Iranian Journal of Fisheries Sciences 12(2) 639-653 2013

Relative growth of the fiddler crab, *Uca sindensis* (Crustacea: Ocypodidae) in a subtropical mangrove in Pohl Port, Iran

Lavajoo F.[1*] ; Kamrani E.[1] ; Sajjadi M.[1] ; Askari M.[2]

Received: February 2011 Accepted: September 2012

Abstract

The relative growth of the fiddler crab *Uca sindensis* in Pohl Port was studied. Ten 0.5 m^2 quadrates were randomly sampled monthly during low tide periods from October 2009 to September 2010. A total of 840 crabs, 449 (53.45%) males and 391(46.5%) females, were sampled. The Carapace width of males ranged from 5.5 to13.5 mm (mean ± SD) (8.92 ± 2.04), and of females from 5.0 to 11.5 mm (mean ± SD) (7.95 ± 1.34). Carapace height (CH) and Carapace length(CL), height of the major cheliped (HMC) of males, abdomen width of females (AW), major cheliped length (LMC), dactiluse (D), feeding cheliped (CHF) and merouse (M) were employed as dependent variables and carapace width(CW) as independent variable. The relationship between CW × CH was positive in males and females. The equation (Log CH=Log-4.881+4.681LogCW) for males ($P<0.05$) and Log CH=Log-1.882+3.299LogCW for females ($P<0.05$). The females showed allometric positive growth for CW × AW relation to male (Log AW= Log0.784+1.217Log CW) ($P<0.05$). Also four male crabs were found with two major cheliped in this study. Remarkable ontogenetic changes were observed in the allometric growth of the male major cheliped and the female abdomen, indicating that these structures are closely connected to the timing of sexual maturity. The allometric growth of *U. sindensis* in Pohl Port mangrove differed from other *Uca* populations so far studied, indicating that growth could have been influenced by environment variables such as food availability, population density, distribution of vegetation, sex ratio, soil temperature , organic matter, different of surface and sediment.

Keywords: Fiddler crabs, *Uca sindensis,* Relative growth, Carapace width, Allometry, Abdomen width

1-Department of Marine Biology, Faculty of Science, University of Hormozgan, P.O.Box 3995, Bandar Abbass, Iran

2- Department of Biology, Faculty of Science, University of Bahonar, P.O.Box76169133 , Kerman, Iran

*Corresponding author`s email: F.Lavajoo@gmail.com

Introduction

Brachyuran crabs found in mangrove forests are important taxa in terms of density and biomass (Nobbs and Mcguinness, 1999; Macia et al., 2001; Skov and Hartnoll, 2001; Skov et al., 2002). They are deposit-feeders and they construct burrows that have different shapes because the burrows shape associated surface sediments (Olafsson and Ndaro, 1997; Skov et al., 2001). The properties of habitat Such as: type of vegetation, food availability, temperature, tide, salinity, sediment of surface and other animals play a major role in biodiversity, population dynamic and distribution and density of fiddler crabs (Aspey, 1978; Icely and Jones, 1978; Rabalais and Cameron, 1985; Ewa and Oboho, 1993; Thurman, 1998; Nobbs, 2003; Cesar et al., 2005; Ribeiro et al., 2005). The crab's population equilibrium is preserved, via competing for food, refuge and reproductive pairing (Fontelles-Filho, 1989). Crabs are consumed by birds, invertebrates and fish, because they are source of energy for both terrestrial and marine ecosystems (Skov and Hartnoll, 2001; Skov et al., 2002; Litulo, 2004).

Uca sindensis live in burrows in sand and silt mangrove sediments in Pohl Port. The chelae size in fiddler crab is characteristic of sexuality and the male crabs have one major claw and the female crabs have two small isomorphic claws (Crane, 1975). The extensive literature on the relative growth of brachyuran crabs presents the theoretical basis on allometry (Hartnoll, 1982; Huxley and Richards, 1931). The knowledge on the relative growth during the juvenile phases is scarce, because of the difficult recognition of the specimens in the natural environment and the low survival rate of the larvae until the juvenile phases in laboratory. Allometry is a study to define the relationship between size and shape, and it was first outlined by Huxley (1972). Allometric growth happens when some part of an animal's body growth at a different rate in size (Hartnoll, 1982). For comparison intra- specific changes in populations from different places used to allometric analysis (Negreiros-Fransozo, 2004). Because of these kinds of studies are powerful tools for both taxonomists and ecologist interested in intra and inter-specific morphological variation (Negreiros-Fransozo, 2004). Some characteristics such as: shape and size of chelipeds, abdomen, pleopods cause of differential growth rates before and after the maturation life phases (Hartnoll, 1974, 1978, 1982, 1985). Also appearance of a rigid exoskeleton in fiddler crabs limits their growth , however part of body dimensions remain constant in the intermolt period but some structures grow in distinct proportions to each other which cause of differences in the growth rate when two body dimensions are compared (Hartnoll, 1974). No previous work has yet been published on the relative growth of *U. sindensis* in sub- tropical areas in Pohl port mangrove forests in Iran. Hence present study is about the relative growth of *U. sindensis* and compares it with data from other locations.

