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The Impact of Ectoparasites on Morphometric Profiles of Hotate Scallop In Funka Bay, Hokkaido, Japan

Dampak Ektoparasit Terhadap Profil Morfometri Kerang Hotate Di Teluk Funka, Hokkaido, Jepang

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ABSTRAK

The hotate clam (Mizuhopecten yessoensis) is one of the clam species that lives in cold-temperature waters with the largest production in the Japanese region. However, the sustainability of this aquaculture is threatened by various factors, including ectoparasite infections that can affect the morphometric profile of the scallop. This study aimed to analyze the impact of ectoparasites on the morphometry of hotate clams in Funka Bay, Hokkaido, and to inventory the types of ectoparasites found. Samples of 25 individual hotate mussels were taken using random sampling techniques and morphometric measurements were taken using Image-J software. Ectoparasite infestation was categorized into four categories: free, low, medium and high. Analysis was conducted using One-Way ANOVA and Fisher's Pairwise Comparison follow-up test (P<0.05), as well as hierarchical cluster analysis based on the Bray-curtis similarity index visualized in a dendrogram. The results showed that there were two types of ectoparasites, namely Polydora sp. and Barnacles sp., with the dominance of Polydora sp. which was found in 17 individuals. Some morphometric distances such as AD, AE, BD, and CE showed significant differences between infestation categories. The dendrogram showed that the 'free', 'low', and 'medium' categories had high morphometric similarity (0.987), while the 'high' category showed lower similarity (0.96).

Keywords: *Ectoparasites, Landmarks, Mizuhopecten yessoensis, Morphometry, Funka Bay*

ABSTRACT

Kerang hotate *(Mizuhopecten yessoensis)* merupakan salah satu spesies kerang yang hidup di perairan bersuhu dingin dengan produksi terbesar di wilayah Jepang. Namun, keberlangsungan budidaya ini terancam oleh berbagai faktor, termasuk infeksi ektoparasit yang dapat mempengaruhi profil morfometri kerang. Penelitian ini bertujuan untuk menganalisis dampak ektoparasit terhadap morfometri kerang hotate di Teluk Funka, Hokkaido, serta menginventarisasi jenis ektoparasit yang ditemukan. Sampel sebanyak 25 individu kerang hotate diambil dengan menggunakan teknik *random sampling* dan dilakukan pengukuran morfometri menggunakan *software Image-J.* Infestasi ektoparasit dikelompokkan menjadi empat kategori: bebas, rendah, sedang dan tinggi. Analisis dilakukan menggunakan *One-Way ANOVA* dan uji lanjutan *Fisher's Pairwise Comparison* (P<0,05), serta analisis klaster hirarki berdasarkan indeks kemiripan *Bray- curtis* divisualisasikan dalam dendrogram. Hasil penelitian menunjukkan bahwa terdapat dua jenis ektoparasit, yaitu *Polydora* sp. dan *Barnacles sp.,* dengan dominasi *Polydora sp.* yang ditemukan pada 17 individu. Beberapa jarak morfometrik seperti AD, AE, BD, dan CE menunjukkan perbedaan signifikan antar kategori infestasi. Dendrogram menunjukkan bahwa kategori 'bebas', 'rendah', dan 'sedang' memiliki kemiripan morfometrik tinggi (0,987), sedangkan kategori 'tinggi' menunjukkan kemiripan yang lebih rendah (0,96).

Kata Kunci: Ektoparasit, Landmark, *Mizuhopecten yessoensis*, Morfometri, Teluk Funka

INTRODUCTION

Japan is an archipelago located in the east of the Asian continent, is one of the largest seafood-producing archipelago countries in the world with most of its population consuming processed seafood such as fish, shrimp, and shellfish. One type of clam that is popular in Japan is the Japanese clam *(Mizuhopecten yessoensis)* or Japanese people often call this clam "Hotate-gai". It can be found widely in the coastal areas of Northern Japan (Aya *et al.* 2014).They have been cultivated since the early 1900s. Data on hotate scallop production in Japan over the past five years (2018-2022) show a relatively stable trend, with total national production of 478,726 tons, 483,901 tons, 495,074 tons, 520,461 tons, and 512,118 tons, respectively. The aquaculture production of hotate clams in major regions such as Hokkaido, Aomori, Iwate, and Miyagi accounts for about 500,000 tons per year. Specifically, the Hokkaido region recorded production of 388,466 tons in 2018, 379,502 tons in 2019, 406,755 tons in 2020, 431,902 tons in 2021, and 425,101 tons in 2022 (Association 2023).

Hotate clam *(M. yessoensis)* is a species of clam that lives in cold-temperature waters with the largest production in Japan, especially the northern region of Hokkaido (Woli *et al.* 2002).The people of Japan, especially Hokkaido, are very fond of these clams because they are delicious, nutritious, large, and fast-growing (Febrianti *et al.* 2023). Hotate clams grow quickly because Hokkaido is an ideal location for clam growth, supported by proper cultivation techniques (Uki, 2006). One of the most widely used scallop culture techniques in the waters of Funka Bay is the ear hanging technique, in which juvenile scallops are tied to twine after having their anterior and posterior ears perforated (Hamada *et al.*, 2000). However, the sustainability of this culture is threatened by various factors, including ectoparasite infections that can affect the morphometric profile and growth of the mussels.

Ectoparasites are parasites that live on the surface of their host's body. Ectoparasites can interfere with or reduce the growth and weight of clams (Hopla *et al.*, 1994). Ectoparasites attached to the shell of the clam can interfere with the movement of the clam when performing the *filter feeder* process to filter food (Shofiyah *et al.,* 2022). Ectoparasites in hotate clams have several types, one of which is *Polydora sp*. (Teramoto, 2013) and *Barnacles sp*. (Donovan, 2003).

