numerous studies done on the length-weight relationships of commercially significant crab species (Sukumaran and Neelkantan, 1997; Gokc *et al*., 2006; Mohapatra *et al*., 2010; Josileen, 2011; Oluwatoyin *et al*., 2013; Khan and Mustaqeem, 2013; Vidya *et al*., 2018). In the present account, the carapace length/width-weight and carapace length-width relationships in *Portunus pelagicus*, *Portunus sanguinolentus*, *Portunus gladiator* and *Charybdis natator* reported since similar studies in brachyurans are limited.

MATERIALS AND METHODS

Sampling

The Gulf of Mannar (GoM) is situated in the Indian Ocean between south-eastern part of India and north-western part of Sri Lanka, ranging 8° 35' N - 9° 25' N latitude to 78° 08' E- 79° 30' E longitude (Vidya *et al*., 2018). It is known for its unique biological wealth and is a store house of marine diversity of global significance. The four commercially important portunid crab species *viz*., *Portunus pelagicus* (Linnaeus, 1758) (Pulli nandu), *Portunus sanguinolentus* (Herbst, 1783) (Mukkannu nandu), *Portunus gladiator* Fabricius, 1798 (Chippi nandu) and *Charybdis natator* (Herbst, 1794) (Par nandu) covering a wide range of size were collected weekly from the four major landing centres of the Gulf of Mannar namely Vedalai, Keelakarai, Therespuram and Thiruchendur for a period of six months from January 2022 to June 2022 (Fig. 1). The specimens were collected from various fishing gears like bottom set gillnet, trawl net and trammel net from which bottom set gillnet dominate the crab fishery along the entire Gulf of Mannar region. The mesh size of this bottom set gillnet operated in Vedalai and Keelakarai varies between 70 and 110 mm whereas in Therespuram and Tiruchendur it varies between 28 and 40 mm. It is noted that the mesh size of cod end of trawl net and trammel net in the study area were 15-20 mm and 40-80 mm respectively. The crabs were collected up to a distance of 7 to 15 nautical miles towards seaward side and depth range of 6–12 m in Gulf of Mannar region.

Identification key of four selected portunid crabs

The portunid crabs were identified up to species level using FAO species identification sheet (Fischer and Bianchi, 1984); CMFRI identification manual (Josileen *et al*., 2017) (Fig. 2).

Genus *Portunus*: Anterolateral carapace cut into nine teeth with last one enlarged as a long spine and propodus of cheliped costate.

P. pelagicus: Nine spine at distal end of posterior border of merus of cheliped; Front with 4 teeth; inner margin of merus of cheliped with 3 spines

P. sanguinolentus: Carapace with three purple to red spots on posterior half; no spine on posterior border of merus of cheliped.

P. gladiator: No spot on dactylus of last ambulatory legs; granules of the meso-gastric region form (T) shape.

Genus *Charybdis*: Anterolateral border of carapace oblique and arched, cut into six teeth, no spine on posterior border of arm of cheliped.

C. natator: Carapace with distinct ridges or granular patches behind level of last pair of anterolateral teeth.

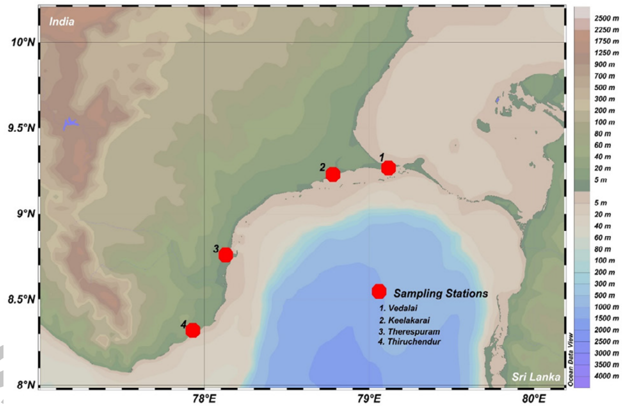

Fig. 1. Study area at Gulf of Mannar.

Fig. 2. Portunid crab species of the Gulf of Mannar, India. *Portunus pelagicus* (A), *Portunus sanguinolentus* (B), *Portunus gladiator* (C) and *Charybdis natator* (D).