Materials and methods

Site Description

The field took place at the Pohl Port mangrove forests Bandar Abbass (27° 01 ´ 50.5"N and 55° 44´ 55.6"E). This place located in Hormuzgan province along the Persian Gulf coasts of Iran, (Fig. 1). The study area has a sub-tropical climate the average annual mean temperature was 26.34 °C. Local tides have a semi-diurnal regime with maximum amplitudes of 3 m. The mangrove vegetation of this area is dominated by *Avicennia marina* (Zahed et al., 2010)

Sampling Methods

Ten 0.5 m^2 quadrates were randomly sampled on monthly basis during low tide period from October 2009 to September 2010.The quadrates ran in two substrates (sand and silt). The quadrates were excavated with a corer to a depth of 35 cm and all fiddler crabs presented in the areas limited by the quadrates were bagged, labeled and preserved in 70% ethanol until further analysis.

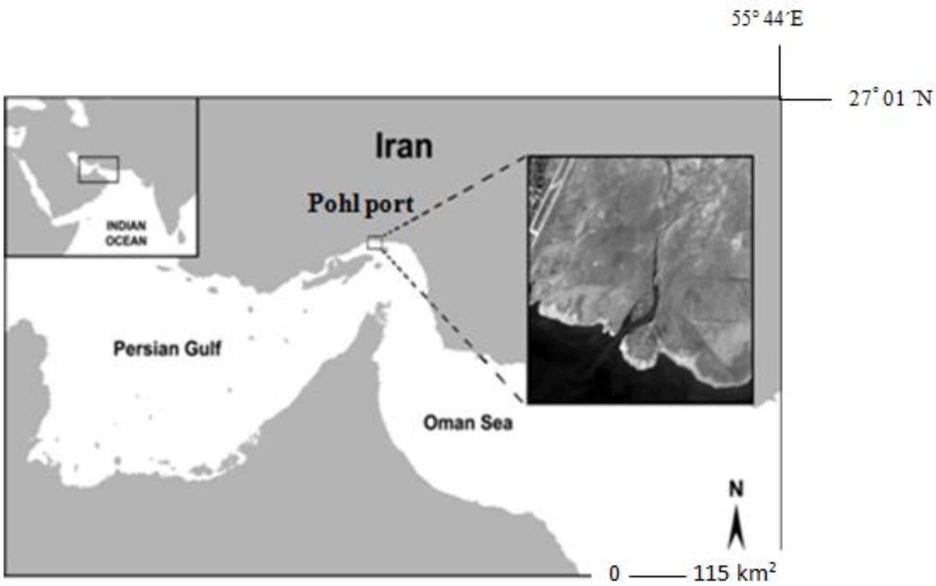

Figure 1: Location of Pohl Port mangrove forest in northern Persian Gulf (Derived from Mokhlesi, 2010)

Laboratory Analysis

The sex determination of specimens was done in the laboratory. The (CW), (CH), (CHF), (AW), (LMC), (D) and (M) were measured using a vernier caliper (± 0.05 mm accuracy). The number of crabs was recorded for each quadrate.

Assessment

Growth ratio for the independent variable (CW) and the other variable (dependent) were determined by using the logarithmic transformation Log Y= Log a + b Log X and the function $Y=aX^b$, where X is the independent variable (CW), Y is the dependent variable, "a"is the value of Y when X=0, and "b"the slope of the regression line (Hartnoll, 1978, 1982; Lovett and Felder, 1989). The "b"value represents the relative growth constant (b=1 means isometric growth; b>1 means positive allometric growth; and b<1 means negative allometric growth). The statistical significance of "b " was tested by students t-test, adopting a significance level of 5% (Negreiros- Fransozo et al., 2003; Benetti and Negreiros- Fransozo, 2004; Cardozo and Negreiros- Fransozo, 2004), and noting the confidence interval of the regression line (Masunari and Swiech-Ayoub, 2003; Masunari and Disenha, 2005; Masunari et al., 2005) .

