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Allometric Relationships of Red Ghost Crab *Ocypode macrocera* (H. Milne-Edwards, 1852) in Sundarbans Mangrove Eco-Region, India

[1]*Sourabh Kumar Dubey,* [2]*Deep Chandan Chakraborty,*
[2]*Chitrak Bhattacharya and* [3]*Amalesh Choudhury*

[1]Department of Aquatic Environment Management, Faculty of Fishery Science,
West Bengal University of Animal and Fishery Sciences, Kolkata-700094, India
[2]Department of Zoology, Chandernagore College, Hooghly, West Bengal-712136, India
[3]S.D. Marine Biological Research Institute, Sagar island, Sundarbans, West Bengal- 743373, India

Abstract: The relationship between carapace length/width-body weight of the red ghost crab *Ocypode macrocera* was studied at the southern proximity of the Sagar island, western sector of Indian Sundarbans (World's largest mangrove biome) that faces the regular tidal influences of Bay of Bengal. The females were more abundant (54%) than males (46%) considering the overall sample and the length/width-weight distribution pattern did not show remarkable differences between sexes. The carapace length and width are linearly related to body weight and appeared to be highly significant (P<0.001) in each case. The regression coefficient (b) of length-weight and width-weight relationship found to be in positive allometry. Moreover, the correlation between weight with length and width is strongly positive in male, female and irrespective of sex. The condition factor (K) value of carapace length between two sexes varies significantly and higher in females. Despite of small sample size, the present study is able to predict the morphometric relationship is useful in stock assessment of the *Ocypode macrocera* and comparing the different stocks of the same species at different geographical locations.

Key words: Allometry · Bay of Bengal · Condition Factor · Indian Sundarbans · Length-Weight Relationship · *Ocypode macrocera* · Sagar Island

INTRODUCTION

Morphometric analysis serves as a handy tool for both taxonomists and ecologists investigating on intra and interspecific morphological variations [1] and also complements well with genetic and environmental stock identification methods [2]. Growth in arthropod follows a distinct pattern compared to other taxonomic groups; they undergo drastic series of transformations from the time of hatching, at post-larval period up to adult phase. Certain dimensions of the organism's body may grow at different rates from than others, phenomenon known as Allometric growth [3-4]. Abrupt variations in body proportions are noticed in body weight versus length/ width relationships in a population are of great importance for estimating the population size of a stock for the purpose of commercial exploitation, general ecological growth modelling and energy flow within ecosystems. The relationship between body mass and length is an effective tool in ecological research in order to estimate body mass from the body length of an organism, as when the direct measurement of dry mass is problematic under natural settings [5-7]. The relationships between carapace length and weight of the crabs were used to calculate the standing stock biomass, condition indices, analysis of ontogenetic changes and several other aspects of crustacean population dynamics [8]. Among all the macrofauna inhabiting in mangrove ecotope of Sundarbans, brachyuran crabs are the most important taxa with regards of species and total biomass. The red ghost crab *Ocypode macrocera* (H. Milne-Edwards, 1852), a non-commercial crab species belonging to family Ocypodidae is one of the predominant

Corresponding Author: Sourabh Kumar Dubey, Department of Aquatic Environment Management, Faculty of Fishery Science, West Bengal University of Animal and Fishery Sciences, Kolkata-700094, India.

residential burrowing brachyuran crabs found in Sundarbans estuarine sand flat where they occupy conspicuous burrows.

Allometric analyses for comparing intraspecific variations among populations from different locations of Ocypodidae were explored by several workers [9-12]. Various researchers [13-18] also studied interrelationships between various morphometric characters of commercially important crab species from Indian water. In Indian Sundarbans mangrove complex, several taxonomic works on estuarine and mangrove brachyuran crabs have been reported [19-22]. However due to dearth of information on the population structure of *O. macrocera*, their stock status of is still unknown. Only one literature available where the relationship between size and weight of *O. macrocera* from southeast coast of India (Pondicherry beaches) was studied [23]. Moreover, no information available pertaining to the morphometric analysis of *O. macrocera* from the landmasses of Sundarbans, the biggest tract of estuarine mangrove forest in the world and UNESCO declared World Heritage Site. Therefore, in this present attempt, the interrelationships between various morphometric characters, viz., carapace length/width-weight, condition factors in males and females of *O. macrocera* were studied and presented. This study will be useful in comparing the different stocks of the same species at different geographical locations.

