Morphometric Relationships in the Blue Swimming Crabs, (Portunus pelagicus) (Linnaeus, 1758) from the Palk Bay, Sri Lanka

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Authors’ contributions

This work was carried out in collaboration among all authors. Author SSKH designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SJWWMMPW and KHKB managed the analyses of the study. Author SJWWMMPW prepared the study area map. Author KHKB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The blue swimming crab (Portunus pelagicus) has become the focus of an important export-oriented fishery in Sri Lanka for a decade. The Palk Bay in the Northern coastal waters of Sri Lanka is one of the best-known fishing grounds for blue swimming crabs in Sri Lanka. This study was undertaken with the aim of establishing some morphometric relationships for P. pelagicus in the Palk Bay.

Biological sampling was conducted for five consecutive days per month from November 2014 - October 2015 in the Northern landing sites in the Jaffna District where the catch of Palk Bay blue swimming crab fishery was landed. P. pelagicus specimens were also randomly collected for laboratory analysis. The morphometric measurements of the specimens for the following parameters were undertaken: CW - carapace width with the spine, CWW - carapace width without spine, MW – mouth width, TL - total length, LCPL - left chelar propodus length, LMOV - left movable
part Length, RMOV - right movable part length, LCPH - left chelar propodus height, RCPH - right chelar propodus height, ABW - abdominal width, ABL - abdominal length and BW - body weight. The least squared method was used to obtain the Length-Length (L-L) and Length-Weight (L-W) relationships.

Of the 65 L-L relationships obtained for *P. pelagicus* from the study, 34 relationships were correlated ($r^2>0.5$). The estimated relationships between BW and CW for males and females were $BW = 0.0001 \text{CW}^{3.01}$ ($r^2 = 0.84$) and $BW = 0.0001 \text{CW}^{2.90}$ ($r^2 = 0.86$), respectively. Positive allometric growth was observed for male *P. pelagicus*, whereas a negative allometric growth was observed for female *P. pelagicus*. Most of the morphometric relationships of *P. pelagicus* obtained in this study were not isometric.

**Keywords:** *Portunus pelagicus*; Palk bay; morphometric relationships; allometric growth; isometric growth.

1. INTRODUCTION

More than 4,500 living species of crabs have been reported worldwide [1]. Most crabs reach sexual maturity in 12 months with males growing to a larger size than females [2]. Blue swimming crab (*Portunus pelagicus*) is considered an important commercial species in many countries, such as Australia, Japan, India and Thailand [3]. In Sri Lanka, blue swimming crab has emerged to become an important export-oriented fishery for a decade. This species is abundant in the Northern waters of Sri Lanka. The Palk Bay and the Gulf of Mannar are the best-known fishing grounds in Sri Lanka for blue swimming crabs. However, the published information on *P. pelagicus* in Sri Lanka waters are scanty.

Growth in crustaceans is a discontinuous process involving a succession of moults separated by intermoult [4]. As growth progresses, certain dimensions of the crustacean’s body grow much more than others, resulting in the phenomenon known as relative growth [5].

In population studies, morphometric analysis provides a powerful complement to genetic and environmental stock identification approaches [6]. The morphometric relationships of the species can be used to determine the well-being of individuals and to determine possible differences between the same species in different areas [7]. Length-weight relationships are important in fisheries management for growth comparative studies [8]. Also, the length-weight relationship is of great importance in fish stock assessment and can be used for estimating biomass of a species from the length frequency distribution and to convert growth-in-length equations to growth-in-weight [8, 9]. The study is an attempt to build the relationships among different morphological parameters of blue swimming crab. This is the first attempt in building such relationships for blue swimming crab in Sri Lankan waters. These relationships will be useful especially in comparing the growth, maturity and well-being of the same species at different geographical locations including aquaculture systems.

