The Relationship Between Morphometric Characteristics and The Weight of *Tubuca forcipata* (Subfamily: Gelasiminae) in The Mangrove Nature Reserve of Eastern Coast Resort Mendahara, Jambi Province

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Abstract

The East Coast Mangrove Nature Reserve (CAHBPT) is one of the nature reserves located in the Jambi Province. CAHBPT is home to a diverse range of flora and fauna, including Tubuca forcipata. T. forcipata exhibits sexual dimorphism, where male individuals have chelipeds of asymmetric sizes. The objective of this research is to analyze the relationship between morphometric characteristics, including the length of the large cheliped, the width of the large cheliped, the length of the carapace, and the width of the carapace, with the weight of male T. forcipata. This research was designed as a quantitative descriptive research aimed at describing, explaining, and detailing the morphology and the results of the analysis of the growth patterns of the chelipeds and carapace in male T. forcipata. Sample collection was carried out at three points within the nature reserve area with the purpose of ensuring sample replication. Data collection was conducted using a convenience sampling approach, employing an exploratory method that combined a 200-meter transect line and Visual Encounter Survey (VES). The research yielded a total of 109 male T. forcipata individuals collected from three research stations in CAHBPT. The conclusion of this research is that the relationship between morphometric characteristics and the weight of T. forcipata indicates a negative allometric growth pattern

Keywords: *Allometric, Fiddler Crab, Morphometric, Morphology*

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INTRODUCTION

The East Coast Mangrove Nature Reserve (CAHBPT) is one of the nature reserves located in the Jambi Province, serving as a conservation area covering 4,126.6 hectares. This area stretches along the eastern coast of Jambi and is administratively situated between two regencies, namely Tanjung Jabung Barat and Tanjung Jabung Timur. The CAHBPT conservation area is a complex mangrove ecosystem, and the complexity of habitats within an ecosystem is a key factor influencing the presence of organisms. Quoted from the BKSDA Jambi website, there is a variety of flora and fauna in the CAHBPT, such as *Nypa fruticans, Rhizopora sp., Sonneratia sp., Bruguiera sp., and others. As for the fauna, it includes Macaca fasicularis, Pteropus vampyrus, Heliactus leucogaster, Carsinoscorpius rotundicauda, Scylla serrata, Tubuca sp., and others.* Previous research on fiddler crabs in the Jambi Province identified several species of the subfamily Gelasiminae in the province, namely *Tubuca forcipata, Tubuca dussumieri, and Tubuca rosea* (Wulandari et al., 2013; Suprayogi et al., 2014; Wulandari, 2015).

Similar to other fiddler crabs, the uniqueness of *T. forcipata* lies in the morphological differences between males and females. Male *T. forcipata* have one significantly larger cheliped compared to the other (asymmetry), while their female counterparts have symmetrical chelipeds (Wulandari, 2015). Asymmetry in male *T. forcipata* reveals significant differences in size between various body parts, making it an intriguing subject for research. To analyze the asymmetry in *T. forcipata*, an allometric approach can be employed (Lavajoo et al., 2013). The relationship between growth parameters of different body parts of *T. forcipata*, such as length, width, and height, can be analyzed through the growth patterns of these body parts (Saher et al., 2019). This is done to determine the extent to which the growth rate of one body part relates to the growth of other body parts in *T. forcipata.*

The chelipeds of the fiddler crab species vary both in terms of shape and size among different species. Based on this, it is important to establish a baseline for the normal relative growth rate in *T. forcipata*, which can then be used as population data. The relationship between morphometric characteristics and weight in crabs can be determined by measuring the length of body parts and their wet weight (Muzammil et al., 2015).

METHOD

This research is a quantitative descriptive research that describes, explains, and elaborates on the morphology and the results of the analysis of the growth patterns of the chelipeds and carapace in male *T. forcipata.* The research stations were located in the Parit Adong mangrove area with coordinates of -1°2'52.74"S and 103°41'6.33"E, Station 2 in the Sungai Siput mangrove area with coordinates of -10°33'34.86"S and 103°40'12.11"E, and Station 3 in the Dermaga Syah Bandar mangrove area with coordinates of -1°2'55.37"S and 103°40'36.12"E (Figure 1).

Data collection was conducted using a convenience sampling approach, which is a data collection technique based on the availability and ease of obtaining data sources. Therefore, based on this approach, an exploratory method was employed, combining a 200-meter transect line (Figure 2) and *Visual Encounter Survey* (VES) (Yustian et al., 2017).

