International Journal of Fisheries and Aquatic Studies 2015; 3(2): 391-396


**ISSN: 2347-5129**
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2015; 3(2): 391-396

www.fisheriesjournal.com
Received: 23-09-2015
Accepted: 24-10-2015

**Sudha Devi AR**
Department of Zoology, Mary Matha Arts & Science College, Mananthavady - 670 645, Wayanad, Kerala, India.

**Smija MK**
Department of Zoology, Mary Matha Arts & Science College, Mananthavady - 670 645, Wayanad, Kerala, India.

**Correspondence**
**Sudha Devi AR**
Department of Zoology, Mary Matha Arts & Science College, Mananthavady - 670 645, Wayanad, Kerala, India.

# Growth and moulting pattern in the freshwater crab *Travancoriana schirnerae*

**Sudha Devi AR, Smija MK**

**Abstract**
The present study analyzed the growth and moulting pattern in the freshwater crab *Travancoriana schirnerae* inhabiting the areca plantations of Mananthavady, Wayanad, Kerala over a period of one year (June 2013 to July 2014). The interrelationships between various morphometric characters, viz., carapace width (CW)-length (CL)/weight were estimated on a total of 610 crabs. The moulting pattern was monitored in relation to frequency, moult increment and intermoult period under laboratory conditions. Results indicated that the regression values for CW-weight and CW-CL relationships were found highly significant ($r^2$= 0.870 and 0.904 for males and 0.885 and 0.906 for females, respectively). The exponential values (b) for CW-weight relationship (1.945 and 1.704 for males and females, respectively) showed a negative allometry. Males grew more rapidly than females as evidenced from the markedly larger moult increments in CW and weight. There is significant variation in the intermoult intervals between the sexes; tend to be longer for females, related to their higher energetic outlay for reproduction.

**Keywords:** Growth pattern, Freshwater crab, Moult pattern, *Travancoriana schirnerae*.

## Introduction

Crustaceans do not exhibit continuous growth; rather, growth is distinct and biphasic in these animals. Their rigid exoskeleton restricts external growth to the brief moulting events and typically display two strategies for growth-indeterminate and determinate. Indeterminate species grow and continue moulting indefinitely while in determinate species, a series of moults happen until the requisite size is reached, at which point moulting and growth stop. Growth in crustaceans results from the interaction of two variable components-the intermoult period and the moult increment. The intermoult period tends to increase with size while moult increment tends to decrease with size, a steady phenomenon throughout crustaceans with a few exceptions [1].

Growth is usually influenced by various intrinsic and extrinsic factors such as maturity, temperature, salinity or water quality and nutrition [2] and can be estimated by moult increment together with frequency of moulting [3] and observations of age and size [4]. Many authors have described the discrepancy in growth pattern according to size, sex and developmental stages in marine brachyurans [5-7]. Araujo and Lira [8] and Gokce *et al*. [9] have examined the carapace width-weight relations in the blue crab *Callinectes sapidus* and the swimming crab *C. danae*. Sukumaran and Neelakanatan [10] studied the carapace length/width-body weight relationships in portunid crabs *Portunus sanguinolentus* and *P. pelagicus*. The growth and moulting pattern in the Japanese mitten crab *Eriocheir japonicus* was investigated under laboratory reared conditions by Kobayashi [11, 12]. Fumis *et al*. [13] evaluated the morphometric relationships in *Hexapanopeus schmitti* of the northern coast of São Paulo, Brazil. The relationships between dry weight and carapace width of two varunid crab species *Helice tridens* and *Chasmagnathus convexus* were scrutinized by Miyasaka *et al*. [14].

Moulting pattern has been extensively studied in a number of marine decapods [15, 16]. Brylawski and Miller [17] studied temperature dependent moulting pattern in *C. sapidus*. Aspects of moulting, growth and survival in the male rock crab *Cancer irroratus* in Chesapeake Bay were examined by Haefner and Engel [18]. Orensanz and Gallucci [19] presented detailed information on moulting incidence and size at each moult in *C. magister* of San Juan Island, Washington. Nevertheless, information is deficient on the pattern of growth and moulting in freshwater crabs except a few reports by Micheli *et al*. [20] in *Potamon fluviatile*, Venancio and Leme [21] in *Trichodactylus petropolitanus* and Patil and Patil [22] in

*Barytelphusa guerini*. The present work intended to evaluate the interrelationships between morphometric characters, viz., carapace width-length/weight and moulting pattern in the edible freshwater crab *Travancoriana schirnerae* inhabiting the wetlands of Mananthavady, Wayanad, is reported to fill this gap.

