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The allometric growth and condition index comparison of white shrimp (*Litopenaeus vannamei*) from fishpond and juata laut waters, Tarakan (Indonesia)

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Abstract. This research aims to analyze the allometric growth and condition index of white shrimp (*Litopenaeus vannamei*) from fishpond and Juata Laut waters, Tarakan (Indonesia). The study was conducted for 3 months, from January to March 2020. The objective method was descriptive quantitative with a case study approach. The determination of the research area by using purposive sampling from fishpond and the catches of trawl fishermen from Juata Laut waters, Tarakan (Indonesia). A sampling of white shrimp (*L.vannamei*) used survey methods in those two locations. The data collection was done by using a laboratory scale in the Biology Laboratory of Faculty of Fisheries and Marine Science, University of Borneo Tarakan. The data instead of sex, total length, carapace length, and the total weight of white shrimp (*L.vannamei*). The research variables were sex ratio, allometric growth, and condition index of the male and female white shrimp (*L.vannamei*). The results study showed that white shrimp (*L.vannamei*) from ponds had a sex ratio for males and females of 1:3 with a percentage of males by 25% and females by 75%. The allometric growth, i.e. total length, and total weight for both of sex were negative, condition index with a thinner body was not found for male and 1.9% for females; thin body shape was 50% and 53.7%; ideal body shape was 5.6% while females were not found; the fat body was 44.4% and 40.7%; the fatter body for male was not found and females by 3.7%. The results from Juata Laut waters obtained the sex ratio for males and females was 1.68:1 with the percentage of males was 62.71%, and females were 37.29%. The allometric growth like total length and a total weight of males and females was negative with condition index of males and females for thin body shapes were 48.6% and 45.5%; ideal body shape were 2.7% and 9.1%; fat



body shape was 45.9% and 45.5%; fatter body shape was 2.7%, respectively and females were not found.

1. Introduction

Tarakan is surrounded by various man-made ecosystems such as reservoir and fishpond ecosystems, during the natural consisting of mangrove, watershed, coastal, and estuary ecosystems. Estuary ecosystems in Juata waters, Tarakan has sea biodiversity with a various mammal, Pisces, gastropod, Bivalvia, and crustacean class. Crustacean class has a high economic value; one of them is vannamei shrimp, which is called white shrimp by society.

The condition of marine aquatic biota, according to Wiharyanto & Salim (2014) [1], explained that the influence of the environment is very important in maintaining the existence of aquatic biota, especially white shrimp (*L.vannamei*) to be made one of the ecological preferences in its survival. In addition, waters of the sea developed pond ecosystem activities rapidly that are managed independently by the local community in increasing the potential of white shrimp (*L.vannamei*). This is in accordance with Anggoro (1992) [2] explained that *vannamei* shrimp became one of the commodities demanded by farmers and, according to Fast & Lester (1992) [3] explained that the vannamei shrimp was the world's largest community needs in the 80's.

According to Haliman & Adijaya, (2005) [4] explained that vannamei shrimp was first recognized and found at a depth of 70 m from the Pacific Ocean in the coastal regions of Mexico and Central South America where the ecological preference obtained salinity of 35 ppt and the sea water temperature was $27\pm 1^{\circ}\text{C}$ for reproducing and ecological habitat of *vannamei* larva phase at low salinity (estuary ecosystem). The vannamei shrimp in the estuary region can survive because it was a fertile area and full of natural food, thus shrimp growth develops rapidly into adulthood.

The data in this study used this shrimp because it has advantages over tiger shrimp (*P.monodon*), which according to Umiliana, Sarjito, & Desrina, (2016) [5] stated that vannamei shrimp could be resistant to disease; according to Fast & Lester, (1992) [3] that vannamei shrimp can be resistant to environmental disturbance; according to Purba, (2012) [6] explained that it grew faster than *P.monodon* shrimp where the composition of *vannamei* shrimp was $67\pm 1\%$ higher than *P.monodon* by 62%; according to Supriyono, Supendi, & Nirmala, (2007) [7] that the survival rate of *L.vannamei* shrimp is high, amount to $> 80\%$ [8].