The scope of this research was limited to adult male *T. forcipata* individuals, identified by their asymmetric cheliped size, and data processing was carried out with natural logarithm transformations.

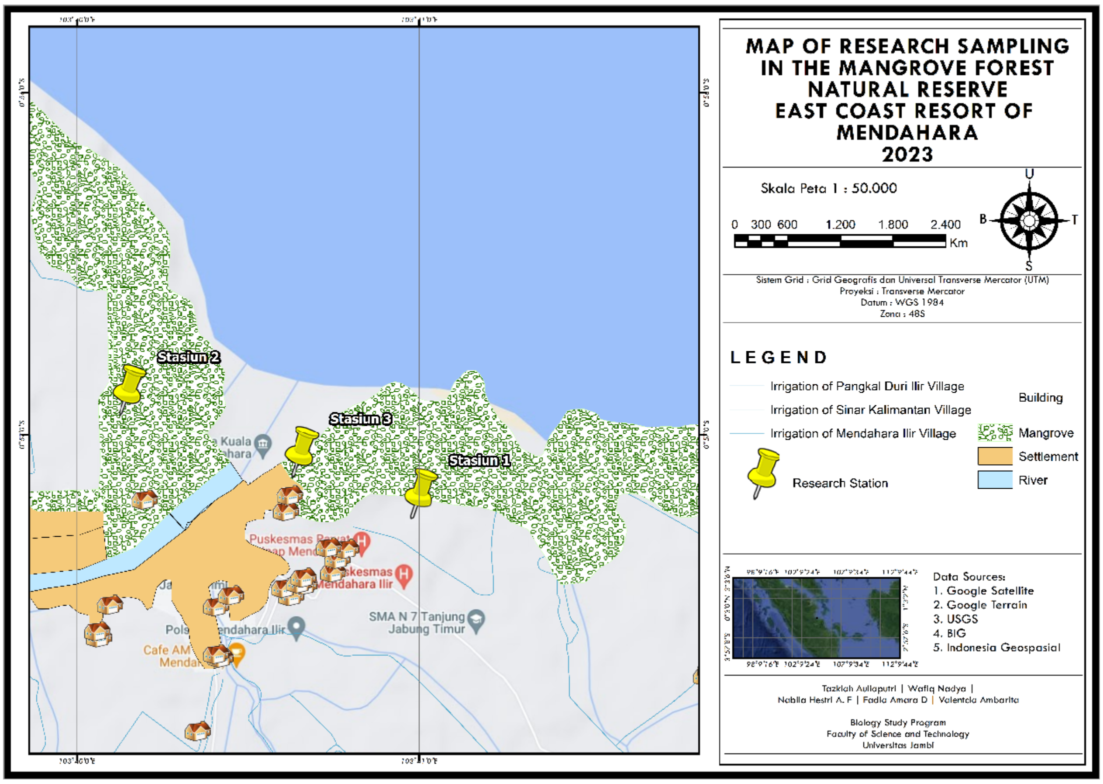

Figure 1. The map depicting the sampling locations.