2. MATERIALS AND METHODS

2.1 Biological Data Collection

The biological data collection was conducted for five consecutive days per month mostly in the second week of the month at four blue swimming crab landing sites in the Jaffna District, Sri Lanka from November 2014 - October 2015 (Fig. 1). The catches of the fishing crafts operated in the blue swimming crab fishery in the Palk Bay were landed on the above landing sites. Accordingly, the carapace width and body weight with the sex of *P. pelagicus* were randomly measured and recorded. A vernier calliper was used for taking carapace width measurements, and the body weight of the crab was measured using a digital balance. Around 150 crabs were measured per day per site by the eight enumerators assigned for four sites. However, biological measurements were not obtained from the crabs which were found to be infected due to parasites or organ damaged. Moreover, biological measurements of *P. pelagicus* representing all maturity stages of male and female crabs were obtained.

2.2 Biological Sample Collection and Laboratory Analysis

Freshly caught blue swimming crab samples were purchased monthly from the fishermen operated in the Palk Bay blue swimming crab fishery between November 2014 and October 2015. The same inclusion and exclusion criteria which followed for biological sampling was
followed in the biological sample collection too. The collected samples were preserved with ice and brought to the Marine Biology Laboratory of National Aquatic Resources Research and Development Agency (NARA), Colombo. In each crab, the total length (TL) (mm), carapace width (CW) (mm) and other size measurements were also described with the body weight (BW) (g) sex wise.

2.3 Carapace Width – Body Weight (CW-BW) Relationships

To establish the CW-BW relationships, the commonly used relationship, \( BW = a \times CW^b \) was applied [10], where \( a \) is the intercept (condition factor) and \( b \) is the slope (growth coefficient). The CW and BW relationships for males, females and genders combined were separately obtained using CW and BW measurements obtained in the field as well as in the laboratory. The non-linear equations were first converted to linear equations with the natural log transformation. Then, the least square method was used to estimate the parameters, \( a \) and \( b \). The \( R^2 \) value, the square of the correlation was estimated to determine the goodness of fit of the equation. The student’s 't' test was used to determine whether exponent of CW - BW relationship for male and female blue swimming crab are significantly differed from '3'.

2.4 Length - Length (L-L) Relationships

The morphometric relationships between the following parameters were obtained (Fig. 2):

- CW - Carapace Width with the spine
- CWW - Carapace Width without spine
- MW - Mouth Width
- TL - Total length
- LCPL - Left Chela-Propodus Length
- RCPL - Left Chela-Propodus Length
- LMOV - Left Movable part length
- RMOV - Right Movable part length
- LCPH - Left Chela-Propodus Height
- RCPH - Right Chela-Propodus Height
- ABW - Abdominal width
- ABL - Abdominal length

Fig. 1. A map of Palk Bay with sampling sites (Mandativu I, Mandativu II, Chatty, and Vellani) in Jaffna District in Northern Sri Lanka

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In order to obtain morphometric relationships between parameters, an allometric growth given by the equation \( y = a x^b \) was assumed. Where \( x \) and \( y \) are any two morphometric parameters listed above and \( a \) and \( b \) are constants. Then, the equation was converted to the linear form by means of natural log transformation. The least square method was used to estimate the parameters, \( a \) and \( b \). Growth was classified as positively allometric when \( b > 1 \), negatively allometric when \( b < 1 \), or isometric when \( b = 1 \). Student’s t – test was used to determine whether relationships are allometric or isometric, with significant level at \( \alpha = 0.05 \). The values of the correlation coefficient (\( r \)) were also computed to know the degree of association between the morphometric parameters.

