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Relative Growth and Morphological Sexual Maturity of *Ilyoplax frater* (Brachyura: Ocypodoidea: Dotillidae) From Mangrove Area of Korangi Creek

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Abstract.- The relative growth and size at morphological sexual maturity of mangrove crab, *Ilyoplax frater* were studied. The crabs were monthly collected from Korangi creek through quadrate method. The morphometric measurement of carapace, abdomen, cheliped and male gonopod were related to carapace width as an independent variable. The growth was isometric with no significant difference in the carapace growth for male and female crabs. The size at onset of sexual maturity in males was estimated as 4.7 mm CW and it was 4.6 mm CW in females. The positive allometric growth of the abdominal width for the females was observed and is likely due to reproductive advantages forming the incubatory chamber. The positive relationship of cheliped length and the gonopod for male crabs were related to mating and other antagonistic behavioral adaptations.

Key words: Allometry, relative growth, *Ilyoplax frater*, Dotillidae, morphometric.

INTRODUCTION

Ilyoplax crabs are the typical inhabitants of sub tidal and inter tidal mud flats of mangrove forest, belong to family Dotillidae (Kitaura and Wada, 2006). The deposit feeding mangrove associated crabs are considered as the primary consumers and they form a link between the primary detritus and the consumer of higher trophic level (Macintosh, 1984; Ashton *et al*., 2003). Like other ocypodid and dotillid crabs, species of *Ilyoplax* crabs construct and reconstruct their burrows and during low tide these crabs come out from their burrows to wander around on the exposed mud flats to feed, and move back to the burrows when the tide ascends. The feeding and burrowing activities (bioturbation) of these crabs help nutrient cycling and energy flow in ecosystem. The genus *Ilyoplax* Stimpson, 1858 currently includes 26 species that are distributed in the temperate and tropical Indo Western Pacific region (Kitaura and Wada, 2006; Ng *et al*., 2008). Tirmizi and Ghani (1996) have reported two species of genus *Ilyoplax* from the coastal areas of Pakistan that include *Ilyoplax frater* and *Ilyoplax* spp.

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The relative growth in crustaceans has been widely studied because of their rigid exoskeleton and consequent discontinuous growth (Hartnoll, 1982; Du Preez and Maclachlan, 1984; Pinheiro and Fransozo, 1993; Qureshi and Kazmi, 1999). Hartnoll (1978) reported individual variation in the standard growth of some organs or body dimensions, between individuals of each sex in the same species or in different species. The secondary sexual characters (size of chelipeds, abdomen and pleopods) show differential growth rates before and after the maturation life phases (Hartnoll, 1978; 1982; Vannini and Gherardi, 1988). The relative growth patterns indicate sexual dimorphism, and can be used for predicting maturity in crabs. Studies of relative growth and morphological sexual maturity are important parameters for determining the reproductive potential of a species and thus can be used for the management of populations of commercial interest (Campbell and Eagles, 1983; Guerrero-Ocampo *et al.,* 1998).

This is the first attempt to study the relative growth of the morphometric parameters of commonly occurring crab *I. frater* from the coastal mud flats of Pakistan.

MATERIALS AND METHODS

Study site and sampling methodology

Regular monthly samples of *Ilyoplax frater*

crabs were collected from the mudflats of Korangi creek (24°79'N, 67°20'E) mangrove area from March 2001 to February 2002 (Saher and Qureshi, 2010), and were brought back to the laboratory for further analyses. In laboratory, crabs were sexed and their length and weight were measured. The following morphometric measurements were made with a vernier caliper to the nearest 0.01 mm. Carapace width (CW) measured at the widest part of the carapace was taken as an independent variable. Carapace length (CL) from the anterior median notch to the posterior carapace margin, cheliped propodus length (Ch.L) and height (Ch.H), abdomen width (AW) of the fifth somite in female, and gonopod length (GL) (the first pair of pleopod) in male.

Data analyses

All crabs were distributed into five categories *i.e*., young males, adult males, young females, adult females and ovigerous females. Young and adult crabs were sorted according to the examination of secondary sexual characters, such as pleopod morphology, free abdomen and distinct cheliped development in adult male crabs as compared to young male and convex abdomen (forming an incubator chamber) in adult females. The relative frequency of adults (%) in each size class was plotted and fitted as a sigmoid curve following the result of the logarithmic equation

$$y = \frac{1,}{1+e^{r\,(CW-CW50)}}$$

Where, CW_{50} was the carapace width at which 50% of the individuals attain sexual maturity, and r was the slope of the curve. The adjusted equation was fitted by the least squares regression method (Vazzoler, 1996; Bertini *et al*., 2007).

