Morphometric relationships of blue swimming crab (*Portunus pelagicus*, Linnaeus, 1758) caught in Negombo coastal waters in Sri Lanka.

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Received: 05.01.2024 Revised: 25.03.2024 Accepted: 08.04.2024 Online: 15.05.2024

Abstract Length-weight relationships provide information about the blue swimming crab (*Portunus pelagicus*) population for successful stock management. Morphometric measurements of Two hundred fifty (250) crab samples were obtained from April to November 2019, of which 128 were males, and 122 were females, showing a sex ratio of 1:1. Chi-square test indicated that the sex ratio was not significantly different from the expected value of 1:1 at 5% level of significance (χ^2_{cal} = 0.144, χ^2_{tab} = 3.84). Carapace width (CW) was measured at the nearest 0.001 cm using a vernier calliper, and total body weight (W) was measured at the nearest gram (g) using a digital scale. The carapace width of males ranged from 7.28 - 15.7 cm, whereas it varied from 3.06 - 15.8 cm in females. The body weight of male crabs varied from 22.45 - 334.6 g, and females had a range from 23.0 - 275.35 g. Length-weight relationships for male and female crabs were $W=0.0495CW^{3.0469}$ (R^2=0.8526) and $W=0.063CW^{2.9428}$ ($R^2=^{0.8179}$) respectively. Student's t-test showed that the growth of male crabs was positive allometric (t = 5.64, $p<0.05$) and negative allometric (t = -8.21, $p<0.05$) for females. The mean condition factors for males and females were 5.68±0.12 and 5.65±0.12, respectively, indicating no significant difference between males and females ($p=0.882$) by two-sample t-tests. Providing baseline data, the present study recommends further studies for successful utilization, development and management of this crab species as it has been recognized as a commercially valuable species with a high market demand.

Keywords: Blue swimming crab, Condition factor, Growth, Length-weight relationship, Sex ratio

Introduction

Blue swimming crab (*Portunus pelagicus*, Linnaeus, 1758) is an aquatic crustacean belonging to order Decapoda and family Portunidae and inhabits both coastal and estuarine waters throughout the Indo-West Pacific region (Prince et al., 2020). In respect to the global fishery status, blue swimming crab fishery has a valuable contribution to the economy of the country both from a local view and an export view owing to the strong market demand for crab meat and the wide distribution of the species (Fujaya et al., 2015; Hidyani et al., 2018). It is proved by the mentioning of the commercial crab fishery in Indonesia (Zairion et al., 2015; Hamid et al., 2016; Jayawiguna et al., 2017), Australia (Potter & Lestlang, 2000), Philippines, Vietnam, Cambodia, Malaysia, Thailand (Hisam et al., 2018), India and Sri Lanka (Haputhanthri et al., 2016). After the 30-year civil conflict ended, the blue swimming crab fishery became the second most important crab fishery in Sri Lanka in 2011. This crab fishery contributed to earning USD 6 million in export value in 2015 (Prince et al., 2020) because of the lifting of fishing restrictions, the establishment of seafood companies and increased demand for the Sri Lankan blue swimming crab products from international markets such as Singapore, United States, United Kingdom and Korea, these countries being important leading export destinations of the Sri Lankan blue swimming crab products in the world (Creech, 2013). Monterey Bay Aquarium Seafood Watch (2023) reported that this crab fishery contributed to earning USD 27.65 million of export value in 2021.

Despite the economic importance of the species, obtaining morphometric data about the species is the key step for understanding the

current situation of the species and ecological conditions of the inhabiting area paving the path to responsible involvement in the fisheries sector.

Hence, length-weight relationships of a population provide information on aquatic biology, physiology, ecology, and stock assessment in fisheries (Rohmayani et al., 2002). This information is also useful in obtaining biomass, condition indices and for comparing the growth of animals and their growth patterns during the development in population dynamics (Khot & Jaiswar, 2018). Variations of length weight relationships and condition factors can describe the physiology of the organism and ecology in the inhabited area because those are dependent on physical and chemical parameters, nutritional condition in the water body and environmental factors in that area (Afzaal et al., 2018). Therefore, this gives an idea on general well-being of individuals in a particular area (Josileen, 2011). Studies on length weight relationship, condition factor and sex ratio are useful for successful fisheries management and harvesting strategies (Songrak & Nuchoo, 2018).