3. RESULTS AND DISCUSSION

3.1 Biological Data Summary

Table 1 summarizes the biological data of blue swimming crabs collected in the field. The CW of male crabs ranged from 70-185mm whereas the CW of female crabs ranged from 67-185mm. The
The observed differences in the CW - BW relationship for male blue swimming crab and for female blue swimming crab also significantly differed from ‘3’ (α= 0.05). The estimated CW - BW relationship for females and combined sexes are shown in Figs. 3.3 CW - BW Relationships

The scatter plots between CW and BW of males, females and combined sexes are shown in Figs. 3, 4 and 5, respectively. The estimated CW - BW relationship for male blue swimming crab was $BW = 0.0001CW^{2.01}$ The $R^2$ value was 0.84. The ‘t’ test confirmed that exponent (b value) of CW - BW relationship significantly differed from ‘3’ (α= 0.05). The estimated CW - BW relationship for female blue swimming crab was $BW = 0.0001CW^{2.00}$ The $R^2$ value was 0.86. The ‘t’ test confirmed that exponent of CW - BW relationship for female blue swimming crab also significantly differed from ‘3’ (α= 0.05). Accordingly, a positive allometric growth was observed for male blue swimming crab, whereas a negative allometric growth was observed for female blue swimming crab. The estimated CW - BW relationship for genders combined was $BW = 0.0001CW^{2.97}$ The $R^2$ value was 0.84. All CW - BW relationships mentioned above were significant at 0.001 level.

The study revealed that the growth of *P. pelagicus* in Palk Bay is not isometric and positive allometric growth and negative allometric growth were, respectively observed for male and female crabs. As observed, the exponential value (b) in the CW - BW relationships of male and female crabs showed a considerable difference. When b value was less than 3, body becomes slimmer with increasing length, and growth becomes negatively allometric whereas when b is greater than 3, body becomes heavier showing a positive allometric growth and reflecting optimum conditions for growth [4,11]. The observed differences in the CW - BW relationships between male and female blue swimming crabs are in agreement with some studies conducted in the Indian Ocean region [4,12]. However, it has been observed that males followed an isometric growth pattern, whereas in females a significant deviation from isometric growth [9]. A number of factors such as sex, maturity, environment, food availability and feeding habits determine the CW - BW relationship and also other morphometric relationships of crabs [9,13,14].

### 3.4 L-L Relationships

Fig. 6 shows the scatter plot of L-L relationships of blue swimming crabs, whereas Table 3 summarises the morphometric relationships of blue swimming crabs. Except fourteen relationships, other morphometric relationships were allometry.

Morphometrics and length–weight relationships are widely used in fisheries. Especially, they have been used to study population characteristics and the stock assessment of commercially important species [9,15]. Though crab specimens used in the study represented all maturity stages in the life cycle of the blue swimming crab and were considered in the study for developing morphometric relationships, the occurrence of different growth rates between distinct parts or organs of the body are possible [5]. The weak relationships obtained between some morphological parameters could perhaps be due to this nature of growth in different maturity stages.

Some studies have confined or focused to obtain morphometric relationships of sexually matured crabs [4,16,17]. A considerable variation in the growth pattern of crabs has been observed between males and females and different results have been obtained accordingly [4,9,18]. However, this factor was taken into consideration in the study when developing the relationships between carapace width and body weight of *P. pelagicus*.

The morphometric relationships obtained for *P. pelagicus* in the present study can be used for comparing the different stocks of this crab at different geographical locations [6,9]. Accordingly, the results of the study could perhaps be used for morphological identification of the stock structure of *P. pelagicus* in Sri Lankan waters. In particular, the results will be beneficial in comparing the stocks of *P. pelagicus* in the Palk Bay and Gulf of Mannar.
Table 1. Summary in biological data of *Portunus pelagicus* collected in Palk Bay, Sri Lanka: from November, 2014 to October, 2015

| Sex      | No.   | CW (mm)        | BW (g)        |
|----------|-------|----------------|---------------|
|          |       | Range | Ave. ± Std dev | Range | Ave ± Std dev |
| Male     | 13,055| 70 - 185 | 133.5 ± 17.3  | 31 - 573 | 184.4 ± 67.5 |
| Female   | 21,685| 67 - 185 | 135.1 ± 14.4  | 31 - 572  | 169.8 ± 62.0 |
| Combined | 34,740| 67 - 185 | 134.6 ± 15.5  | 31 - 573  | 179.4 ± 67.1 |