The relative growth was studied using the power function $y = ax^b$ (Huxley, 1950) for allometry for each sex, and was linearized (log y = log a + blog x), where b indicated the slope and a, the Y-intercept. The pattern of the growth established for length and weight relationships was characterized as positive allometry when b > 3, negative allometry b < 3 and isometry b = 3 (Hartnoll, 1982). The best fit linear regression equation was calculated using least square method to determine the relationship between morphometric variables (Teissier, 1960; Hartnoll, 1982, Qureshi and Kazmi, 1999) and growth was considered isometric when 0.9 < b < 1.1 (Kuris and Carlton 1977; Castiglioni and Negreiros-Fransozo, 2004). Newcombe (1948) suggested carapace length (CL), whereas Williams (1974) recommended carapace width (CW) for relative growth predictions, both CW and CL were studied in the present study.

RESULTS

A total of 857 *Ilyoplax frater* specimens were collected during the study period, of which 350 were male (205 adults and 145 juveniles) and 507 females (267 Non ovigerous females, 125 Ovigerous and 115 juveniles). The size (CW) of the male and female crabs ranged from 2.5 to 11.5 mm and 2.5 to 11.0 mm, respectively (Table I) and was not significantly different (t = 0.96, P = 0.34).

Table I.- Summary of descriptive statistics.

Variable	Sex	n	Mean ± SD	Min	Max
CL (mm)	F	507	5.05±1.34	2.0	7.5
	M	350	5.22±1.32	2.0	8.0
CW (mm)	F	507	7.05±1.84	2.5	11.0
	M	350	7.21±1.87	2.5	11.5
Ab.L (mm)	F	507	4.68±1.31	1.50	7.0
	M	350	4.79±1.25	1.50	7.5
Ab.W (mm)	F	507	4.79±1.75	0.75	8.5
	M	350	2.56±0.99	0.50	5.5
Ch. L (mm)	F	507	3.34±0.97	0.50	5.5
	M	350	4.94±1.67	1.0	9.0
Ch. H (mm)	F	507	1.47±0.49	0.25	2.5
	M	350	2.01±0.79	0.25	4.5

Abbreviations used: CL, carapace length; CW, carapace width; Ab.L, abdominal length; Ab.W; abdominal width; Ch.L, chela length; Ch.H, chela height. For male and female *Ilyoplax frater* collected from the Korangi creek from March 2001 to February 2002.

Sexual maturity in male and female crabs

The growth curve in juvenile and adult phases differed in all the regressions. The size at which 50% of the population was morphologically mature is shown in Figure 1. The result of the logistic equation indicates that approximately 50% male crabs were sexually mature at the size of 4.7 mm

whereas for female this proportion was found at the size of 4.6 mm. Thus, the estimated size at onset of sexual maturity was 4.6 mm and 4.7 mm for males and females, respectively.

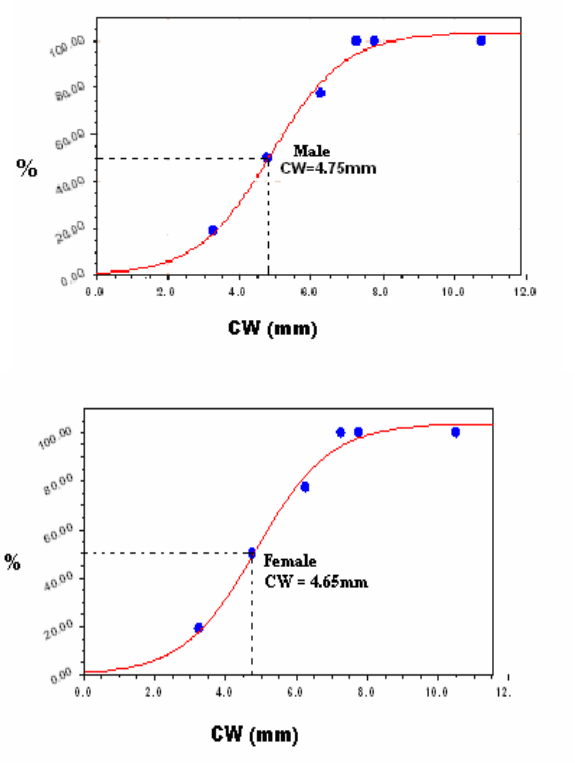

Fig. 1. Sigmoid curve between the carapace width (CW) and percentage of adult males and females of *Ilyoplax frater*.

Length (CL) and weight relationship

The relative growth showed negative allometry between CL (carapace length) and wet weight of the body (Fig. 2). The relative growth was negatively allometric and showed higher value of the slope 'b' for the male crabs compared to female crabs (Table II), and there was no significant difference between the carapace length and weight relationships of male and female crabs.