The impact of these ectoparasites is also evident in the morphometric profile of hotate mussels. Morphometry is a characteristic related to the size of the body or body parts of an organism. This size is one of the things that can be used as a taxonomic characteristic when identifying organisms (Gaol, 2017). Physical damage to the shell or morphometric impacts on the shell by *polychaeta* worm ectoparasites can cause direct damage to the shell that can reduce the aesthetic value and marketability of the shell. Damage caused by these ectoparasites can be in the form of erosion of the shell surface. In addition, ectoparasites can also cause variations in body shape, damaged shells and disrupted growth (Silaban *et al.,* 2022). Morphometric studies can also provide insight into the distribution of the measured mussel populations, i.e. guesses about the availability of mussel size. Through morphometry, it can be estimated the size of mussels that can be taken or netted for marketing, in this case selectively so that the availability of mussels can be maintained in the future (Nagir, 2013).

Given that there is limited understanding of the impact of ectoparasites on the morphometric profiles of hotate mussels, this study was necessary. This study aims to analyze the impact of ectoparasites on the morphometric profile characteristics of hotate clams in Funka Bay and inventory them. The results of this study are expected to serve as useful reference information for further development and management of hotate mussel aquaculture.

METHODS

This study was conducted in May-June 2024 at the Fukushima gyogyou Co., Ltd. located in the waters of Funka Bay, Hokkaido, Japan. Funka Bay is a Hotate clam farming site in the Toyako-Cho area of Hokkaido. The study was conducted along the shore adjacent to the hotate clam farming site. The sampling depth of the study was between 15-20 meters and the hotate clam collection site was about 500 meters away from the harbor.

Research Work Procedure

Hotate clam sampling was conducted four times in May and four times in June. Three to four mussels were taken for each sampling, resulting in a total of 25 mussels collected. Samples were collected in-situ, the mussels were photographed using *millimeter block photo mat* and weighed using *digital scales*. Photographs were taken with the mussels in a vertical position. Photo files of mussels were saved in jpg format, then analyzed using the Image-J application. Morphometry of hotate mussels measured included length, height and weight. The length of hotate mussels was measured using a millimeter block with an accuracy of 0.1 cm horizontally. Measurement of shell length starts from the anterior to posterior end (Prasetya *et al.,* 2010). After being measured, it was recorded and analyzed. Weighing the total weight of hotate clams using digital scales with an accuracy of 0.01 grams. Total weight weighing is done by weighing the clams one by one.

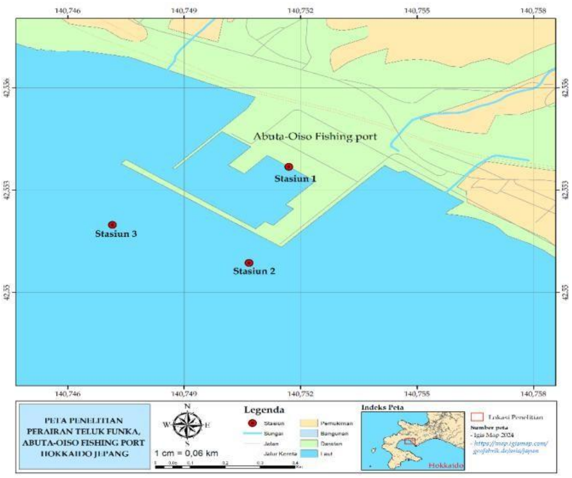

Figure 1: Map of the Research Location
Source: Igis Map, 2024

Observation of ectoparasites in hotate mussels was carried out with the help of a *magnifying glass*. The hotate clam was placed on a *millimeter block*, then the part of the clam shell that contained ectoparasites was observed using a *magnifying glass*. After that, take a picture and save it in jpg format for analysis. This study was conducted to determine the size morphometry of each landmark using tpsDig2 software in measuring hotate clam species infected with ectoparasites. The study measured the shells of hotate clams (*M. yessoensis)* using landmark-based geometric morphometric analysis with 21-30 landmark measurements. Data collection was carried out with the following steps, measuring the length, height and weight of the hotate mussels taken and photographed on a *millimeter block mat.* The results of the mussel photos were input into the tpsDig2 software.

Morphometric measurements of each landmark in the tpsDig2 software begin with a photo that is calibrated first on the set scale menu set at 1 cm, after that click measure then the landmark digitization is ready to use.

Hotate clams that have been landmarked are then calculated for the infestation ratio of shells affected by ectoparasites. The purpose of measuring the infestation ratio is to help determine the extent to which ectoparasites affect the clams physically or morphometrically. The infestation ratio formula is as follows:

Infestation Ratio = *area of infestation/total shell surface area* × 100%

Infestation Level Category:

No	Category	Infestation Rate (%)
1.	Low	<4%
2.	Medium	4%-10%
3.	High	>10%

(Schloesser *et al.,* 1996)

Formula for calculating the area of a clam shell:

$$\mathrm{L} = \Pi \frac{p}{2} . \frac{l}{2}$$

Description:

L = Shell area (mm^2)

p = Shell lenght (mm)

l = Shell width (mm)

(Smith *et al.,* 2020)

Data analysis

The data analysis used in the study was quantitative descriptive analysis. This method is a method to make a picture or description of a situation objectively using numbers, starting from data collection, interpretation of the data and the results (Arikunto, 2006). Data on length, height and weight of hotate mussels were analyzed by regression using excel software which was then tabulated into tables and discussed descriptively quantitatively. Landmarks were carried out using tpsdig2 software, landmarks were carried out to help analyze the shell area when it would be calculated in Image-J.Measurement of the infestation ratio using Image-J to support data on the area of shells affected by ectoparasites so as to determine the category of infestation and increase the relevance of the data. Then, morphometric distance measurements between landmarks on hotate clams were carried out using Image-J software as well, after which the results were analyzed using parametric tests used to analyze morphometric differences between ectoparasite infestation groups (One-Way ANOVA) using Minitab 19 software and Fisher's Pairwise Comparison follow-up test was carried out with a significance level of P < 0.05 if significant differences were found in ANOVA. Furthermore, Hierarchical Clustering analysis was conducted using the Bray-curtis similitude test through PAST4 software to see patterns of morphometric similarity between infestation categories, which were then visualized in the form of a dendrogram. This analysis aimed to identify the closeness of m orphometric shapes between groups of ectoparasite-free mussels and groups infested at various levels.

