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Length-Weight Relationship and Condition Factors of Hotate Clams (*Patinopecten yessoensis*) Cultivated in Funka Bay, Japan at Different Stations

Fasya Pingka Diandari[1*], Emyliana Listiowati[1], Rima Oktavia Kusuma[1]

[1]Department of Aquaculture, Faculty of Fisheries and Marine Sciences, Jenderal Soedirman University, Purwokerto 53122, Central Java, Indonesia.

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Correspondence :
fasya.diandari@mhs.unsoed.ac.id

Abstract

Hotate clams (*Patinopecten yessoensis*) are a species of Bivalvia that is often found in the waters of Funka Bay, Hokkaido, Japan. The information regarding the relationship between length and weight and condition factors for hotate clams is important for knowing their growth patterns. This research aimed to examine the length-weight relationship and conditions of 56 Hotate clams collected in August of 2022 at two different locations. The relationship between length-weight and growth patterns shows that the range of b values at stations A and B is 2.45, and 1.86 in the waters of Funka Bay while the growth pattern in Funka Bay displays negative allometric growth with r values ranging from 0.90-0.92 (strong positive correlation). The condition factor values for Hotate clams at stations A and B are 5.45 and 1.28. There is a good welfare value for Hotate clams because the condition factor (Kn) is greater than one.

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Introduction

Funka Bay is a semi-enclosed bay located in southwest Hokkaido, Japan. The bay has a surface area of 2,315 km^2 and a coastline of 195 km connected to the northwestern Pacific Ocean. The maximum depth is around 107 m in the middle of the bay, and around 85 m at the edge of the bay (Radiarta & Saitoh, 2008). Funka Bay is an ideal operational area for Hotate clams cultivation. Other main operational areas for Hotate clams cultivation are Lake Saroma, the Sea of Okhotsk and Funka Bay, Hokkaido, and Mutsu Bay, Honshu. The production of Hotate clams in Funka Bay is quite high because the production is around 500 thousand tons per year with a value of around 840 million USD (Uki, 2006). Coastal Hokkaido fisheries companies are the main suppliers of marine products, including Hotate clams, which are the region's major food source (Ichinokawa et al., 2017).

Hotate clams (*Patinopecten yessoensis*) are a species of cold water clam whose ecosystem is naturally distributed along the northern coastline of Japan, namely Hokkaido (Hou et al., 2011). The cold temperatures of Japan are an ideal habitat for Hotate clams because they are poikilothermic animals (Jiang et al., 2016). Hotate clams are distributed and grow widely on the coast of the Northwest Pacific Ocean, and the highest densities live on sandy or muddy beaches (Silina & Zhukova, 2007). Geographically, the cultivation location is in two different locations in Funka Bay. Location A is located at 42º 29' 39. 48" E and 140º22' 33.90" W and location B is located at 42º 29' 44. 11" E and 140º22' 48.41" W. Hotate clams cultivation is one of the important cultivation areas and efforts are being made to develop production results and quality in the fisheries sector in Japan (Yu et al., 2019). One aspect of Hotate clams cultivation that can be measured is the growth pattern.

The growth pattern of Hotate clams can be observed by looking at the increase in shell size (Chauvaud et al., 2012). Hotate clams have a shell consisting of two left valves and a right valve as support. The left valve is flat or slightly concave, and the right valve is more convex. Both valves are the same size and serrated (Fisheriesaquaculture & Paper, 2022). Individual Hotate clams have shell colors that are white-dark brown and white-reddish brown. The growth patterns of white-reddish brown Hotate clams were superior to dark-white-brown Hotate clams, even though both were cultured in similar conditions (Ding et al., 2015).

Growth patterns are seen from the length-weight relationship and condition factors (Zbarun et al., 2016). The length-weight relationship was used to estimate the growth pattern of aquatic organisms, specifically the Hotate clams. The length-weight relationship is estimated by measuring the distribution of body length and weight data (Rochmady, 2012). The condition factor is a parameter used to compare the well-being of a species between populations which also states the physiological status of shellfish (Sinaga et al., 2018). Calculation of condition factors is influenced by biological and ecological factors that influence growth rate, reproduction, degree of fitness, and environmental suitability. Different Hotate clam cultivation locations result in the length-weight relationship being different between species and also between stocks from Hotate clam cultivation locations (Kuriakose, 2017). The results of research by Zabarun et al., (2016) show that the length-weight relationship for clams with a negative allometric pattern and the comparison with condition factors in clams is almost the same. Due to a lack of information regarding the length-weight relationship and condition factors of Hotate clams at two different stations in Funka Bay, measurements will be conducted in this study.