The local term of *L.vannamei* was different from other countries, but it is known as white shrimp in Indonesia. The *L.vannamei* has the characteristic of having a reddish-white pigment that is on the body of the shrimp known as a carotenoid pigment, where the more molting the pigment will be reduced because it is wasted by the molting process [4]. The habitat is in the mud area by immersing themselves and breathing using gills. It also has cannibalism due to it has molting liquid produced by giving off a fragrant odor that makes others shrimp to approach, the way to defend themselves by jumping to the surface of the water so that it can accelerate the release of fragrant white shrimp shell carapace [4].

The *L.vannamei* shrimp do molting because molting is an activity of an organism in growing in the form of weight or body length where a complex biological process occurs with factors that affect it with available/sufficient energy. It requires sustainable management to maximum and long-lasting, so research on the population of *L.vannamei* shrimp is needed consist of allometric growth and condition index from the pond ecosystem and marine waters of Tarakan.

The research objective is a comparative analysis of the allometric growth and index condition of white shrimp (*Litopenaeus vannamei*) from Ponds and Juata Laut Waters, Tarakan (Indonesia).

2. Methodology

2.1. Time and Place

The white shrimp (*L.vannamei*) research was carried out for 3 months from January 2020 to March 2020. The method of conducting the research was purposive random sampling with two different

research stations; they are pond and Juata waters originating from the catch of trawlers in the Tarakan city (Indonesia).

2.2. Research methods

The research method uses quantitative descriptive methods. The sampling method uses the direct survey in the field at two different stations, such as fishpond Juata Laut waters of Tarakan city. The data collection method was carried out with secondary data in the form of sex, total length, and the total weight of white shrimp (*L.vannamei*) in the Biology Laboratory of Fisheries and Marine Science Faculty, University of Borneo Tarakan.

2.3. Research Parameters

The research parameters tested were sex ratio, allometric growth, and index condition parameters of *L.vannamei*. The variables from the sex ratio are male and female; allometric growth variables are the relationship between total length and total weight and condition index variables such as the body shape of *L.vannamei*.

2.3.1. Sex Ratio and size distribution Parameters

The sex ratio is used by comparing the percentage of the male and the female sex variable from white shrimp (*L.vannamei*).

The determination of sex using the method of direct observation on a laboratory scale using a gender identification manual. The sex ratio variable is done by combining the ratio of the number for males and females with the Chi-Square test method according to the Steel & Torrie method, (1993) [9].

$$X^2 = \sum \frac{(O_i - e_i)^2}{e_i} \quad (1)$$

Note O_i = frequency of male and female *L.vannamei* observed
 e_i = the expected frequency, namely the frequency of *L.vannamei* male plus female divided by two
 x^2 = a value for the random variable x^2 whose distribution, for example approaching the distribution of x^2

2.3.2. Allometric growth Parameter

The allometric growth model was the length and weight value to analyze population growth overall use equation-based Bal & Rao (1984) dan The estimation based on Effendie (1979) [10]:

$$Y = a + X^b \text{ or } \log Y = \log a + b \log X \quad (2)$$

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

The value of b was an allometric coefficient that reflected relative growth. When b value=3, allometric growth characteristic was isometric, length growth was the same with weight growth. 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 correlation coefficient Effendie (1979)[10].

Table 1. Correlation criteria [11]

No	Correlation value	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

The condition index of the crustacean/fish was based on five criteria i.e. very flatfish (0.01-0.50), flatfish boy (0.51-0.99), proportional/ideal fish (1), fat fish (1.01-1.50), and the obese fish (>1.50) [12–16, 29].

The allometric growth used Weatherley (1972) [18], and isometric growth used Lagler (1949)[19] and Effendie (1979) [10] method. Based on Lagler, (1949) in Effendie (1979) to obtain fish condition factor with isometric growth characteristic can use this equation as follows:

$$K_{(TI)} = 10^5 x \frac{W}{L^3} \quad (3)$$

W = total weight of *L.vannamei* (gr);

L = total length of *L.vannamei* (mm);

10^5 = the equation was taken, so $K_{(TI)}$ value is close to 1.

