Analysis of allometric growth and condition index of tiger shrimp (Penaeus monodon) in Juata Laut Waters and Fishpond, Tarakan (Indonesia)

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Abstract. The purposes of this research were to analyze the growth of allometric and condition index of tiger shrimp (P. monodon) in Juata Laut waters and fishpond, Tarakan (Indonesia). The implementation of research for 3 months from January to March 2020. The research method used a quantitative descriptive with a case study and exploratory approach. The determination of the study area was done with purposive judgment sampling originating from the catch of trawl fishermen in Juata Laut waters and fishpond, Tarakan (Indonesia). A sampling of tiger shrimp (P. monodon) based on surveys of the catches from those two locations. The data collection method involved the differences between sex, total length, carapace length, and the total weight of tiger shrimp (P. monodon) in the Laboratory of Fisheries Biology, Faculty of Fisheries and Marine Science, University of Borneo Tarakan. The research variables were sex ratio, allometric growth, and condition index of male and female tiger shrimp. The results from Juata Laut waters obtained a sex ratio for males and females was 2:1 with a percentage of the male at 66.7% and female at 33.3%. The allometric growth, i.e., a total length and a total weight of male was positive and female was negative with a condition index of male and female for thin body shape was 56.3% and 50%; ideal body shape of 12.5% and female not found; fat body shape was 31.3% and 50%, respectively. The results from fishpond showed that the sex ratio for males and females was 1:1.52, with a percentage of 39.6% for males and females was 60.4%. The allometric growth of total length.
and total weight from the male was negative and female was positive with condition index of a male was 2.4% and female was not found; the thin body shapes was 32.7% and 48.4%; the ideal body of 2.4% and 1.6%; the fat body was 57.1% and 50% for each one; very fat body was 2.4% and female was not found.

1. Introduction

Tarakan Island is a part of the coast that has a high economic value ecologically and geomorphologically. However, the waters around the Tarakan border directly between freshwater and seawater are known as the Estuary region administratively. The waters in Tarakan has potential fisheries biological resources such as pomfret, pepija fish (nomei), crabs, white shrimp, and tiger shrimp. Tiger shrimp based on scientific terms known as Penaeus monodon. The distribution of it found in the territorial waters of East Aceh, Java Sea, East Kalimantan, Sebatik of North Kalimantan [1] and Juata Laut waters of Tarakan.

The catching of tiger shrimp (P. monodon) in Juata waters is quite high using trawl and it also found in fishpond areas in Tarakan. The fishpond was traditional so they were influenced by activities directly from nature, especially from tides. The fishing activities by using mini trawls fishing gear are carried out continuously throughout the year. According to Firdaus and Salim [2–5], trawl has a net mesh size of 1.5 inches (0.5 cm). According to Saputra et al. [5], the width of a net was 1 inch. According to Saputra et al. [5], fishermen used mini trawl that has been modified in Juata waters. The potential of shrimp based on the Decree of the Minister of Marine Fisheries Number 50 / KEPMEN-KP / 2017 was 7,945 tons with fully exploited status. Tiger shrimp was cached as 0.05% from the total of fishermen catches that originated from the waters of North Brebes and Tegal, Central Java stated by Wahyuni, Solichin, and Saputra [6].

The research data for tiger shrimp size with a maximum weight can reach 261 grams, according to Uddin, Ghosh, and Maity [7]. The protein content was 149 mg/g [8]. The weight of tiger shrimp with the high protein content causes the high demand from abroad so that many tiger shrimp catches (P. monodon) were sold to large companies, especially for export (cold storage) in Tarakan. However, the great demand from the International community causes the degradation of the size and weight of tiger shrimp from Juata Laut waters, so that efforts were needed in sustainable management.

The potential of fisheries catches by trawl that is not suitable for sustainable management causes degradation of the size and weight of the tiger shrimp population in Juata Laut waters. The application in proper management about the distribution from marine waters and fishpond in Tarakan, so the research is needed to examine the growth of allometric, condition index, and sex ratio of tiger shrimp (P. monodon). The study focus on tiger shrimp (P. monodon) that has done in Kalimantan instead of biological characteristics and utilization level of tiger shrimp in Sebatik waters, North Kalimantan [1] population dynamics and utilization level of tiger shrimp (P. monodon) in Tarakan waters, East Kalimantan (2013). However, there was no research on allometric growth and condition index of tiger shrimp (P. monodon) from Juata Laut waters and ponds in Tarakan city (Indonesia).

The purposes of this study were to analyze the allometric growth and condition index of tiger shrimp (P. monodon) from Juata Laut waters and fishpond in Tarakan city (Indonesia).

2. Material and Method

2.1. Time and Place

The research was conducted for 3 months from January 2020 to March 2020, where the research location in two places, they were Juata Laut waters based on the catches and fishpond in Tarakan. The determination method was designed by using purposive random sampling. The determination of the research location aims to get tiger shrimp (P. monodon) in Juata Laut waters and fishpond, Tarakan city.