RESULTS AND DISCUSSION

Based on the results of the study, 25 individuals of hotate mussels *(M. yessoensis)* were used as samples. The variations in length, height, weight of the hotate mussels are presented in Table 2.

Table 2. Mean, Standard deviation and range of morphometric sizes of hotate mussels *(M. yessoensis)*

Parameter	Range	Average ±SD
Lenght (cm)	5,45-13,43 cm	7,77 ± 2,50
Height (cm)	5,42-13,01 cm	7,65 ± 2,40
Weight (g)	16,91-132,72 g	45,08 ± 42,32

As a result of the measurements, the clam length ranged from 5.45 to 13.43 cm, height from 5.42 to 13.01 cm, and weight from 16.91 to 132.72 grams. The mean and standard deviation of the length, height, and weight parameters were 7.77 ± 2.50 cm, 7.65 ± 2.40 cm, and 45.08 ± 42.32 grams, respectively. These values are still within the general size range of cultivated hotate mussels, as described in the reference (Febrianti *et al.,* 2023).

Figure 2. Ectoparasites on hotate mussels *(M. yessoensis)* from Fukushima Gyo Gyou in Funka Bay, Hokkaido, Japan: a. Composition of hotate mussels based on ectoparasite infection by ectoparasite type. b. Ectoparasite *Polydora sp.* c. Ectoparasite *Barnacles sp.*

Hotate mussels are susceptible to infestation by various types of ectoparasites, which can affect their growth and physiological condition. Ectoparasites generally attach to the shell, causing morphological changes and potentially disrupting metabolic processes. This study aimed to identify the types and patterns of ectoparasite infestation in 25 individual hotate clams. The analysis showed that there were two dominant types of ectoparasites infesting the mussels, as shown in Figure 2.

Based on Figure 2, out of a total of 25 individual mussels, 18 hotate mussels were infected with ectoparasites. The dominant type of ectoparasite in this study was *Polydora sp.,* which was found in 17 (68%) of the total 25 individual mussels analyzed. Meanwhile, one other individual (4%) was infested by another ectoparasite, *Barnacles sp*. Seven individuals (28%) had no ectoparasites present. The average attached ectoparasite in this study was found on the left shell, which was dark brown in color.

Based on this study, the infestation ratio of each individual hotate mussel was calculated. This infestation ratio is then used as the basis for grouping individuals into infestation categories, namely free, low, medium and high. Table 3 presents data on the number of individuals as well as the infestation ratio value of each individual based on these categories.

Based on Table 3. the free category consists of individuals with an infestation ratio of 0.00, which means that no ectoparasites were found at all in the hotate mussels. The low category shows a relatively small infestation ratio, ranging from 1.68 to 2.74. Meanwhile, the medium category had higher ratio values, ranging from 4.33 to 8.91. The high category includes individuals with the highest infestation ratios, ranging from 11.92 to 18.75. The different ranges of infestation ratios illustrate the significant variation in the level of ectoparasite infestation between individuals, so grouping into these categories is important to see the impact on mussel morphometry.

Table 3. Categories Based on the Ratio of Ectoparasite-infected Shell Area and Total Shell Area in Hotate Scallops *(M. yessoensis)*

Category	Number of individuals	Minimum Ratio	Maximum Ratio	Average Ratio
Free	7	0,00	0,00	0,00
Low	7	0,28	2,74	1,48
Medium	5	4,33	8,91	6,84
High	6	11,92	18,75	15,52

Description: The free category represents mussels with no ectoparasites present.

Morphometric variables were analyzed to evaluate the differences in body shape of hotate mussels *(M. yessoensis)* in each category of ectoparasite infestation level (free, low, medium, and high). Measurements were taken at several distances between landmarks (AB, AC, AD, AE, BD, CE, and GH) using Image-J software. Subsequently, one-way ANOVA analysis and Fisher Pairwise Comparison test with a significance level of $P < 0.05$ were conducted to identify significant differences between groups. The results of the analysis of the mean (± SD) of each morphometric distance are shown in Table 4 below:

The BD and CE distances also show a similar pattern, with the high infestation category having smaller values than the other categories. This further strengthens the notion that heavy infestation can cause deformation or a decrease in size proportions in certain parts of the shell. In contrast, at distances AB, AC and GH no significant differences were found between categories, indicating that these parts were relatively unaffected by the level of ectoparasite infestation.