Data collection

The carapace length was measured from the front tooth of the rear end of the carapace along the midline while the carapace width was measured as a distance between the tips of the posterior most lateral carapace spines. The carapace length/ width was measured to the nearest 0.1 cm and body weight to the nearest 0.01 g using the vernier calliper and sensitive electronic balance. In the present study, the carapace length for *P. pelagicus* was ranged from 30 to 83 mm; carapace width ranged from 46 to 156 mm and weight ranged from 21 to 469 g. The carapace length of *P. sanguinolentus* was varied between 27 to 75 mm, carapace width ranged from 37 to 148 mm and weight ranged from 11–331.5 g. The carapace length of *P. gladiator* ranged from 28 to 62 mm, carapace width ranged from 39-96 mm and 17-143.5 g of weight was recorded. The carapace length recorded for *C. natator* in the present study varied between 34 to 89 mm, 54 to 128 mm of carapace width and 28.5 to 510 g of weight.

Statistical analysis

The CLWR and CWWR for the four species were established by using the least square linear regression equation W= aL^b, where 'W' is the body weight in gm, 'L' is the carapace length/ width in cm, '*a*' is the intercept and '*b*' is the slope of the regression curve (Le Cren, 1951) considering the sexes separate. The degree of association between the variables was computed by the determination of coefficient, R^2. Outliers were removed before linear regression analysis. The statistical significance, 95% confidence limits of the parameters '*a*' and '*b*' were calculated using regression analysis. All analyses were performed using MS Excel (Microsoft Office, 2016).

RESULTS

Weekly samples were taken along the entire coast of Gulf of Mannar from the four landing centres (Fig. 2). Statistical description of the parameters including sample size (number of specimens observed), carapace length (CL)/ carapace width (CW) range (cm), total body weight (W) range (gm), length weight relationship (LWR) parameters '*a*' and "*b*" with 95% confidence limits and coefficient of determination (R^2) are shown in Table I. A positive allometry was evident in sexes between carapace length and body weight for *P. pelagicus*, *P. sanguinolentus* with high degree of correlation. However, a negative allometry growth in sexes was evident for *P. gladiator* and *C. natator* with a high degree of corelation. With regard to carapace width–body weight, a negative allometry was evident in sexes for *P. pelagicus*, *P. sanguinolentus* and *P. gladiator* (<3), however a positive allometry was evident for *C. natator* (>3). The relative condition factor (Kn) for the selected four portunid crab species of Gulf of Mannar with regard to CLWR and CWWR are shown in Table II. The overall wellbeing condition (Kn) was found to be high for *C. natator* and *P. pelagicus* while the same was less for *P. sanguinolentus* for CLWR while for CWWR the Kn value was found to be high for *P. sanguinolentus* and less for *C. natator*. The reason behind high Kn value for *C. natator* and *P. pelagicus* may be due to landing of higher female sex ratio during the study period as study shows that mean condition factors always higher in females than in males, due to the heavier gonads in the former (Noori *et al*., 2015).

Table I. Estimated CLW and CWW parameters for four commercially important portunid crab species from Gulf of Mannar, India.

Species	n	CL (cm) Min-Max	CW (cm) Min-Max	BW (g) Min-Max	Regression parameters (CLW)					Regression parameters (CWW)				
					a	95% CI a	b	95% CI b	R^2	a	95% CI a	b	95% CI b	R^2
Portunus pelagicus														
Male	184	3-7.5	4.6-14	21-372	0.75	0.70-0.80	3.27	3.18-3.36	0.96	0.73	0.68-0.78	2.52	2.45-2.58	0.96
Female	248	4.2-8.3	6.2-15.6	48.5-469	0.82	0.78-0.86	3.12	3.06-3.18	0.98	0.75	0.70-0.80	2.47	2.41-2.53	0.97
Pooled	432	3-8.3	4.6-15.6	21-469	0.85	0.81-0.88	3.09	3.04-3.15	0.96	0.77	0.74-0.81	2.44	2.40-2.49	0.96
Portunus sanguinolentus														
Male	145	2.8-7.5	3.7-14.8	11-331.5	0.75	0.70-0.81	3.18	3.07-3.29	0.96	0.09	0.01-0.01	2.00	1.92-2.09	0.96
Female	147	3-7.4	4.3-14.1	10-305	0.70	0.65-0.76	3.28	3.18-3.39	0.96	0.72	0.65-0.80	2.45	2.35-2.55	0.95
Pooled	292	2.8-7.5	3.7-14.8	11-331.5	0.72	0.69-0.76	3.24	3.17-3.31	0.96	0.90	0.85-0.96	2.22	2.16-2.29	0.95
Portunus gladiator														
Male	222	2.8-5.6	3.9-8.6	17-116	0.88	0.83-0.93	2.91	2.87-2.99	0.95	0.83	0.77-0.90	2.40	2.30-2.49	0.91
Female	121	2.9-6.2	4.2-9.6	17.5-143.5	0.91	0.83-0.99	2.82	2.67-2.96	0.95	0.92	0.80-1.06	2.21	2.03-2.39	0.91
Pooled	343	2.8-6.2	3.9-9.6	17-143.5	0.83	0.80-0.86	2.99	2.93-3.05	0.96	0.74	0.69-0.79	2.53	2.44-2.61	0.92
Charybdis natator														
Male	192	4.8-8.9	6.6-12.8	56.5-510	0.88	0.81-0.96	2.99	2.88-3.09	0.96	0.49	0.45-0.55	3.07	2.96-3.19	0.95
Female	132	3.4-6.5	5.4-9.8	28.5-211.5	0.91	0.84-0.98	2.97	2.86-3.08	0.95	0.50	0.43-0.58	3.04	2.88-3.21	0.90
Pooled	324	3.4-8.9	5.4-12.8	28.5-510	0.93	0.88-0.98	2.92	2.85-2.99	0.97	0.48	0.44-0.52	3.10	3.01-3.18	0.96

