The Length-Weight Relationships and Condition Factors of *Potamocorbula faba* Hinds., 1843 in the Permisan Bay, East Java, Indonesia

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Abstract. The objective of the study was to determine the growth pattern of clam *Potamocorbula faba* inhabited the estuarine of Permisan Bay, Indonesia by using the Linear Allometric Model (LAM). Its also evaluated by using the length-weight relationships (LWR) and Fulton's condition factor (K–value). A total of 7 996 specimens with length intervals of 3.5 mm to 17 mm and weight intervals of 0.013 g to 0.636 g were collected from nine sites in Permisan Bay. Based on the length-weight relationships (LWR), equations in ST–1 (0.000886870 $L^{2.17379}$); ST–2 (0.000884219 $L^{2.15471}$); ST–3 (0.000832626 $L^{2.18971}$); ST–4 (0.000746758 $L^{2.21150}$); ST–5 (0.000687148 $L^{2.28593}$); ST–6 (0.000765876 $L^{2.23830}$); ST–7 (0.000657461 $L^{2.31064}$); ST–8 (0.000379673 $L^{2.52229}$); and ST–9 (0.000799816 $L^{2.22922}$) were obtained. Regarding the *b*–value, almost all sites showed b < 3, and thus the growth pattern could be categorized as negative allometric. Condition factor (K-value) in all nine sites ranged between 1.1101 to 1.1552. The highest K-value was from ST–7 while ST–2 showed the lowest. During the study period (September 2014 to April 2015), Fulton's condition factor (K–value) of all nine sites was not significantly different ($P > 0.05$).

Keywords: Allometric variable, bivalve species, dynamic population, environmental, growth pattern

1 Introduction

Potamocorbula faba Hinds, 1843 [1] is a bivalve species that thrive in the estuarine of Permisan Bay, Sidoarjo, East Java, Indonesia; the clam was dispersed in the shallow water floor of the high intertidal zone [2]. Studies of bivalve biology and allometric variables were required to manage resources either under normal as well as degraded environmental conditions. Several environmental factors are known to influence the

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morphology and the body's relative proportion of shell are latitude, depth, coastal level, tidal, current, water turbulence, wave exposure, type of seafloor, and type of sediment [3–6]. Those variables are therefore important to provide information regarding growth rate and organism condition, recruitment prediction, stock estimation, and also to solve taxonomic problems. Earlier studies about allometric relationships of bivalve species from some researchers were used as references for this study [7–16].

Length-weight relationships (LWR) and Fulton's condition factor are crucial biological parameters in providing information about growth rate, growth pattern, and individual conditions. Fulton's condition factor of the body or K–value is most useful in explaining the well-being of a species and finding out the difference that emerges due to seasonal changes; in particular those related to the age and sex of the organism in a habitat [17, 18]. It gives a useful comparison of the relative weight of the organism against its length. Fulton's condition factor also reflects the bivalve physiological characteristics such as morphology, nutritional value, and growth rate [19]. Furthermore, if regularly examined, this K–value could also be used to assess the overall health, productivity, and the physiology of bivalve population [20].

For the last decade, the ecological conditions of Permisan bay have undergone a drastic change. It might be due to the deforestation of mangroves, fishpond waste, industrial waste, global climate change as well as other human activities which caused a decline in water quality (pers. comm with local government). As the consequence, those activities affect the physiological and morphological condition of *P. faba*.

The biology and growth studies have been conducted on some *Corbula* species, such as those carried out by [10, 21–24]. However, specific studies concerning length-weight relationships (LWR) and condition factor of *Potamocorbula* species in Indonesia are still very limited or none.

As it is believed to be the first for *P. faba* in Indonesia, the objective of this study was to provide baseline data for comprehensive management of the species, in particular the estuarine population of Permisan Bay.

2 Materials and methods

2.1 Study site and sampling methods

P. faba sample was collected in the estuarine of Permisan Bay, Sidoarjo, East Java, Indonesia. Sampling locations were located in nine sites (Figure 1).