Table 4. Comparison of Morphometric Distances of Hotate Mussels between Infestation Categories Ectoparasites

Infestation Category	Morphometric Landmark Distance						
	AB	AC	AD	AE	BD	CE	GH
Bebas	0,26 ± 0,03^{a}	0,26 ± 0,04^{a}	0,40 ± 0,03^{a}	0,39 ± 0,04^{a}	0,23 ± 0,02^{a}	0,25 ± 0,04^{a}	0,96 ± 0,03^{a}
Rendah	0,26 ± 0,03^{a}	0,25 ± 0,05^{a}	0,40 ± 0,03^{a}	0,39 ± 0,04^{a}	0,25 ± 0,02^{a}	0,25 ± 0,04^{a}	0,94 ± 0,02^{a}
Sedang	0,26 ± 0,02^{a}	0,25 ± 0,01^{a}	0,40 ± 0,03^{a}	0,35 ± 0,04^{ab}	0,23 ± 0,02^{a}	0,22 ± 0,02^{ab}	0,94 ± 0,02^{a}
Tinggi	0,26 ± 0,03^{a}	0,25 ± 0,04^{a}	0,36 ± 0,03^{b}	0,34 ± 0,03^{b}	0,19 ± 0,02^{b}	0,19 ± 0,03^{b}	0,93 ± 0,01^{a}

Notes: Different superscript values (^{a}, ^{b}) in the same column indicate significant differences based on Fisher Pairwise test ($P < 0.05$). The morphometric landmark point distances presented in the table are the mean results of all individual mussels analyzed.

The results in Table 4 show that most of the morphometric distance variables between landmarks did not show significant differences between infestation categories (indicated by the same superscript letter). However, there are some distances that show significant differences based on the Fisher Pairwise test results, namely AD, AE, BD, and CE. At distances AD and AE, the group with high infestation category showed significantly lower values than the free, low, and medium groups (indicated by superscript (b)). This indicates that high-intensity ectoparasite infestation can inhibit growth or cause changes in the body structure of clams in that section.

Cluster analysis using the hierarchical method was also conducted as a complement to the Fisher Pairwise statistical test to see the level of morphometric similarity between categories of ectoparasite infestation. The results of the analysis were visualized in the form of a dendrogram Figure 12, which showed that the ‘Low’ and ‘Free’ categories had the highest level of morphometric similarity. The ‘Medium’ category is in a relatively similar group to ‘Low’ and ‘Free’, while the ‘High’ category shows the most striking differences compared to the other three categories. This indicates that morphometric changes in mussels become more pronounced as the level of ectoparasite infestation increases.

Figure 3 shows the results of the hierarchical cluster analysis based on morphometric distance similarity between categories of ectoparasite infestation levels. This dendrogram illustrates the level of similarity on the vertical axis, where values closer to 1 indicate higher similarity. Based on the dendrogram, the ‘Low’ and ‘Free’ categories have the highest level of morphometric similarity, indicated by clustering at a very close similarity level (around 0.987). Furthermore, the ‘Medium’ category joined the same group as ‘Low’ and ‘Free’, indicating that all three had relatively similar morphometric patterns. Meanwhile, the ‘High’ category formed its own branch and only joined at a lower similarity level (around 0.96), indicating that it has the most distinct morphometric characteristics compared to the other three categories.

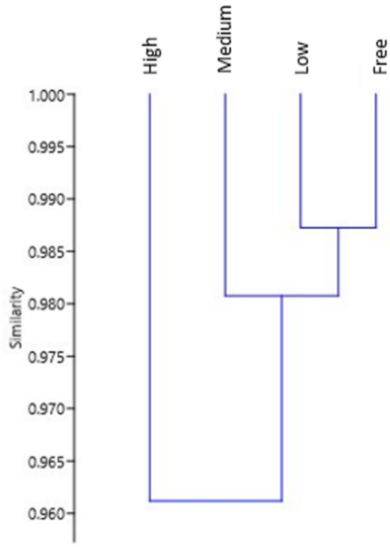

Figure 3. Dendrogram of Hierarchical Cluster Analysis of Hotate Clam *(M. yessoensis)* Morphometry Based on Ectoparasite Infestation Levels

Although visually showing a clustering pattern, the dissimilarity value obtained is very low at 0.04. This indicates that the level of similarity between groups reached 0.96 or 96%, which is classified as very high. This means that the morphometric profiles of mussels at various levels of ectoparasite infestation are still very similar to each other. This low value of dissimilarity indicates that ectoparasite infestation does not have a significant effect on changes in the shape or morphometric size of hotate mussels.

Based on the observations, the clams ranged in length from 5.45 to 13.43 cm, height from 5.42 to 13.01 cm, and weight from 16.91 to 132.72 grams. These variations reflect the natural growth conditions of hotate clams in Funka Bay waters, which are influenced by environmental and biological factors. Hotate clams are a type of clam that has a smooth outer shell. Its morphology is characterized by a body height and length of about 20 cm and a width of about 4.5 cm. Hotate clams have two shells, the right shell is white and the left shell is brown, while on the seabed the right shell is at the bottom (Association, 2020).

Hotate clams are widely distributed along the northern coast of Japan. Funka Bay, located in Hokkaido, is one of the areas that accounts for more than 80% of the national hotate clam production. The optimal temperature for hotate clam growth is in the range of 5-20^{0}C, with the lower and upper limits of growth temperature being 4^{0}C and 22-23^{0}C, respectively. Maximum growth of hotate mussels occurs at temperatures between 1-15^{0}C. Although seedlings are still capable of growing at temperatures up to 25^{0}C, the lethal temperature for one-year-old hotate mussels is in the range of 22-23^{0}C (Kosaka, 2016). Hotate mussels are a type of mussel that can live in cold waters with an optimum growth temperature of 15^{0}C.
These mussels feed on phytoplankton and detritus in the form of particles found in the sea. However, if the current speed exceeds 20 cm/s, the process of food liquefaction and clam growth may be inhibited (Kosaka, 2016). One other factor that can affect the morphology of hotate mussels is the presence of ectoparasites. Ectoparasites can affect the amount and type of *phytoplactones* available and alter the pattern of water flow across hotate mussel culture areas. This creates competition for space and food resources (Gavrilova *et al.*, 2019).

