Population structure of lamp shells (Brachiopoda: *Lingula anatina* Lamarck, 1801) in Aceh Northern Shore, Indonesia

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**Abstract.** This study aimed to determine the population structure of *Lingula* sp. in the Aceh northern shore. This research uses purposive sampling method where the sampling locations at Ujong Pancu beach, Kuala Cangkoi beach, Syiah Kuala beach and Alue Naga beach. Sampling was carried out using a quadratic transect (1x1 m) with three stations at each location. The results showed that there is one type of Brachiopods, namely the genus *Lingula* (Bruguière 1791), species *Lingula anatina* Lamarck, 1801 which are scattered on the north coast of Aceh. Overall, the abundance of *L. anatina* was quite high at each location, especially at Kuala Cangkoi beach (2.43 ind/m²), while the lowest abundance was found at Ujong Pancu beach (1.11 ind/m²). In addition, it was also found that *L. anatina* had a similarity distribution on the Aceh northern shore. The existence of *L. anatina* on the Aceh northern shore is very dependent on good environmental conditions, in general, the quality of the waters of Aceh northern shore is still within the tolerance limits of these biota. Therefore, population structure of *L. anatina* is stable, so that this biota resource must continue to be considered and managed properly.

1. **Introduction**

The Aceh northern shore are at the coordinates of 05°00'00"- 06°00'00" North Latitude and 95°00'00"- 96°00'00" East Longitude and are directly adjacent to the Indian Ocean and the Malacca Strait which are located to the east. The western tip of Sumatra Island so that the northern waters of Aceh have abundant and diverse biological resource potential [1, 2]. The northern waters of Aceh have abundant marine biological ecosystems and one of them is the existence of the phylum Brachiopods. Based on direct observations in the field, the Phylum Brachiopods found at that location was the species *Lingula anatina* Lamarck, 1801.

Phylum Brachiopods is a group of aquatic invertebrates that live as benthic animals in the sea with closed soft bodies in a shell consisting of two different valves [3, 4]. This phylum was an important component of early Cambrian marine fauna [5] and one of the marine invertebrates with the most
complete fossil record due to its emergence from the early Cambrian to its distribution in the modern ocean [6]. Since the Paleozoic era, around 30,000 fossil species of the phylum Brachiopods have been found, but in the Mesozoic era the diversity and abundance of Brachiopods has decreased drastically and at this time it is considered a minor phylum [4]. Brachiopods are derived from the Greek words Brachios which means hand and Podos which means foot. So these Brachiopods are animals that have organs that function as hands and feet [7].

One of the Brachiopods phyla that can still be found is L. anatina. The local name for L. anatina is lamp shells, but the local name for the regions of Aceh and North Sumatra is baree or biree.

According to [8] and [9] these lamp shells can be found under sediments or substrates in the intertidal zone in a waters. The intertidal zone is the area of the sea closest to the land and extends only from the high tide to the low tide area. Apart from being an ancient animal, it turns out that the existence of this lamp shell has an important ecological meaning in the environment [10, 11]. These lamp shells include benthic or benthos group animals. This benthos community can be used as a basis for information regarding indications of pollution in a waters [12]. According to [13], benthos with its natural properties can be used as an indicator of the health of a waters. In addition, these organisms also play a major role in the food chain cycle, which can be primary consumers (herbivores) and secondary consumers (carnivores) or as decomposers that convert organic matter into simpler elements so that they can be used again by other organisms [14].

The previous research on L. anatina was [9] on the eco-biology of Brachiopods at the confluence of the Subarnarekha Estuary with the Bay of Bengal, India. In Indonesia, [15] conducted research on lamp shells in Lubuk Damar, Aceh Tamiang. In addition, research on the density and distribution of lamp shells on the Aceh northern shore has also been conducted by [16]. However, it turns out that not much research has been done on the population structure of lamp shells, in Indonesia, especially in Aceh Province, so that researchers believe the existence of this ancient fauna still needs to be explored further in order to examine information, especially the population structure of lamp shells so that it can be a reference for future researchers. The purpose of this study was to determine the population structure of lamp shells through density approaches, distribution patterns and habitat conditions.