**Materials and methods**

Specimens were collected between June 2013 and July 2014 from the areca plantations of Ondayangadi, about 5km northeast of Mananthavady in Wayanad district of Kerala (11.82231649° N and 76.0232338° E, altitude 767 m). The carapace width (CW), length (CL), body weight and moult stages were recorded for all the specimens collected. Moult stages were identified by noting the changes in the exoskeleton and observing the maxilliped epipodites in males and setae of pleopods in females. The specimens were released unharmed after recording the necessary data.

**Growth pattern**

A total of 610 specimens (CW 3.3-6.1 cm for males and 3.8 to 5.8 cm for females) were used to study the morphometric relationships. The width-weight relationships were determined by the expression**:** $W=aL^b$, where W is the wet weight, L is the carapace width, a is the intercept and b is the slope of equation (growth constant); a and b were estimated bylinear regression analysis from logarithmically transformed data. The equation is represented in log transformation.

Log W = Log a+ Log bL [23].

The strength of width-weight relationship is calculated by the determination coefficient ($r^2$) and the slope value (b=3) is tested by Student's t-test to determine the level of significance.

**Moulting pattern**

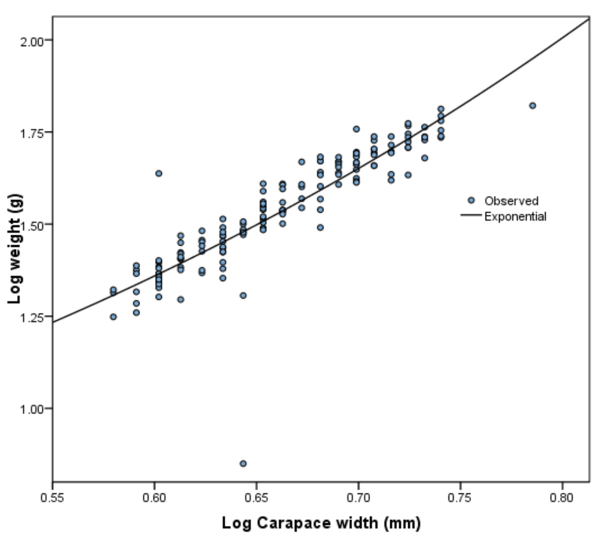
In order to study the moulting pattern, 60 juvenile crabs within the size range 0.3-1 cm CW were maintained in cement tanks under laboratory conditions for a period of one year. The specimens were acclimated to the conditions of the laboratory for one week. During the course of the experiment, juveniles were fed ad libitum with boiled egg, green algae and artificial pelletized food while crabs above 1 cm CW were fed with fresh beef liver and clam meat. Plastic tubs were regularly cleaned to remove uneaten food and faecal matter. Crabs were daily examined, recording the following events: date of moulting and size after moulting (CW and weight). The presence of exuviae or a crab with a soft shell was used to determine a moulting event. The differences in CW before and after moult were processed to determine growth at moult and absolute size increment in both the sexes. Intermoult period estimates were derived from the number of days between moulting events.

Adult crabs (4.0-6.0 cm CW) were collected monthly (n=30 each) from June 2013 to May 2014and the percentages of premoult, postmoult and intermoult individuals were recorded separately for males and females. They were released unharmed to the same field from where they were collected. The monthly percentages of moult stages were represented by a bar diagram.

