Length-weight relationship of *Penaeus indicus* and *Penaeus merguiensis* in the Langsa mangrove area, Aceh Province

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Abstract. The two Penaeid shrimps *Penaeus indicus* and *Penaeus merguiensis* are the most common commercial species found in the Langsa mangrove forest. The growth pattern of these two Penaeid shrimps are strongly influenced by environmental factors such as temperature, pH, dissolved oxygen (DO), salinity, availability of food and predators, which ultimately determines the abundance and catch of commercial adult shrimps obtained. The present study aims to investigate the length-weight relationship of *P. indicus* and *P. merguiensis* in the Langsa mangrove forest, Aceh Province. The sampling was conducted in November 2018 with the stratified random sampling method. A total of 124 shrimps consisted of 92 samples *P. indicus* and 32 samples *P. merguiensis*. The results showed that growth pattern of two Penaeid shrimps was categorized as negative allometric. The highest b value is shown in *P. merguiensis* with b value of 2.87 while *P. indicus* 2.55. The value of the relative weight condition factor (Wr) of the two shrimps indicates a value of >100. It is concluded that the waters of the mangrove forest in Langsa City are still able to support the survival of *P. indicus* and *P. merguiensis*.

1. Introduction

Mangrove forests are important habitats for fish, shrimps, crabs, aquatic birds, and marine mammals, so mangroves are the beginning of the coastal food chain. Several commercially important fish were also found associated with mangrove habitats, because mangrove roots and fallen leaves provide substrates for nutrients and biofilm expansion in the aquatic environment that can stimulate the production of fish [1-3]. Thus, the mangrove forests potentially improving national economy in many countries around the world [4, 5]. In Indonesia, the East Coast of Sumatra is one of the areas dominated by mangrove forest.

The east littoral of Sumatra is part of the Malacca Strait, which is one of the highest shrimps catch areas in Indonesia. The existence of a high mangrove population and muddy beaches make this area an important habitat for all Penaeid shrimps. However, in recent years, the state of the mangrove forests on
the east littoral of Sumatra has continued to decline, causing a decrease in the stock of Penaeid shrimps in this area and this state has happened in the Langsa mangrove forest [6]. One of the causes of the decline in the stock of Penaeid shrimps in the waters of the mangrove forest is the degradation of mangrove habitat, thereby reducing the survival of Penaeid shrimps. *Penaeus indicus* and *Penaeus merguiensis* are crustaceans belonging to the order decapods and the family Penaeidae [7, 8], which are most abundant in the Langsa mangrove forest. These two Penaeid shrimps have high economic value, so they are the main targets for fishing in the wild [9].

The increasing number of Penaeid shrimp catches can endanger the survival of their population in nature, so it is necessary to conduct research to assess the survival and growth of *P. indicus* and *P. merguiensis* shrimps. Research on these two Penaeid shrimps has been widely reported, such as growth patterns study [10-23]; morphometric study [24, 25]; distribution pattern study [26, 27]. However, there is no information about the growth pattern of *P. indicus* and *P. merguiensis* in the in the Langsa mangrove forest. This study aims to determine the growth pattern of *P. indicus* and *P. merguiensis* in the Langsa mangrove forest, Aceh Province. Furthermore, this study is expected to provide data on the environmental conditions of the Langsa City mangrove forest on the growth patterns of *P. indicus* and *P. merguiensis* shrimps, which ultimately determine the abundance and catch of commercial adult shrimps.

2. Material and Methods

2.1. Time and Site

This research was conducted on November 13-14 in the Langsa mangrove forest, Aceh Province, Indonesia (Figure 1). The site of sampling was chosen by stratified random sampling, where the location was selected based on three zones namely inside, middle and outside zones of the Langsa mangrove forest.

![Figure 1. Research site in Langsa mangrove forest, Aceh Province](image-url)
2.2. Sampling procedure
Shrimps samples were collected using phok (a fishing tool used by local fishermen). Phok is applied by fishermen in the area of small rivers with a net area of ± 200 meters and a net size of 1.5 inches, which is considered selective in catching large shrimps. Shrimps collection is carried out at night. The caught shrimps are placed in a sample box. The shrimps caught were selected based on the type of species, then the length of the shrimps was measured using a digital caliper Z503576-1EA with an accuracy of 0.1 mm (Sigma-Aldrich), while the weight was measured using a digital scale (Adam Equipment Product, USA).