MATERIALS AND METHODS

Study Site: The study site, Gangasagar beach (21°37.973' N to E 88° 04.195') is located in the extreme southern part of the Sagar island of Indian Sundarbans with the confluence of Bay of Bengal (Figure 1). Average annual maximum temperature is around 35°C. The summer (pre-monsoon) extends from the middle of March to mid-June and the winter (post-monsoon) from mid-November to February. The monsoon usually sets in around the middle of June and lasts up to the middle of October. Average annual rainfall is 1920 mm. Average humidity is about 82% and is more or less uniform throughout the year. This sand flats of the mixed and open sea inter tidal zone consists of 96% of fine to very fine sand with good sorting. Sagar island, mostly reclaimed from mangrove swamps, has triangular outline with a length of 30 km North-South and a maximum width of 10 km of East-West towards South. On the East and West of the island are respectively Muriganga and Hooghly tidal River. The southern margin of the island faces the tidal action of Bay of Bengal which is fully disturbed due to almost all sorts of direct and indirect anthropogenic stresses and famous for pilgrimage spot. Flora like *Suaeda maritima*, *Ipomoea pes-caprae, Myriostachya wightiana, Tamarix dioica* etc were discretely found in the study site.

Sampling and Biometric Analysis: The crabs were collected from the study site by hand picking method and excavating the burrow during the daytime. The collection was made in the post monsoonal period of 2013. Individuals were counted and sexed according to the morphology of the abdomen, narrow for male and wider for female. Carapace width (CW) and carapace length (CL) were measured (in cm) using Vernier callipers with an accuracy of 0.5 mm. Body weight (W) of the crab (in gram) was determined using a digital weighing balance (Kern EMB 500-1; D= 0.1g).

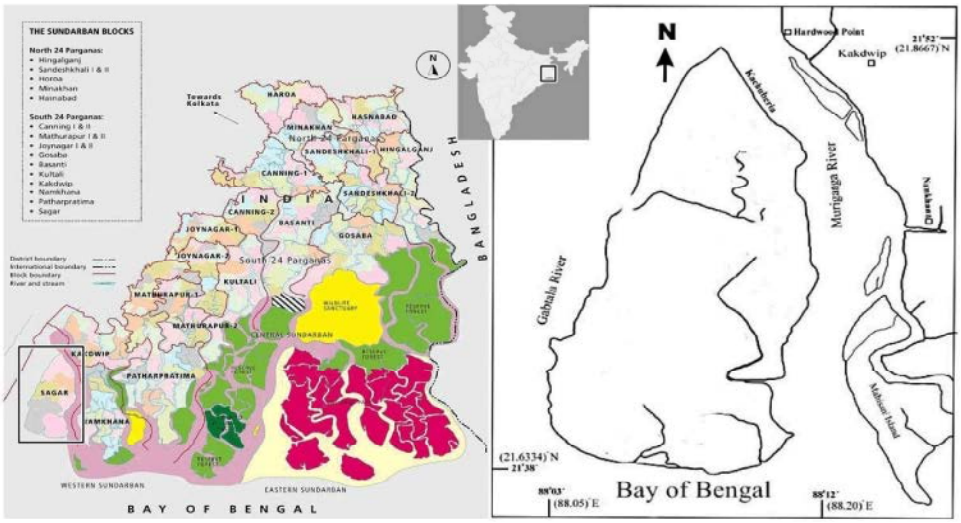

Fig. 1: Map of Indian Sundarbans showing the study area

Estimating Length-Weight Relationship: Crustacean allometric growth is generally defined as $Y = aX^b$ and growth ratios for the independent variable and the other variables (dependent) were determined by logarithmic transformation expressed as Y= log a+b log X. 'a' and 'b' were estimated by the linear regression where 'a' = Intercept of the regression curve and 'b' = Regression coefficient (Slope). The 'b' value represents as the relative growth constant (b = 1 means isometric growth; b > 1 means positive allometric growth; and b < 1 means negative allometric growth) [4, 24]. The statistical significance of 'b' was tested by Student's t-test, adopting a significance level of $P<0.05$. The variation between the regression coefficient (b) in male and female calculated using ANOVA (Analysis of variance). The correlation coefficient (r) was determined to know the degree of association of the two variables involved. The Fulton's condition factor (K) of individual sample was calculated using the formula $K\ 100W/L^3$ where W denoted as total body weight (g) and L denoted as carapace length/carapace width (cm) [25-26]. The variation in condition factors between the sexes was tested by Student's t-test ($P<0.05$). The entire statistical tests were performed using statistical software Medcalc® version 12.7.0 (MedCalc Software bvba, Ostend, Belgium).