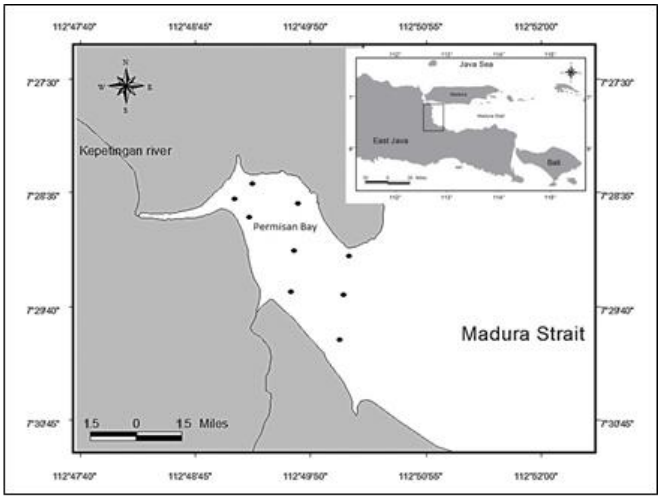

Fig. 1. Sampling location of *P. faba* in Permisan Bay, East Java, Indonesia.

Collected specimens were taken from within quadratic box 1 m^2 placed at the sediment-water interface. All sediment substrates were sampled until 10 cm depth. *P. faba* was collected by hand, put into a zipped–plastic bag wrapped in aluminum foil inside a cool–box prior to being transported to the laboratory for further treatments, *i.e.* cleaning, sorting, weighing, and measuring. Specimen within the length interval of 3.5 mm to 17 mm were collected randomly. Shell length was measured using a vernier caliper of 0.05 mm precision. Bodyweight was measured by means of an electronic weight with an accuracy of 0.001 g.

Length and weight relationships of *P. faba* to evaluate the growth pattern were analyzed using this Equation (1)

$$W = \alpha L^b \text{ [25, 7–10]} \quad (1)$$

urging the specimen evenly treated all ways long through the process. Subsequently, length and weight relationships were analyzed using The Linear Allometric Model (LAM) with Equation (2):

$$\log W = \log a + b \log L \quad (2)$$

where x and Y are the measurements of parts of the body to be compared, i.e., W= total weight (gram) and L= length (mm).

The exponent *b* is the growth coefficient, which illustrates the relative growth rate of the two variables measured while the constant *a,* is the value of Y when x is unity. Therefore, since in this study Y is a weight or volume (cubic: g or cm^3) and x is a length (linear: cm), then b equal to 3/1 would correspond to isometry. If b is greater than 3/1 is positively allometry, whilst if it was less than 3/1 is negatively allometry. A simple t-test was applied to confirm b–value against 3 [26, 7–10], and one–way ANOVA using the SPSS 11.5 statistical was used to evaluate the difference between sites combinations.

2.2 Condition factor (K)

Fulton's condition factor is usually used as species well–being indicator and it could reflect the seasonal effect and the habitat difference in an organism [18]. Calculating the ratio of weight and length serves as a way to evaluate the physical condition of individuals. A larger ratio would indicate better condition. This condition is shown by the value of the condition factor [27, 28]. In this study Fulton's condition factor (K) was calculated using the following Equation 3 [29]:

$$K = \frac{1000\ W}{L^3} \quad (3)$$

The Relative Condition Factor (K_n) hence exerted (Equation 4) :

$$K = \frac{W}{\alpha L^b} \quad (4)$$

for which K = condition factor, W = specimen body weight (g), L = specimen body length (mm), the value of a and b come from the length weight relationships. K–value significance was analyzed using one–way ANOVA [26] to compare species condition between the observed sites.

3 Result

Parameter of the relationships between the length and body weight of *P. faba* from the Permisan bay, Indonesia is shown in Table 1. Based on all sites in the study, the mean total length ranged from 9.998 mm ± 2.222 mm to 10.390 mm ± 2.225 mm. The largest average TL of *P. faba* was found in ST–8, while the minimum TL was observed in ST–7. In general, the total length of all nine sites did not show any significant difference ($P > 0.05$).

In addition, the mean of body weight (BW) ranged from 0.145 g ± 0.092 g to 0.162 g ± 0.105 g. The heaviest average body weight of *P. faba* was observed in ST–9 and the minimum was found in ST–2. In this study, the bodyweight of all nine sites was not significantly different ($P > 0.05$).