In respect of world studies on length weight relationship analysis of this crab species, Sukumaran & Neelakanthan (1997) Karnataka coast, India, Abdurahiman et al. (2004) in southern coast of Karnataka, India, Razek et al., (2006) in Bardawil Lagoon, northern Sinai, Egypt, Ehsan et al., (2010) in Bandar Abbas coastal waters, northern Persian gulf, Josileen (2011) in Mandapam coast, India, Afzaal et al., (2018) in Pakistani waters, northern Arabian Sea and Tirtadanu (2019) in Kwandang waters, Indonesia have carried out morphometric relationship related studies. With respect to the Sri Lankan status, although Soyza et al., (2018) have carried out a morphometric related study in Batticaloa and Trincomalee and Haputhanthri et al., (2021) have carried out a study in Palk Bay, Sri Lanka, morphometric analysis of this species in Sri Lanka is scarce and there seems to be no evidence available about the studies on morphometric relationships of this species in Negombo coastal waters. Monterey bay aquarium seafood watch (2023) indicated that being the core area is Jaffna, the major areas of the Sri Lankan blue swimming crab fishery regarding the effort, production, purchasing, processing and export are Puttlam, Mannar, Kilinochchi and Jaffna. Sri Lankan blue swimming crab fishery diffuses from Negombo on the southwest coast of Sri Lanka to unidentified location off the coast of Trincomalle district (possibly Pulmudai) on the northeast coast (Creech, 2013). This study was carried out to build a length weight relationship for blue swimming crab inhabiting the Negombo coastal waters of Sri Lanka. Further, it would be useful for conservation purposes by providing baseline data as the presence of the remarkable and significant demand for the blue swimming crab product from many international markets. Therefore, the present study will be important to prepare suitable fisheries assessments on the blue swimming crab stock, make regulatory management actions for sustainable utilization and for the development of the blue swimming crab fishery in Negombo coastal waters of Sri Lanka.

When paying attention to the blue swimming crab fishery in Negombo area, it is an artisanal fishery carried out by the local community using the major fishing gear 'bottom set gillnets' with different mesh sizes range from 3.8 cm to 17 cm. Theppam was the non-motorized, traditional fishing craft, while outboard fibre-reinforced plastic boats with engine horsepower of 9, 15, 25, 30 and 40 were motorized, non-traditional fishing crafts engaged in catching blue swimming crabs in Negombo waters. Being blue swimming crab target species, 35 by-catch species, including bony fishes, cartilaginous fishes and crustaceans, were identified. Fishing distance from the shore ranged from 1 km to 10 km (Perera & Wickramage 2020).

Therefore, considering fishery of this species, this study was carried out to build a length weight relationship for blue swimming crab inhabiting the Negombo coastal waters of Sri Lanka. The present study will be important to prepare suitable fisheries assessments on the blue swimming crab stock, make regulatory management actions for sustainable utilization and for the development of the blue swimming crab fishery in Negombo coastal waters of Sri Lanka. Further, it would be useful for conservation purposes providing baseline data as the presence of the remarkable and significant demand for the blue swimming crab product from many international markets and the rapid growth of this fishery after the end of the 30 year civil conflict accompanied with the demand and development of the country including the

fisheries sector is able to impact on the sustainability of the fishery unless the fishery is not managed properly.

Materials and Methods

Two hundred and fifty (250) crab samples were collected monthly from freshly caught, early morning commercial catches operated in the Negombo commercial fish landing centre ($7^0$12′37.22N $79^0$49′51.39′E) from April to November in 2019. Crabs were packed in ice and transported to the laboratory of the Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka. Crabs were sorted into males and females and after thawing, the weight was recorded to the nearest 0.01g using an electronic balance. Carapace width of each individual crab was measured using a vernier calliper to the nearest 0.001 cm (Figure 1). It was hypothesized that there (3) was no significant difference in the sex ratio between males and females of the crab and it was statistically tested using the Chi Square test. Growth pattern was determined based on the results of Student's t test when the b value of the length-weight relationship equation (growth coefficient) was compared with three (3). Mean condition factor of males and females of the crab was statistically tested using two sample t test.