2.3. Length-weight relationship analysis
Shrimps growth pattern estimation was carried out using the Linear Allometric Model (LAM) by De-Robertis and William [28] with the following formula: \( W = \text{total body weight (g)}, \ L = \text{total length (mm)} \), \( a = \text{model regression intercept}, \ b = \text{regression coefficient}, \ e = \text{variance of the LAM model residuals}, \) 0.56 as a correction factor.

2.4. Relative weight condition factor
The calculation of the relative weight condition factor (Wr) follows the Wr calculation carried out by Rypel and Richter, namely \( Wr = \left( \frac{W}{W_s} \right) \times 100 \), where \( W = \text{body weight (g)}, \ W_s = \text{weight prediction based on the LAM model}, \) formulated by \( W_s = axL^b \) [29].

3. Results and Discussions
A total of 124 Penaeid shrimp samples were collected, \( Penaeus \text{ indicus} \) 92 samples and \( Penaeus \text{ merguiensis} \) 32 samples. Total length measurement data shows the average total length (TL) of \( P. \text{ indicus} \) was 18.50 mm (mean±SD; max. 23.5 mm and min. 14.5 mm) while \( P. \text{ merguiensis} \) was 22.99 mm (mean±SD; max. 34.9 mm and min. 17.5 mm). The average weight of \( P. \text{ indicus} \) was 5.29 g (mean±SD; max. 12.7 g and min 2.1 g) and \( P. \text{ merguiensis} \) 11.2 g (mean±SD; max. 31.1 g and min 4.5 g). The measurement data indicated that the total length and weight of \( P. \text{ merguiensis} \) were higher than \( P. \text{ indicus} \). Penaeid shrimp distribution in the same area has been previously reported by Damora et al. [27], which dominate the distribution of \( P. \text{ indicus} \) at 70.49% while \( P. \text{ merguiensis} \) at 25.41% and \( P. \text{ monodon} \) at 4.09%. Thus, it can be described that \( P. \text{ indicus} \) dominate in the waters of the Langsa mangrove forest compared with \( P. \text{ merguiensis} \).

Data analysis of the length-weight relationship shows that the highest \( b \) value was shown in \( P. \text{ merguiensis} \) species of 2.87 while \( P. \text{ indicus} \) was 2.55 (Figure 2). The results showed that the growth pattern of both Penaeid shrimps was negative allometric with a value of \( b < 3 \), which means that the length increase was faster than the weight gain. The negative allometric growth pattern illustrates that a species is experiencing adaptation efforts to conditions in the waters, such as aquatic environmental conditions, food availability and exploitation levels [30].

![Figure 2. Length-weight relationship of (a) Penaeus indicus (b) Penaeus merguiensis](image-url)
Figure 3. Comparison of observed and predicted growth for (a) Penaeus indicus (b) Penaeus merguiensis

Table 1. Report of the growth pattern P. merguiensis and P. indicus in our study and other areas in Indonesia.