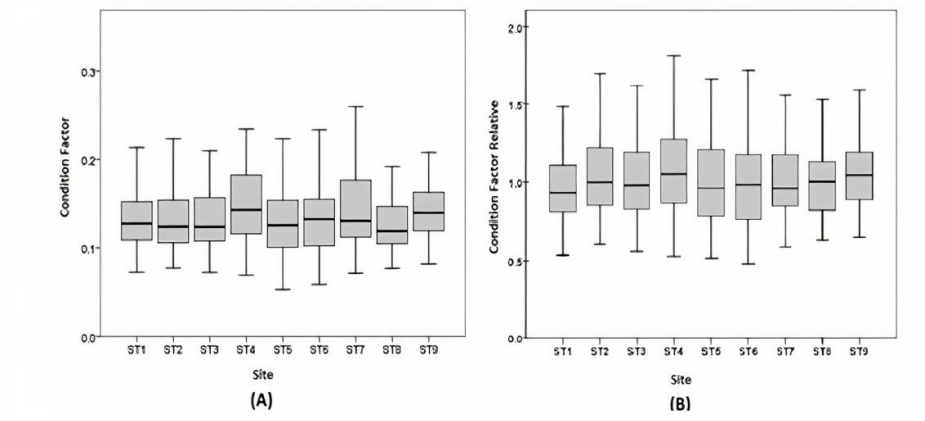

Fig. 2. Box–plots of Fulton's condition factor of the *P. faba* at nine sites. (A) condition factor (B) relative condition factor (K_n), significant at $P > 0.05$ to the relevant site. (Line = median, box = 25th and 75th percentile, whiskers = 10th and 90th percentile).

The present study showed that the collected specimens have a size ranging from 3.5 mm to 17 mm, which was then later used to calculate the length-weight relationships (LWR). Intercept (*a*–value) of LWR ranged from 0.000 379 673 to 0.000 886 870. The lowest *a*–value was in ST–8 and the highest was in ST–1. Slope (b–value) ranged from 2.522 29 to 2.154 71. The lowest b–value was in ST–2 and the highest value was found in ST–8. Based on the coefficient of determination (r^2) which ranged from 0.87 to 0.90, shell length and body weight was highly correlated. The relationship between length and weight was negative allometry.

Box–plots of Fulton's condition factor of *P. faba* at the nine site is presented in Figure 1. The median condition factor (K) value for all nine sites ranged between 0.063 1 to 0.278 7 The highest median of the *P. faba* condition factor was found in ST–4 while the lowest value was observed in ST–8 as shown in Figure 1 (A). Based on all K–values in the study, the condition factor was not significantly different between all sites ($P > 0.05$).

On the other hand, the median relative condition factor (K_n) value for all nine sites was ranged between 0.936 45 to 1.050 66 and the highest median of *P. faba* condition factor was found in ST–4. Meanwhile, the lowest value was observed in ST–1 as presented in Figure 1 (B). Based on all K–value in the study, the condition factor was not significantly different between all sites ($P > 0.05$).

Table 1a. Descriptive statistics and allometric relationships between the length and the bodyweight of *P. faba* in Permisan Bay, Indonesia

Site	N, ind.	Total Length/TL (mm)				Body Weight/BW (g)			
		mean	SD	min	max	Mean	SD	min	max
ST–1	405	9.998	2.266	4.27	16.81	0.149	0.101	0.022	0.581
ST–2	222	10.156	2.134	5.09	15.76	0.145	0.092	0.034	0.502
ST–3	319	10.208	2.247	4.56	15.99	0.152	0.104	0.033	0.563
ST–4	2604	10.179	2.256	1.11	17.79	0.158	0.110	0.013	0.634
ST–5	1843	10.159	2.254	3.67	17.92	0.157	0.111	0.034	0.632
ST–6	2225	10.160	2.283	4.00	17.99	0.157	0.112	0.025	0.636
ST–7	126	9.987	2.222	4.71	16.61	0.155	0.115	0.036	0.492

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Table 1a. Continued

Site	N, ind.	Total Length/TL (mm)				Body Weight/BW (g)			
		mean	SD	min	max	Mean	SD	min	max
ST–8	84	10.390	2.225	5.21	16.49	0.160	0.117	0.033	0.571
ST–9	168	10.295	2.222	4.10	16.21	0.162	0.105	0.041	0.483

*significant at $P < 0.05$; (N = number of *P. faba* examined. min = minimum, max = maximum, a = constant, b = slope (growth exponent), S.E. = standard error, r^2 = coefficient of determination, S.D. = standard deviation).

