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 *Hexapanaopeus 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 5 km 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. Moulting 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=aLb, 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 by linear 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 (r2) 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 moulting were processed to determine growth at moulting 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 2014 and 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 moulting 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) (Figs. 1A-D and 2A-B).
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 14th 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 14th instar in a mean of 367 days. The average weight gained during this period was from 30 mg to 29.810 g. In both the sexes, the highest percent growth per moult (CW) occurred from 2nd to 3rd and 3rd to 4th instars (50 and 40% each for males and females, respectively) while the lowest percent occurred from 13th to 14th 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 9th to 10th moult in males (68%) while that in females from 11th to 12th moult (37%). The intermoult intervals also differed between the sexes, tend to be longer for females than males. After reaching 2 cm CW (9th instar), females took 264 days to reach the 14th instar while males attained the same stage in 221 days. Adult crabs exhibited annual moult pattern and June-August is the moult 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 up to September (Fig. 3A-B).
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 [9]. The exponential values for the weight-width 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 allometric growth in *T. schirnerae*, the maximum size attained by *C. granulatus* and *T. schirnerae* is smaller in *P. pelagicus* than males in Goan waters. In *T. schirnerae* and *Cardisoma guanhumi* females were heavier than males in *G. japonicus* and *T. schirnerae* [21].

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. petropolitanaus*, there was no significant difference in size between males and females [23].

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 [34]. 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 in *E. japonicus*, during the younger phase, the percentage of moult increase 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 *Pisida tetraodon* [42] with terminal anocyes. 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 camtschaticus* and *Geryon maritae*.

In *P. pelagicus*, females took an average of 272 days 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 camtschaticus* 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 mouling 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 mouling season which corresponded to the onset of southwest monsoon [37]. In *Mudagapotamon umburti*, 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* moult 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 mouling season seems to indicate that males were slightly more advanced in their mouling cycles. Besides, the mouling 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 have similar moult cycles. A higher incidence of intermoult males occurred in the mouling season seems to indicate that males were slightly more advanced in their mouling cycles. Besides, the mouling 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 have similar moult cycles. Moreover, in the two-spotted spider crab *P. sanguinolentus*, 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 camtschaticus* 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 mouling 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 mouling season which corresponded to the onset of southwest monsoon [37]. In *Mudagapotamon umburti*, 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* moult 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 mouling season seems to indicate that males were slightly more advanced in their mouling cycles. Besides, the mouling 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 have similar moult cycles. A higher incidence of intermoult males occurred in the mouling season seems to indicate that males were slightly more advanced in their mouling cycles. Besides, the mouling 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 have similar moult cycles.

**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**