Size (CW) and weight relationship

The relationship between wet weight and carapace width of *Ilyoplax frater* also showed negative allometric growth for the male and female crabs (Figure 2; Table II). The value of slope 'b' for male crab was higher (b=2.87) than the female (b=2.63) crab.

Relative growth of the carapace length, abdominal length and abdominal width

The linear relationship between the carapace length and carapace width showed nearly isometric growth for both male and female crabs (Table III). The relationship between carapace length and abdominal length was also linear and isometric for both adult and juveniles males and females. The positive allometric growth of the abdominal width was observed in the juvenile and adult non ovigerous females (b = 1.47, and 1.19 respectively) but was isometric for the male crabs (Table III).

Relative growth of cheliped length, cheliped height and pleopod length

The relative growth showed positive relationship between carapace width and cheliped length for adult male crabs (b = 1.36) and was isometric in juvenile male crabs (Table III). However, slightly negative allometric growth was observed for the female (b = 0.89) crab and was significantly different between the sexes (t = -7.38, $P < 0.001$). The maximum cheliped size was larger (9 mm) for the male crabs compared to female crabs (5.5 mm). The growth of pleopod length was positive allometric (b = 1.28) in immature crabs as compared to mature male crabs (Fig. 3).

DISCUSSION

Growth in crustaceans is commonly typically influenced by various environmental factors as photoperiod, temperature, rainfall and food resource (Campbell and Eagles, 1983). The relative growth in crustaceans has been studied extensively using the morphometric data (Hartnoll, 1982). The morphometric measurements of the carapace characteristically show isometry represented as an interval of b = 0.9 - 1.1 (Hartnoll, 1978, 1982; Kuris *et al*., 1987; Pinheiro and Fransozo, 1993), however, the length weight relationship is essentially cubic and is usually represented by the power function and can be linearized using log-log transformation.

In present study, CL and CW both, show nearly similar slightly negative allometric relationship with wet weight. The carapace width has been generally considered an independent variable in brachyuran morphometric studies because

Table II.- Relative growth of male and female crabs of *Ilyoplax frater* based on carapace length (CL) and carapace width (CW) as an independent variables and wet weight as dependant variable (+ve) positive allometry, (-ve) negative allometry and (0) isometry. (TM= total male, TF= Total female).

Species	Sex	N	LogY= loga+b logX	R	Allometry
CL vs Wet wt.	TF	507	LogY = - 2.95 + 2.64 (logX)	0.71	-ve
	TM	350	LogY = - 3.09 + 2.86 (logX)	0.71	-ve
CW vs Wet wt.	TF	507	LogY = - 3.32 + 2.63 (logX)	0.71	-ve
	TM	350	LogY = - 3.51 + 2.87 (logX)	0.74	-ve

Table III.- Relative growth of morphometric measurements in male and female crabs of *Ilyoplax frater* with carapace width (CW) as an independent variables (+ve) positive allometry, (-ve) negative allometry and (0) isometry. (TM, total male; TF, total female; AM, adult male; AF, adult female; JM, Juvenile male; JF, juvenile female).

Species	Sex	N	LogY= loga+b logX	R	Allometry
CL vs CW	TF	507	= - 0.102 + 0.94	0.91	0
	TM	350	= - 0.097 + 0.94	0.92	0
CW vs Ab. L	TF	507	= - 0.144 + 0.96	0.84	0
	TM	350	= - 0.13 + 0.95	0.85	0
CW vs Ab.W	AF	267	= -0.34 + 1.19	0.75	+ve
	JF	115	= -0.60 + 1.47	0.70	+ve
	OF	125	= -0.26+ 0.95	0.89	0
	TM	350	= -0.58 + 1.10	0.80	0
CW vs Ch. L	AF	507	= -0.24 + 0.89	0.93	-ve
	AM	205	= -0.53 + 1.36	0.90	+ve
	JM	145	= -0.27 + 0.95	0.89	0
CW vs Ch. H	TF	507	= - 0.80 + 1.11	0.75	0
	TM	350	= - 0.96 + 1.46	0.68	+ve
CW vs Pl. L	JM	145	= -0.56+ 1.28	0.85	+ve
	AM	205	= -0.29 + 0.97	0.79	0

it shows few physiological changes throughout a crab's life history (Barnes, 1968). However, literature shows the relationship between carapace length and width is not appropriate to express all biological alterations that occur in crab's life (Santos *et al.*, 1995).