The crustacea condition factor with crustacea *L.vannamei* allometric characteristic used this equation [17]:

$$Kn = \frac{\hat{W}}{W} \quad (4)$$

W = total weight of of *L.vannamei* (gr);

$\hat{W}$ = allegation of total weight of *L.vannamei* (gr);

W = a L^b obtained using the regression equation of length-weight) correlation.

Table 2. Modification Efeendie (2003) in Salim, (2013); Salim, (2015); Indarjo et al., (2020)

No	Range Value of K^{TI}	Shape Body
1	0,01 – 0,49	Very thin body shape
2	0,50 – 0,99	Thin body shape
3	1,00	Ideal body shape
4	1,01 – 1,50	Fat body shape
5	>1,50	Very fat body shape

3. Results and Discussion

3.1. Gender Ratio and Size Distribution

The results of the study based on the sex ratio and the total length distribution of male white shrimp (*L.vannamei*) in the ponds obtained sex ratio of 25% (figure 1) with a total length about 14.4 ± 2.9 cm (table 3) and the total weight of $15,345 \pm 5,605$ grams (Table 3), then the sex ratio of male white shrimp (*L.vannamei*) originating from the Juata Laut was 62.71% (figure 1) with a total length about 17.2 ± 1.9 cm (table 3) and the total weight was 24.65 ± 9.21 grams (table 3). This showed that the condition of male shrimp in the Juata waters is abundant compared to in fishpond. This is in accordance with the

opinion of Wiharyanto & Salim, (2014) [1] uttered that the level of biodiversity in the Juata Laut waters was 23 species more than those in fishpond with 19 species. Meanwhile, the total length and total weight in Juata Laut waters is greater than the total length and total weight in the fishpond. This shows that the marine aquatic habitat was larger and there is an abundance of food resources in the waters than in the fishpond where it requires a source of nutritional food derived from tidal activities, this is according to Iromo, Azis, & Cahyadi, ((2010) [21] stated that traditional fishponds require supplies from natural tidal activities.

The research on female *L.vannamei* based on sex ratio and total length structure derived from fishponds was obtained by 75% (figure 1) with a total length of 12.3 ± 6.3 cm (table 3) and total weight about $23,025 \pm 20,055$ grams (table 3), while the sex ratio of *L.vannamei* originating from the Juata Laut was 37.29% (figure 1) with a total length from 17.1 ± 2.7 cm (table 3) and the total weight was $23,485 \pm 10,375$ grams (table 3).

The female sex ratio and the total weight of white shrimp (*L.vannamei*) in fishponds more abundance than Juata Laut waters; however, the total length in Juata Laut waters were larger compared to fishponds. This explains that female *vannamei* shrimp in fishponds are more aggressive in achieving total weight growth than in Juata Laut waters; thus it showed that traditional fishpond waters for female *vannamei* shrimp grow faster. This is in accordance with Wyban & Sweeney, (1991) [22] uttered that the growth of individual female *vannamei* in a fishpond scale is faster than male.

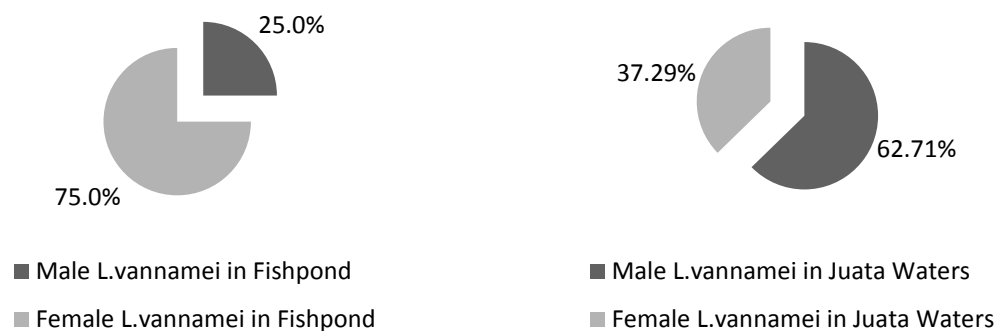


Figure 1. Ratio sex of *L.vannamei* in Fishpond and Juata Laut Waters

Table 3. Structure Size of male and female *L.vannamei* lengths based on study location