Results

A total of 840 crabs, 449 males and 391 females, were sampled. The CW of males ranged from 5.5 to13.5 mm (8.92 ± 2.04 SD), and of females from 5.0 to11.5 mm (7.95 ± 1.34 SD). The relationship between CW×CH was positive of males and females (see Figs.5, 6). The equation LogCH=Log-4.881+4.681LogCW for males (P<0.05) and LogCH=Log-1.882+3.299LogCW for females (P<0.05). Concerning the relationship between CW × LMC, was positive allometry. The equation was described by the following formula: LogLMC=Log0.212+1.730LogCW (P<0.05). The relationship of CW×AW was positive allometry (Fig.4). The equation LogAW= Log0.784+1.217Log CW (P<0.05). The relationship between CW × M was positive of males. The equation Log M=Log0.493+1.126LogCW (P<0.05). Concerning the relationship between CW × D, was positive allometry. The equation was described by the following LogLD =Log 0.318 +1.304LogCW (P<0.05). A positive allometric growth was observed for the relationship between CW × CHF , in males and negative for females(see Figs. 2,3). Table 1 shows the growth relationships between body dimensions and correlation coefficient for each sex. In the males allometric growth was positive for the relationship between CW × HMC, being described by Log HMC= 0.289+Log1.260CW (P<0.05). Fig 1 shows Anatomy *Uca sindensis* for position recognition.

Table 1: *Uca sindensis*. Statistics on the relationship between the independent variable (CW) and the dependent variables (CH), (LMC), (HMC), (AW), (D), (CHF), (M), (R^2) determination coefficient, (a) intersection,(N) number of sample, (+)positive allometry, (-) negative allometry.

Variables	n	a	b	R^2	ALL
CW X CH (males)	449	-4.881	4.681	0.899	+
CW X CH (females)	391	-1.882	3.299	0.732	+
CW X LMC	449	0.289	1.260	0.82	+
CW X AW (females)	391	0.784	1.217	0.57	+
CW X M	449	0.493	1.126	0.67	+
CWXCHF (females)	391	0.645	0.821	0.72	–
CWXCHF (males)	449	0.402	1.101	0.80	+
CW X D	449	0.318	1.304	0.69	+
CW X HMC	449	0.289	1.260	0.73	+

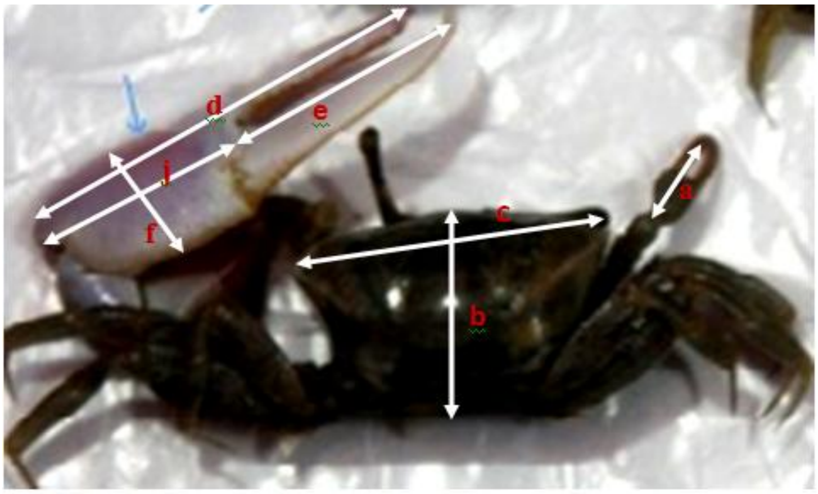

Figure 1: Anatomy *Uca sindensis*: a (Feeding Cheliped height), b (Carapace height), c (Carapace width), d (Major cheliped length), e (Dactilus), f (Major cheliped height), j (Merouse).

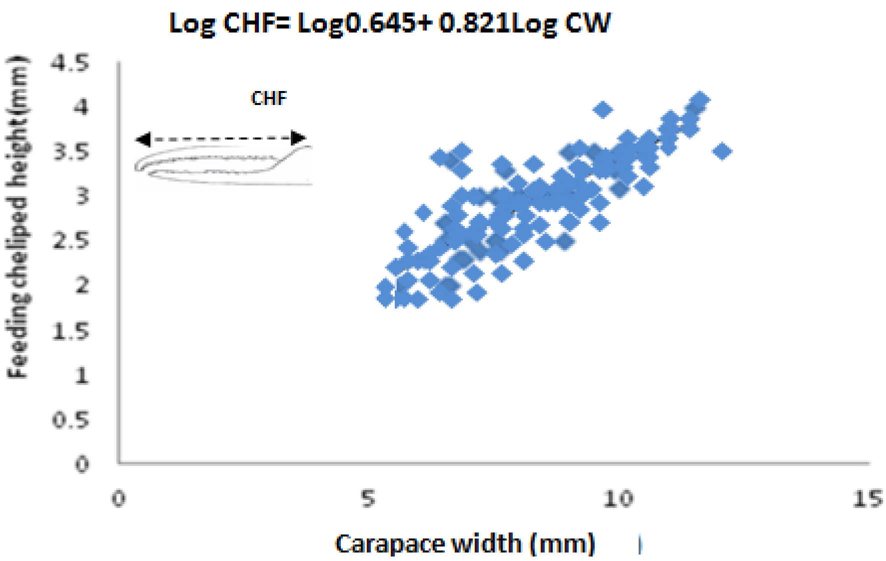

Figure 2: Relationship between feeding cheliped height and carapace width in females of *U. sindensis* from Pohl Port mangrove

