Morphometric study of pacific oyster (*Crassostrea gigas*) in the coastal area of Banda Aceh

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Abstract. This study aimed to analyze and to assess differences in morphometric characteristic of Pacific oyster (*Crassostrea gigas*) found in the coastal area of Banda Aceh, specifically at Tibang region (mangrove forests of the city, Tibang’s river mouth and reservoirs) and Ulee Lheue region (Deah Baro mangrove, Ulee Lheue fishing harbor, and the estuary area of Banda Seafood). The research used purposive sampling method, with sample collected using line transect method. Three morphometric characteristics measured in the study were total length (PT), width (L) and height (H). Obtained morphometric data was then analyzed using univariate approach (ANOVA). The result indicates significantly different (P <0.05) morphometric characteristics of Pacific oyster (PT, L and T) in the waters of Banda Aceh where the Pacific oyster in Tibang region showed greater result of total (PT), width (L) and height (H) compared to Ulee Lheue region (PT=33.22-82.63; 20.40-39.71; L=42.60-116.70; 40.54-96.36; and T=21.83-140.31; 21.04-118.85). Furthermore, the result was validated using discriminant function analysis (DFA) which aimed to explore the contribution of each morphometric characteristics in classifying oyster population at different locations. DFA analysis shows there are morphometric variations of Pacific oyster at these regions, however, the morphology of the populations is clustered and overlapping therefore it can be concluded they are the same species (*Crassostrea gigas*).

1. Introduction

The coastal area of Banda Aceh possess diverse natural resources that can be relied as sources of food and income by its surrounding communities [1]. These potential resources need to be explored and conserved for the common good. One of these resources is oysters, which a lot of people depend on as their source of life. Oyster is well known by the public as a highly nutritious food [2, 3, 4]. This molluscs creature has an important role in the fishing community, especially for the fisherwomen. Fisherwomen are often not engaging in skillful fishing activities thus relying on abundant, more accessible, and easier to catch creatures such oysters. By catching oysters, fisherwomen help to contribute to their family’s economy.
when their husbands’ catch from the ocean unable or barely cover household expenses. Today however, many coastal villagers are complaining that the number of oysters continues to decline. Fishing exploitation such as excessive catching of young oysters, can be one of the factors that caused the fall of oysters’ population that area is currently experiencing [5].

The coastal areas of Banda Aceh that regard oysters as their main commodities areas of Gampong Tibang and Gampong Ulee Lheu. Gampong Tibang is one of the gampong located within the district of Syiah Kuala, bordering with Gampong Alue Naga and Gampong Deah Raya. Women living in this Gampong mainly work as oysters’ catchers and sellers. The community has long been oysters’ farmer, making Gampong Tibang a highly potential oyster’s producers area. At the experiment site of Gampong Tibang, the region is considered more as freshwater instead of seawater. The water in this area comes from Krueng Aceh which then flows to Krung Lam Nyong, then towards the last disposal at the river mouth located in Gampong Tibang. Due to the nature of its location, the government of Banda Aceh city has built a reservoir in Gampong Tibang as an effort to cope with floods. This reservoir also facilitates the encounter of seawater and land during tidal period. The natural phenomenon resulted in waters that is also greatly influenced by the condition of the sea.

According to [6] there are five species of Pacific oysters in Kuala Gigieng, Aceh Besar. The species consists of genus *Ostrea* and *Crassostrea*, and they are *Crassostrea virginica*, *Crassostrea gigas*, *Crassostrea iridescens*, *Crassostrea angulata* and *Ostrea edulis*. This study also finds that one of the most common species found was *Crassostrea gigas*. *Crassostrea gigas* is a Pacific oyster from the *Ostreidae* family and belongs to the bivalve class (has two shells). This type of oysters have the characteristics of coarsely coated with irregular shapes shell. *Crassostrea gigas* is the most abundant and most common type of oysters in the world. This is because species proved more adaptable in different environment. In addition, *Crassostrea gigas* also tends to settle in one location compared to other species of oysters. Along with their high adaptability, *Crassostrea gigas* also has the shape and color in its shells according to the substrate it occupies. In addition to easily be obtained, *Crassostrea gigas* poses larger and tenderer meat which make them popular in the coastal community. Generally, shell’s length of *Crassostrea gigas* is less than 20 cm, but literature mentions that *Crassostrea gigas* can grow its shell up to 40 cm and lives up to 30 years in a conducive environment.