n, sample size; CL, carapace length; CW, carapace width; BW, total body weight; a, intercept; b, slope; CI, confidence intervals; R^2, co-efficient of determination

Table II. Relative condition factor (Kn) of selected portunid crab species from Gulf of Mannar.

Species	Kn- value with regard to CLWR	Kn value with regard to CWWR
Portunus pelagicus	0.8128	0.7256
Portunus sanguinolentus	0.6625	0.8899
Portunus gladiator	0.7574	0.7106
Charybdis natator	0.9059	0.5614

A significant relationship at 1% level was evident using ANOVA (MS Excel version 2016), between species for *P. pelagicus* and *P. sanguinolentus; P. pelagicus* and *P. gladiator*; *P. pelagicus* and *C. natator*; *P. sanguinolentus* and *P. gladiator*; *P. sanguinolentus* and *C. natator and P. gladiator* with *C. natator* between CLW (Table III) and between CWW (Table IV).

DISCUSSION

The coefficient of determination (R^2) for CLWR and CWWR for both sexes of all these four species was very close to one in the regression analysis (Table I). Thus, the nature of the relationship between CL and BW and CW and BW can be expressed as highly positive. The value of exponent (b) is a very important indicator for judging the

Table III. Test of significance for carapace length-weight (CLW) among all studied species.

Source of variation	Degree of freedom	Sum of square	Mean square	Observed F
Difference between Regression	1	46.2499	46.2499	20698.15*
Deviation from individual within *P. pelagicus and P. sanguinolentus*	723	1.6155	0.0022	
Difference between Regression	1	77.2620	77.2620	33893.46*
Deviation from individual within *P. pelagicus and P. gladiator*	773	1.7620	0.0022	
Difference between Regression	1	30.6432	30.6432	13762.51*
Deviation from individual within *P. pelagicus and C. natator*	754	1.6788	0.0022	
Difference between Regression	1	40.4805	40.4805	20286.91*
Deviation from individual *P. sanguinolentus and P. gladiator*	634	1.2650	0.0019	
Difference between Regression	1	37.5604	37.5604	14215.91*
Deviation from individual *P. sanguinolentus and C. natator*	615	1.6249	0.0026	
Difference between Regression	1	56.7088	56.7088	22175.71*
Deviation from individual *P. gladiator and C. natator*	665	1.7005	0.0025	

* Significant at 1% level.

Table IV. Test of significance for carapace width-body weight (CWW) among all studied species.

Source of variation	DF	Sum of square	Mean square	Observed F
Difference between Regression	1	45.3010	45.3010	12774.06*
Deviation from individual within *P. pelagicus and P. sanguinolentus*	723	2.5639	0.0035	
Difference between Regression	1	77.2918	77.2918	34488.09*
Deviation from individual within *P. pelagicus and P. gladiator*	773	1.7323	0.0022	
Difference between Regression	1	27.2032	27.2032	4006.98*
Deviation from individual within *P. pelagicus and C. natator*	754	5.1188	0.0067	
Difference between Regression	1	38.9847	38.9847	8952.67*
Deviation from individual *P. sanguinolentus and P. gladiator*	634	2.7607	0.0043	
Difference between Regression	1	30.7910	30.7910	2255.98*
Deviation from individual *P. sanguinolentus and C. natator*	615	8.3939	0.0136	
Difference between Regression	1	55.6829	55.6829	13581.49*
Deviation from individual *P. gladiator and C. natator*	665	2.7264	0.0040	

* Significant at 1% level.

growth pattern of a species. However, ecological factors (i.e., food availability, water quality parameters, sample size, and length range) can cause variation in slope (*b*) in the case of any species (Mommsen, 1998; Ighwela *et al*., 2011).