Materials and methods

Research Time and Location

This research was conducted in Funka Bay, Hokkaido, Japan. This activity was conducted in August 2022. Research data collection was conducted at two different stations. Station A on August 22, 2022, and station B on August 24, 2022.

Research Location

The research was conducted in Funka Bay, at two different stations. Station A is located at 42° 29' 39. 48" East Longitude and 140°22' 33.90" West Longitude and station B is located at 42° 29' 44. 11" East Longitude and 140°22' 48.41" West Longitude. The average and maximum depths in Funka Bay are 38 m and 107 m. This bay has a surface area of 2,315 m^2, and a coastline of 195 km, and is connected to the northwestern Pacific Ocean via a 30 km wide shallow sill in the eastern part of the bay (Radiarta et al., 2008).

Sampling

Sampling was conducted at two different stations in Funka Bay, Japan. Station A has coordinates at 42° 29' 39. 48" East Longitude and 140°22' 33.90" West and station B is located at coordinates 42° 29' 44. 11" East Longitude and 140°22' 48.41" West. Clams were sampled in large nets using a random sampling method at stations A and B. Thirty individual clams were

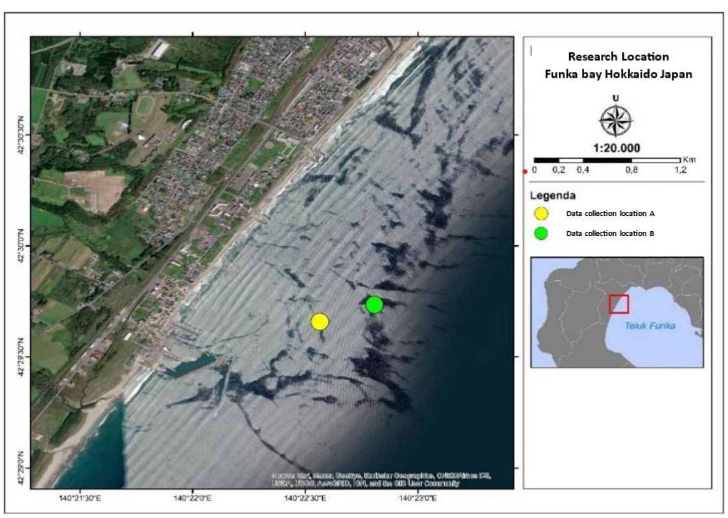

Figure 1. Research Location

sampled at station A, and 26 individual clams were sampled at station B. Sample collection was conducted in situ. In-situ are parameters that are observed directly at the time of sampling.

The samples were collected in situ, followed by weighing, measuring, and photographing the shells for documentation with a digital scale. Photos are taken with the shell in a vertical position and the files are saved in JPG format.

The length of the Hotate clamshell sample was measured by measuring from the outermost side of the left shell (anterior) to the outermost side of the right shell (posterior). Height measurement is conducted by measuring from the dorsal side to the ventral side (Mau et al., 2023).

Calculation of the length and weight of clams

The growth pattern of Hotate clams can be determined through the relationship between shell length and body weight of Hotate clams (wet weight) which is analyzed through a quadratic equation relationship (power regression) as proposed by Ricker (1975), namely:

$$W = a\ Lb$$

Where :

W = wet weight of clams (g)

L = shell length (mm)

a and b = constants in the equation.

It is possible to determine the value of b = 3 by applying a b value test, which determines whether the relationship between length and weight is isometric or allometric (Rochmady, 2012).

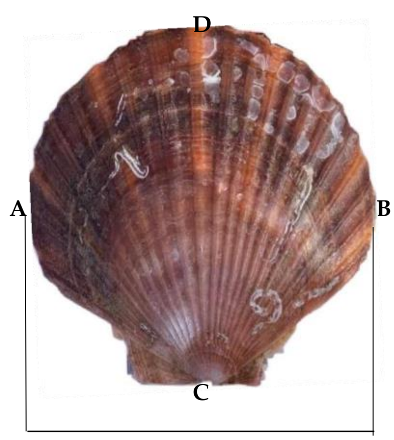

Figure 2. Scheme for measuring the shell length of the *Patinopecten yessoensis* clam

Description: AB: Shell Length; CD: Shell Height A: Anterior; B: Posterior; C: Dorsal; D: Ventral

Table 1. Growth Patterns of Hotate Clams Based on Length-Weight Relationships

b Value	Information	Growth pattern
< 3	The increase in length of clams is faster than the increase in weight.	Negative allometric
> 3	The increase in length of clams is not as fast as the increase in weight.	*Positive allometric*
= 3	The increase in length of the clams is balanced by the increase in weight.	*Positive allometric*

The values a and b are constants which are then transformed into a linear logarithmic equation as follows:

$$\text{Log } W = \log a + b \log L$$

The b values obtained are grouped into 3 growth pattern categories, which are attached in Table 1.