Based on the results of this study, two types of ectoparasites were found to infest hotate mussels. The most dominant ectoparasite was *Polydora sp.* which was identified in 17 of the 25 mussels observed. This ectoparasite was found attached to the left side of the shell. *Polydora sp*. has a body length of up to 16 mm and can cause the host clam to secrete abnormal secretions in the form of brown or black colored shells on its shell surface. In addition, the infestation rate of this ectoparasite was significantly higher on the left shell compared to the right shell during the two years of the study (Teramoto, 2013).

In a previous study 115 *polydora sp*. were found on an individual clam shell and were more abundant on the right shell than on the left shell. *Polydora sp*. were most commonly found around the annual rings and clustered on the shell ears (Teramoto, 2013). The study used six individual samples of hotate mussels and focused on DNA extraction and life history of *Polydora sp*. The results showed that the number of *Polydora sp*. extracted from both shells tended to have the highest values throughout the observation time, with peaks reaching around 55-60 ectoparasitic individuals in some months in 2008 and 2010. The number of *Polydora sp.* from the left shell was consistently higher than that from the right shell during most of the observation period. The highest value on the left shell was recorded at around 45 ectoparasite individuals. Meanwhile, the number of *Polydora sp*. from the right shell tended to be the lowest, with peak values only reaching around 25-30 ectoparasites. This distribution indicates that *Polydora sp.* infestation is more dominant on the left shell, as also mentioned in a previous study by (Teramoto, 2013). These data reinforce the assertion that *Polydora sp*. infestation is likely due to its more exposed position in the hanging culture system. In addition, this finding also provides an insight into how ectoparasites such as *Polydora sp*. can attach and develop on the surface of clam shells that are directly exposed to ocean currents and parasite larvae. A similar distribution pattern was also found in this study, where infestation levels were higher on certain parts of the shell, suggesting agreement between these observations and previous studies. One other ectoparasite found was *Barnacles sp. Barnacles* have smooth edges and measure 1-2 cm (Hitchhikers, 2025). In August 2010, many barnacles were attached to clam shells due to the continuing heat wave (Teramoto, 2013).

According to Dvoretsky (2022), in the Sea of Japan, there are about 100 species of epiboitic organisms living on the shells of hotate clams, with the highest density and biomass found in barnacles *(Hesperibalanus hesperius and Balanus rostratus),* and *Polydorid polychaetes (Dipolydora bidentata and Polydora brevipalpa).* When epibionts occur in high numbers, negative impacts on hosts can occur, such as decreased water flow, reduced food accessibility and increased shell weight. Shell-dwelling organisms such as *Polydora, Dipolydora and Odostomia* may also exacerbate the erosion process, showing signs of parasitism.

The influence of ectoparasites is an important concern in the hotate clam farming industry in Funka Bay (Kanamori *et al.,* 2014). Continuous monitoring of the presence of ectoparasites and appropriate management to address their impact are critical in maintaining aquaculture sustainability (Kurniawan, 2024).These findings are important in understanding ectoparasite infestation patterns and in developing management and mitigation strategies for infestation in hotate mussel aquaculture.

Based on the results of the study, there are four categories to categorize the level of ectoparasite infestation in the morphometry of hotate clams. The free category is one in which no ectoparasites were found at all in the hotate mussels. The low category shows a relatively small infestation ratio of <4%. Meanwhile, the medium category has a higher ratio value than the low category of 4%-10%, while the high category includes individuals with the highest infestation ratio >10%. Then, there are morphometric landmark distances that function to understand variations in ectoparasite distribution in mussel morphometry quantitatively. Some distances showed significant differences based on the Fisher Pairwise test results, namely AD, AE, BD, and CE. This indicates that around these landmark points there is a distribution of ectoparasites that could potentially affect morphometric changes in the area.

At the Spat/Larva stage, which is microscopic in size up to two centimeters, mussel larvae can be infected with parasitic organisms in the aquatic environment. Parasites such as protozoa and other microorganisms can attach to or infect the larvae, potentially affecting their survival and development (Rollinson, 2017). At the juvenile stage, after Hotate larvae have grown and settled on the substrate, they are more susceptible to various types of parasites that can invade their tissues or shells. Parasites such as protozoa, bacteria and worms can infect juvenile mussels, which can negatively affect their health, growth and survival rates (Getchell *et al.,* 2016).

Previous studies have suggested that there is a tendency for the early stages of ectoparasite infestation to occur in a narrow section around the outer edge of the left shell. This infestation generally occurs in one-year-old mussels during the first winter after stocking. In addition, burrows formed by ectoparasites often penetrate to the adductor muscle, so the presence of ectoparasites is thought to contribute to the low growth rate of clams in Abashiri waters (Mori, 1985). This is in line with this study, in which data were collected in Funka Bay during the mimizuri process, when the clams were estimated to be about one year old. The impact of infestation on mussel morphometry showed significant changes at certain morphometric distances, indicating that the presence of ectoparasites can cause deformation or growth disruption in specific areas of the mussel body.

Then, in the hierarchical analysis calculation, objects within a cluster have a high level of similarity and between clusters have a low level of similarity. This low dissimilarity value indicates that ectoparasite infestation does not have a significant effect on changes in the shape or morphometric size of hotate mussels. Based on Dvoretsky's research, the similarity level of hotate mussels reached 86.7%, indicating that there is a high level of similarity in each hotate mussel cultivation waters (Ichiro *et al.,* 2014). Whereas in research (Aulya, 2023), on 60 individuals of hotate mussels had a similarity of 70%-85%. This causes genetic deversity due to different environmental selection, meaning that if a cluster comes from the same area but not the environment where it grows differently, it will affect genetic deversity (Fatimah, 2013). Therefore, within a hotate mussel population, some individuals may be more resistant to ectoparasite infestation because they have certain gene variations. Ectoparasites can also be addressed through an integrated pest management (IPM) approach, which is a holistic method of managing pests and parasites by combining various strategies to minimize negative impacts while maintaining environmental sustainability. This approach includes several key steps, namely: 1. The importance of regular monitoring of the presence of pests and parasites. 2. Optimization of farming practices, such as maintaining a healthy environment to significantly reduce the risk of infestation (Deguine *et al.,* 2021). In addition, practices such as regular cleaning and physical removal can also affect parasite attachment rates and abundance (Hoffman & Brown, 2019).