2. Material and Methods

2.1. Site and Time

This research was conducted in four locations in the northern waters of Aceh, namely Ujong Pancu Beach, Kuala Cangkoi Beach, Syiah Kuala Beach, and Alue Naga Beach in April-July 2021. Identification of lamp shells was carried out in the Marine Biology laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala and substrate analysis was carried out. The research location can be seen in Figure 1.
2.2. Data Collection

In collecting data on lamp shells (L. anatina), several tools were used such as quadratic transects (1x1 m), paralon pipes (5 cm diameters), machetes, plastic samples, digital cameras, thermometers, litmus paper, refractometers, stationery, trays, tweezers, calipers, and Ohaus scales (0.0001 g), while the materials used were samples of L. anatina, substrate, and aquadest and seawater.

Furthermore, sampling of lamp shells was carried out by purposive sampling method. Biota and substrate samples were taken using a 1x1 m quadratic transect. Then the lantern shell samples were brought to the laboratory to be analyzed for their type, density and distribution pattern. It is different with water and substrate quality parameter data, measurement of water quality, namely temperature, pH, salinity, is carried out in situ. The substrate was taken in situ and then the substrate was analyzed ex situ. Substrate samples were taken using a paralon pipe at a depth of 30 cm. Substrate sampling was carried out only once at each station. After that, the substrate sample that has been taken is inserted into the sample plastic. Furthermore, the substrate samples were marked using name paper and brought to the Laboratory of Soil Chemistry, Faculty of Agriculture, Universitas Syiah Kuala for texture, C-organic and N-total analysis.

2.3. Data Analysis

2.3.1. Lingula’s Density and Distribution Pattern (Morisita Index).

The Lingula’s density and Morisita index refers to [17] using the following formula:

\[
D = \frac{N_i}{A} \\
I_d = \frac{N^2 - N}{N (N - 1)}
\]

Where, D is density index of L. anatina (Ind/m²); N is number of individuals (Ind); A is area; and \( I_d \) is Morisita index.

For Morisita index, after analyzing the formula above, it will then be grouped based on the number of its \( I_d \) values. For the value \( I_d < 1 \), the individual grouped is uniform, while for the value \( I_d > 1 \) it means that the individual is grouped.
2.3.2. Habitat Condition.

The grouping of research locations was based on physico-chemical parameters. This grouping is determined using the Canberra metric [18, 19] with a similarity value ranging from 0 to 1, where if the similarity value is close to 1, the similarity level is high. From this value, a similarity matrix and dendrogram can be made between observation stations using the EXCELSTAT version 2020.4 program to determine the level of similarity and grouping of stations based on physico-chemical parameters.

$$c = \frac{1}{n} \sum_{i=1}^{n} \frac{|y_{i1} - y_{i2}|}{y_{i1} + y_{i2}}$$

$$S = 1 - C$$

Where, C is Canberra metric; S is similarity; n is number of parameters compared; yi1 is number of chemical-physics parameters-i for station 1; yi2 is is number of chemical-physics parameters-i for station 2.

3. Result and Discussion

3.1. Density of Lingula anatina Lamarck, 1801

The results of the research on the abundance of L. anatina and type of substrat Aceh Northern Shore that have been carried out can be seen in Table 1. Table 1 shows that the highest abundance value is at the Kuala Cangkoi Beach location with a total abundance of 2.43 ind/m². The high abundance of L. anatina is caused by several factors. The first factor is the type of substrate. The type or type of substrate is very influential on the abundance of L. anatina. According [20] stated that organisms, especially L. anatina which includes benthic animals, have a range of distribution on sandy and muddy substrates, but these organisms prefer places where the substrate is muddy sand. In accordance with the above statement, the abundance of L. anatina at the Kuala Cangkoi Beach location is high because the type of substrate at that location is suitable, namely loamy sand which is in Table 1.