RESULTS

Composition and Sizes of the Crab: A total 50 individuals of *O. macrocera* were captured during the whole study. From the sampling study, females were found more abundant (54%) than males (46%) considering the overall sample. In males, carapace length (CL) ranged between 2.6 - 3.9 cm; carapace width (CW) ranged between 2.4 - 3.2cm and weight ranged between 12-27.25g. In females, carapace length (CL) ranged between 2.9-3.7 cm; carapace width (CW) ranged between 2.4-3.4 cm and weight ranged between 12.5-26g (Table 1).

Length-Weight Relationship: The regression equation for the carapace length and body weight relationship were W=0.0727+2.251 CL for males, W=-0.0259+2.538 CL for females and W=0.114+2.221 CL for overall sample respectively. The b values estimated were 2.25, 2.53 and 2.22 for males, females and total sample population respectively. The correlation coefficient (r) values of males, females and total sample population were 0.72, 0.83 and 0.74 respectively. The regression equation for the carapace width and body weight relationship were W=-0.0169+2.899 CW for males, W=0.408+1.974 CW for females and W=0.274+2.262 CW for overall sample

Table 1: Length, width and weight characteristics of *Ocypode macrocera* caught in Sagar island sandy beach

		Length characteristics (cm)			Width characteristics (cm)			Weight characteristics (g)		
Sex	n	Mean ± SE	Min	Max	Mean ± SE	Min	Max	Mean ± SE	Min	Max
Male	23	3.38 ± 0.28	2.6	3.9	2.76 ± 0.20	2.4	3.2	18.89 ± 5.23	12.5	27.25
Female	27	3.25 ± 0.24	2.9	3.7	2.74 ± 0.27	2.4	3.4	19.13 ± 4.40	12.5	26
Overall	50	3.31 ± 0.27	2.6	3.9	2.75 ± 0.23	2.4	3.4	19.02 ± 4.75	12.5	27.25

n = Sample size, SE = Standard error

Table 2: *O. macrocera*: regression analyses of morphometric data during study period

Sex category	Relationship	b	SE (b)	95% CI (b)	r	R^2	t (b=1)	F-ratio	All
Male (n=23)	CL-W	2.25	0.45	1.29-3.20	0.72	0.53	4.89*	23.94	+
	CW-W	2.89	0.52	1.81-3.98	0.77	0.59	5.57**	31.08	+
	CW-CL	0.91	0.17	0.54-1.27	0.74	0.55	5.16**	26.67	-
Female (n=27)	CL-W	2.53	0.33	1.85-3.22	0.83	0.70	7.66**	58.67	+
	CW-W	1.97	0.26	1.42-2.52	0.82	0.68	7.34**	53.90	+
	CW-CL	0.71	0.06	0.57-0.85	0.90	0.81	10.52**	110.83	-
Overall (n=50)	CL-W	2.22	0.28	1.64-2.79	0.74	0.55	7.76**	60.23	+
	CW-W	2.26	0.26	1.73-2.78	0.77	0.60	8.62**	74.38	+
	CW-CL	0.78	0.08	0.61-0.95	0.80	0.64	9.42**	88.89	-

CL- carapace length; CW- carapace width; W- weight; b- slope (general allometric factor); CI- confidence interval; r- correlation coefficient; R^2- coefficient of determination; All- allometry; + positive allometry; - Negative allometry; t- Student's t-test for H_0 b= 1: * significant ($P < 0.001$); ** highly significant ($P < 0.0001$); All F-ratio correspond to $P < 0.001$.

Table 3: Fulton's condition factor (K) *Ocypode macrocera* during study period

		K_{CL}			K_{CW}		
Sex	n	Mean ± SE	Min	Max	Mean ± SE	Min	Max
Male	23	48.45 ± 9.85*	36.63	71.11	88.13 ± 15.98	60.58	128.02
Female	27	55.14 ± 7.06*	40.81	74.07	92.27 ± 14.79	64.81	117.18
Overall	50	52.07 ± 9.02	36.63	74.07	90.37 ± 15.33	60.58	128.02

* Significant (P<0.05) in Independent samples t-test

respectively. The b values estimated were 2.89, 1.97 and 2.26 for males, females and total sample population respectively. The correlation coefficient (r) values of males, females and total sample population were 0.77, 0.82 and 0.77 respectively (Table 2).