So far, the research on *Crassostrea gigas* is still not common in Aceh. Some researches that have done on *Crassostrea gigasinclude*: the analysis of heavy metal content of Pb on *Crassostrea cucullata* oysters on the coast of Krueng Raya, Aceh Besar [7]. Pacific oysters’ community structure in estuary waters of Kuala Gigieng, Aceh Besar District, Aceh Province [1], diversity of macrozoobenthos in the waters of Kuala Gigieng, Aceh Besar District [8], cadmium, lead and zinc contamination on Pacific oysters (*Crassostrea gigas*) harvested from the Lamnyong river estuary, Banda Aceh, Indonesia [9], the relations of height and width of *Ostreidae* family at Kuala Gigieng estuary, Aceh Besar regency, Indonesia [10]. However, research on measurement of the oysters’ morphometric characters, especially c, has never been done. [11] say that data on measurements of morphometric characters for identification and taxonomic purposes is still limited. Therefore, it is important to conduct a research related to morphology aspects of *Crassostrea gigas*. In addition, this research will also be a significant contribution in the field of invertebrates’ morphology (character of the outer body). More importantly, it can be used as a tool to be utilized for future conservation of Pacific oysters population in Aceh.

2. Methods

2.1. Time and Location

The research was conducted in the waters area of Banda Aceh which are in Gampong Tibang (mangrove ecosystem of urban forest, Tibang river estuary, and Tibang reservoir) and in Gampong Ulee Lheue (Deah
Baro mangrove ecosystem, Ulee Lheue fishing port, and Banda Seafood estuary). At each location, sampling was conducted at three stations. For Gampong Tibang location, the locations were mangrove ecosystem of urban forest, Tibang river estuary and Tibang reservoir. On Gampong Ulee Lheue location, the stations were Deah Baro mangrove ecosystem, Ulee Lheue fishing port, and Banda Seafood estuary area. Field survey and data collection were conducted in July 2017.

Figure 1. Map of the research sites. This study will be conducted at two locations, Tibang and Ulee Lheu. Each location has three location points for sampling

2.2. Methodology
This research used purposive sampling method by observing coastal regions in two locations (Tibang and Ulee Lheu). Sample collection was conducted using line transect method.

2.2.1. Data Collection. Collected oysters were measured in length using a digital caliper (Precision Measuring Error = 0.01 mm). Similarly, the oysters’ weight was also measured using a digital scale (Pocket Scale, MH-Series, Error = 0.01 g). Morphometric characters measurement was performed in the laboratory after the sample first preserved using 10% formalin solution.

2.2.2. Morphometric Measurement. Samples that had been preserved were measured of its morphometric characters. The method used was traditional morphometric measurements referred to [12] and [1]. Measurements are as follow:
Table 1. Measurement traditional morphometric

| No | Code | Character | Explanation |
|----|------|----------|-------------|
| 1  | PT   | Total Length | Distance measured between the anterior and posterior of the oyster |
| 2  | L    | Width      | Distance measured between the left and the right side of the oyster |
| 3  | T    | Height     | Distance measured between the top and bottom of the oyster. |

Measured data then calculated in Microsoft excel using [13] formula below:

$$M_{trans} = \frac{M \times 100}{TL}$$

Where: $M_{trans}$ = data transformation, $M$ = measurement data obtained, $TL$ = Width. Height

Calculated data then processed further using SPSS version 22.0 before being passed for univariate (ANOVA) and multivariate (discriminant function analysis, DFA) ( [12] tests. The result will explain morphologi closeness or cluster between different populations within the same species.

3. Results and Discussions

3.1. Univariate Analysis

Statistical results of the study show significant differences (P <0.05) in each characters of oysters population collected from the six sites (Table 2). This findings suggest there are differences in morphological characters occurring in the oysters’ population despite being the same species. This is likely due to differences in environmental conditions that affect the shape of oyster morphology.
Table 2. Statistical tests result of oyster population’s morphometric characters in six sites. The values followed by different superscript show significantly different (P <0.05).

| Character (Code) | Gampong Tibang | Gampong Ulee Lheue | Sig (P) |
|------------------|----------------|-------------------|---------|
|                  | St I           | St II             | St III  |         |
| Total length (PT) (cm) | 27.81-72.77 (71.02±0.21) | 33.22-82.63 (77.95±2.69) | 20.46-76.04 (72.04±0.50) | 24.22-51.50 (36.47±0.94) | 20.40-39.71 (32.30±0.68) | 22.95-72.70 (39.88±1.22) | 0.000 |
| Width (L) (cm)   | 42.93-117.58 (77.96±2.10) | 42.60-116.70 (75.76±2.19) | 39.94-123.21 (75.60±2.16) | 35.76-137.54 (77.17±3.54) | 40.54-96.36 (65.94±1.87) | 27.79-124.66 (59.53±2.34) | 0.000 |
| Height (T) (cm)  | 23.38-72.15 (40.18±1.54) | 21.83-140.31 (37.76±2.37) | 20.63-108.06 (37.99±1.83) | 25.40-94.69 (44.07±1.80) | 21.04-118.85 (39.89±2.58) | 12.81-55.03 (29.76±1.37) | 0.000 |

3.2. Mutivariate Analysis

The result of discriminant function analysis (DFA) shows oyster population from the six sites can be discriminated into two distinct groups. Samples from Tibang I, Tibang II and Tibang III can be grouped into one same group (Group I), while Ulee Lheue I, Ulee Lheue II and Ulee Lheue III can be discriminated against in different groups (Group II) (Figure 3). DFA analysis yielded 3 functions. First function had 2.31 eingenvalue value which described 94.4% total variance, second function had 0.13 eingenvalue value which explained 5.5% total variance and last function had 0.004 eingenvalue which explained 0.1% total variance (Table 4). In addition, PT as a morphometric character contributed to function 1, while characters L and T contributed to function 2 (Table 3).