As a reference to previous research (Mukhlis, 2019), states that parasites can cause considerable problems for the mussel farming industry. This is because they cause serious erosion of the shell matrix and cause premature shell loss. Therefore, there is a prevention so that more and more are not affected by ectoparasites, one of which is regular shell cleaning, either manually or with a high pressure hose (Mukhlis, 2019).

CONCLUSIONS

Based on the research and calculations that have been carried out, it can be concluded that; Cultivation of hotate clams *(M. yessoensis)* in Funka Bay, Hokkaido, Japan, found two common types of ectoparasites, namely *Polydora sp*. and *Barnacles sp.* and Ectoparasites affected the morphometry of Hotate clams *(M. yessoensis),* especially at certain body distances (AD, AE, BD and CE) based on Fisher's test. Although hierarchical cluster analysis showed a high degree of similarity (96% similarity) between infestation groups, localized changes in the shell area did occur. This suggests that the presence of ectoparasites is an important consideration in aquaculture.

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REFERENCES

Agesi, A.V., 2011. *Variasi morfometri dan Kariotipe Rana hosii Boulenger, 1891 di Sumatera Barat*. Skripsi Sarjana Biologi. Jurusan Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam. Universitas Andalas. Padang.

Anonymous. 2021. The Scallop Business Is Paralyzed. A Maricultural Disaster. Aviable online: https://konkurent.ru/article/43829. (Accessed on 18 Desember 2024).

Arikunto, S. 2006. Prosedur Penelitian: Sebuah Pendekatan Praktik. Jakarta: Rineka Cipta.

Association, 2020. Buku Teks Untuk Tes Keterampilan Perikanan Budidaya: 23-37. Association, J.H. 2023. What is Hotate. Diakses pada 25 April 2025, dari https://j-hotate.com/

Aulya, A. dkk. 2023. Keragaman Morfologi Kerang Hotate *(Patinopecten yessoensis*, Jay 1857) di Teluk Funka Hokkaido Jepang. Jurnal Maiyah, **2**(2): 139-147.

Aura, C. M. 2015. An Integrated Approach of Habitat Suitability Model for Management of Japanese Scallop *(Mizuhopecten yessoensis)* aquaculture: A Comparative Study in Funka Bay and Mutsu Bay, Japan. *Thesis Journal Hokkaido University*.

Aura, C. M., Saitoh, S. I., Liu, Y., Hirawake, T., Baba, K., and Yoshida, T. 2016. Implications of Marine Environment Change on Japanese Scallop

(Mizuhopecten yessoensis) Aquaculture Suitability: A Comparative Study in Funka and Mutsu Bays, Japan. *Aquaculture Research*, **47**(7): 2164-2182.

Aya, F. A., Hidaka, Y., & Kudo, I. 2014. Clearance Rates and Ingestion Efficiency of the Japanese Scallop *(Patinopecten yessoensis). Plankton and Benthos Research*, **8**(3): 134-140.

Aya FA, Kudo I. 2007. Isotopic Determination of Japanese Scallop *Patinopecten (Mizuhopecten) Yessoensis* (Jay) Tissues Shows Habitat-Related Differences in Food Sources. *Journal of Shellfish Research*, **26** (2): 295–302.

Caddy, J., R.A. Chandler, and E.I. Lord. 1970. Bay of Fundy scallop surveys 1966 and 1967 with observations on the commercial fishery. Tech. Rep. Fish. Res. Board Can. 168.

Deguine, J. P., Aubertot, J. N., Flor, R. J., Lescourret, F., Wyckhuys, K. A. G., & Ratnadass, A. 2021. Integrated pest management: good intentions, hard realities. A review. Agronomy for Sustainable Development, **41**(3).

Dvoretsky, Alexander G. and Vladimir G. Dvoretsky. 2022. Biological Aspects, Fisheries, and Aquaculture of Yesso Scallops in Russian Waters of the Sea of Japan. *Journal Diversity*, **14**: 399.

Donovan, Deborah A. dkk. 2003. E¡ects of barnacle encrustation on the swimming behaviour, energetics, morphometry, and drag coefficient of the scallop *Chlamys hastata*. *Journal of the Marine Biological Association of the United Kingdom,* **83**: 813-819.

Effendie, M.I. 1997. Metode Biologi Perikanan. *Yayasan Dewi Sri*. Hal, 111.

Elston, R.A. Dungan, C.F., Meyres, T.R., & Recce, K.S. 2003. *Perkinsus sp.* infection risk for manila clams, *Venerupis philippinarus* (A. Adams dan reeve, 1950) on the Pasific Coast of North and Central America. *Journal of shellfish Research*, **22**(3): 661-665.

Fajrina, N., Sarong, M.A., Saputri,M., Huda, I., Khairil. 2020. Pola Pertumbuhan Kerang Air Tawar *(Anadonta woodiana)* Berdasarkan Substrat Di Perairan Sungai Aron Patah Kecamatan Panga Kabupaten Aceh Jaya, **5**(1): 34.

FAO (Food and Agriculture Organization). 2009. The State of World Fisheries and Aquaculture, 2008, pp. 196. FAO, Rome.

Fatimah, S. 2013. Analisis Morfologi dan Hubungan Kekerabatan Sebelas Jenis Tanaman Salak (*Salacca zalacca* (Gertner) Voss Bangkalan. Agrovigor, **6**(1): 1-15.