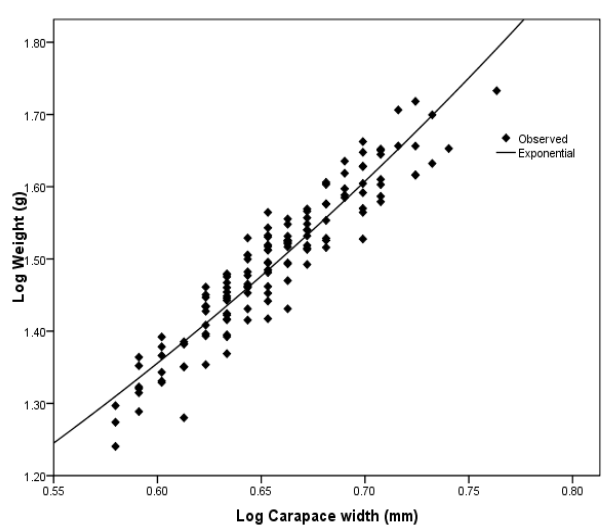
**Results**

**Growth pattern**

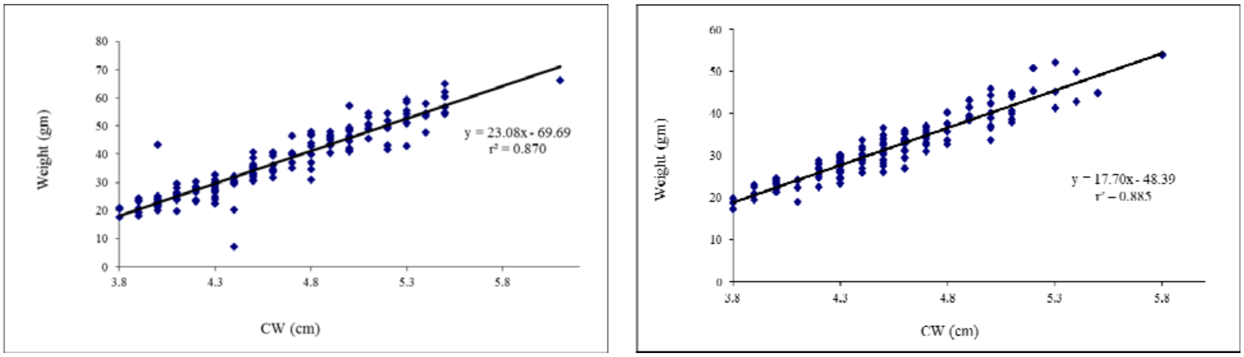
Our observations revealed that males were found larger and heavier than females (CW 4.6±0.49 and 4.5±0.39 cm and weight 36.56±12.16 and 32.09±7.50 g respectively for males and females) (t=2.00 and 3.88 respectively, $p < 0.05$). The exponential values (b) for the CW-weight relationships in males and females (1.945 and 1.704 respectively) showed a marked deviation from the isometric growth pattern. Males had larger b values than females and growth showed a negative allometric pattern for both the sexes. Student's t- test confirmed that the 'b' values significantly differed from 3(t=20.54 and 31.94 for males and females, respectively). Morphometric relationships between CW-weight and CW-CL demonstrated highly significant results ($r^2$= 0.870 and 0.904 for males and 0.885 and 0.906 for females, respectively) (Figs. 1A-D and 2A-B).