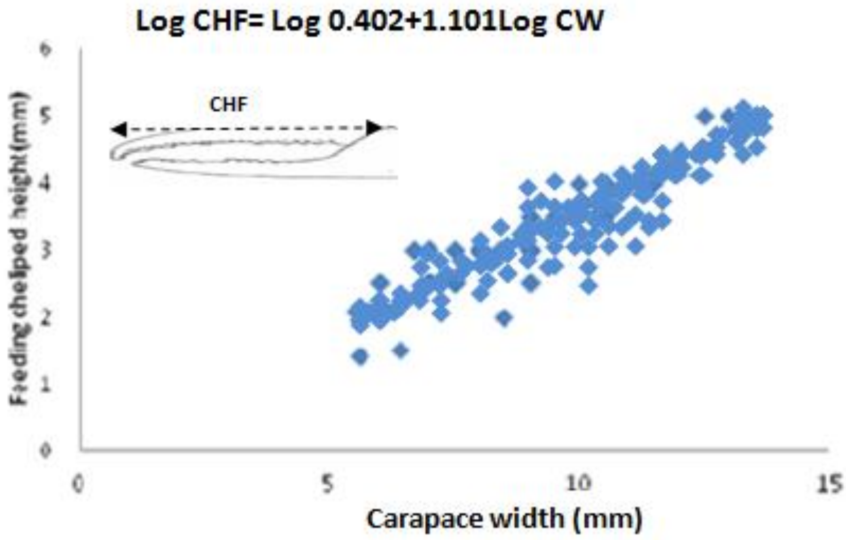

Figure 3: Relationship between feeding cheliped height and carapace width in males of *U. sindensis* from Pohl Port mangrove

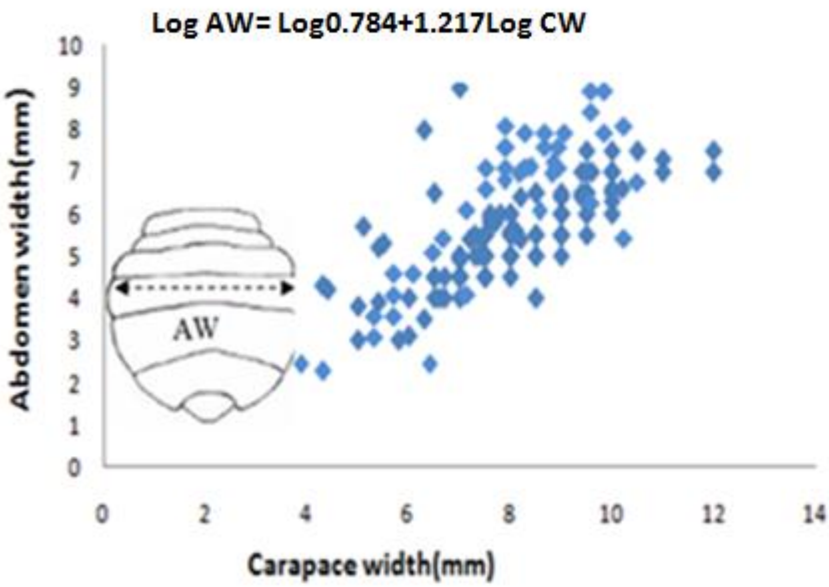

Figure 4: Relationship between abdomen width and carapace width in females of *U. sindensis* from Pohl Port mangrove

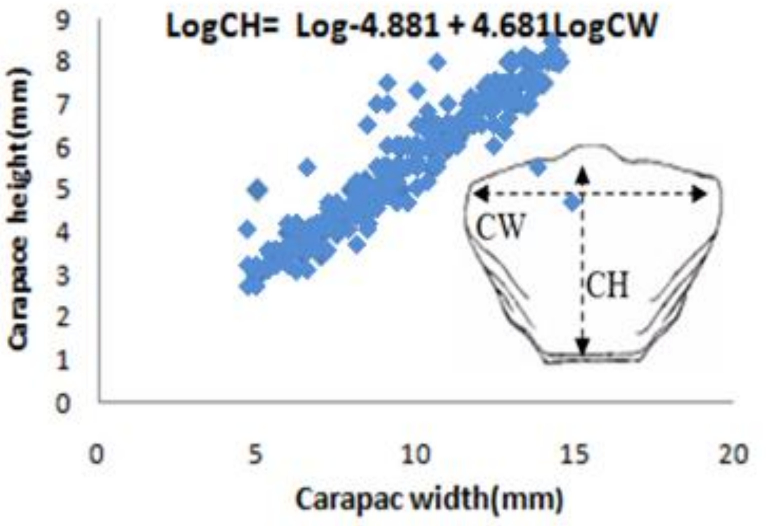

Figure 5: Relationship between Carapace height and carapace width in males of *U. sindensis* from Pohl Port mangrove