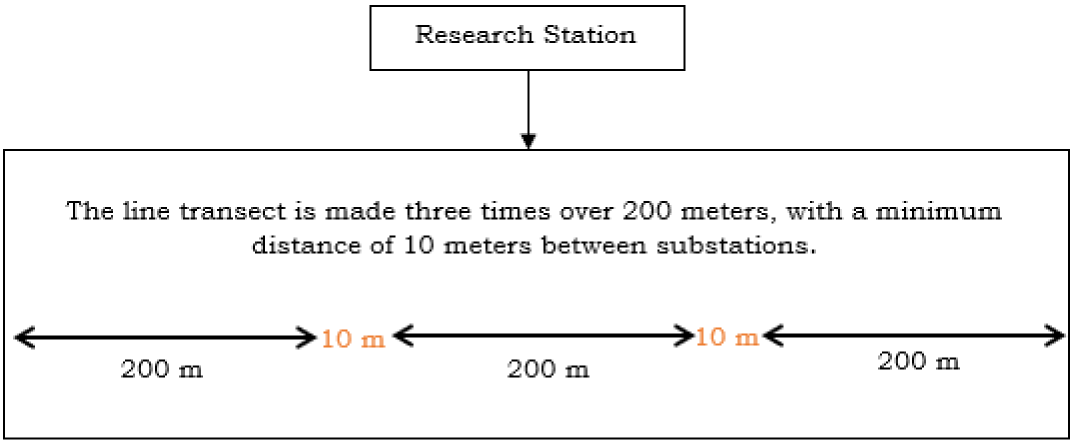

Figure 2. The research transect design

The growth pattern is depicted through linear regression analysis (Siringoringo et al., 2017), aiming to examine the relationships between carapace width, carapace length, cheliped width, and cheliped length with the weight of *T. forcipata*. The equation representing the morphometric character relationships with the weight of *T. forcipata* according to (Huxley, 1924 in Pralon & Negreiros-Fransozo, 2008; Wulandari, 2015; Kasril et al., 2017; Majidah, 2018; Safira et al., 2019; Hanjani, 2019) namely:

$$W = aL^b \quad (1)$$

Explanation:
W = Weight of *T. forcipata* (g)
a = Intercept
L = Morphometric character (mm)
b = Slope (Estimate of the growth pattern of morphometric character-weight)

The strength of the relationship between the two parameters of growth patterns (morphometric characters and weight) can be demonstrated by the correlation coefficient (r) obtained from the formula according to Siringoringo et al., (2017); Nane (2019) as follows:

$$r = \frac{N(\sum \log L \times \log W) - (\sum \log L)(\log W)}{\sqrt{\{N(\sum log^2 L) - (\sum log L)^2\}\{N(\sum log^2 W) - (\sum log W)^2\}}} \quad (2)$$

Explanation:
r = correlation coefficient
N = Number of *T. forcipata* tails
W = Weight of *T. forcipata* (grams)
L = Length/width of *T. forcipata* morphometric characters (mm)

Therefore, based on the formula, conclusions can be drawn according to Siringoringo et al., (2017); Hanjani (2019); Nane (2019) as follows:

- When the value of r is between 0.00 and 0.19, the correlation is very weak.
- When the value of r is between 0.20 and 0.39, the correlation is weak.
- When the value of r is between 0.40 and 0.69, the correlation is moderate.
- When the value of r is between 0.70 and 0.89, the correlation is strong.
- When the value of r is between 0.90 and 1.00, the correlation is very strong.

RESULTS AND DISCUSSION

The Morphology of Tubuca forcipata

In adult male T. forcipata, the chelae exhibit differences in size among each other, a phenomenon referred to as asymmetry. This asymmetry in the chelae of *T. forcipata* also displays antisymmetry, meaning that the larger chela can be found on either the right or left side (Figure 3) (Wulandari, 2015).

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Figure 3. Asymmetry and antisymmetry of the chelae in *T. forcipata.*

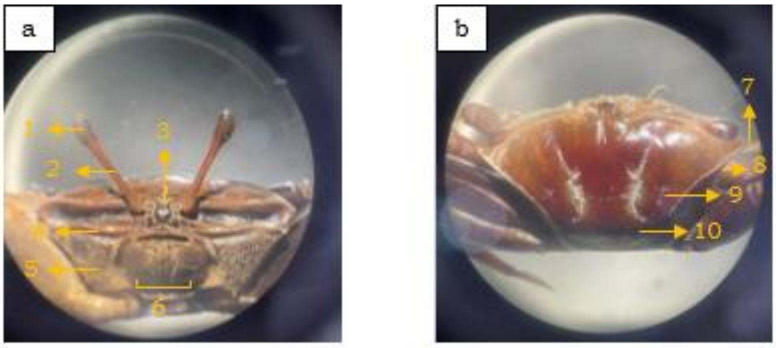

Figure 4. Face carapace and carapace of *T. forcipata.* Note: (a) Frontal: 1. Eyes (with a pseudopupil), 2. Eyestalk, 3. Face carapace, 4. Suborbit, 5. Maxilliped. (b) Dorsal: 7. Orbital angle/antero-lateral angle, 8. Antero-lateral margin, 9. Dorso-lateral margin, 10. Postero-lateral margin/fold.