The size at morphological sexual maturity based on fifty percent mature crabs was 4.7 mm in males and 4.6 mm in females. The increment between the 3.75 and 6.0 mm is nearest to that recorded in other crabs (Hartnoll, 1982, 1983; Bellwood and Perez, 1989; Snowden *et al*., 1991) and it is probably around this size that the male chelae enlarge, and the level of allometry of ambulatory limbs changes (Clayton and Snowden, 1991). The female abdomen also enlarges at this size (Clayton and Snowden, 1991), and the CW recorded for the smallest ovigerous female of *Ilyoplax frater* was 4mm (Saher and Qureshi, 2010).

Adult males display positive allometric growth with cheliped length and height and there was clear sexual dimorphism as in female chelar growth relative to CW show slightly negative allometric to isometric growth. The male chelipeds play an important role in reproductive behaviour, and are used by the males for inter and intra specific aggression in combat, as well as in courtship to display and handling of females to eventual success. The strong chelar growth in brachyuran male makes the reproductive behavioral display efficient, because they use it to manipulate the female during mating as well, and male with large chelae has an advantage in partner selection especially in semi terrestrial and terrestrial crabs, where visual and tactile stimuli are most important for couple formation (Pinheiro and Fransozo, 1999; Góes *et al*., 2000).

The ontogenic changes in the abdomen width

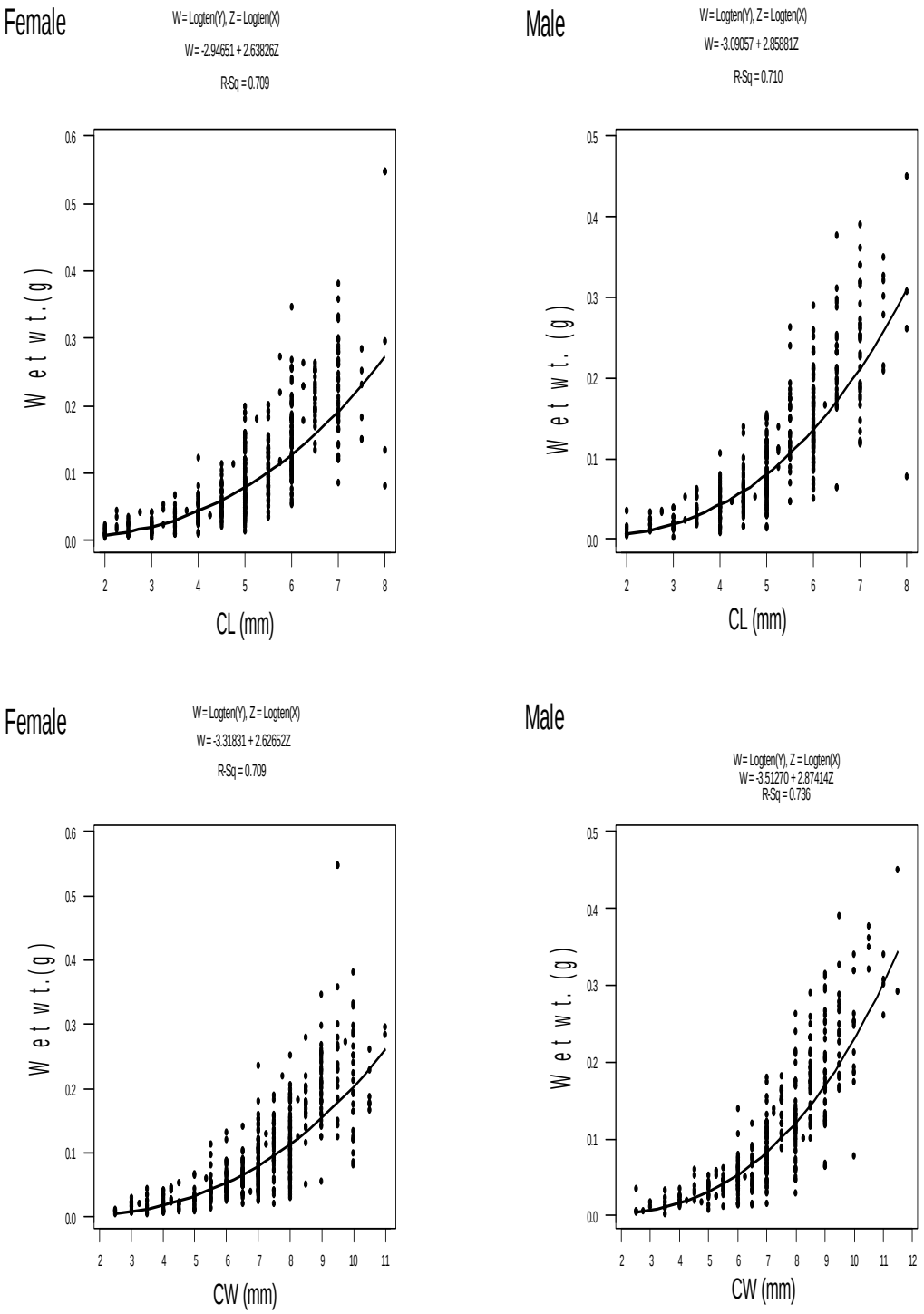

Fig. 2. Length (CL) weight (Wet wt.) and size (CW) weight (Wet wt.) relationship for female and male crabs of *Ilyoplax frater*.