**Fig. 3.** Carapace Width (CW) – Body Weight (BW) relationship of male *Portunus pelagicus* in the Palk Bay, Sri Lanka

**Fig. 4.** Carapace Width (CW) – Body Weight (BW) relationship of female *Portunus pelagicus* in the Palk Bay, Sri Lanka
Table 2. Summary in morphometric sample analysis of *Portunus pelagicus* in the Palk Bay, Sri Lanka: from November, 2014 - October, 2015

| Morphometric parameters | MW  | CW  | CWW | TL  | ABL | ABW | LCPL | LCPH | LMOV | RCPL | RCPH | RMOV |
|-------------------------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Sample size             | 656 | 702 | 700 | 702 | 700 | 699 | 682  | 683  | 679  | 689  | 689  | 687  |
| Minimum value           | 11.0| 66.0| 53.0| 31.0| 22.0| 23.0| 16.0 | 9.0  | 16.0 | 17.0 | 8.0  | 13.0 |
| Maximum value           | 32.0| 177.0|142.0| 99.0| 71.0| 84.0| 126.0| 38.0 | 61.0 | 129.0| 33.0 | 58.0 |
| Average value           | 23.4| 128.2|102.7| 58.0| 45.2| 43.7| 79.2 | 19.0 | 37.3 | 79.7 | 20.4 | 36.9 |
| Standard deviation      | 3.3 | 16.9| 14.3| 8.7 | 7.3 | 6.7 | 16.3 | 3.6  | 7.4  | 16.7 | 4.1  | 7.6  |

CW-Carapace Width with the spine, CWW - Carapace Width without spine, MW – Mouth Width, TL-Total length, LCPL-Left Chela-Propodus Length, RCPL-Left Chela-Propodus Length, LMOV-Left Movable part Length, RMOM-Right Movable part Length, LCPH-Left Chela-Propodus Height, RCPH-Right Movable part Height, ABW-Abdominal Width, ABL-Abdominal Length

![Graph](https://example.com/graph.png)

**Fig. 5.** Carapace Width (CW) – Body Weight (BW) relationship for genders combined *Portunus pelagicus* in the Palk Bay, Sri Lanka

Table 3. Some morphometric relationships of blue swimming crab in the Palk Bay, Sri Lanka (n: sample size, R²: Coefficient of determination, b: Regression coefficient (slope of the line), t (b=1): student’s t-test when b =1)