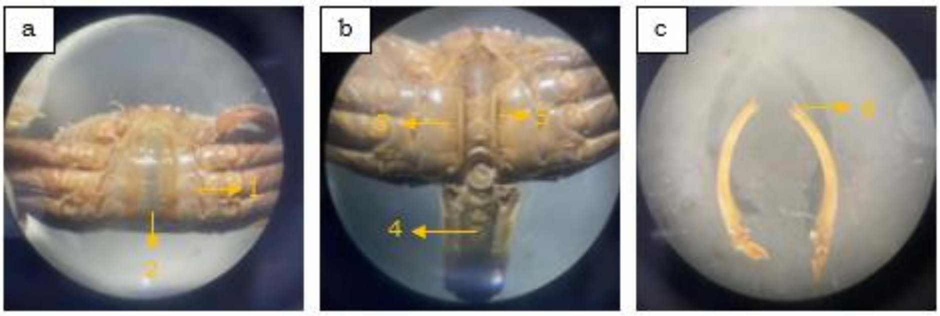

Figure 5. Abdomen. Note: (a) Ventral area on the left in males and on the right in females, (b) Ventral abdomen area is covered: 1. Sternum, 2. Abdomen. (c) Ventral abdomen area is open: 3. Sternum, 4. Abdomen, 5. Gonopod. (d) Gonopod: 6. Flange.

Distribution of Research Data

The total number of analyzed adult *T. forcipata* samples was 109 individuals. Based on the distribution of measurement data for *T. forcipata* (Table 1), it is evident that each character has a dominant number of individuals within specific size ranges. For the body weight character, there were 35 individuals within the size range of 7.4-9.4 g. In terms of the length of the major cheliped, there were 34 individuals within the size range of 39-44 mm. The width of the major cheliped character had 39 individuals within the size range of 14.6-16.6 mm. As for the length of the carapace character, there were 43 individuals within the size range of 14.3-16.3 mm. Lastly, the width of the carapace character had 41 individuals within the size range of 26.9-29.9 mm.

Table 1. Research data

No.	Character	Size Range	Mean ± SD
1	Weight (g)	5,3-17,2	9,4±2,7
2	Length of major cheliped (mm)	18,6-57,6	40,7±7,3
3	Width of major cheliped (mm)	8,3-20,4	14,9±2,2
4	Length of carapace (mm)	12,2-25,4	15,9±1,9
5	Width of carapace (mm)	8,3-33,3	25,7±3,3

Regression Analysis of Morphometric Characters with the Weight of *Tubuca forcipata*

Based on the linear regression analysis that has been conducted, the relationship between the length of the major cheliped, the width of the major cheliped, the length of the carapace, and the width of the carapace with the weight of *T. forcipata* shows a pattern of negative allometric growth with equations in (Table 2). Each equation has a slope expressed as the regression coefficient (determinant of growth pattern) less than 3 ($b<3$). From the analysis, it can be concluded that the relationship between morphometric characters and body weight is of a negative allometric nature, meaning that the increase in each unit of morphometric character is more dominant than the increase in body weight (Costa et al., 2021). Each equation can also define values for intercept and slope, where each increase in the length of morphometric characters expressed by the slope value will influence body weight by the amount of the intercept value.

Table 2. Tabulation of regression analysis

Character	Equation	Coefficient Determination (R^2)	Pattern Growth
ChL	$W = 0{,}1746L^{1{,}9356}$	0,63	Negative allometric
ChW	$W = 0{,}3779L^{1{,}7764}$	0,67	Negative allometric
CL	$W = 0{,}2273L^{2{,}2306}$	0,50	Negative allometric
CW	$W = 0{,}2273L^{2{,}2306}$	0,31	Negative allometric

The analysis results are supported by the correlation test and its coefficient of determination. The relationship between morphometric characters and the weight of *T. forcipata* has correlation values (r) of 0.79, 0.83, 0.70, and 0.56, respectively. Based on the classification of correlation values, it can be observed that the relationship between the length of the major cheliped, the width of the major cheliped, and the length of the carapace with body weight exhibits strong correlations. Meanwhile, the relationship between carapace width and body weight shows a moderate correlation. In the relationship of the length of the major cheliped, a coefficient of determination (R^2) of 0.6372 or 63.72% was obtained.

Therefore, it can be concluded that the increase in the length of the major cheliped contributes to 63.72% of the weight of *T. forcipata* (Figure 6). And in the case of the width of the major cheliped, a coefficient of determination (R2) of 0.6787 or 67.87% was obtained. Thus, it can be concluded that the increase in the width of the major cheliped contributes to 67.87% of the weight of *T. forcipata* (Figure 7). In the relationship of carapace length, a coefficient of determination (R^2) of 0.5003 or 50.03% was obtained. Therefore, it can be concluded that the increase in carapace length contributes to 50.03% of the weight of *T. forcipata* (Figure 8). And in the case of carapace width, a coefficient of determination (R2) of 0.3154 or 31.54% was obtained. Thus, it can be concluded that the increase in carapace width contributes to 31.54% of the weight of *T. forcipata* (Figure 9).