A

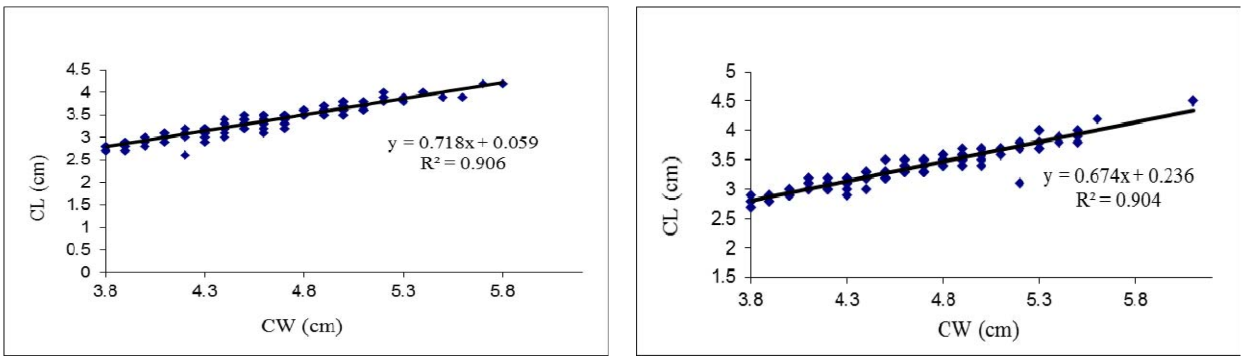



B




C D

**Fig 1:** Carapace width-weight relationships in *Travancoriana schirnerae.* (A) & (C) Male, (B) &(D) Female.



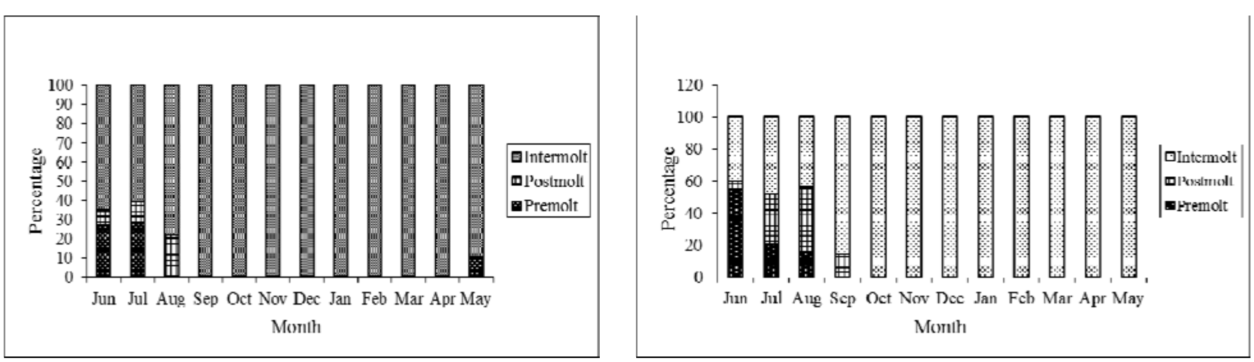

A) B)

**Fig 2:** Relationship between carapace width and length in *Travancoriana schirnerae.* (A) Male, (B) Female.

**Moulting pattern**

*Travancoriana schirnerae* successfully completed 14 moult cycles when maintained under laboratory conditions for one year. The duration of intermoult periods varied from cycle to cycle and ranged from 3 to 60 days for males and 3 to 90 days for females. Moult increments in CW and weight were markedly larger in males than females. Juvenile males grew from an initial average CW of 0.3 to 4.0 cm from first instar to 14$^{th}$ instar, in a mean period of 324 days. The average total weight gained was 35.180 g from an initial weight of 30 mg. Female crabs grew from an initial average CW of 0.3 to 3.8 cm and reached the 14$^{th}$ instar in a mean of 367 days. The average weight gained during this period was from 30 mg to 29.810g. In both the sexes, the highest percent growth per moult (CW) occurred from 2$^{nd}$ to 3$^{rd}$ and 3$^{rd}$ to 4$^{th}$ instars (50 and 40% each for males and females, respectively) while the lowest percent occurred from 13$^{th}$ to 14$^{th}$ instar (12.9% for males and 8% for females). Though the weight increment steadily increased after each moult in both the sexes, the increment was smaller in females compared to males. The maximum weight gain was recorded during 9$^{th}$ to 10$^{th}$moult in males (68%) while that in females from 11$^{th}$ to 12$^{th}$ moult (37%). The intermoult intervals also differed between the sexes, tend to be longer for females than males. After reaching 2 cm CW (9$^{th}$ instar), females took 264 days to reach the 14$^{th}$ instar while males attained the same stage in 221 days.

Adult crabs exhibited annual moulting pattern and June-August is the moulting season. In males, the premoult stage extended from May-July while in females this stage extended from June to August, with the highest percentage of premoult individuals recorded in June. There was a gradual decline in the percentage of premoult females from July to August. In males, the postmoult period ended in August while in females this stage lengthened upto September (Fig. 3A-B).




A) B)

**Fig 3:** Bar graph showing the pattern of moulting in adult *Travancoriana schirnerae* population. (A) Male, (B) Female.