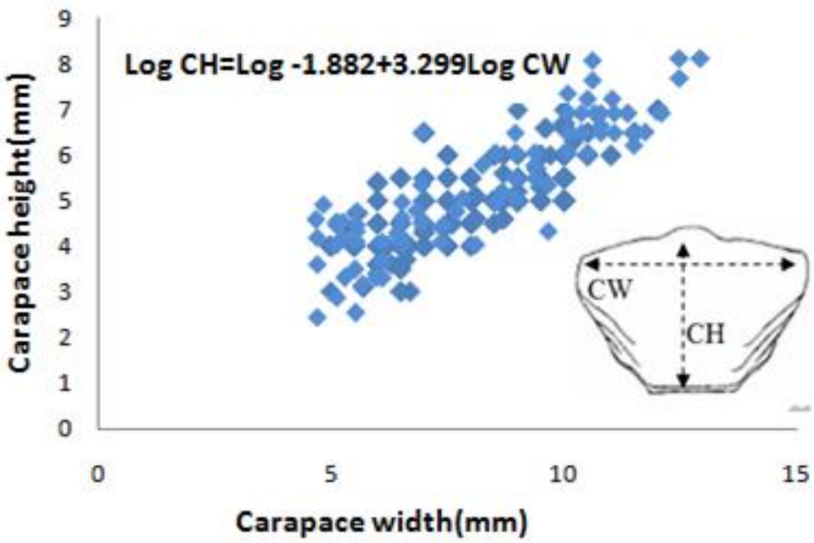

Figure 6: Relationship between Carapace height and carapace width in females of *U. sindensis* from Pohl Port mangrove

Discussion

Allometry is a well- known study particularly in statistical shape analysis for its theoretical developments, as well as in biology for practical applications to study the differential growth rates of the parts of a dimensions of appendages such as feeding Cheliped, antennae, or carapace width and appendix in major cheliped in male crabs. Remarkable ontogenetic changes were observed in the allometric growth of the male major cheliped and the female abdomen, indicating that these structures are closely connected to the timing of sexual maturity. The measure of carapace width used as an independent factor for growth analysis of crabs because it exhibits all of physiological changes that happened over their life history (Castiglioni and Negreiros-Fransozo, 2004).The role of major cheliped is in the reproductive behavior of *Uca*. Also appendage is used by *Uca* crabs in intra- and interspecific contests for combative behavior, exhibits and territory defense. The bigger major cheliped has an important role to an advantage in combats among males and in handling females during copulation (Crane, 1975).

According to (Masunari and Swiec-Ayoub, 2003), the major cheliped maintain body balance and redoundtoreduction of allometry level of the chelipeds. Major cheliped necessary for burrows dig. Moreover, larger size of male proportion to female may have chances ofobtaining females for copulation and successful in intra- specific fights (Henmi, 2000).The allometric growth of the major cheliped of males was positive. Table 2 shows the positive allometry in *Uca*.

Female crabs are smallest than males, because they spend some of energy for gonad development (Lopez Greco et al., 2000; Mantelato et al., 2003). In this study, carapace width is about 13.5 mm for males and 11.5 for females. The lower abundance of males in smaller sizes was probably caused by differential growth rates of both sexes. Lower growth rate of females is expended to their energetic for reproductive activity thus has smaller sizes (Hartnoll and Gouland, 1988).

The abdomen shows a marked dimorphism in crabs, being the female's body part where eggs are incubated during embriogenic periods. *Uca sindensis*from Pohl Port mangrove had a positive allometric growth of males (CW × LMC) (b= 1.26 (+)) and females (CW × AW) (b=1.21(+)). This result is almost toward result (Castiglioni and Negreiros–Fransozo, 2004) of *Uca rapax*(b= 1.52(+)) for adult males and (b=1.23(+)) for adult females. The abdomen works in conjunction with sternum. After crab reach the age of maturation and molting the disproportionate growth happened in length of abdomen that cause of reduce the efficiency of the walking mechanism, hampering the pereiopod steps. The same description was also on growth pattern in *U.rapax* by (Castiglioni and Negreiros-Fransozo, 2004) and in *U.thayeri* by Negreiros-Fransozo et al. (2003), in Ubatuba (Sao Paulo State) coast. Table 2 presents the allometric level for the relationships of CW with LMC and AW calculated for several species of *Uca* from different localities. One application of allometry, for crabs is in the study of various *Uca* species, where a small change in overall body size can lead to an enormous and disproportionate increase in the determination coefficient showed in relationship between length and width so with increased width, the length to proportion increased. Also a good correlation was between Carapace Width and Abdomen width (R^2= 0.57) (Fig.4). In contrast the relationship between Carapace width with cheliped feeding in males and females, the allometry in males was positive and females is negative allometry because in males has a one feeding cheliped whereas females crabs have two feeding chelipeds and male crabs spend most energy for feeding, Thus must have a big cheliped feeding against females. The CW × CH relationship is not suitable in expression biological changes in the life history of male *Uca* crabs.