Figure 1. Measuring the carapace width of blue swimming crab using a vernier calliper. Length-weight relationship was estimated using the equation $W=a\ CW^b$ as described by Rahman et al. 2019).

$W = aCW^b$

(1)

Where,

W = Weight,

CW = Carapace Width and

a and b = constants and b is the growth coefficient.

The condition factor was calculated using the Fulton method (Hajjej et al., 2016),

$K = 100W/(CW)^3$

(2)

Where,

K = Condition factor

W = Weight

CW = Carapace Width

Results and Discussion

Out of two hundred fifty crabs (250), males were one hundred twenty eight (128) and females were one hundred twenty two (122) giving the sex ratio of 1:1 between males and females of the crab. Chi square test resulted that there was no significant difference of sex ratio from the expected value of 1:1 between males and females at 5% level of

significance (p = 0.704). Carapace width of males ranged from 7.28 cm to 15.7 cm whereas it varied between 3.06 cm and 15.8 cm in females. Therefore, the carapace width ranged from 3.06 cm to 15.8 cm showing that the highest frequency, 23.2% of crabs recorded 10.5 cm as average length of carapace width (Figure 2). Palk Bay, Sri Lanka, reported that carapace width of male crabs ranged from 7 cm – 18.5 cm when female crabs had a range of 6.7 cm – 18.5 cm (Haputhanthri et al., 2021). This showed that fishermen in Negombo coastal waters have exploited smaller sized female crabs than that of Palk Bay and both males and females of the crab that have been caught by fishermen in Negombo waters were smaller than that of blue swimming crabs inhabiting the Palk Bay.

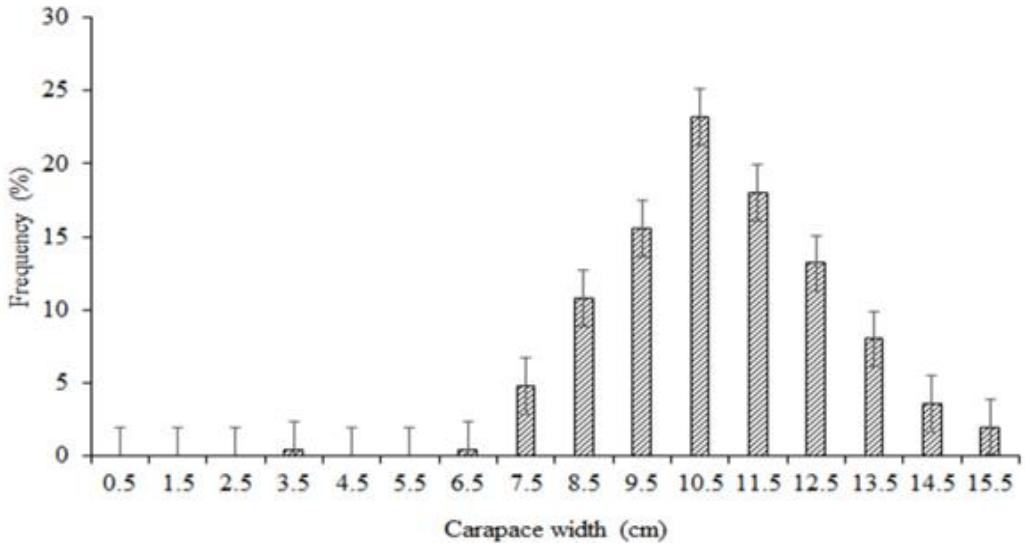

Figure 2. Carapace width-frequency distribution of blue swimming crab.