Condition Factor Calculation

Condition factor analysis determines the formulation after knowing the length growth pattern. If the b value ≠3, then K is calculated using the formula:

$$Kn = \frac{w}{aL^b}$$

Where :

Kn = Condition Factor

W = Weight (g)

L = Total length (cm)

a and b = Constant

If the value of b = 3, then Kn is calculated using the formula:

$$Kn = \frac{10^5 w}{L^3}$$

Where :

K = Condition factor

L = Total length

W = Weight (Wiwiet et al., 2016).

Data analysis

Hotate clams sample data processing was conducted using Microsoft Excel and SPSS software. Data were tabulated and processed using regression analysis in Microsoft Excel. Then the shell length data was tested using the Kruskal Wallis test and the shell weight data was tested using the T-test in the SPSS application.

Table 2. Growth Pattern of Hotate clams based on Condition Factors

Kn Value	Information
< 1	The organism grows poorly
>1	The organism grows well (Ogunola et al., 2017)

Results and Discussion

Hotate Clams Size

Hotate clams have different sizes because they are influenced by age, disease, parasites, and the habitat in which they live. Mussel shell growth is influenced by physical, chemical, and biological factors, population density, habitat, and water quality. The clams samples at station A totaled 30 individuals, and at station B there were 26 individuals, so the total number of samples obtained was 56 individuals. Data on the length and weight of Hotate clam samples taken in Funka Bay, Hokkaido, Japan at stations A and B are attached in Table 3.

Based on the results of Table 3, the size of the shells at station A is 10.62 ± 1.72 cm long and weighs 124 ± 50.31 g. Station B, Hotate clam shell length 10.19 ± 1.65 cm and weight 123.23 ± 39.60 g. The length and weight of clams at these two stations are included in the adult stage. According to Fisheriesaquaculture & Paper (2022), adult stage clams measure from 11 to 13 cm in length.

The results of the Kruskal Wallis test data on the length of Hotate clams at stations A and B showed results that were not significantly different from the Asymp value. Sig. (2-tailed) > 0.05.

The results of the T-test on Hotate clam weight data at station A and station B showed results that were not significantly different ($p>0.05$). The results of the length data test values at stations A and B have the same value, presumably because the Hotate clams samples are in the same stage, namely the adult stage with a size range of 11-13 cm (Fisheriesaquaculture & Paper, 2022). In addition to that, the same length values resulted from placing clams at the same depth at stations A and B, namely 5-10 meters in enclosed water and 15-20 meters in open water (Dvoretsky, 2022).

Length – Weight Relationship

In fisheries biology and population dynamics, the length-weight relationship is

Table 3. Length and weight of Hotate shells at station A and station B

Variable	Station A	Station B
Length (cm)	10,62±1,72^a	10,19±1,65^a
Weight (g)	124±50,31^a	123,23±39,60^a

Note: The same letter notation indicates results that are not significantly different, P > 0.05.

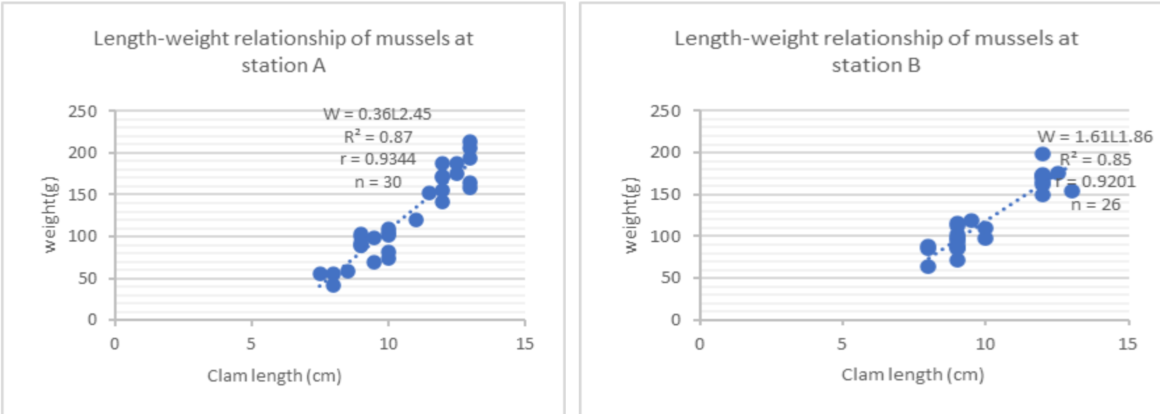

Figure 3. (a) Graph of the relationship between length and weight of Hotate clams at station A; (b) Graph of the relationship between length and weight of Hotate clams at station B

crucial for determining growth patterns and stock estimates. Biometric parameters like the length-weight relationship are important for conservation and fisheries management. A weight growth value that is greater than length indicates that the condition and health of the clams are good. The length-weight relationship is influenced by various biotic and abiotic factors such as sex, season, food availability, genetics, and fishing (Alnahdi et al., 2016). The results of calculating the relationship between length and weight at two different stations are attached in Figure 3.