2.2. Research Method
The research method used in this study was a quantitative descriptive based on a case study approach. A sampling of tiger shrimp (P. monodon) was done by a direct survey in the field with two different locations. The first location in Juata Laut waters by following the Trawl fishing gear fishermen using the experimental fishing method. The second location was carried out in the fishpond area by using the purposive sampling method.

Samples obtained from these two different locations were collected to take data at the fisheries biology laboratory of the Fisheries and Marine Sciences Faculty, University of Borneo Tarakan. Retrieval of data included sex, total length, and a total weight of tiger shrimp. The data were used for growth testing through allometric growth models and condition index of tiger shrimp (P. monodon). Parameters tested were allometric growth, condition index, and sex ratio variables.

2.3. Growth Parameters

2.3.1. Sex Ratio Variable

The variable of growth parameters, one of them was the sex ratio of tiger shrimp (P. monodon) that was done by direct observation in the laboratory-based on the guideline identification sex of tiger shrimp. Samples that were known to be male and female sex were measured using the Chi-square test by comparing the number of them according to Steel & Torrie [9].

\[ X^2 = \sum \frac{(O_i - e_i)^2}{e_i} \]  

Note  
Oi = Frequency of male and female tiger shrimp that was observed.  
ei = Expectation frequency was male tiger shrimp plus female divided two.  
x\textsuperscript{2} = A value for the random variable x\textsuperscript{2} whose withdrawal distribution, for example, approaches the distribution of x\textsuperscript{2}

The genital ratio or the sex ratio of tiger shrimp was the number that showed about the amount of male and female individuals in a population of certain environmental habitats where the sex ratio uses the equation according to Effendie [10].

\[ Gender\ ratio = M/F \]  

Note:  
M = The amount of male tiger shrimp.  
F = The amount of female tiger shrimp.

2.3.2. Variable Allometric growth. The allometric growth models were the length and weight value to analyze population growth overall used equation based on Bal and Rao [11] and the estimation based on Effendie [12]:

\[ Y = a + X^b \text{ or } \log Y = \log a + b \log X \]  

Note:  
Y = Total weight of P. monodon (gram); X = Total length P. monodon (mm); a+b= coefficient (intercept)

The b value was an allometric coefficient that reflected in relative growth. If b value = 3, allometric growth characteristic was isometric, length growth was the same with weight growth. If b value < 3 (allometric negative) or b > 3 (allometric positive), so length growth was not the same with weight growth. The correlation between length and weight calculated by the correlation coefficient [13].
Table 1. Correlation criteria [14]

| No | Correlation value | Explanation of correlation criteria |
|----|-------------------|-------------------------------------|
| 1  | 0                 | : No correlation                     |
| 2  | >0 – 0.25         | : Very weak correlation              |
| 3  | >0.25 – 0.5       | : Sufficient correlation             |
| 4  | >0.5 – 0.75       | : Strong correlation                 |
| 5  | >0.75 – 0.99      | : very strong correlation            |
| 6  | 1                 | : Perfect correlation                |

2.3.3. Variable Condition index. Condition index of the crustacea based on five criteria i.e. very thin body shape (0.01-0.50), Thin body shape (0.51-0.99), proportional/ideal body shape (1), Fat body shape (1.01-1.50), and very fat body shape (>1.50) [2–4,15,16, 25]. The allometric growth used Weatherley [17] and isometric growth used Lagler [18] and Effendie [12] method. Based on Lagler (1949) in [12] to obtain fish condition factor with isometric growth characteristic can use this equation as follows:

\[ K(TI) = 10^{5}x \frac{W}{L^3} \] (4)

\( W \) = total weight of \( P.monodon \) (gr);
\( L \) = total length of \( P.monodon \) (mm);
10⁵ = the equation was taken, so \( K(TI) \) value was close to 1.

The fish/crustacea condition factor with crustacea \( P.monodon \) allometric characteristic used this equation Weatherley [19]:

\[ Kn = \frac{\bar{W}}{W} \] (5)

\( W \) = total weight of of \( P.monodon \) (gr);
\( \bar{W} \) = allegation of the total weight of \( P.monodon \) (gr);
\( W \) = a \( L^b \) obtained using the regression equation of length-weight) correlation.