| Variables     | n  | Power function | R²  | t (b=1) | Allometry level |
|---------------|----|----------------|-----|---------|-----------------|
| MW & CW       | 656| CW = 8.33MW^{0.87}| 0.85** | 9.23 | -               |
| MW & CWW      | 656| CWW = 5.70MW^{0.92}| 0.86** | 5.70 | -               |
| MW & TL       | 656| TL = 3.48MW^{0.89}| 0.76** | 5.48 | -               |
| MW & ABL      | 656| ABL = 1.70MW^{1.04}| 0.79** | -1.88| =               |
| MW & ABW      | 656| ABW = 2.16MW^{0.95}| 0.79** | 2.37 | -               |
| MW & LCPL     | 656| LCPL = 1.81MW^{1.19}| 0.57** | -4.69| +               |
| MW & LCPH     | 656| LCPH = 0.84MW^{0.98}| 0.51** | 5.00 | -               |
| MW & LMOV     | 656| LMOV = 0.96MW^{1.16}| 0.63** | -4.43| =               |
| MW & RCPL     | 656| RCPL = 2.07MW^{1.15}| 0.54** | -3.56| =               |
| MW & RCPH     | 656| RCPH = 1.03MW^{0.94}| 0.43  | 1.34 | =               |
| MW & RMOV     | 656| RMOV = 0.73MW^{1.24}| 0.67** | -7.06| +               |
| CW & CWW      | 700| CWW = 0.70CW^{1.03}| 0.94** | -3.15| +               |
| CW & TL       | 700| TL = 0.43CW^{1.01}| 0.85** | -0.61| =               |
| CW & ABL      | 700| ABL = 0.16CW^{1.17}| 0.87** | -9.61| +               |
| CW & ABW      | 699| ABW = 0.23CW^{1.08}| 0.88** | -5.26| +               |
| CW & LCPL     | 682| LCPL = 0.13CW^{1.32}| 0.59** | -7.58| +               |
| CW & LCPH     | 683| LCPH = 0.08CW^{1.11}| 0.54** | -2.92| +               |
| Variables       | n  | Power function | R²   | t (b=1) | Allometry level |
|----------------|----|----------------|------|---------|-----------------|
| CW & LMOV      | 679| LMOV = 0.06CW^{1.31} | 0.68** | -8.87  | +               |
| CW & RCPL      | 689| RCPL = 0.17CW^{1.26} | 0.57** | -6.23  | +               |
| CW & RCPH      | 689| RCPH = 0.10CW^{1.09} | 0.49  | -2.13  | +               |
| CW & RMOV      | 687| RMOV = 0.05CW^{1.38} | 0.73** | -11.84 | +               |
| CWW & TL       | 700| TL = 0.70CWW^{0.95} | 0.84** | -6.15  | -               |
| CWW & ABL      | 700| ABL = 0.28CWW^{1.10} | 0.85** | -5.56  | +               |
| CWW & ABW      | 699| ABW = 0.38CWW^{1.02} | 0.87** | -1.48  | =               |
| CWW & LCPL     | 682| LCPL = 0.24CWW^{1.25} | 0.60** | -6.43  | +               |
| CWW & LCPL     | 682| LCPL = 0.13CWW^{1.07} | 0.56** | -1.80  | =               |
| CWW & LMOV     | 679| LMOV = 0.12CWW^{1.23} | 0.68** | -6.98  | +               |
| CWW & RCPH     | 689| RCPH = 0.30CWW^{1.20} | 0.58** | -5.12  | +               |
| CWW & RCPH     | 689| RCPH = 0.18CWW^{1.02} | 0.48  | -0.47  | =               |
| ABW & RCPH     | 689| RCPH = 0.99CWW^{1.31} | 0.74** | -10.23 | +               |
| TL & ABL       | 700| ABL = 0.83TL^{0.38} | 0.74** | 0.69   | =               |
| TL & ABW       | 699| ABW = 0.93TL^{0.95} | 0.81** | 2.99   | -               |