Febrianti, S., Listiowati, M., Wijaya, R., Kasprijo., Ekasanti, A., & Maya, I. 2023. Karakter Morfologi dan Morfometrik Kerang Hotate pada Stadia Berbeda di Teluk Funka, Hokkaido, Jepang. *Jurnal Maiyah*, **2**(4): 349-358.

Gaol, Natal Nail Lumban. 2017. *Perbandingan Morfometri Kerang Bulu (Anadara antiquata) di Belawan dan Tanjung Pura Sumatera Utara*. Skripsi. Universitas Medan Area: **10**.

Getchell, R. G., Smolowitz, R. M., McGladdery, S. E., & Bower, S. M. 2016. Diseases and Parasites of Scallops. *Developments in Aquaculture and Fisheries Science*, **40**: 425–467.

Griffiths, C.L. & J.S. Griffiths. 1987. Bivalvia. In: J.H. Pandian & F.J. Vernberg, (eds.). Animals energetics, Academic Press, New York, **2**: 1-88.

Hamada, T., Yamashita, N., Takagi, S., & Natsume, S. 2000. Difference in Perfomance of Three Ear-hanging Methods in Scallop Farming. *Bull. Fac. Fish.* Hokkaido Univ, **51**(2): 105-106.

Hidayat, Rifaldi. dkk. 2023. Hama Predator dan Organisme Penempel pada Budidaya Kerang Hotate *(Mizuhopecten yessoensis)* di Teluk Funka, Hokkaido, Jepang. Jurnal Ilmiah Perikanan dan Ilmu Kelautan, **11**(4): 150-161.

Hitchhikers, 2025. MT Sea Grant College Program. Barnacles.

Hoffman, G. L.& Brown, B. L. 2019. Parasites of North American Freshwater Fishes. Hopla, C.E., Durden, J.E., Keirans. 1994. Ectoparasites and Classification. Rev. sci. tech.Off. int. Epiz.,., **13** (4): 985–1017.

Japan Fisheries Association. 2020. Buku Teks Untuk Tes Keterampilan Perikanan (Budidaya). Hokkaido, Jepang.

Ichiro, I., Shimada, H., Akiyoshi, S., Baba,K., Kanamori,M., Sato, M., Kuwahara, Y., Miyoshi, K., Tada, M., Hirano, K., Miyazono, A., & Itakura, S. 2014. Prediction of toxic alga bloom occurrences and adaptation to toxic blooms to minimize economic loss to the scallop aquaculture industry in Hokkaido, Japan. Proceedings of the Workshop on Economic Impacts of Harmful Alga Blooms on Fisheries and Aquaculture North Pacific Marine Science Organization, **47**: 7-16.

Kenchington, E.L., M.J. Lundy, and S.J. Smith. 1997. Bay of Fundy scallop stock assessment: Areas 2, 3, 4, 5, 7. DFO Can. Stock Assess. Secr. Res. Doc. 97/63.98 pp.

Kurniawan, Elang., dkk. 2024. Budidaya Kerang Hotate. Penerbit Deepublish. Sleman: 2- 55.

Kosaka, Y. 2016. Scallop Fisheries and Aquaculture in Japan. In *Scallops: Biology, Ecology, Aquaculture and Fisheries:* 891-936.

Latifa, Ria. 2021. Pengembangan Buku POP UP Sebagai Media Pembelajaran Pada Materi Annelida Kelas X di MA Roudhotul Huda. Skripsi. Institut Agama Islam Negeri Metro: 20-25.

Lestari, R. 2024. Hubungan Panjang Dan Berat Benih Kerang Hotate *(Mizuhopecten yessoensis)* Pada Fase Hon-Bunsan Di Teluk Funka, Hokkaido, Jepang. Skripsi. Universitas Jenderal Soedirman.

MacDonald, B.A., and R.J. Thompson. 1985. Influences of temperature and food availability on the ecological energetics of giant scallop *Placopecten magellanicus* (Gmelin). I. Growth rates of shell and somatic tissue. Mar. Ecol. Prog. Ser. 25:279-294

Merdeka, K. 2023. Inventarisasi Hama Dan Parasit Pada Budidaya Kerang Hotate *(Patinopecten yessoensis)* Di Teluk Funka, Hokkaido, Jepang. Skripsi. Universitas Jenderal Soedirman.

Mori, K., Sato, W., Nomura, T., Imajima, M., 1985. Infestation of the Japanese Scallop *Patinopecten yessoensis* by the boring polychaetes, Polydora, on the Okhotsk Sea Coast of Hokkaido, especially in Abashiri Waters. Bulletin of the Japanese Society of Scientific Fisheries, **51**: 371-380.

Morse, Dana. L., Hugh S. Cowperthwaite., Nathaniel Perry., Melissa Britsch. 2020. Methods And Materials For Aquaculture Production Of Sea Scallops *(Placopecten magellanicus)*. *MEU (Maine Sea Grant).* University of Maine: 1-9.

Mukhlis, Alis., Marzuki, M., Ibadur, R., Introduksi Metoda Penanggulangan Parasit Pada Benih Kerang Mutiara *Pinctada maxima* di Dusun Siung, Desa Batu Putih, Kabupaten Lombok Barat, **1:** 328.

Nagir, M.T., 2013. Morfometri Kerang Darah *Anadara granosa l* Pada Beberapa Pasar Rakyat Makassar, Sulawesi Selatan. Universitas Hassanudin, Skripsi: 1-48.

Naidu, K.S. 1991. Sea scallop, *Placopecten magellanicus*. In: S.M. Shumway (ed.), Scallops: Biology, ecology and aquaculture. Elsevier, Amsterdam: 861-897

Nurasmi, 2023. Karakteristik Morfometrik dan Meristik Ikan Nilem, *Osteochilus vittatus* (Valenciennes, 1842) di Danau Tempe, Kabupaten Wajo dan Danau Sidenreng, Kabupaten Sidenreng Rappang, Sulawesi Selatan. Skripsi: 4.