The genetic discrimination in marine organisms is highly influenced by their dispersal capacity therefore the specific ecological requirements and life history traits affected to population genetic structure and growth in marine environments (Bagley and Geller, 1999; Santos et al., 2006).Thus in this study we couldn’t indicate that the genetic differentiation is closely connected to the relative growth because all of samples gathered of same location. The relative allometric growth of *U.sindensis* in Pohl Port mangrove differed from other *Uca* populations so far studied, indicating that growth could have been influenced by environment variables such as food availability, organic matter, different surface and sediments, distribution of vegetation, population density, sex ratio and soil temperature.

Table. 2: Allometry levels for *Uca Sindensis* . Using carapace width as independent variable in Pohl port mangrove in Iran, (+) positive allometry, (-) negative allometry, (0) isometry

Species	Authors	Males(CW × LMC)		Females(CW × AW)	
		Juvenile	adult	Juvenile	adult
Uca burgersi	Benetti and Negreiros–Fransozo, 2004	1.66(0)	2.01(+)	1.29(0)	1.64(+)
Ucaburgersi	Benetti and Negreiros – Fransozo, 2004	1.62(+)	2.04(+)	1.40(+)	1.59(+)
UcaLeptodactyla	Masunari and Swiech – Ayoub, 2003	2.19(+)	1.24(0)	1.30(+)	1.07(0)
Ucamordax	Maunari and Disenha, 2005	1.51(+)	2.37(+)	1.22(+)	1.60(+)
Ucarapax	Castiglioni and Negreiros–Fransozo, 2004	1.43(+)	1.86(+)	1.45(+)	1.31(+)
Uca rapax	Castiglioni and Negreiros – Fransozo, 2004	1.55(+)	1.52(+)	1.67(+)	1.23(+)
Uca thayeri	Negreiros – Fransozo et al., 2003	1.52(+)	2.24(+)	1.32(+)	1.10(+)
Uca maracoani	Masunari et al., 2005	1.39(+)	1.95(+)	1.00(0)	1.51(+)
Ucarapax	Tarso Costa and AbilioSoares-Gomes, 2008	1.98(+)	0.84(-)	1.44(+)	1.31(+)
Uca sindensis	Present study	Males(CW× LMC) All 1.26 (+)		Females(CW ×AW) All 1.21(+)	

Acknowledgements

We particularly thanks of M. Dehghani,P. Mahmoudi, H. Dehghani and O. Parshan for assistance in the field. Thanks of A. Golmoradi for assisting in statistical analysis.

References

Aspey, W. P., 1978. Fiddler crab behavioral ecology: burrow density in *Ucapugnax* (Smith) and *Uca pugilator* (Box) (*Decapoda: Brachyura*).*Crustaceana*, 34(3):235-24.

Bagley, M. J., Lindquist, D. G. and Geller, J.B., 1999. Microsatellite variation, effective population size, and population genetic structure of vermilion snapper, *Rhomboplitesaurorubens*, off the southeastern USA. *Marine Biology* 134(4):609-620.

BenettiA. S. and Negreiros-Fransozo M. L., 2004. Relative growth of *Ucaburgersi* (*Crustacea: Ocypodidae*) from two mangroves in the southeastern Brazilian coast. Iheringia 94(1):67-72.

Castiglioni, D. and Negreiros-Fransozo, M. L., 2004. Comparative analysis of the relative growth of *Ucarapax* (Smith)(*Crustacea: Ocypodidae*) from subtropical mangroves in Brazil. University of Ciencia 20(39): 15-22.

César, I. I., Armendáriz L. C. and Becerra R.V., 2005.Bioecology of the fiddler crab *Ucauruguayensis* and the burrowing crab *Chasmagnathusgranulatus* (*Decapoda, Brachyura*) in the Refugio de Vida Silvestre Bahía Samborombón, Argentina.*Hydrobiologia*, vol. 545, no. 1, p. 237-248.