Location Research	Structure Size	Male	Female
		Standard Deviation Length total	Standard Deviation Length total
Fishpond	Small	12.29 ± 0.79	7.32 ± 1.32
	Medium	14.09 ± 0.91	10.70 ± 1.29
	Large	16.20 ± 1.10	15.68 ± 2.92
Juata Waters	Small	15.84 ± 0.54	15.16 ± 0.76
	Medium	17.06 ± 0.58	16.86 ± 0.85
	Large	18.42 ± 0.68	18.80 ± 1.00

The research-based on the total length structure of male white shrimp (*L.vannamei*) was obtained in three sizes (table 3); they are small size, medium-size and large size. Based on the results of research on the fishponds, three different sizes were found, i.e., in the small size from 12.29 ± 0.79 cm (table 3) as much as 22.2% (figure 2); the medium size was 14.09 ± 0.91 cm (table 3) of 66.7% (figure 2), and the large size was 16.20 ± 1.10 cm (table 3) of 11.1% (figure 2). There are three different sizes of male

L.vannamei obtained in Juata waters, for small size, the range was 15.84 ± 0.54 cm (table 3) as much as 27.03% (figure 2); medium size about 17.06 ± 0.58 cm (table 3) as 37.84% (figure 2) and large size between 18.42 ± 0.68 cm (table 3) of 35.14% (figure 2). Based on the comparison of the total length from different locations, it was found that the locations in fishponds and Juata Laut waters were found to be the largest total length of white shrimp (*L.vannamei*), which is of medium size. The results of this study explained that the total length of female shrimp (15.68 ± 2.92 cm) in fishponds was faster than male (16.2 ± 1.1 cm); this is in accordance with the statement from Wyban & Sweeney, (1991) that the growth of females grows faster than male *vannamei* shrimp. In addition, in terms of quality, the number of population in fishponds has areas that maintain the density of *vannamei* shrimp, and it does not require much energy in moving due to the absence of predators so that shrimp in fishponds are more focused in weight growth compared to length. This is evidenced from the results of this study explained that the length growth of male *vannamei* (18.42 ± 0.68 cm) and female (18.8 ± 1.00 cm) in the Juata Laut waters is faster than the growth of weight in the fishpond, both of male (16.2 ± 1.1 cm) or female (15.68 ± 2.92 cm).

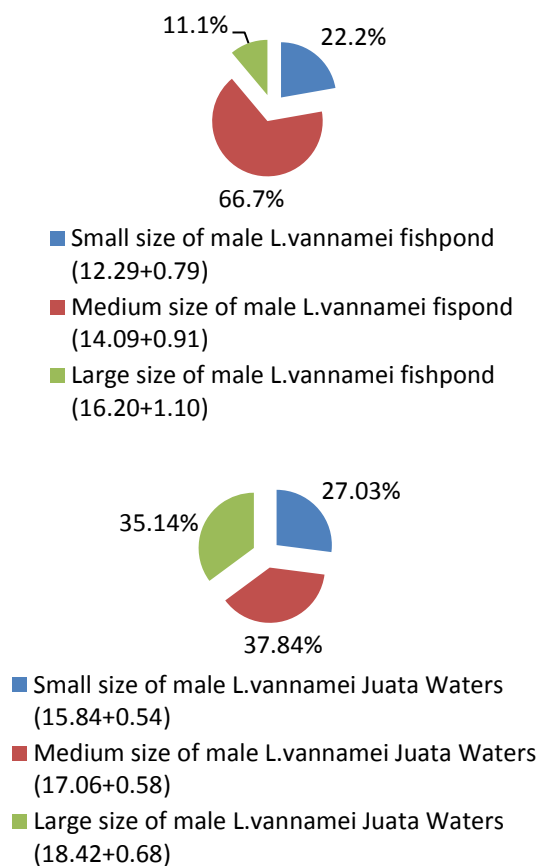


Figure 2. Distribution Structure Length of Male *L.vannamei* in Fishpond and Juata Laut Waters