Table 1b. Descriptive statistics and allometric relationships between the length and the bodyweight of *P. faba* in Permisan Bay, Indonesia

Site	N, ind.	Length–Weight Relationship $W = aL^3$		SE *of b*	r^2	Relationship (t–test)
		a	b			
ST–1	405	$8.8687 * 10^{-4}$	217.379	0.056	0.89	Allometry -
ST–2	222	$8.8422 * 10^{-4}$	215.471	0.082	0.87	Allometry -
ST–3	319	$8.3263 * 10^{-4}$	218.971	0.068	0.88	Allometry -
ST–4	2604	$7.4676 * 10^{-4}$	225.226	0.024	0.87	Allometry -
ST–5	1843	$6.8715 * 10^{-4}$	228.593	0.027	0.89	Allometry -
ST–6	2225	$7.6588 * 10^{-4}$	223.856	0.026	0.88	Allometry -
ST–7	126	$6.5746 * 10^{-4}$	231.064	0.119	0.87	Allometry -
ST–8	84	$3.7967 * 10^{-4}$	252.229	0.137	0.90	Allometry -
ST–9	168	$7.9982 * 10^{-4}$	222.922	0.087	0.89	Allometry -

*significant at $P < 0.05$; (N = number of *P. faba* examined. min = minimum, max = maximum, a = constant, b = slope (growth exponent), S.E. = standard error, r^2 = coefficient of determination, S.D. = standard deviation).

4 Discussion

Relationships length-weight was meant to estimate the growth rate of shell *P. faba*. The growth pattern was evaluated through the dispersion tendency of length and weight data obtained from the morphometrical components. Parameter estimation (coefficient of length-weight correlation), b (slope), and determination of coefficient (r^2) were analyzed using power regression simplified using the logarithmic equation [30]. This study aimed to discover the relationships of length-weight of *P. faba* in order to obtain information regarding the allometric or isometric growth pattern of *P. faba* based on b–value (slope) indication from the equation.

Generally, according to Froese [31], the exponent *b*–value lies between 2.5 and 3.5. On the contrary, Jisr *et al.* [10] showed that the pattern of the length-weight relationship in several bivalves has *b*-value ranging from 0.823 to 3.016 and an r-value ranging from 0.051 to 0.898. It indicates a close correlation. The allometric pattern is considered positive if b–value >3, while the negative allometric pattern is indicated by b-value < 3. If b-value = 3 in the bivalve shell, it means that the growth pattern is isometric [30].

Based on results from this study, the length-weight relationships pattern of *P. Faba* *b*–value ranged between 2.154 71 to 2.522 29. Thus, the growth pattern of this species was categorized as negative allometric (b < 3) (Table 1b). It also means that the length increase is faster than tissue weight. Therefore, it can be stated that *P. faba* has an unbalanced growth. The same results were reported by Jisr *et al.* [10] reporting that the *b*-value of *Corbula gibba* (Olivi, 1792) was 2.963 showing a negative allometric growth pattern. On the opposite, Robinson *et al.* [32] found that *C. gibba* has a positive allometric growth pattern since the *b*-value = 3.280. The *b*-value in a population

depends on its biological environmental condition, geographical condition, temporal factors, and sample [31, 33, 18], and also *b*-value shows the mature process and gonad growth of bivalve [34, 35]. According to Turra *et al.* [11], factors that influence the shell tissue and the growth are temporal abundance and availability of various food and organism density. Shell morphological change could also be affected by the phenotypic variation, whereas this variation would impact the tissue's length $(\text{weight})^{-1}$ ratio with its length $(\text{width})^{-1}$ ratio. Lower habitat quality could also influence the shell's ability to obtain food in an effort to meet the nutritional requirement as an energy source [32].