Costa, T. M. and Negreiros-Fransozo, M.L., 2003. Population biology of *UcathayeriRathbun*, 1900 (*Brachyura: Ocypodiae*) in a sub-tropical SouthAmerican mangrove area: results from transect and catch-per-unit-effort techniques. *Crustacean* 75:1201-1218.

Crane, J., 1975. Fiddler crabs of the world, (Ocypodidae: Genus *Uca*)Princeton University press, NewJersey.

Ewa-Oboho, I. O., 1993.Substratum preference of the tropical estuarine crabs, *UcatangeriEydoux* (*Ocypodidae*) and *Ocypode cursor Linne* (Ocypodidae).*Hydrobiologia*271:119-127.

Fontelles-Filho, A. A., 1989, Recursospesqueiros, biologia e dinâmicapopulacional. Fortaleza, Imprensa Oficialdo Ceará 296 p.

Hartnoll, R. G., 1978. The determination of relative growth in crustacean. *Crustaceana* 34(3):281-293.

Hartnoll, R. G., 1982. The biology of crustacean: embryology, morphology and ecology. *In*: Bliss D. E. (Ed.). Growth. New York Academic Press, New York (NY) 111-185.

Hartnoll, R. G. and Gould,P., 1988. Brachyuran life history strategies and the optimization of egg production. Proc. Zoological Symposium 59: 1-9.

Henmi, Y., 2000. Comparisons of life history traits among populations of the ocypodid crab *Macrophthalmus japonicas* in habitats with contrasting food availability. Crustacean. Res. 29: 109-120.

Huxley, J. S., 1972. Problems of Relative Growth.Second edition. Dover Publication, Inc., New York 312 p.

Icely, J. D. and Jones, D. A., 1978. Factors affecting the distribution of the genus *Uca* (*Crustacea:*

Ocypodidae) on an East African shore. *Estuarine and Coastal Marine Science* 6: 315-325.

Johnson, P. T. J., 2003. Biased sex ratios in fiddler crabs (*Brachyura: Ocypodidae*): Areview and evaluation of the influence of sampling method, size class and sex-specific mortality. *Crustaceana* 76: 559-580.

Litulo, C.,2004. Reproductive aspects of a tropical population of the fiddler crab *Ucaannulipes*(H.Milne Edwards, 1837) (*Brachyura: Ocypodidae*) at Costa do Sol mangrove,Maputo Bay, Southern Mozambique. *Hydrobiologia* 525: 157-173.

Litulo, C., 2005a. Population structure and reproductive biology of the fiddler crab *Uca inversa* (Hoffman, 1874) (*Brachyura: Ocypodidae*). *Acta Oecological* 27: 135-141.

Litulo C., 2005b. Population structure and reproductive biology of the fiddler crab *urvillei* (Brachyura: Ocypodidae) in Matupo Bay(South Mozambique). Journal of Natural Science, 39(25): 2307-2318.

Lopez Greco,L. S., Hernandez, J. E.,Bolanos, J. E., Rodriguez,E. M. and Hernandez,G., 2000. Population features of *MicrophrysLatreille*, 1825 (*Brachyura: Majidae*) from Isla Margarita, Venezuela. *Hydrobiologia* 439:151-159.

Lovett, D. L. and Felder, D.L.,1989. Application of regression techniques to studies of relative growth in crustaceans.*Journal of Crustacean Biology* 9(4):529-539.

Macia, A., Quincardete, I. and Paula, J., 2001. A comparison of alternative methods for estimating population density of the fiddler crab *Ucaannulipes* at Saco mangrove, Inhaca Island (Mozambique). *Hydrobiologia* 449:213-219.

Mantelatto, F., FransozoL. M. A. andNegreiros-Fransozo,M. L., 1995. Population Structure of *Hepatuspadibundus* (*Decapoda: Calappidae*) in Fortaleza Bay, Brazil. Rev. Biology. Tropical 43:265-270.

Mantelatto, F. L. M., Faria, F. C. R. and Garcia, R. B., 2003. Biological aspects of *Mithraculus forceps* (*Brachyura: Mithracidae*) from *Anchieta* Island, *Ubatuba*, Brazil. *Journal of Marine Biology*.Ass. UK 83: 789-791.

Masunari, S. and Swiech-Ayoub, B. P., 2003. CrescimentorelativoemUcalepto *dactylaRathbun* (*Crustacea, Decapoda, Ocypodidae*).RevistaBrasileira de zoologia, 20(3): 487-491.

Masunari, S. and Dissenha, N., 2005. Alometria no crescimento de *Ucamordax* (Smith) (*Crustacea, Decapoda, Ocypodidae*) da baia de Guaratuba, Parana, Brasil. Revista Brasileira de Zoologia 22(4): 984-990.