The research results in Figure 3 show that the equation of the relationship between length and weight and the coefficient value (R2) of Hotate clams at station A and station B respectively is W = 0.36L2.45, W = 1.61L1.86, the correlation coefficient value or (R2-) station A is 0.36 and station B is (R2) =1.61.

The results of the analysis of the relationship between the length and weight of Hotate clams at station A and station B show b values of 2.45 and 1.86 respectively (Figure 3), indicating that Hotate clam growth is negative allometric at both stations A and B of Funka Bay (b < 3) where the growth in clams length is more dominant than the growth in weight. Meanwhile, the r values at station A and station B are 0.93; and 0.92, which shows the relationship between the two factors is quite strong. According to Aban et al. (2017), this indicates that the clam length is a good estimation tool for the Hotate clam population in the waters of Funka Bay, Hokkaido, Japan. A negative allometric growth pattern indicates that the food supply

Table 4. Hotate clams condition factors at station A and station B

Station	n	Average Length (cm)	Average weight (g)	b	Condition Factor
A	30	10,62	124	2,45	5,45 [b] ± 0,53
B	26	10,19	123,23	1,86	1,28 [a] ± 0,09

Note: Letter notation indicates results that are not significantly different, P > 0.05

in the waters is lacking so the increase in length is more dominant than in weight. Energy collected from food is focused on increasing shell length compared to shell weight at the beginning of the clams's life. Apart from food, growth patterns have internal factors such as heredity (genes) and sex, as well as external factors, namely parasites, disease, food, and temperature.

The results of calculating the length-weight relationship for Hotate clams in this study show that the growth pattern (b) at station A and station B is negative allometric ($b < 3$). This is thought to be related to the growth in length of the clams being more dominant than the growth in weight of the clams. The results of the growth pattern analysis are not much different from research by Rohmah & Muhsoni (2020); Wanimbo & Kalor (2019), that the value ($b < 3$) means that growth in length is faster than growth in weight. The clams are undergoing a growth phase, which accounts for the faster increase in shell length. Meanwhile, weight growth tends to be slow because the clams have not yet entered the reproductive stage and are still concentrating on growing shell length.

Condition Factors

Condition factor is a parameter that can see the condition of an organism's plumpness in the form of a number based on the results of length and weight. Condition factors are used to explain the state of an organism (Sharma, 2005). Based on the results of the condition factor calculations, it is shown in Table 4.

The results of the T test for condition factor data at stations A and B showed significantly different results with a P value <0.05. The Condition Factor value at station A is higher than at station B attached in Table 4, this is thought to be because the b value at station A is greater than at station B because the behavior of Hotate clams at station A is more active than at station B. This is in accordance with Muchlisin et al. al., (2010) who stated that the size of the b value is influenced by the behavior of the mussels, for example actively moving mussels show lower b values compared to passively moving mussels.

Condition Factors at stations A and B are 5.45 and 1.28. The value of the condition factor at stations A and B has good well-being. It can be seen from the value that at station A it is much greater than station B, this causes the species at station A to look much fatter than the species at station B visually. The results of the analysis of condition factor values are not much different from the research of Silaban et al., (2021), that a condition factor value of more than 1 (Kn>1) reflects environmental conditions that are quite good for an organism, and vice versa. According to Ogunola et al., (2017) high Kn values are also caused by the abundance of food such as phytoplankton in their living habitat which influences the growth and size of clams. According to Buban et al., (2019), condition factor values for clams that are equal to or greater than 1.0 indicate that the species is relatively fat and in good condition. This means that the waters of Japan's Hokkaido Funka Bay are a good habitat for Hotate clams to live.

According to Silaban et al., (2021), the high value of the condition factor at station A is due to the high current speed found there. This can be seen from the dominant substrate type, namely sand. High current speeds can carry larger sand and mud particles, which will indirectly affect the availability of food for the clams and will affect growth patterns. Condition factors were initially used to determine condition in fish, but now condition factors have been successfully used in Bivalves (Buban et al., 2019) such as the *Andara gubernaculum* species and the *Marcia hiantina* species (Fauzan et al., 2018) because the method is suitable and simple.

Conclusion

Based on the results above, it can be concluded that the relationship between length and weight of Hotate clams at station A and station B has a negative allometric growth pattern. Furthermore, the condition factors for Hotate clams at stations A and B are respectively 5.45 and 1.28, indicating good health for both.

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