A study conducted at Permisan bay showed that almost all sampling sites had negative allometric growth patterns ($b < 3$). This might be due to higher shell mortality in this region. Bad environmental conditions might not support optimum growth for shells in this area. This study revealed the highest *b*–value was in ST–8 (2.522 29) while the lowest was in ST–2 (2.1547 1). Therefore, it could be assumed that the *b*–value in this study was mostly affected by food availability and environmental conditions such as temperature, pH, and dissolved oxygen. The difference in *b*–value between sites in this study might be due to different sample collection in the location that has different characteristic. Patimar *et al.* [36] suggested that the *b*–value would be different if the sites and the zone have different characteristics, whereas different environmental characteristics would cause a different response from a species toward its habitat.

However, particularly in this study, the difference in *b*–value between nine sites was not significantly different ($P > 0.05$). This might be due to *Corbula* which have the ability to survive in a stressful habitat [21–23]. With a higher tolerance ability toward the environmental disturbance, the population growth of this species was dispersed on all sites.

LWR equation of *P. faba* (Figure 2) showed that the overall coefficient (r^2) from all sites was similar ranging between 0.87 to 0.90. It emphasized that the relationship between length and body weight was strong. In this study at Permisan bay, the relationships between total length and body weight of *P. faba* showed a positive correlation. A prediction plot of body weight with length (Figure 2) was observed and calculated from regression analysis [37]. In addition, the prediction of growth patterns based on the regression equation showed that there was not a significant difference between all nine sites. However, for a certain biological evaluation, growth development data, and long-term monitoring data of *P. faba* were necessary. This information would help to monitor species population dynamics, growth, and invasion of *P. faba*.

Condition of the species *P. faba* could be estimated with a weight–length ratio. A larger ratio usually means the condition of the species better well–being. This condition was shown by the condition factor value [17, 31]. Condition factor expresses the condition of an organism represented by its physical capacity for survival and reproduction. Results from this study showed that the median condition factor (K) value for all nine sites ranged between 0.314 34 g $(\text{cm}^3)^{-1}$ to 1.067 25 g $(\text{cm}^3)^{-1}$ then the median relative condition factor (K_n) value was between 0.93645 to 1.05066. The highest median of *P. faba* condition factor was observed in ST–4, and the lowest value was in ST–8 (Figure 1A). The highest median of *P. faba* relative condition factor was observed in ST–4, and the lowest value was in ST–1 (Figure 1B). Another study reported that the condition factor value for bivalve *Mya arenaria* (Linnaeus, 1758) ranged from 0.83 g $(\text{cm}^3)^{-1}$ to 1.17 g $(\text{cm}^3)^{-1}$ [38]. Another study in Canada showed that bivalve *Mya arenaria* ranged from 1.7 g $(\text{cm}^3)^{-1}$ to 3.9 g $(\text{cm}^3)^{-1}$ [20]. The condition factor in this study was similar to the study conducted by Gagne *et al.* [39] of a bivalve from the species (blue mussel) *Mytilus edulis* (Linnaeus, 1758) conducted in France and Canada with 0.08 g $(\text{cm}^3)^{-1}$ to 0.27 g $(\text{cm}^3)^{-1}$ and slightly lower than Schmidt *et al.* [40] ranged between 0.29 g $(\text{cm}^3)^{-1}$ to 0.4 g $(\text{cm}^3)^{-1}$. This variation of conditional factor and relative condition factor might be due to the environmental difference and species condition. According to Şaşı [41] and Ndome [42], variation in the number of conditional factors of the species might occur due to the different age, sex, stress, preservation, maturity, and environmental condition (seasons, pollutants, availability of food)

5 Conclusion

The present study evaluates the length-weight relationships and Fultons' condition factor of *P. faba* from nine sites at Permisan bay. The study showed that the length-weight relationships pattern of *P. faba* is negative allometric. Fulton's condition factor of *P. faba* shows that the Permisan bay estuary still supports the life and the growth of *C. faba*. It is also assumed that *P. faba* has high tolerance toward environmental pressure thus it makes this species easier to adapt to the environmental condition at Permisan bay.

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