Furthermore, the discriminant function analysis (DFA) results indicate that oyster population in Gampong Tibang is overlapped and clustered within the same group, while the oyster population from Gampong Ulee Lheue is separated in other different group. This shows that the oyster’s morphological characters at the same location has high similarity, which is why they are seen to be gathered in one cluster in the scatter plot (Figure 3).
3.3. Discussions

Result indicates that site differences may cause variations in oysters’ morphological characters despite being the same species. Differences due to environmental factors are likely to significantly contribute to the oysters’ morphological characters of PT, L and T (Table 2). This result is in accordance with the statement of [14] that oysters collected from different sites have different morphological characters as the physical, biological and chemical factors from the environment affect the growth ratio and oysters’ meat weight. [15] mentions that oysters’ morphology variation occurs due to the high intra-specific variation, this often results in difficulty during the identification process. In addition, oysters are often exposed to high pollutants due to their natural behavior of inhabiting the bottom of the waters (benthos). This negatively affect the oysters’ growth as the creatures spent much of their energy for adapting instead of growing [16].

Oysters are settled on hard media at the bottom of the water. The growth and the fertility of the oysters are heavily dependent on the presence of available food sources in the vicinity of the waters. Oysters that live in a fertile environment will easily form a shell, therefore size of the shell can be used as an indicator food availability. Sufficient nutrients will result in bigger and thicker oysters than ones that live in an infertile environment. According to [11] environmental conditions play a major role in the formation of oyster shells. These environmental factors include climate, food sources, temperature, current, quantity of pollutants and aquatic salinity [14, 15, 17].
The univariate analysis shows that PT, L and T character of oysters collected from Gampong Tibang are higher than the oysters collected from Ulee Lheue. This explains that the oyster size from Gampong Tibang is greater than the oysters from Gampong Ulee Lheue. Morphology variations that occur there may be due to differences in environmental circumstances that occur in two locations. In addition to the different types of oysters [12], genetic factors also play important role in oysters’ morphological variations [5, 18]. Furthermore, genetic factors also indicate the specificity of different types and habitats of oysters [19].

There are noticeable different environmental condition on waters of Gampong Tibang and Gampong Ulee Lheue as observed during field survey. Sampling location at Gampong Ulee Lheue waters is actively used as a station for fishermen ships whereas Gampong Tibang waters is only occupied by few small size speed boat. In addition, Gampong Ulee Lheue has one oil refueling station for the ships, whereas Gampong Tibang does not have it. Consequently, human activities in Ulee Lheue waters is higher thus produces higher sound and waste pollution compared to Gampong Tibang. The waste generated from the human activities as well as the ship station comes in the form of organic and inorganic waste. Organic waste contained in the waters can be filtered and used for oyster growth. [20] argue that oysters serve as filtration agent, bioremediation, and contributor in the nitrogen cycle process in aquatic environment. Unlike the organic waste, inorganic materials contained in the waters will negatively affect the growth and survival of oysters as it turn into harmful residues thus making the oysters unhealthy for humans to consume [9]. Previous research by [21] on the effect of oil leakage on the waters of the Deepwater Horizon, USA, illustrates this danger. The phenomenon caused significant adverse effects on the growth and as well as recruitment of oysters (*Crassostrea virginica*) due to the suspension of oil in the waters.

Similar result is also shown in the DFA test, where the morphological characters of the oysters at the same location will converge on similar group due to their high character similarity (Figure 3). Oysters from different locations are discriminated separately with oysters from other locations. Although variations of morphology often results in different clusters, the oysters at the Gampong Tibang and Gampong Ulee Lheue sites seems to be from similar cluster as illustrated on the DFA scatter plot. Previous research by Grizzle *et al.* (2016)[22] on growth, morphometric variations and food types at *Crassostrea Virginica* in New Hampshire, USA, mentions that morphometric variation is caused by season, nutrient concentration, as well as carbon and nitrogen concentrations in the waters. Therefore, it can be concluded that the oyster species at the Gampong Tibang and Gampong Ulee Lheue sites are the same species.

4. Conclusions
Based on univariate analysis result, it can be concluded that there is significant difference (P <0.05) to oysters’ morphology characters from the two different sampling locations. Similar result was also seen from DFA test, there are morphological variations among the oysters yet as located at closely distance it can be concluded samples are from the same species. Furthermore, different sampling sites may also affect the morphological structures of oysters which caused variations in morphological forms.

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