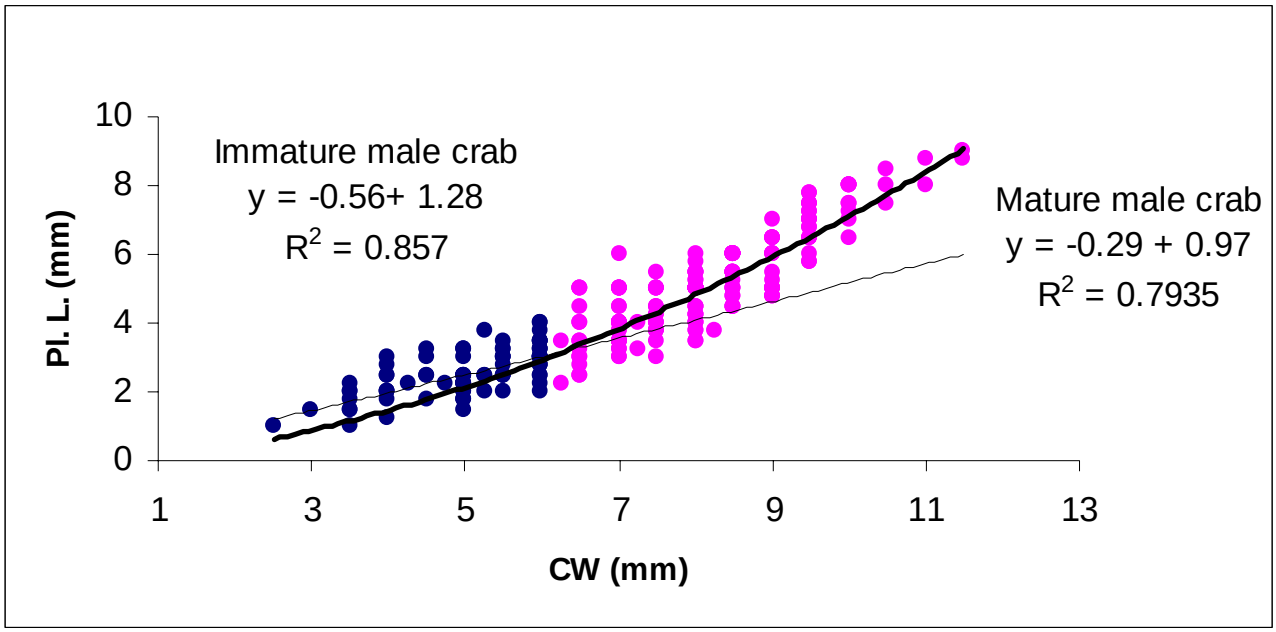

Fig. 3. Relative growth of the first pleopod of immature and mature male crabs of *Ilyoplax frater* (CW, Carapace width; Pl.L., pleopod length).

of females in *I. frater* can be related to the capacity of females to incubate the egg mass. In brachyurans, the relative growth of the abdomen has been used only to estimate the size of females at puberty, because certain somites showed striking modification in growth and morphology during ontogeny (Huxley and Richards, 1931), whereas similar changes are not observed in males (Hartnoll, 1974).

The developing eggs are attached to the pleopods throughout incubation, with an efficient size and shape of the abdomen forming a cover to facilitate fixation and to act as an incubatory chamber. The growth of male abdomen showed isometric pattern as the male abdomen sustains and protects two pairs of pleopods that are responsible for transferring sperm during mating. In males, the abdomen is only used as a support structure for the pleopods, with a copulatory function (Pinheiro and Fransozo, 1993).

The relationship between CW and pleopod length (Pl.L) indicated positive allometric growth during juvenile phase, and that changed to isometric growth with the passage to the adult phase. These results are comparable with other studies and this differential growth has been related to the ability of wide size range of males to copulate successfully with wide range of females improving their reproductive output (Hartnoll, 1974; Bertini *et al*., 2007).

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