| Species           | Location    | a   | b   | r²   | Growth Pattern         | References |
|-------------------|-------------|-----|-----|------|------------------------|------------|
| P. merguiensis    | Langsa      | 0.002 | 2.55 | 0.87 | Negative Allometric   | Recent study|
| P. indicus        | Langsa      | 0.001 | 2.87 | 0.98 | Negative Allometric   |            |
| P. merguiensis    | East Aceh   | 0.05 | 1.78 | 0.76 | Negative Allometric   | [14]       |
| P. indicus        | East Aceh   | 0.07 | 1.72 | 0.70 | Negative Allometric   |            |
| P. merguiensis    | Segara anakan | 0.009 | 2.24 | 0.81 | Negative Allometric   | [22]       |
| P. merguiensis    | Dolak       | -   | 2.44 | 0.95 | Negative Allometric   | [11]       |
| P. merguiensis    | Bagan Asahan | -   | 2.984 | 0.93 | Negative Allometric   |            |
| P. indica         | Bagan Asahan | -   | 3.18 | 0.92 | Positive Allometric   | [21]       |
| P. merguiensis    | West Aceh   | -   | 2.95 | 0.95 | Isometric              |            |
| P. merguiensis    | West Aceh   | -   | 3.12 | 0.89 | Isometric              | [16]       |
| P. merguiensis    | Nagan Raya  | -   | 2.42 | 0.76 | Negative Allometric   |            |
| P. merguiensis    | Nagan Raya  | -   | 2.69 | 0.96 | Negative Allometric   | [17]       |
| P. merguiensis    | Berombang   | -   | 3.30 | 0.79 | Positive Allometric   |            |
| P. merguiensis    | Berombang   | -   | 3.54 | 0.80 | Positive Allometric   | [13]       |
| P. indica         | Belawan     | -   | 2.82 | 0.88 | Negative Allometric   | [10]       |
| P. merguiensis    | Cilacap     | -   | 2.62 | -    | Negative Allometric   |            |
| P. merguiensis    | Cilacap     | -   | 3.10 | -    | Isometric              | [18]       |
| P. indica         | Karang Gading | -   | -   | 0.94 | Negative Allometric   | [12]       |
| P. merguiensis    | Kaimana     | -   | -   | 0.80 | Negative Allometric   |            |
| P. merguiensis    | Kaimana     | -   | -   | 0.80 | Negative Allometric   | [15]       |
| P. indicus        | North Coast | -   | -   | -    | Negative Allometric   | [19]       |
| P. indicus        | North Coast | -   | -   | -    | Negative Allometric   | [20]       |
| P. indicus        | Brebes      | -   | -   | 0.83 | Isometric              |            |
| P. indicus        | Brebes      | -   | -   | 0.94 | Negative Allometric   |            |
| P. indicus        | Tegal       | -   | -   | 0.89 | Positive Allometric   | [23]       |
| P. indicus        | Tegal       | -   | -   | 0.87 | Isometric              |            |

Descriptions: a= model regression intercept; b= regression coefficient, r²= coefficient of determination

Studies related to the growth patterns of the two Penaeid shrimp have been reported in other areas of Indonesia, which are presented in Table 1. The Table 1 shows that there are differences in growth patterns of the two Penaeid shrimps in Indonesian waters, but in general negative allometric growth patterns dominate in each region, these differences may reflect the influence of different factors such as habitat type and eating habits. Froese [31], suggested that the length-weight relationship of fish can be
different in each habitat, this is due to the influence of various factors, such as habitat, size range, growth, sex and season. The comparison between the measured growth pattern and the predictions listed in Figure 3. The graph shows that both the data are mutually correlated, meaning that the observed and predicted values show good results.

Furthermore, the relative weight condition factor (Wr) of both Penaeid shrimps ranged from 100.26 to 100.95 (Wr > 100), this shows that the waters of the mangrove forest are still able to maintain and support the survival of shrimps. In addition, the Wr value also represents health and physiological conditions that are directly related to the ecology of the waters where the shrimps live [32]. According to Muchlisin et al. [33], a Wr value > 100 describes stable environmental conditions, low predators, the food sources available and low foraging competition among populations. However, the latest research (in 2020) reported that the mangrove forest of Langsa City is experiencing forest criticality with an area of damage reaching 2,556.82 ha and heavily damaged reaching 1,955.96 ha [34]. Based on the Ministry of Environment Regulation No. 201 of 2004 states that the damaged mangrove forest ecosystem can be divided into three levels, namely light, moderate and severe damage. Damage to the light category only has a small effect on the life of the fauna, for the damage to the moderate category can result in most of the fauna losing their food and shelter sources, while the damage to the heavy category can result in the life of the fauna living there being threatened and even causing the extinction of species [35]. If there is no special handling of this criticality, it will cause ongoing damage so that it has a bad impact on the sustainability of mangrove plants and also disrupts the survival of organisms that live in the Langsa mangrove forest.

4. Conclusion
It can be concluded that *Penaeus indicus* and *Penaeus merguiensis* in the Langsa mangrove forest, Aceh Province, have a negative allometric growth pattern with the Wr value of both Penaeid shrimp ranged from 100.26 to 100.95 (Wr > 100), which indicates that the waters of the mangrove forest in the City of Langsa was still able to support the survival of *P. indicus* and *P. merguiensis*.

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