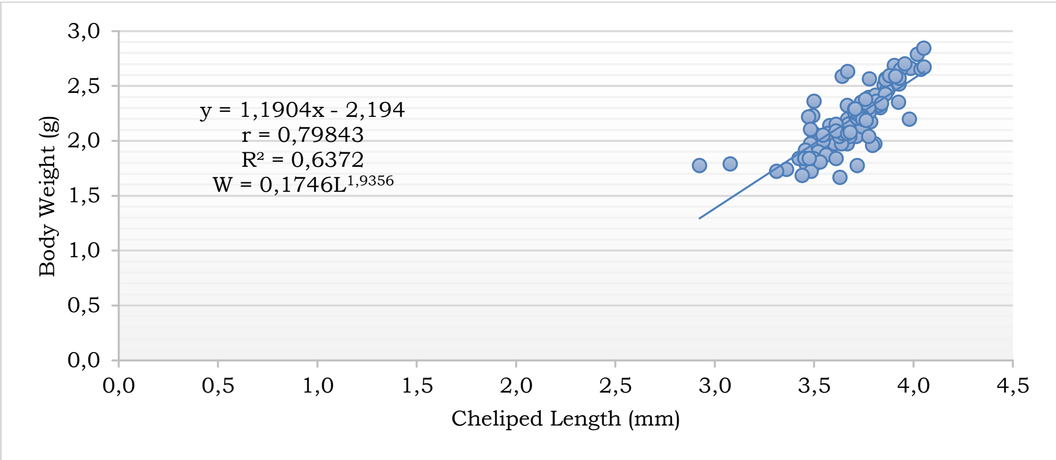

Figure 6. Graph illustrating the relationship between the length of the major cheliped and the weight of *T. forcipata*.

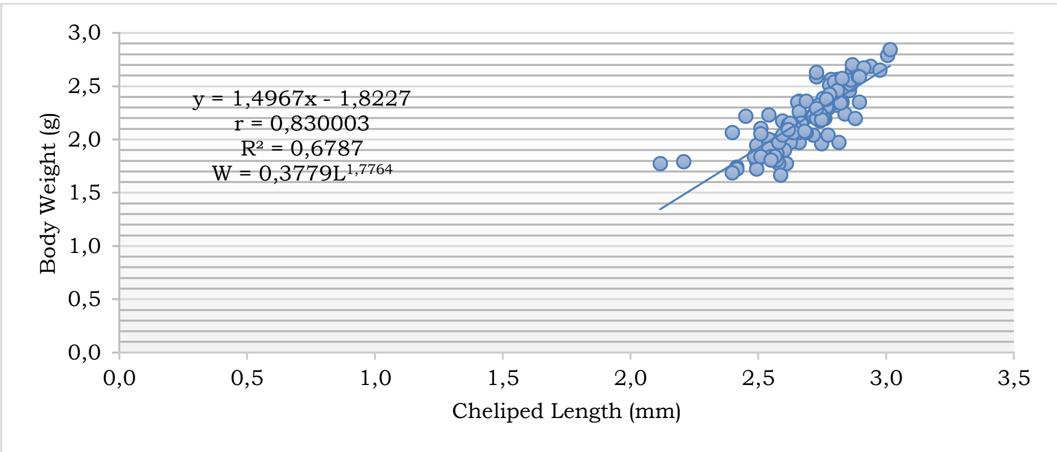

Figure 7. Graph of the width of the major cheliped with the weight of *T. forcipata*.