Masunari, S., Dissenha,N. and Falcao,R.C., 2005. Crescimento relative e destreza dos quelipodosem*Ucamaracoani* (*Crustacea, Decapoda, Ocypodidae*) no BaixoMirim, Baia de Guaratuba, Parana, Brasil. Revista Brasileira de zoologia 22(4):974-983.

Masunari, S., 2006.Distribuicao e abundancia dos caranguejos *Uca* Leach (*Crustaceea*: *Decapoda: Ocypodidae*) naBaia de Guaratuba, Parana, Brasil. Revista Brasileira de Zoologia, 23(4): 901-914.

Mokhlesi, A., Kamrani, E., Backwell, P and Sajjadi, M., 2010. Study on the behaviour of two fiddler crabs, *Uca sindensis Uca anuulipes* (Decapoda: Ocypodidae), in Bandar Abbas, Iran. *Journal of the Marine Biological Association of the United Kingdom* 91(1): 245 – 249.

Negreiros-Fransozo, M. L.,Colpo, K.D. and Costa,T.M., 2003.Allometric growth in the fiddler crab *Ucathayeri* (*Brachyuyra: Ocypodidae*) from a subtropical mangrove. *Crustaceana* 23(2):273-279.

Nobbs, M. and McGuinness, K. A., 1999. Developing methods for quantifying the apparent abundance of fiddler crabs (Ocypodidae: *Uca*) in mangrove habitats. *Australian Journal of Ecology* 24:43-49.

Nobbs, M., 2003. Effects of vegetation differ among three species of fiddler crabs (*Uca* spp.). *Journal of Experimental Marine Biology and Ecology*, 284: 41-50.

Olafsson, E. and Ndaro, S. G. M., 1997. Impact of the mangrove crabs *Ucaannulipes* and *Dotilla fenestrate* on meiobenthoss. Marine Ecology progress Series 158: 225-231.

Oshiro, L. M. Y., 1999. Aspectosreproductivos do caranguejoguaiaMenippenodifronsStimpson (Crustacea, Decapoda, Xanthidae) da baia de sepetiba, Rio de Janeiro, Brazil. Rev. Bras. Zoologia 16: 827-834.

Pinheiro, M. A. A.and Fransozo, A., 1998. Sexual maturity of swimming crab *Arenaeuscribrarius* (Lammarck, 1818) (Decapoda, Brachyura, Portunidae), in the Ubatuba Littoral, Sao Paulo state, Brazil.*Crustaceana*, 71(4): 434-452.

Rabalais, N. N. and Cameron, J.N., 1985.Physiological and morphological adaptations of adults *Ucasubcylindrica* to semi-arid environments. Biology Bulletin 168: 135-146.

Ribeiro, P. D., Iribarne, O. O. and Daleo, P., 2005. The relative importance of substratum and recruitment in determining the spatial distribution of the fiddler crab *Ucauruguayensis* Nobili. *Journal of Experimental Marine Biology and Ecology* 314(1): 99-111.

Santos, S., Hrbek, T., Farias, I. P., Schneider, H. and Sampaio, I., 2006.Population genetic structuring of the king weak Wsh, *Macrodonancylodon*(Sciaenidae), in Atlantic coastal waters of South America: deep genetic divergence without morphological change. *Molecular Ecology* 15:4361–4373.

Skov, M. W. and Hartnoll, R. G., 2001.Comparative suitability of binocular observation, burrow counting and excavation for the quantification of the mangrove fiddler crab *Ucaannulipes*(Milne Edwards H).*Hydrobiologia*449:201-212.

Skov, M. W., Vannini, M., Shunnula, J. P., Hartnoll, R. G. and Cannicci, S., 2002. Quantifying the density of mangrove crabs.Ocypodidae and Grapsidae.*Marine Biology* 141: 725-732.

Spivak, E. D., Gavio, M. A. andNavarro,C. E., 1991. Life history and structure of the worlds southernmost *Uca*population:*Ucauruguayensis* (*Crustacea: Brachyura*) in Mar Chiquita Lagoon (Argentina). *Bulletin of Marine Science* 48: 679-688.

Thurman, C. L., 1998. Osmorregulation by six species of fiddler crabs (*Uca*) from the Mississipi delta area in the northern Gulf of Mexico.*Journal of Experimental Marine Biology and Ecology* 291:233-252.

Trott, T. J., 1998. On the sex ratio of the painted ghost crab *Ocypodegaudichaudii* H. Milne Edwards & Lucas, 18 43 (Brachyura: Ocypodiae). *Crustaceana* 71:47.

Zahed, M. A., Ruhani, F. and Mohajeri, S., 2010. An overview of Iranian mangrove ecosystem, northern part of the Persian Gulf and Oman Sea. *Electronic Journal of Environmental, Agricultural and Food Chemistry* 9 (2): 411-417.