The results of the study for female shrimp based on the total length with the different locations of the fishpond ecosystem and Juata Laut waters, then get three types of sizes (table 3), such as small size, medium-size and large size. It was found that in fishponds only have two different sizes; they are the small size about 7.32 ± 1.32 cm (table 3) as much as 5.56% (figure 3) and the large size range of 15.68 ± 2.92 cm (table 3) as much as 94.44% (figure 3). Whereas female *L.vannamei* obtained in Juata waters, there are three different sizes, for small size was about 15.16 ± 0.76 cm (table 3) as much as 9.09% (figure 3); medium size with a range between 16.86 ± 0.85 cm (table 3) of 63.64% (figure 3) and large size was 18.80 ± 1.00 cm (table 3) of 27.27% (figure 3). The results of the total length measurement

showed that the growth in Juata Laut waters is faster than the growth in fishponds. This is seen from the type of female *vannamei* size in juata waters is faster than the size in fishponds. This is consistent with the research in table 4, where the value of growth in Juata Laut waters was 2.7167 higher than the growth in ponds of 2.2603. In addition, it can also be seen from the size obtained from the results of this study where the smallest size in Juata Laut waters (15.16 ± 0.76 cm) is greater than the total length of female *vannamei* in fishpond (7.32 ± 1.32 cm).

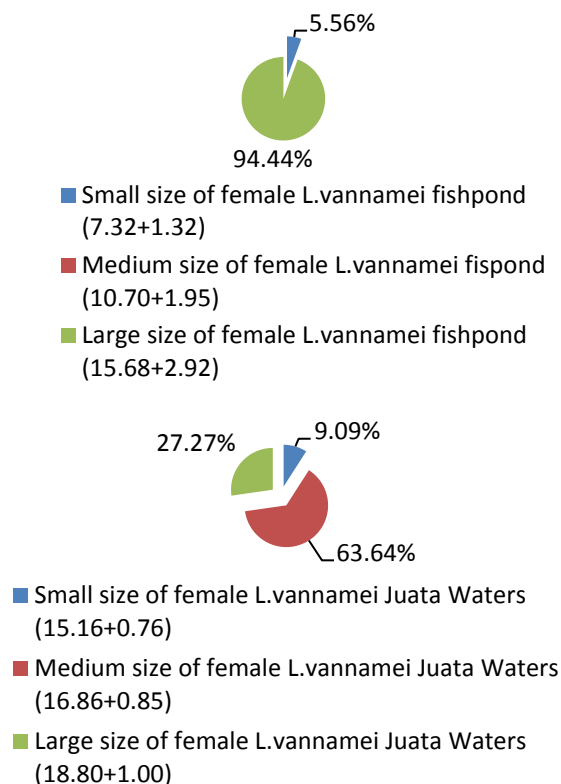


Figure 3. Distribution Structure Length of Female *L.vannamei* in Fishpond and Juata Laut Waters

3.2. Allometric Growth Variable

The allometric growth variable differences were obtained by sex. The results of the research showed for male sex, the growth in Juata Laut waters is better than in fishpond. This can be seen from the value of the linear regression equation derived from Juata Laut waters that is $2.2522x - 1.4157$ (figure 4) with a correlation level of 0.6328 (63.28%) (table 4) and the value of the linear regression equation derived from fishpond waters is $1.9293x - 1.0191$ (figure 4) with a degree correlation of 0.7914 (79.14%) (table 4). As for the regression equation of female sex *vannamei* shrimp, The growth of *vannamei* shrimp in Juata Laut waters is better compared to fishpond ecosystems, which can be seen from the linear regression equation derived from Juata Laut waters by $2.7167x - 2.001$ (figure 4) with a correlation value of 0.8498 (84.98%) (table 4) and the linear regression equation derived from fishpond is $2.2603x - 1.3523$ (figure 4) with a correlation value of 0.9001 (90.01%) (table 4). It is explained that the growth of *vannamei* shrimp both male (1,923 in table 4) or female (2,2603 in table 4) in fishpond location and for both male (2.2522 in table 4) and female (2.7167 in table 4) in Juata Laut waters, then the obtained of allometric growth of b less than three ($b < 3$). According to Effendie, (2002)[23]; Adisusilo, (1983) [24]; Indarjo et al., (2020)[16] uttered that the value of $b < 3$ has negative allometric properties with the total length growth of *vannamei* shrimp is faster than the total weight growth. This is reinforced by the correlation value which shows the range between 63.28% - 90.01%. According Sarwono (2006) [11] if

the correlation value > 50% - 75%, it has a strong correlation and a range > 75% - 99% has a very strong correlation value.