## Discussion

In *T. schirnerae*, the exponential values (b) for CW-weight relationship in males and females showed a marked departure from the isometric pattern of growth and followed negative allometry. These observations were supported by the findings of Patil and Patil [22] in *Barytelphusa guerini*. Among marine brachyurans, a negative allometry in the weight vs. CW relationship was observed in *Liocarcinus depurator* [24] and *C. sapidus* [25] while *C. ornatus* [26] presented positive allometry. In *P. pelagicus*, males followed isometric growth pattern while females exhibited significant deviation from isometry [5]. The exponential values for the width-weight relationship in juveniles, adult males and females indicated an isometric growth pattern in *P. sanguinolentus* [10]. Growth was allometrically positive in the early ontogenesis and isometric after the pubertal moult in *Uca leptodactylus* [27]. The relationship between CL and body weight indicated negative allometric growth in the shrimp *Plesionika izumiae* [28]. The relationship between CW/CL and weight is an indication of the condition factor and is of practical value in estimating the biomass and in calculating the recovery of edible meat from crabs of various sizes [23].

In the present investigation, the CW-weight relationship indicated that males are found heavier than females of the same size. This is in accordance with the observations of Potter *et al*. [29] in *P. pelagicus*, Thomas [30] in *P. sanguinolentus* and Prasad *et al*. [31] in *Scylla serrata*. By contrast, Dhawan *et al*. [32] found that females of *P. pelagicus* are heavier than males in Goan waters. In *T. petropolitanus*, there was no significant difference in size between males and females [21].

The maximum size reached by *T. schirnerae* is smaller in females than males which may be explained by the differences in growth increments and intermoult periods. Likewise, in the estuarine crab, *C. granulatus*, the maximum size attained by females is smaller than males [33]. In portunidae, the annual growth in females is less than that of males, due to lesser moult increments and lower moulting frequencies which may be explained to the utilization of nutrients for multiple spawning and body growth [16]. Mackay and Weymouth [34], Butler [35] and Bennett [36] have proposed similar conclusions in *C. magister* and *C. pagurus*. Adiyodi [37] also reported that the possible mechanism limiting female size could be lengthening of the moult interval compared with males, caused by the onset of reproductive activity which is restricted to the intermoult period in Anomura and Brachyura.

In *T. schirnerae*, juvenile crabs reared in the laboratory have growth patterns that are similar to other brachyuran crabs, exhibiting a decline in moult increment and an increase in intermoult period with age. Similar observations were made in *C. granulatus* by Luppi *et al.* [33] wherein the moult increment decreased gradually with size. However, in *E. japonicus*, during the younger phase, the percentage of moult increment decreased and during the older phase showed marked fluctuation [12]. Longer term laboratory studies in *Chionoecetes opilio* indicated that small males have smaller moult increments [38]. Generally, in most decapods the increment at moult declines with size [1], but some exceptions do exist, e.g. *Carcinus maenas* [39]. *C. mediterraneus* [40], *Maja squinado* [41] and *Pisa tetraodon* [42] with terminal anecdyses.

In the current study, the intermoult intervals differed between the sexes; tend to be longer for females than males. After the 9th instar, females took 264 days to reach the 14th instar while males attained the same stage in 221 days. In *P. pelagicus*, males took an average of 272 days only to reach the 16th instar stage from the first, but females reached the same stage after 332 days. Bennet [36], Mc Caughran and Powell [43] and Melville-Smith [44] also reported similar findings in *C. pagurus*, *Paralithodes camtschatica* and *Geryon maritae*.

When compared to marine crabs, there are several reasons for the smaller moult increments in terrestrial/semiterrestrial crabs. One possibility is the constraint in the supply of water to produce the quick postmoult increase in size. Crabs that moult out of contact with the water must depend upon water stored in the pericardial sacs and in the hemolymph generally, which may limit the size increase. Another factor is the constraints of the terrestrial environment such as the risk of dessication which may facilitate smaller moult increments [45].

Though moulting is a response to the regulation of the endocrine system [46, 47], there are external factors that may have an effect on its seasonality. In keeping with this, the moulting season in adult *T. schirnerae*, programmed during June-August, is coincided with the rainy season (June-September). In land/freshwater crabs, the seasonal availability of water is more significant than temperature and moulting may be restricted to the rainy season [48]. In the Calicut population of the freshwater crab *Paratelphusa hydrodromous*, June-July is the moulting season which corresponded to the onset of southwest monsoon [37]. In *Madagapotamon humberti*, moulting is restricted to the wet season [49]. By contrast, crabs whose burrows reach the water table are not under water constraints, thus *Cardisoma guanhumi* moults throughout the year [50].