Width-Length Relationship: The regression equation for the carapace width and carapace length relationship were CW=0.127+0.910 CL for males, CW=0.200+0.712 CL for females and CW=0.174+0.785 CL for total sample population. The b values estimated were 0.91, 0.71 and 0.78 for males, females and total sample population respectively. The correlation coefficient, r values of males, females and total sample population were 0.74, 0.90 and 0.80 respectively (Table 2).

Condition Factor: The mean Fulton's condition factor (K) estimated from carapace length (K_{CL}) and width (K_{CW}), standard errors and ranges of both the sexes were presented in Table 3. In males, K_{CL} ranged between 36.63-71.11 and K_{CW} ranged between 60.58-128.02. In females, K_{CL} and K_{CW} ranged between 40.81-74.07 and 64.81-117.18 respectively.

DISCUSSION

Crustaceans are widely used in relative growth studies due to their rigid exoskeleton and discontinuous growth [27]. The unique relationship can also be used as a quantitative indicator of the healthiness or "well being" of the species within its environment, through the condition factor [28].

In this study, the carapace length and width found to be linearly related to body weight which is statistically highly significant (P<0.001) in all categories and the regression coefficient value (b) of length versus weight and width versus weight relationship indicated positive allomerty. These findings were strongly follow the trends of the research done on the same species in south-east coast of India [23], *Uca rapax* at Southwest Brazil [1], *Callinectes sapidus* in Beymelek Lake, Turkey [8], *Macropipus tuberculatus* in Mediterranean sea [29] and *Callinectes amnicola* in Nigerian coast [30]. A positive allometric length-weight relationship indicates that, weight increases, as and when the carapace length increases. Change in b value depends primarily on the shape and fatness of the species. Seasonal or annual difference in length-weight relationships often depends upon a number of environmental factors such as temperature, salinity, food (quantity and quality), sex and maturity stage [31]. Moreover, 'b' values indicated that the males are heavier than females. Same trend was found for *Scylla tranquebarica* [18]. The calculated correlation coefficient 'r' of male, female and overall sample indicated a very good positive correlation between weight with length and width of *O. macrocera* as found by others with *Callinectes amnicola* in Nigerian coast [30, 32]. The coefficient of determination (R^2) value of all the variables is above 50% significance level in both sexes alike others [30].

The condition factor (K) value of carapace length between sexes differed significantly (t= 2.78, df = 48, P= 0.0076). The condition factor of the females found to be higher than that of males sampled during study period. Similar results were observed in many brachyuran crab species such as *Callinectes danae* [33-34], *C. Sapidus* [8], *Dilocarcinus pagei* [35] and *Ucides cordatus* [36].

The condition factor is strongly influenced by the environment factors, gonad development, feeding and growth rate, degree of parasitism of the biota. It is interesting to note that a small variation in b value between sexes generates great diversities in the condition factor. Besides, sexual dimorphism in the metabolic rates, nutritional aspects, stage of maturity and time of recruitment might also affect sexual differences of the condition factor [36-38].

CONCLUSION

O. macrocera, being a non-commercial brachyuran crab species, performs many important ecological services in order to maintain a steady state of the mangrove

ecosystem. Due to their burrowing practice, they substantially contribute in nutrient recycling and leaf litter degradation of mangroves. At larval stages, they play an important ecological role in marine food chain being as food for many carnivores. Capturing intact specimen is extremely difficult, as the extremities of the crab can be damaged and become unacceptable for morphometric analysis. Under this condition, if precise mathematical equations between the length and weight or width and weight are established then by computing the other is known to researcher. In this way huge specimen misuse can be avoided. Even with this small sample size, it is possible to predict that morphometric relationship provides valuable information on the stock assessment and biology of *O. macrocera*. Periodic scientific assessments on the occurrence of *O. macrocera* using above approach can be considered as helpful matrix for determining pilgrimage impact upon Gangasagar sandy beaches for future and in particular as a predictive tool for efficient species conservation strategies.

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