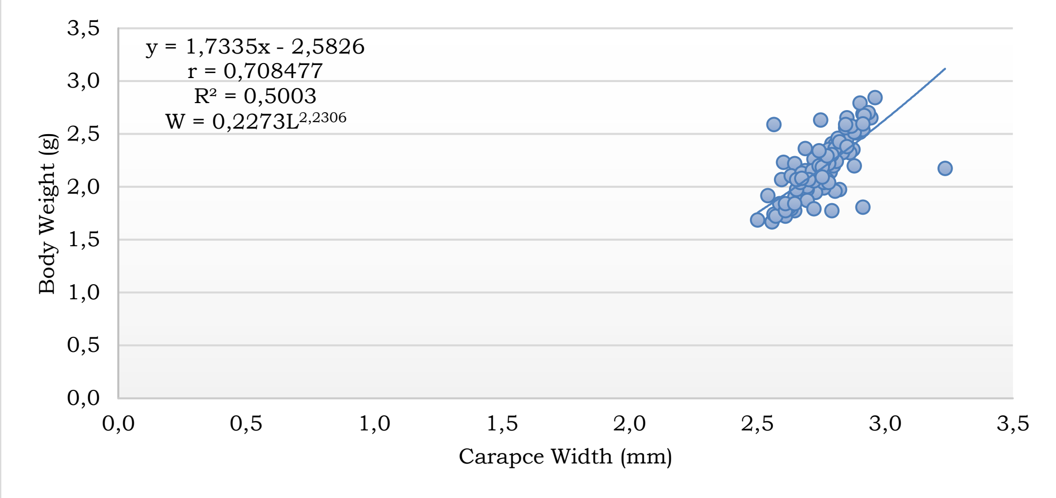

Figure 8. The Relationship Graph of carapace length with the weight of *T. forcipata*

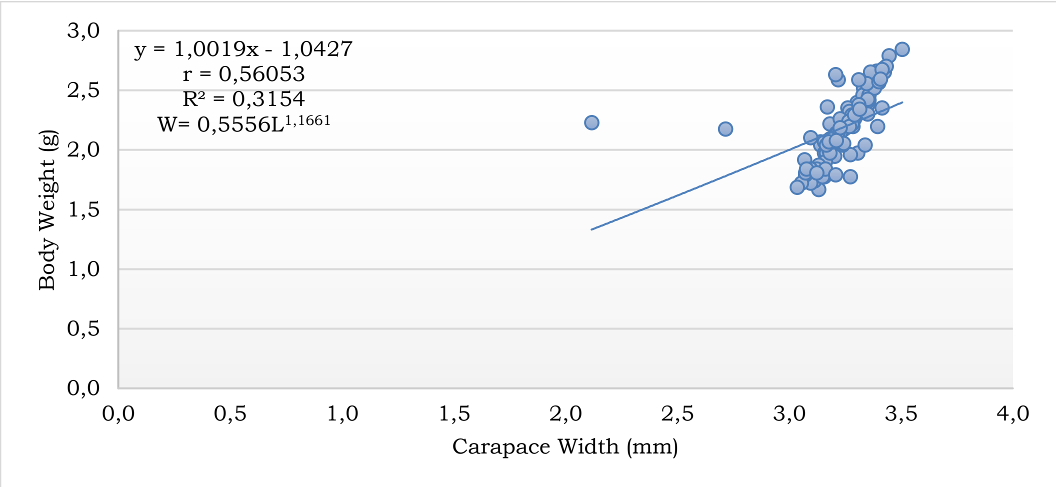

Figure 9. The Relationship Graph of carapace width with the weight of *T. forcipata*

The analysis results of the entire morphometric characters on the weight of *T. forcipata* indicate a pattern of negative allometric growth, where the value of b<3. This is consistent with the statement by (Okon & Sikoki, 2014) that negative allometry has a value of b<3, which also defines that the increase in length, width of the major cheliped, and carapace of the unity unit is more dominant compared to the weight of *T. forcipata.* The changes in the value of b also depend on the shape and robustness of *T. forcipata,* season, temperature, salinity, food (quantity, quality, and size of food), gender, and sexual maturity. Unlike the value of a, the value of b can vary with the season, even within different microhabitats.

From the correlation test and determination coefficient, it is revealed that the length of the large chelae, the width of the large chelae, the length of the carapace, and

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the width of the carapace each contribute to the weight of *T. forcipata* by 63.72%, 67.87%, 50.03%, and 31.54%, respectively. Based on these analysis results, the largest contribution to the weight of *T. forcipata* comes from the large chelae, which is also attributed to the larger proportion of the large chelae compared to the carapace size (Pena & Levinton, 2021). Other contributions that can affect the weight of T. forcipata may come from the environment, as also stated by Campbell & Eagles (1983) who mentioned that environmental factors influence the overall size of adult crabs. These factors include sediment characteristics, age, food sources, human activities that affect crab sexual maturity and development, salinity, temperature, organic matter content, and soil granulometry composition (Kasril et al., 2017; Saher et al., 2019).

CONCLUSION

The conclusion of this research is that the relationship between weight and the size of the large chelae, the width of the large chelae, the length of the carapace, and the width of the carapace in T. forcipata shows a pattern of negative allometric growth, where all values of b are less than 3. Therefore, the relationship between weight and these morphometric characteristics exhibits a pattern of negative allometric growth.

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