In the present study, monthly evaluation of the percentage of specimens in the three moult stages revealed that males and females have similar moult cycles. A higher incidence of intermoult males occurred in the moulting season seems to indicate that males were slightly more advanced in their moulting cycles. Besides, the moulting season in *T. schirnerae* is coincided with the mating season. In many brachyurans, earlier moulting of the males is linked to the fact that, mating requires the males to be in the hard intermoult stage and females in the soft postmoult stage. In portunid crabs, mating generally occurred between hard males and soft females [51]. On the contrary, in spider crabs, mating may take place when both the sexes are in the intermoult stage [52]. The slightly earlier moulting of male individuals could be related to the difference in the energy balance between the sexes, linked to the start of reproductive period [53].

## Conclusion

The current study revealed that juvenile crabs of *T. schirnerae* have growth patterns similar to other brachyuran crabs exhibiting a decline in moult increment and an increase in intermoult period with age. Males grew more rapidly than females as evidenced from the markedly larger moult increments in CW and weight. The intermoult intervals differed between the sexes; tend to be longer for females, related to their higher energetic outlay for reproduction.

## Acknowledgements

The authors kindly acknowledge the financial support received from Kerala State Council for Science, Technology and Environment.

## References

1. Hartnoll RG. Growth. In: Biology of the Crustacea (ed. by LG. Abele), Academic Press, New York, 1982, 111-

196.
2. Hartnoll RG. Growth, sexual maturity and reproductive output. In: Factors in adult growth (ed. by AM. Wenner), Balkema Press, Rotterdam, Netherlands, 1985, 101-128.
3. Spivak E. Moult and growth in *Cyrtograptus angulatus* Dana (Decapoda, Brachyura). J Nat His. 1988; 22:617-629.
4. Oliva NJ, Arana Espina P, González Ynope A. Crecimiento y mortalidad del cangrejo violáceo *Platyxanthus orbignyi* en la zona costera de Lambayeque, Perú. Inf Inst Mar Perú 1997; 126:55-74.
5. Josileen J. Morphometrics and length-weight relationship in the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura) from the Mandapam coast, India. Crustaceana 2011; 84(14):1665-1681.
6. Flores AAV, Negreiros-Fransozo ML. On the population biology of the mottled shore crab *Pachygrapsus transversus* (Gibbes, 1850) (Brachyura, Grapsidae) in a subtropical area. Bull Mar Sci 1998; 65(1):59-73.
7. Branco JO, Lunardon-Branco MF, Souto FX. Estrutura populacional de *Portunus spinimanus* Latreille (Crustacea, Portunidae) na Armação do Itapocoroy, Penha, Santa Catarina, Brasil. Rev Bras Zool 2002; 19(3):733-738.
8. Araújo MSLC, Lira JJPR. Condition factor and carapace width versus wet weight relationship in the swimming crab *Callinectes danae* Smith 1869 (Decapoda: Portunidae) at the Santa Cruz Channel, Pernambuco State, Brazil. Nauplius 2012; 20(1):41-50.
9. Gokce G, Erguden D, Sangun L, Cekic M, Alagoz S. Width/length and relationships of the blue crab (*Callinectes sapidus* Rathbun, 1986) population living in Camlik Lagoon Lake (Yumurtalik). Pak J Biol Sci 2006; 9(8):1460-1464.
10. Sukumaran KK, Neelakantan B. Length-weight relationship in two marine portunid crabs, *Portunus* (*Portunus*) *sanguinolentus* (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus) from the Karnataka coast. Indian J Mar Sci. 1997; 26:39-42.
11. Kobayashi S. Growth Patterns of the Japanese mitten crab *Eriocheir japonica* (De Haan) in its river phase in Fukuoka prefecture, Japan. J Crust Biol. 2011; 31(4):653-659.
12. Kobayashi S. Moulting growth patterns of the Japanese mitten crab *Eriocheir japonica* (De Haan) under laboratory-reared conditions. J Crust Biol. 2012; 32(5):753-761.