However, from the value of b showed that if the value of b is getting closer to number 3, the growth will be isometric while if it is less than three ($b < 3$) then the growth will be negative allometric. The results of the study are based on male sex by distinguishing between research locations in fishpond and in Juata Laut waters, explained that the growth of *vannamei* shrimp in Juata Laut waters (value $b = 2.2522$ in table 4) is better compared to fishpond (value of $b = 1.9293$ in table 4). Whereas the allometric growth of female sex in Juata Laut waters (value $b = 2.7167$ in table 4) is better than in fishpond waters (value $b = 2.2603$ in table 4). This explains that the growth of *vannamei* shrimp, both of male and female in Juata Laut is better than in fishpond. The growth of white shrimp (*L.vannamei*) is influenced by various environmental factors that are stable because Juata Laut Waters are not too high in changes for salinity that tends to be stable and the presence of an abundance of food. This is in accordance with the statement of Mulfizar, Muchlisin, & Dewiyanti, (2012) [25] that shrimp growth is influenced by stable physiological and environmental conditions such as temperature, pH, salinity and geographical location and according to Anggoro, (1992)[2] said that the respiration rate of *L. vannamei* is in accordance with the availability of dissolved oxygen contained in waters with stable salinity, the shrimp respiration rate is included in the osmoregulator category. Otherwise, the results from fishpond can cause high salinity due to the evaporation of freshwater, this is in accordance with Boyd & Fast, (1992) that shrimp can live and grow well in waters with a range of salinity between 15 ‰ - 30 ‰, thus if it has too high salinity, it can cause the shrimp growth rate to decline, so the *vannamei* shrimp respiration rate including osmoregulator category [2].

The growth of *vannamei* shrimp both male and female in two different study locations obtained non-isometric growth patterns (allometric); this is explained by Nair et al. (2015) that allometric growth is affected by changes in specific gravity and physical shape in the growth process.

Table 4. The allometric growth of Male and Female *L. vannamei* by study location

Location Research	Male <i>L.vannamei</i>			Female <i>L.vannamei</i>		
	b Value	Growth Allometric	Correlation	Regression Linear	Growth Allometric	Correlation
Fishpond	1.9293	Allometric negative	0.7914 79.14%	2.2603	Allometric negative	0.9001 90.01%
Juata Waters	2.2522	Allometric negative	0.6328 63.28%	2.7167	Allometric negative	0.8498 84.98%

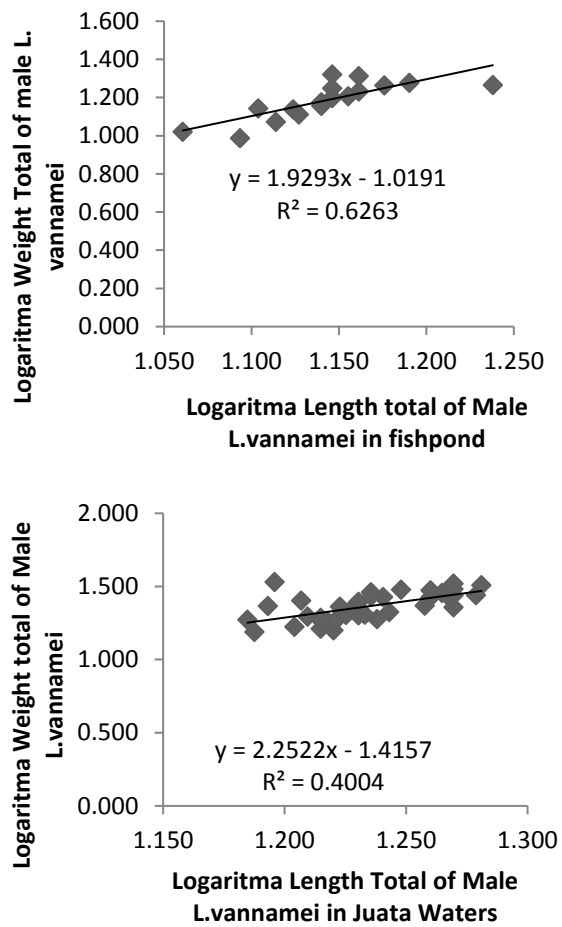


Figure 4. Relationship of total length of male *L. vannamei* based on study location