Body weight of male crabs varied from 22.45 g to 334.6 g and females had a range from 23.0 g to 275.35 g. Length-weight relationships for male and female crabs were $W=0.0495CW^{3.0469}$ ($R^2=0.8526$) and $W=0.063CW^{2.9428}$ ($R^2=0.8179$) respectively (Figure 3 and Figure 4) showing the negative allometric growth of females ($t = -8.21$, $p<0.05$) and positive allometric growth of males ($t = 5.64$, $p<0.05$) based on the results of student's t test when the b value was compared with three (3). Mean condition factor for males was 5.68±0.12 while females had the mean condition factor of 5.65±0.12 and there was no significant difference of mean condition factor between males and females of the crab ($p=0.882$) according to the two sample t test. Condition factor for males ranged from 2.29 to 12.9 while that of females it ranged from 3.31 to 12.16.

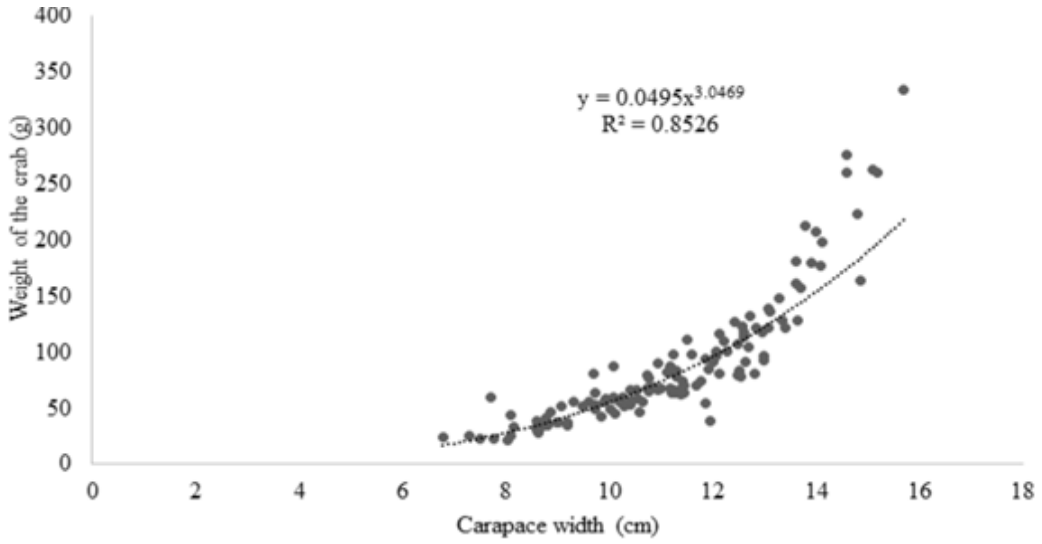

Figure 3. Carapace width - weight relationship of male blue swimming crab ($t = 5.64$, $p<0.05$).

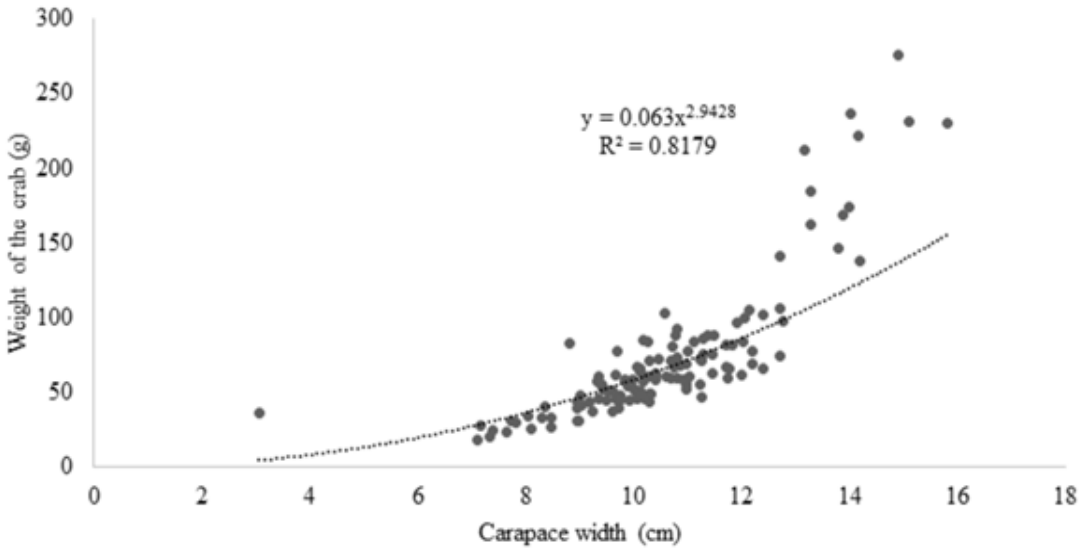

Figure 4. Carapace width - weight relationship of female blue swimming crab ($t = -8.21$, $p<0.05$).