13. Fumis PB, Fransozo A, Bertini G, Braga AA. Morphometry of the crab *Hexapanopeus schmitti* (Decapoda: Xanthoidea) on the northern coast of the state of São Paulo, Brazil. Rev Biol Trop 2007; 55:163-170.
14. Miyasaka H, Genkai-Kato M, Omori YGK. Length-weight relationships of two varunid crab species, *Helice tridens* and *Chasmagnathus convexus*, in Japan. Limnology, 2007. DOI 10.1007/s10201-006-0195-8.
15. Tagatz ME. Growth of juvenile blue crabs, *Callinectes sapidus* Rathbun, in the St. Johns river, Florida. Fish Bull 1968; 67:281-288.
16. Josileen J, Menon NG. Growth of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura) in captivity. Crustaceana 2005; 78(1):1-18.
17. Brylawski BJ, Miller TJ. Temperature-dependent growth of the blue crab (*Callinectes sapidus*): a moult process approach. Can J Fish Aquat Sci 2006; 63:1298-1308.
18. Haefner PA, Engel WA. Aspects of moulting, growth and survival of male rock crabs, *Cancer irroratus*, in Chesapeake Bay. Chesapeake Sci 1975; 16:253-265.
19. Oresanz JM, Gallucci VF. Comparative study of post larval life history schedules in four species of *Cancer* (Decapoda: Brachyura: Cancridae). J Crust Biol. 1988; 8:187-220.
20. Micheli F, Gherardi F, Vannini M. Growth and reproduction in the freshwater crab, *Potamon fluviatile* (Decapoda, Brachyura). Freshwater Biol 1990; 23:491-503.
21. Venâncio FA, Leme MHA. The freshwater crab *Trichodactylus petropolitanus* (Goeldi, 1886) (Decapoda, Trichodactylidae) associated with roots of *Hedychium coronarium* Koenig (Zingiberacea). Pan-Am J Aquat Sci. 2010; 5(4):501-506.
22. Patil KM, Patil MU. Length-weight relationship and condition factor of freshwater crab *Barytelphusa guerini*, (Decapoda, Brachyura). J Exp Sci. 2012; 3(5):13-15.
23. Lagler KF. Capture, sampling and examination of fishes. In: Methods for assessment of fish production in freshwaters. (ed. by WE. Ricker), IBP, Handbook 1968; III:7-35.
24. Mori N, Zunino P. Aspects of the biology of *Liocarcinus depurator* (L.) in the Ligurian Sea. Invest Pesquera 1987; 51:135-145.
25. Atar HHS, Seçer S. Width/length-weight relationships of the blue crab (*Callinectes sapidus* Rathbun, 1896) population living in Beymelek Lagoon Lake. Turk J Vet Anim Sci. 2003; 27:443-447.
26. Branco JO, Fracasso HAA. Biologia populacional de *Callinectes ornatus* (Ordway) na Armação do Itapocoroy, Penha, Santa Catarina, Brasil. Rev Bras Zool 2004; 21(1):91-96.
27. Masunari S, Swiech-Ayoub BP. Crescimento relativo em *Uca leptodactyla* Rathbun (Crustacea, Decapoda, Ocypodidae). Rev Bras Zool 2003; 20(3):487-491.
28. Ahamed F, Ohtomi J. Growth patterns and longevity of the pandalid shrimp *Plesionika Izumiae* (Decapoda: Caridea). J Crust Biol. 2012; 32:733-740.
29. Potter IC, Chrystal PJ, Loneragan NR. The biology of the blue manna crab *Portunus pelagicus* in an Australian estuary. Mar Biol Berlin 1983; 78:75-85.
30. Thomas M. Studies on portunid crabs (Crustacea: Decapoda: Brachyura). Ph.D. Thesis, Department of Marine Sciences, University of Cochin, Cochin, 1984, 1-155.
31. Prasad PN, Reeby J, Kusuma N, Neelakantan B. Width-weight and length weight relationship in three portunid crab species. Uttar Pradesh J Zool. 1989; 9(1):116-120.
32. Dhawan RM, Dwivedi SN, Rajamanickam GV. Ecology of the blue crab *Portunus pelagicus* (Linnaeus) and its potential fishery in Zuari estuary. Indian J Fish. 1976; 23(1-2):57-64.
33. Luppi TA, Spivak ED, Bas CC, Anger K. Molt and growth of an estuarine crab, *Chasmagnathus granulatus* (Brachyura: Varunidae), in Mar Chiquita coastal lagoon, Argentina. J Appl Ichthyol. 2004; 20:333-344.
34. Mackay DCG, Weymouth FW. The growth of the Pacific edible crab, *Cancer magister* Dana. J Biol Bd Canada. 1935; 1:191-212.
35. Butler TH. Growth and age determination of the Pacific