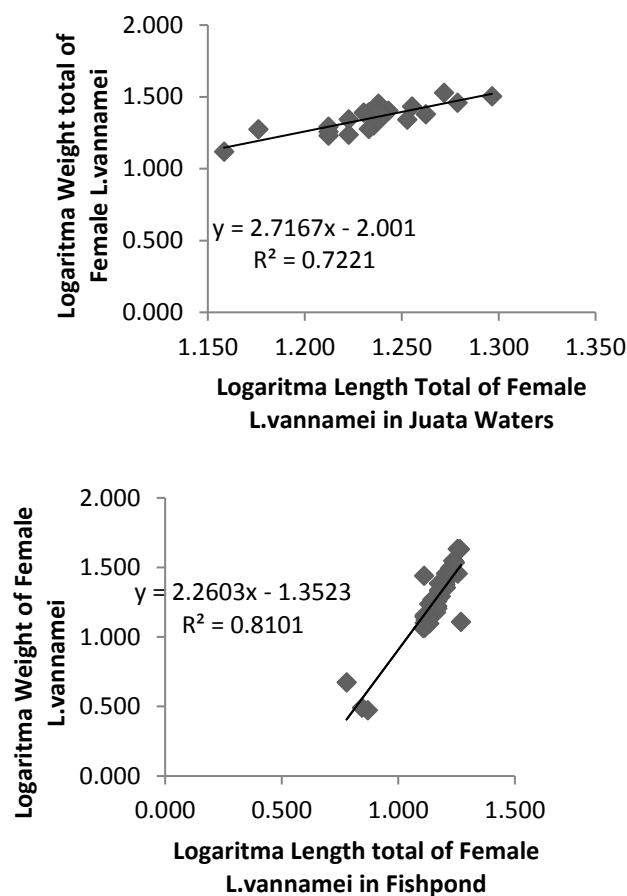


Figure 5. The correlation of total length and weight of female *L.vannamei* based on research location

3.3. Condition Index Variable

The research of Salim (2013) [13] stated that a condition index is a number that describes the body shape growth of biota or marine water organisms from the Pisces and crustacean class, where the division of the body shape criteria is categorized into 6 different parts. There are 5 categories of body shape criteria according to the modification of Salim, (2013) [13], Salim, (2015) [14] and Indarjo et al., (2020) [16], i.e., very thin body; thin body; ideal body; fat body, and very fat body shape. Salim, (2013) [13] explained that the condition index value of Pisces or crustaceans could describe the body shape of the thin category ($K_n < 1$), proportional category ($K_n = 1$) and the fat category ($K_n > 1$).

According to Indarjo et al., (2020) that the application in the use of the condition index method is adjusted to the results obtained from the allometric growth model. If the results obtained isometric, then using a formula based on Effendie, (1979) while the research indicates allometric, then using a formula based on Weatherley, (1972). The condition index criteria values are obtained based on table 2 regarding the modification of Efeendie (2003) in Salim, (2013), Salim, (2015) and Indarjo et al., (2020).

The condition index value in male *vannamei* shrimp originating from marine waters, there are four categories (table 5), they are a thin body with 48.6%; the ideal body was 2.7%; fat body shape of 45.9% and very fat body shape was 2.7%, while male *vannamei* from the fishpond ecosystem contained three categories (table 5), i.e. thin body shape as 50%; ideal body shape by 5.6% and fat body shape of 44.4%. This explains that the body shape of male *vannamei* that was found in Juata Laut waters is better than in the fishpond ecosystem, where it is influenced by environmental factors, especially from food and sex. This is in accordance with Effendie, (1979); Tesch, (1971) [26]; Ricker, (1973) [27]; Rosli & Isa,

(2012) [28], said that variations value of condition factors depend on food factors, age, sex and gonad maturity level.