The growth coefficient 'b' value of three (3) shows the isometric growth, while a 'b' value greater than three indicates positive allometric growth and a 'b' value less than three for negative allometric growth. According to the results of length-weight relationships of male and female crabs, the growth coefficient of males was greater than three, indicating males had positive allometric growth, and it was less than three in females, showing growth as negative allometric growth. Since the b value of males is greater than that of females, males are heavier than females at the same size of carapace width. It has been shown that males of blue swimming crabs can spend more energy in growth to protect the female crabs and compete for them. Regression coefficients resulting from the length-weight relationship of both males and females of the crab were greater than 0.8, indicating that there was a very high correlation among compared characters of body weight and carapace width (Rohmayani et al., 2002). Haputhanthri et al., (2021) reported that the length weight relationship for male blue swimming crab was $BW=0.0001CW^{3.01}$ ($R^2=0.84$) and for females was $BW=0.0001CW^{2.9}$ ($R^2=0.86$) and 'b' values of length weight relationship of both males and

females of the crab was significantly differed indicating that males had a positive allometric growth whereas females had a negative allometric growth. Therefore, in agreement with that study, the present study also showed the same growth patterns for males and females. The variations of the growth coefficient depend on internal and external factors such as sexual dimorphism, maturity, food supply and physical parameters of water such as salinity and temperature. The condition factor is an index of growth dependent on feeding intensity, habitat, and other environmental parameters such as temperature and salinity. It describes the suitability and quality of the habitat for the growth of the animal (Khot & Jaiswar, 2018). Furthermore, dimorphism in metabolic rates, stage of maturity, and nutritional requirements may have an effect on the differences in the condition factor between sexes (Rohmayani et al., 2002). The mean condition factor for males was 5.68±0.12 while females had a mean condition factor of 5.65±0.12. Recorded sex ratio was 1 : 1 indicating sex ratio was not significantly different from the expected value of 1:1 at 5% level of significance (χ^2_{cal} = 0.144, χ^2_{tab} = 3.84) by the Chi square test and it is an indicator of population's ability to sustain the ongoing recruitment (Ehsan et al., 2010) and because of effect by breeding season, migration and habitat preferences, differences in sex ratio can be identified (Rahman et al., 2019). However, the differences in condition factor in terms of sex are dependent upon dimorphism in metabolic rates, nutritional aspects, stage of maturity and time of recruitment (Hajjej et al., 2016).

Conclusion

Upon tested blue swimming crab samples, sex ratio of 1 : 1 was observed showing that there was balanced sex ratio and there (3) was no significant difference in number of male crabs and female crabs. Male *Portunus pelagicus* in Negombo coastal waters had positive allometric growth when female crabs had negative allometric growth. Furthermore, males are heavier than females of the crab because males had greater growth coefficient than that of females at the same carapace width. Since there was no sexual difference in mean condition factor, it is able to conclude that there is no difference in effect of factors affecting the condition factor and suitability and quality of the habitat affected similarly on both sexes. Regarding these facts, further detailed studies are needed to force successful assessments and fisheries management strategies for a sustainable utilization of this species in Negombo area.

Acknowledgement

Authors are highly acknowledged the facilities provided by the University of Kelaniya and fishermen who gave necessary information.

Conflicts of interest

The authors declare that they have no conflict of interest.

Author Contribution

S. W. Wickramage gave the contribution for the data gathering, application of statistical analysis, investigation process, finding a methodology, and coordination responsibility for writing the original research paper.

H. A. C. C. Perera involved in the process of finding the research concept, research planning, editing and funding acquisition for the research carried out from University of Kelaniya, finding a methodology, supervision of the research study and project administration.

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