edible crab *Cancer magister* Dana, 1852. J Fish Res Bd Canada. 1961; 8:873-891.
36. Bennett DB. Growth of the edible crab *Cancer pagurus* Linnaeus, 1758, off south-west England. J Mar Biol Assoc UK. 1974; 54:803-823.
37. Adiyodi RG. Reproduction and its control. In: The biology of Crustacea (ed. by G. Abele), Vol 8, Academic Press, New York, 1985, 147-215.
38. Hoenig JM, Dawe EG, O'Keefe PG. Moult indicators and growth per moult for male snow crabs (*Chionoecetes opilio*). J Crust Biol. 1994; 14(2):273-279.
39. Crothers JH. The biology of the shore crab *Carcinus maenas.* Field Studies1967; 2:407-434.
40. Veillet A. Recherches sur Ic parasiiisme des crabes et des gasathecs par les rhizocephales el des epicarides. Ann 'Institut Oceanograph 1945; 22:193-341.
41. Carlisle DB. On the hormonal inhibition of moulting in decapod Crustacea. *2.* The terminal anecdysis in crabs. J Mar Biol Assoc UK. 1957; 36:291-307.
42. Vernet-Cornubert G. Biologie generalede Pisa *tetraodon.* Bull I'lttstitut Oceanograph 1958; 1113:1-52.
43. Mc Caughran DA, Powell GC. Growth model for Alaska king crab *Paralithodes camtschatica* (Tilesius, 1815). J Fish Res Bd Canada. 1977; 34:989-995.
44. Melville-Smith RA. Growth model for the deep sea red crab (*Geryon maritae* (Manning & Holthuis, 1981)) off South-West Africa/Namibia (Decapoda, Brachyura). Crustaceana 1989; 56:279-292.
45. Hartnoll RG. Growth and moulting. In: Biology of the land crabs (ed. by WW. Burggren and BR. McMahon), Cambridge University Press, New York, 1988, 186-210.
46. Skinner DM. Moulting and regulation. In:The Biology of Crustacea. (ed. by DE. Bliss and LH. Mantele), Academic Press, New York 1985; 9:43-146.
47. Chang ES. Endocrine regulation of moulting in Crustacea. Rev Aquat Sci 1989; 1:131-157.
48. Alexander HGL. An ecological study of the terrestrial decapod Crustacea of Aldabra. PhD Thesis, University of London, 1976.
49. Vuillemin S. Observations e´cologiques et biologiques sur *Madagapotamon humberti* Bott, 1965 (Crustace´, De´capode, Potamonide´) du massif de l'Ankarana (Madagascar), Ann l'Univ´ Madagascar 1970; 7:245-266.
50. Henning HG. Kampf Fortpflanzungs und hautungsverhalten –Wachstum und Geschle chtsreife von *Cardisoma guanhumi* Latreille (Crustacea, Brachyura). Forma Funct 1975; 8:463-510.
51. Sukumaran KK, Neelakantan B. Spawning biology of two portunid crabs, *Portunus sanguinolentus* (Herbst) and *Portunus pelagicus* (Linnaeus) from the Karnataka coast. The Fourth Indian Fisheries Forum Proceedings, November Kochi, 1996, 24-28, 35-38.
52. Sampedro MP, González-Gurriarán E, Freire J. Moult cycle and growth of *Maja squinado* (Decapoda: Majidae) in coastal habitats of Galicia, Northwest Spain. J Mar Biol Assoc UK. 2003; 83:995-1005.
53. González-Gurriarán E, Freire J. Movement patterns and habitat utilization in the spider crab *Majasquinado* (Herbst) (Decapoda, Majidae) measured by ultrasonic telemetry. J Exp Mar Biol Ecol. 1994; 184:269-291.