| TL & LCPL      | 682| LCPL = 0.82TL^{1.12} | 0.54** | -3.03  | +               |
| TL & LCPL      | 683| LCPL = 0.36TL^{1.97} | 0.52** | 0.81   | +               |
| TL & LCPL      | 679| LCPL = 0.44TL^{1.10} | 0.59** | -2.63  | +               |
| TL & RCPL      | 689| RCPL = 0.91TL^{1.32} | 0.52** | -2.43  | +               |
| TL & RCPH      | 689| RCPH = 0.44TL^{1.94} | 0.45  | 1.46   | -               |
| TL & RMOV      | 687| RMOV = 0.32TL^{1.16} | 0.64** | -4.84  | +               |
| ABL & ABW      | 699| ABW = 1.59ABL^{0.87} | 0.88** | 10.76  | -               |
| ABL & LCPL     | 682| LCPL = 2.76ABL^{0.88} | 0.42  | 3.12   | -               |
| ABL & LCPL     | 683| LCPL = 0.76ABL^{0.84} | 0.50** | 4.86   | -               |
| ABL & LMOV     | 679| LMOV = 1.20ABL^{0.90} | 0.51** | 3.05   | -               |
| ABL & RCPL     | 689| RCPL = 2.86ABL^{0.87} | 0.43  | 3.41   | -               |
| ABL & RCPH     | 689| RCPH = 0.88ABL^{0.82} | 0.45  | 5.13   | -               |
| ABL & RMOV     | 687| RMOV = 0.91ABL^{0.87} | 0.57** | 0.98   | =               |
| ABW & LCPL     | 682| LCPL = 2.05ABW^{0.96} | 0.44  | 0.91   | =               |
| ABW & LCPL     | 683| LCPL = 0.60ABW^{0.91} | 0.50** | 2.59   | -               |
| ABW & LMOV     | 679| LMOV = 0.99ABW^{0.96} | 0.51** | 1.24   | =               |
| ABW & RCPL     | 689| RCPL = 2.13ABW^{0.95} | 0.44  | 1.11   | =               |
| ABW & RCPH     | 689| RCPH = 0.66ABW^{0.90} | 0.46  | 2.62   | -               |
| ABW & RMOV     | 687| RMOV = 0.69ABW^{1.05} | 0.57** | -1.40  | +               |
| LCPL & LCPL    | 682| LCPL = 1.79LCPL^{0.54} | 0.38  | 17.40  | -               |
| LCPL & LMOV    | 679| LMOV = 1.18LCPL^{0.79} | 0.73** | 11.39  | -               |
| LCPL & RCPL    | 682| RCPL = 1.97LCPL^{0.85} | 0.71** | 7.36   | -               |
| LCPL & RCPH    | 682| RCPH = 2.84LCPL^{0.45} | 0.23  | 17.36  | -               |
| LCPL & RMOV    | 682| RMOV = 1.15LCPL^{0.79} | 0.69** | 9.99   | -               |
| LCPL & LMOV    | 679| LMOV = 4.31LCPL^{0.73} | 0.49  | 9.34   | -               |
| LCPL & RCPH    | 683| RCPL = 13.80LCPL^{0.59} | 0.27  | 10.80  | -               |
| LCPL & RCPH    | 683| RCPL = 4.53LCPL^{0.51} | 0.23  | 13.65  | -               |
| LCPL & RMOV    | 679| RMOV = 4.86LCPL^{0.69} | 0.40  | 9.60   | -               |
| LMOV & RCPL    | 679| RCPL = 3.78LMOV^{0.84} | 0.60** | 5.87   | -               |
| LMOV & RCPH    | 679| RCPH = 2.66LMOV^{0.56} | 0.31  | 13.41  | -               |
| LMOV & RMOV    | 679| RMOV = 1.40LMOV^{0.91} | 0.76** | 4.76   | -               |
| RCPL & RCPH    | 689| RCPH = 2.17RCPL^{0.51} | 0.30  | 16.58  | -               |
| RCPL & RMOV    | 687| RMOV = 1.15RCPL^{0.79} | 0.67** | 9.95   | -               |
| RCPH & RMOV    | 687| RMOV = 4.78RCPH^{0.68} | 0.42  | 10.79  | -               |