Generally, the slope value (*b*) is usually three in the length weight relationship of most of the decapod crustaceans, but due to changing of specific gravity and shape of the body contour the cube law need not hold good (Rounsefell and Everhart, 1953). Morphological changes due to age also cause the coefficient of logarithmic of weight on logarithmic of length to depart substantially from 3.0. In the present study, the slope value is more than three for two species namely *P. pelagicus* and *P. sanguinolentus* indicating positive allometric growth and less than three for *P. gladiator* and *C. natator* indicating a negative allometric growth pattern in relation to CLWR. With regard to CWWR, the slope value (*b*) lies below three for three species, except *C. natator*, thus showing a marked deviation from the isometric growth pattern, indicating negative allometric growth.

However, on comparing the sexes with regard to CLWR, the slope value (*b*) shows variation. The males of *P. pelagicus* and *P. gladiator* have a higher exponent value compared to females while in *P. sanguinolentus*, the slope value is higher in females compared to males and exponent value is almost similar between sexes in *C. natator* (Table I). From this, it is evident that males are heavier than females in *P. pelagicus* and *P. gladiator*, whereas in *P. sanguinolentus* the females are heavier than males. In *C. natator*, the growth of the males and females do not show any variation at a given length or body weight. In the present study, the growth of males is higher compared to females which is in agreement with the observation made by Sukumaran and Neelakantan (1997), Josileen (2011) and Vidya *et al*. (2018) for *P. pelagicus*. The higher slope values in males comparing with females was also observed by Thirunavukkarasu and Shanmugam (2011) in *Scylla tranquebarica* in Parangipettai coast of southeast coast of India. Afzaal (2017) observed that growth of females was high compared to males in this species. In the present study, comparing the sexes of *P. sanguinolentus*, the females were found to be heavier compared to males. However, Sukumaran and Neelakantan (1997) and Vidya *et al*. (2018) observed males with higher growth rate compared to females in *P. sanguinolentus*. In the present study, the exponent value is very close to three in *C. natator* indicating the isometric growth. Similar exponent value nearing three was also observed by Vidya *et al*. (2018) for females of *C. natator.*

Presently, with regard to CWWR for *P. pelagicus, P. gladiator and C. natator*, the slope value is higher in male compared to female while in *P. sanguinolentus* the female showed a higher slope value comparing with male. A similar observation was also observed by Sukumaran and Neelakantan (1997) and Vidya *et al*. (2018) for *P. pelagicus*. In *Scylla serrata*, a similar relationship was observed by Khan and Mustaqeem (2013). A deviation was recorded by Afzaal *et al*. (2017) in which female showed higher growth rate compared to male. In the present study, the slope value was found to be higher in female compared to male for *P. sanguinolentus*. A higher growth in male compared to female was observed by Sukumaran and Neelakantan (1997) and Vidya *et al*. (2018) for this species.

Further, relative condition factor (Kn) is the important biological parameters which indicate the suitability of a specific water body for growth of fish (LeCren, 1951). Condition factor has been used as an index of growth and feeding intensity (Fagade, 1979). It is also reported to decrease with increase in length (Bakare, 1970; Fagade, 1979) and influences the reproductive cycle in fish (Welcome, 1979). The condition factor (Kn) showed variation between carapace length-weight (0.6625 – 0.9059) and carapace width-weight relationship (0.5614 – 0.8899) which may be influenced by the seasonal changes of gonads, feeding intensity, habitat and other environmental factors (Dubey *et al*., 2014). The Kn value for *Scylla serrata* and *S. tranquebarica* were 0.83–1.21 and 0.76–1.35 reported in Chilika lagoon, east coast of India (Mahapatra *et al*., 2010) which supports the present study (Table II) as Kn value of the selected species has not been attempted in India by the earlier workers.

CONCLUSIONS

The present studies provide the first detailed information on carapace length/ width-weight relationship of *P. gladiator* and *C. natator* along the Gulf of Mannar coast. For the rest two species has also limited information in the study area. For successful development, management practices and production, it can serve as a guide for future research by fishery biologists and conservation biologists. The fishing of juvenile and berried crabs is currently permitted in many nations, and the minimum size at capture is not strictly enforced. Release of young, berried, and soft crabs into the ocean while they are still alive is the sole alternative for conservation. The greatest strategy to guarantee a year-round sustainable fishery while simultaneously enhancing yield quality is to forbid the capture and sale of undersized and berried crabs. The relative condition factor also provides the status of portunid crabs throughout the study period which may further help to the crab biologist to understand the developmental biology.

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IRB approval

For this study, approvals was given by the advisory committee members.

Ethical statement

Not applicable.

Statement of conflict of interest

The authors have declared no conflict of interest.

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