Prasetya, J. D., Sprijanto, J., dan Hutabarat, J. 2010. Potensi Kerang Simping di Kabupaten Brebes Jawa Tengah. *Seminar Nasional Tahunan Hasil Penelitian Perikanan dan Kelautan.* (VII):1-4.

Prayudhi, Anshar. 2021. Teritip *(Barnacles).* Biologi Animalia.

Radiarta, I. N., & Saitoh, S. I. 2009. Biophysical models for Japanese scallop, *Mizuhopecten yessoensis*, aquaculture site selection in Funka Bay, Hokkaido, Japan, using remotely sensed data and geographic information system. Aquaculture international, **17**(5): 403-419.

Radiarta, I. N., Saitoh, S. I., and Miyazono, A. 2008. GIS-based Multi-Criteria Evaluation Models for Identifying Suitable Sites for Japanese Scallop *(Mizuhopecten yessoensis)* Aquaculture in Funka Bay, Southwestern Hokkaido, Japan. *Aquaculture*, **284**(1-4): 127-135.

Robert, G., M.A.E. Butler-Connolly, and M.J. Lundy 1990. Bay of Fundy stock assessment—1989. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 90/31. 35 pp.

Rollinson, D. 2017. Advances in Parasitology. Life Sciences.97: 326.

Rudders, David. *et al.,* 2019. An Investigation into the Scallop Parasite Outbreak on the Mid-Atlantic Shelf: Transmission Pathways, Spatio-Temporal Variation of Infection and Consequences to Marketability: Final Report. William & Mary.

Safitri, Elok. Dkk. 2021. Identifikasi Ektoparasit dan Endoparasit pada Kerang Hijau *(Perna viridis).* Prosiding SEMNAS BIO. Universitas Negeri Padang: 1257-1264.

Schick, D.F., S.E. Shumway, and M.A. Hunter. 1988. A comparison of growth rates between shallow water and deepwater populations of scallops, *Placopecten magellanicus* (Gmelin, 1791), in the Gulf of Maine. Am. Malacol. Bull, **6**: 1-8.

Schloesser,Don W. 1996. Zebra Mussel Infestation of Unionid Bivalves *(Unionidae)* in North America.University of Nebraska, **36**(1): 300-310.

Shofiyah, B., Farikhah, F., & Safitri, N. M. 2022. Intensitas dan Prevalensi Ektoparasit *Balanus* sp. Pada Kerang Hijau Yang Dibudidayakan Dalam Bagan Tancap Di Perairan Banyuurip, Ujungpangkah, Gresik. *Jurnal Perikanan Pantura (JPP)*, **5**(1): 163–170.

Shumway, S.E., R. Selvin, and D.F. Schick. 1987. Food resources related to habitat in the scallop *Placopecten magellanicus* (Gmelin, 1791): A qualitative study. J. Shellfish Res, **6**: 89-95.

Silaban, Rosita., Johny Dobo., & Gresela Rahanubun. 2022. Proporsi Morfometrik Dan Pola Pertumbuhan Kerang Darah (*Anadara granosa*) di Daerah Intertidal, Kota Tual. *Jurnal Kelautan*, **15**(2): 143-152.

Sulistiono, *et al.*, 2014. Karakteristik Morfologi Teritip Spons Indonesia. Depik. **3**(2): 178- 186.

Sun, X., Yang, A., Wu, B., Zhou, L., dan Liu, Z. 2015. Characterization of the Mantle Transcriptome of Yesso Scalloop *(Patinopecten yessoensis):* Identification of Genes Potentially Involved in Biomineralization and Pigmentation. Plos One, **10**(4): 1-19.

Taylor, J., R.A. Rose, P.C. Southgate. 1997. Fouling animals and their effect on the growth of *silverlip pearl oysters*, *Pinctada maxima* (Jameson) in suspended culture. Aquaculture, **153**: 31–40.

Teramoto, Wataru.dkk. 2013. Morphology, 18S rRNA gene sequence and life history of a new *Polydora* species (*Polychaeta*: Spionidae) from northeastern Japan. Aquatic Biology, 18: 31–45.

Thompson, K.J., S.D. Inglis, and K.D.E. Stokesbury. 2014. Identifying spawning events of the sea scallop (*Placopecten magellanicus*) on Georges Bank. *J. Shell. Res.*, **33**(1): 77–87.

Uki, Nagashisa. 2006. Stock enhancement of the Japanese scallop *Patinopecten yessoensis* in Hokkaido. *Fisheries Research*, **80:** 62-66

Wiharyanto, Dhimas. Dkk. 2013. Pendekatan Metode Von Bertalanffy Untuk Analisis Pertumbuhan Kerang Kapah *(Meretrix meretrix)* Yang Berasal Dari Pengepul Pantai Amal Lama Kota Tarakan. *Jurnal Akuatika*, **6**(1): 102-114.

Woli, K. P., Nagumo, T., & Hatano, R. 2002. Evaluating impact of ldan use dan N budgets on stream water quality in Hokkaido, Japan. Nutrient Cycling in Agroecosystems, **63**(2–3): 175–184.

Zhurba,E.K.,Leskova,S.E. 2017. The Experience of Cultivating the Seaside Scallop (*Mizuhopecten yessoensis* Jay, 1857) in Severnaya Bay (Peter the Great Bay, Sea of Japan). In the State and Ways of Aquaculture Development in the Russian Federation In The Light Of Import Substitution And Ensuring The Country's Food Security*: Proceedings of the II National Scientific and Practical Conference, St. Petersburg*: 43-47.