CW - Carapace Width with the spine, CWW - Carapace Width without spine, MW – Mouth Width, TL - Total length, LCPL - Left Chela-Propodus Length, RCPL - Left Chela-Propodus Length, LMOV- Left Movable part Length, RMOV- Right Movable part Length, LCPH-Left Chela-Propodus Height, RCPH-Right Chela-Propodus Height, ABW- Abdominal Width, ABL- Abdominal Length, n - number of individuals; = isometry, + positive allometry, - negative allometry. The morphometric relationships which are correlated are indicated by ***(R²>0.5).**
4. CONCLUSION

The growth of *P. pelagicus* in the Palk Bay, Sri Lanka is not isometric and positive allometric growth and negative allometric growth were, respectively observed for male and female blue swimming crabs. Moreover, many morphometric relationships of *P. pelagicus* that were obtained in this morphometric study were not isometric. The results of the study could be made use for population studies and stock assessments of *P. pelagicus*.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Garth JS, Abbott DP. Brachyura: The true crabs. Intertidal Invertebrates of California. In: Morris RH, Abbott DP, Haderlie EC, editors. Stanford, CA: Stanford University Press;1980.
2. Sumpton WD, Potter MA, Smith GS. Reproduction and growth of the commercial sand crab, *Portunus pelagicus*
(L.) in Moreton Bay, Queensland. Asian Fish. Sci. 1994;7:103–113.
3. Kunsook C, Gajaseni N, Paphavasit N. The feeding ecology of the blue swimming crab, Portunus pelagicus (Linnaeus, 1758), at Kung Krabaen Bay. Chanthaburi Province, Thailand. Trop. Life Sci. Res. 2014;25:13–27.
4. Rasheed S, Mustaquim J. Relative growth and morphometric measurements as an index for estimating meat yield of two edible crabs Portunus pelagicus and P. sanguinolentus from the coastal waters of Pakistan. Int J Inn and Appl Stud. 2014;9(4):1994-2009.
5. Hartnoll RG. Variation in growth pattern between some secondary sexual characters in crabs (Decapoda Brachyura). Crustaceana. 1974;27:131–136.
6. Cadrin SX. Advances in morphometric identification of fishery stocks. Rev. Fish Biol. Fish. 2000;10:91-112.
7. King M. Fisheries biology assessment and management. Oxford, UK, Fishing News Books. Blackwell Science Ltd;1995.
8. Moutopoulos DK, Stergiou KI. Length-weight and length-length relationships of fish species from Aegean Sea (Greece). J. Appl. Ichthyol. 2002;18:200-203.
9. 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.
10. Pauly D. Length converted catch curves. A powerful tool for fisheries research in the tropics (Part I). ICLARM Fishbyte. 1983;1:9-13.
11. Jisr N, Younes G, Sukhn C, El-Dakdouki MH. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. The Egypt. J. Aquat. Res. 2018;44:299-305.
12. Dineshbabu AP, Sreedhara B, Muniyappa Y. Fishery and stock assessment of Portunus sanguinolentus (Herbst) from south Karnataka coast, India J Mar Biol Assoc. India, 2007;49:134 - 140.
13. Gorce G, Erguden D, Sangun L, Cekic M, Alagoz S. Weight/length – Weight and relationships of the blue crab (Callinectes sapidus Rathbun, 1986) population living in Camlik Lagoon Lake (Yumurtalik), Pakistan J. Biol. Sci. 2006;9,1460-1464.
14. Silva TE, Fumis PB, Almeida AC, Bertini G, Fransozo V. Morphometric analysis of the mud crab Hexapanepeus paulensis Rathbun, 1930 (Decapoda, Xanthoidea) from the south eastern coast of Brazil. Lat. Am. J. Aquat. Res. 2014;42:588-597.
15. Ragonese S, Bertolino F, Biancini ML. Biometric relationships of the red shrimp, Aristaeomorpha foliacea (Risso 1827), in the Strait of Sicily (Mediterranean Sea). Sci. Mar. 1997;61:367–377.
16. Fumis PB, Fransozo A, Bertini G, Braga AA. Morphometry of the crab Hexapanepeus schmitti (Decapoda: Xanthoidea) in the northern coast of the State of São Paulo, Brazil. Rev Biol Trop. 2007;55:163-170.
17. Miranda I, Mantelatto FLM. Sexual maturity and relative growth of the porcelain crab Petrolisthes armatus (Gibbes, 1850) from a remnant mangrove area, southern Brazil. Nauplius. 2010;18:87-93.
18. Hajjeg G, Sley A, Jarboui O. Morphometrics and length-weight relationship in the blue swimming crab, Portunus segnis (Decapoda, Brachyura) from the gulf of Gabes, Tunisia. J. Eng. Appl. Sci. 2016;3(12):10-16.

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