Table 2. Modification of [3]

| No | Range of value \( K_{TI} \) | Body shape        |
|----|-----------------------------|-------------------|
| 1  | 0.01 – 0.49                | Very thin body shape |
| 2  | 0.50 – 0.99                | Thin body shape   |
| 3  | 1.00                        | Proportional / ideal shape |
| 4  | 1.01 – 1.50                | Fat body shape    |
| 5  | >1.50                      | Very fat body shape |

3. Results

3.1. Size Distribution and Sex Ratio
The study results showed that the total length of tiger shrimp (\( P.monodon \)) from fishermen’s catches from the Juata Laut waters with male and female types were 19.9 ± 2.6 cm and 19.75 ± 2.05 cm respectively and the total weight obtained for male was 43 ± 18.74 grams and female was 35.345 ± 15.255 grams. The results on tiger shrimp (\( P.monodon \)) from fishpond obtained the total length for male was 13.8 ± 5.8 cm and female was 13.5 ± 2.6 cm. The total weight for male was 13.13 ±10.72 grams and female was 18.17 ±11.16 grams in the fishpond. Based on the total length growth for tiger shrimp that was found, male sex was faster than others in Juata waters. This data was supported by the research from Hedianto, Suryandari, and Tjahjo [20], who explained that female tiger shrimp had faster growth than males at the same age. [21,22] stated that the \( K \) value was a curvature parameter that can explain the velocity of tiger shrimp in reaching its asymptotic length. Hedianto et al. [20]
uttered that the total length growth of male tiger shrimp (30.36 cm) was faster than female (23,104 cm) in Aceh waters.

Whereas the fastest growth of tiger shrimp (*P. monodon*) was male sex than others in Juata Laut. In table 4 explained that the growth value of allometric from male tiger shrimp was higher (3.4268) than the negative of others, where male tiger shrimps are positive allometry. Besides, the salinity factor was a determinant in the growth rate and the food was quite an abundance in Juata Laut waters. Tiger shrimp maintained in freshwater can adjust the environmental osmotic pressure. Large energy adjustment requires a large amount of energy so it needs food for physiological processes; one of them was the weight growth process.

**Table 3.** Length size structure from *P. monodon* based on location differences and sex ratio

| Location Research | Size   | Male *P. monodon* Deviation Standard Length | Percentage | Female *P. monodon* Deviation Standard Length | Percentage |
|-------------------|--------|---------------------------------------------|------------|---------------------------------------------|------------|
|                   | Small  | 9.34±1.34                                   | 33.30%     | 11.61±0.71                                  | 14.06%     |
| Juata Waters      | Medium | 12.61±1.83                                   | 54.80%     | 13.23±0.81                                  | 64.06%     |
|                   | Large  | 17.07±2.53                                   | 11.90%     | 15.12±0.98                                  | 21.88%     |
| Fishpond          | Small  | 18.04±0.74                                   | 31.30%     | 18.29±0.59                                  | 50.00%     |
|                   | Medium | 19.70±0.81                                   | 37.50%     | 19.26±0.29                                  | 25.00%     |
|                   | Large  | 21.56±0.94                                   | 31.30%     | 20.70±0.36                                  | 25.00%     |

Based on the research results of tiger shrimp (*P. monodon*) from Juata Laut waters, three types of different size distributions (Table 3) match with the data in the field. They are for total length; male tiger shrimp was small with total length size of about 9.34 ± 1.34 cm or 33.3% and female tiger shrimp was in small size with a total length of 11.61 ± 0.71 cm approximately or 14.06%. The medium size of tiger shrimp for male and female was 12.61 ± 1.83 cm or 54.80% and 13.23 ± 0.81 cm with 64.06% percentage (Figure 1).

The results of the study found that the natural growth of tiger shrimp in Juata Laut waters for male and female species obtained in a sufficient abundance than small and large size, where 54.80% male shrimp and 64.06% of medium-sized female shrimp were found in Juata Laut. It indicates that tiger shrimp (*P. monodon*) are quite abundant in Juata Laut waters; however, much small shrimp were caught with a percentage of 33.3% for male and 14.06% for female. If it was viewed from the sex ratio of tiger shrimp (*P. monodon*) for male and female was 39.6% and 60.4% respectively in Juata Laut waters (figure 3). This explained that the composition of tiger shrimp in Tarakan waters was dominated by females than males. These proved that tiger shrimp from Tarakan waters still had a large population. It can be seen from the size, which is quite large, with a size of 17.07 ± 0.94 cm for males and 15.12 ± 0.98 cm for females (Table 3), according to Hedianto et al. [20] that the growth rate of female tends to be faster than male. Primavera [23] stated that female was dominant than male due to it secretes pheromone hormones after molting in response to males. Beard and Wickins [24] also uttered that the right ratio of female and male shrimp could naturally spur copulation.
The results of research on tiger shrimp (*P. monodon*) from fishpond obtained small, medium, and large sizes that are quite varied. Tiger shrimp catches from fishpond based on male get almost the same size, however, the medium size of tiger shrimp about 37.5%, and female was 50% for the smallest size (Figure 2). The data about sex ratio between male and female tiger shrimp from fishpond showed that the differences of them that were 66.7% and 33.3% (Figure 3). The population of tiger shrimp in fishpond was in large amount than in Juata Laut waters, this is in accordance with Primavera [23] explained that tiger shrimp inmate process could occur when female do molting, and it will be followed by 2-3 male tiger shrimp; however, only one male can mate with it.