Table 5. Index criteria for male and female conditions based on the study location

Criteria Index Condition	Body Shape <i>L.vannamei</i>	Male		Female	
		Fishpond	Juata Laut Waters	Fishpond	Juata Laut Waters
0	No body shape	0.00%	0%	0.00%	0%
0.01 - 0.49	Very thin body shape	0.00%	0.00%	1.90%	0.00%
0.50-0.99	Thin body shape	50.00%	48.60%	53.70%	45.50%
1	Ideal body shape	5.60%	2.70%	0.00%	9.10%
1.01 - 1.50	Fat body shape	44.40%	45.90%	40.70%	45.50%
> 1.51	Very fat body shape	0.00%	2.70%	3.70%	0.00%

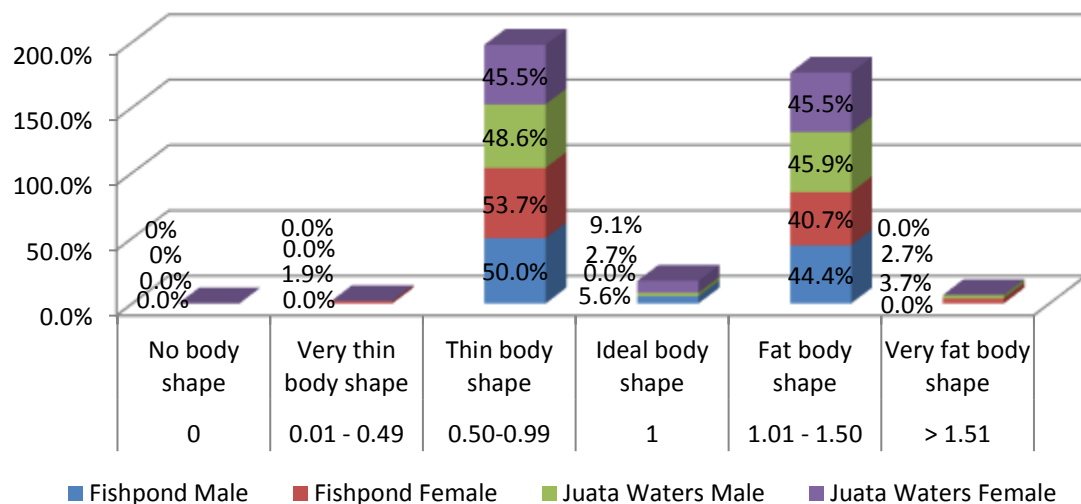


Figure 6. The percentage of body shape criteria based on research location and gender

The results of the research showed that female *vannamei* from Juata Laut waters has three categories of condition index (body shape) (table 5), that is thin body shape by 45.5%; ideal body by 9.1%; and fat body shape by 45.5%, while female from the fishpond ecosystem has four categories, namely very thin body shape by 1.9%; the thin body was 53.7%; fat body shape of 40.7% and very fat body shape by 3.7%. This showed that the habitat condition of female *L.vannamei* in Juata Laut waters could affect growth which has a wide habitat by not taking into account population density and environmental factors that tend to be stable compared to the fishpond, so the fat body forms are found in large amount than fishpond ecosystem. This is in accordance to Effendie, (1997) where abiotic factors can affect growth, such as temperature, salinity, pH, feed, the density of organisms, parasites, and disease.

4. Conclusions

The results obtained that *L. vannamei* shrimp from fishpond based on sex ratio for male and female, which is 1: 3 with a percentage of 25% and 75%. The male *L. vannamei* shrimp has a negative allometric with a percentage value of condition index for male lean body shape was 50%; the ideal shape was 5.6%, and the fat body was 44.4%. Otherwise, female *L. vannamei* was negative allometric with a percentage

value index for very thin body shapes was 1.9%; the thin body was 53.7%; body shape fat was 40.7%, and very fat body shape was 3.7%.

The results showed *L. vannamei* shrimp from Juata Laut waters based on sex ratio for male and female sex was 1.68: 1, with a percentage of 62.71% and 37.29%. The results for allometric growth between total length and total weight for male *L. vannamei* was negative allometric with a percentage of condition index for lean body shape was 48.6%; the ideal body was 2.7%, and the fat body was 45.9%, and very fat body shape was 2.7%. Whereas, Female *L. vannamei* was negative allometric with a percentage index value for the thin body was 45.5%; the ideal body was 9.1%, and fat body shape was 45.5%.

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