The results study on the comparison of the tiger shrimp growth based on fishing areas from Juata Laut waters (Figure 1) and fishpond (Figure 2) showed that the tiger shrimp growth from Juata Laut waters was faster than in fishpond. The high salinity makes it easier to adjust for doing osmoregulation of tiger shrimp to the environment so that the energy needed was not too much in adaptation.
3.2. Variable of Allometric Growth

Condition index according to Indarjo et al. [15]; Salim [3]; Salim [4] explained that a number or index did not have a unit where the value describes the body shape of fish or shrimp or crab species according to the provisions in the body shape category criteria as many as 5 categories of body shape and different values. According to Salim [3] that the condition index criteria of the Pisces and crustacean class have 5 different body shape categories. The body shape for Pisces and crustaceans with values ranging from 0.01-0.50 have a very thin body. The condition index value between 0.51-0.99 has a thin body shape. The condition index value with the number of 1.00 explained that the body shape is proportional or ideal. Condition index value from 1.01 - 1.50 has a fat body shape, then > 1.51 has a very fat body shape. Condition index criteria, according to Salim [3]; are used if the body shape from the linear regression equation of the variable differences between total length and total weight had allometric values (b <3) and b> 3). The method used in the allometric equation refers to Weatherley [17].

The results of the condition index from tiger shrimp obtained the highest body shape of males from Juata Laut waters with the thin body shape by 56.3%, the ideal body was 12.5 % (table 5), very thin body and fat were not found. Whereas for female tiger shrimp with a thin and fat body in the same percentage, that was 50% (table 5). However, the very thin body, ideal, and very fat body were not found.

The study results of the condition index for tiger shrimp from fishpond obtained male with the fat body was 57.1% (Table 5), while the very thin and very fat body was 2.4%. The female tiger shrimp that had fat body shape was 50% and the ideal was 1.6%. The very thin and very fat body was not found.

| Criteria Index Condition | Body Shape       | Juata Waters | Fishpond |
|--------------------------|-----------------|--------------|----------|
|                          | *P.monodon*     | Male         | Female   | Male | Female |
| 0                        | No body shape   | 0.0%         | 0.0%     | 0    | 0      |
| 0.01 - 0.49              | Very thin body shape | 0.0%   | 0.0%     | 2.4% | 0.0%   |
| 0.50-0.99                | Thin body shape | 56.3%        | 50.0%    | 35.7%| 48.4%  |
| 1                        | Ideal body shape| 12.5%        | 0.0%     | 2.4% | 1.6%   |
| 1.01 - 1.50              | Fat body shape  | 31.3%        | 50.0%    | 57.1%| 50.0%  |
| > 1.51                   | Very fat body shape | 0.0%   | 0.0%     | 2.4% | 0.0%   |
Figure 4. The condition index criteria of male and female *P. monodon* in Juata Waters

![Condition index criteria of *P. monodon* in Juata Waters](image1)

Based on figure 6, it is obtained that the body shape of tiger shrimp was dominated by males and females with thin body shape cumulatively from Juata Laut waters. Whereas in Figure 7, the male and female tiger shrimp was dominated by the fat body in the fishpond. The significant differences explained that waters condition which was suitable with ecological preference and the food abundance in fishpond better than Juata Laut waters. In Juata Laut waters, the tiger shrimp had large habitat, so the energy that was used in adapted to the environment, especially salinity, prevent the predator, food competition in nature higher than tiger shrimp growth in the fishpond. This data was supported by Hedianto *et al.* [20] stated that salinity could affect the growth rate due to it was influenced by osmotic pressure from the body so it can affect the osmotic rate performance in adapted to the environment, where the tiger shrimp’s ecology in high salinity (seawater) need less energy for adapting and molting.

![Condition index criteria of *P. monodon* in Fishpond](image2)
4. Conclusion
The results from Juata Laut waters obtained sex ratio for male and female was 2:1 with a percentage of the male at 66.7% and female at 33.3%. The allometric growth, i.e., a total length and a total weight of male was positive and female was negative with a condition index for thin body shape was 56.3% and 50%; ideal body shape of 12.5% and female not found; fat body shape was 31.3% and 50%, respectively.

The results from fishpond showed that the sex ratio for males and females was 1:1.52, with a percentage of 39.6% for males and females was 60.4%. The allometric growth for total length and total weight from the male was negative and female was positive with condition index of a male was 2.4% and female was not found; the thin body shape was 32.7% and 48.4%; the ideal body was 2.4% and 1.6%; the fat body was 57.1% and 50% for each one; the very fat body was 2.4%, and female was not found.

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