Table 1 also shows the lowest abundance at the Ujong Pancu Beach location with an abundance value of 1.11 ind/m². This is presumably not due to the condition of the type of substrate that affects the water quality but other factors such as predation or competition with other species.
quality, but in the Ujong Pancu area, the people often take this *L. anatina* for consumption, so it is possible that this is the cause of the low abundance in the area.

### 3.1.1. Distribution Pattern of *Lingula anatina* Lamarck, 1801

The results of the research on the distribution pattern of *L. anatina* can be seen in Table 2. The results in Table 2 show that the distribution pattern of *L. anatina* from all locations that have been obtained is uniform, with the value of the morisita index at the Ujong Pancu location is 0.018, Kuala Cangkoi 0.107, Syiah Kuala 0.036, and Alue Naga 0.091 where from the total obtained from all locations the average is 0.063 so that *L. anatina* in the northern waters of Aceh is grouped uniformly.

| Location        | Morisita Index (*I*ₐ) | Category       |
|-----------------|-----------------------|----------------|
| Ujong Pancu     | 0.018                 |                |
| Kuala Cangkoi   | 0.107                 | similar        |
| Syiah Kuala     | 0.036                 |                |
| Alue Naga       | 0.091                 |                |

The similar pattern of *L. anatina* in the northern waters of Aceh is also influenced by environmental conditions in these waters and is also influenced by the type of substrate, where in all research locations the substrate type tends to be muddy sand. This is in line with previous research conducted by [19] where the distribution pattern produced is due to differences in habitat, environmental changes, reproductive patterns, social behavior, and daily and seasonal weather conditions. In addition, previous research conducted by [15] in Lubuk Damar, Aceh Tamiang found that the density was also evenly distributed in the intertidal area with a muddy substrate type.

### 3.2. Habitat Condition of *Lingula anatina* Lamarck, 1801

Habitat analysis on *L. anatina* can be done by predicting it by grouping observation stations based on their physico-chemical parameters, namely water quality such as temperature, salinity, water pH, C-Organic, N-Total and substrate type conditions. Habitat grouping based on physico-chemical parameters using Canberra metric. The results obtained can be seen in Figure 2.

The picture above shows locations 3 and 4, namely Alue Naga Beach and Syiah Kuala Beach which have high habitat inequality values because the graph is close to 1 so that based on physicochemical and biological parameters they become one group, while locations 3 and 4 are Ujong Pancu Beach and Kuala Cangkoi separate groups because they have low habitat inequality (close to 0) which can be seen in the graph above. This means that based on the results of the physical and chemical parameters of the waters and substrate, the beaches of Kuala Cangkoi and Ujong Pancu have similar habitats, while the beaches of Alue Naga and Syiah Kuala also have similar habitats but are not the same as those of the beaches of Ujong Pancu and Kuala Cangkoi. Differences in habitat grouping are caused by the effect of differences in density and the presence of aquatic environmental factors [21].
Note: KC is Kuala Cangkoi; UP is Ujung Pancu; AN is Alue Naga, SK is Syiah Kuala

Figure 2. Habitat condition in Aceh northern shore

Table 3. Parameters of water and substrate on Aceh northern shore

| Parameter of Water Quality and Substrate | Alue Naga | Kuala Cangkoi | Syiah Kuala | Ujong Pancu |
|------------------------------------------|-----------|---------------|-------------|-------------|
| Temperature (°C)                         | 28,3      | 28,3          | 30          | 33,6        |
| Salinity (‰)                            | 15        | 14            | 30          | 16          |
| pH                                       | 7         | 7             | 6           | 7           |
| C-organik (%)                            | 0,08      | 0,39          | 0,16        | 0,71        |
| N-total (%)                              | 0,03      | 0,04          | 0,04        | 0,03        |
| Criteria                                 | Clayey sand | Clayey sand | Sand       | Clayey sand |
4. Conclusion

Based on the research conducted, only one species was found, namely *L. anatina*. The highest density of *L. anatina* was found at the Kuala Cangkoi Beach and the lowest density of *L. anatina* was found at Ujong Pancu Beach. The distribution pattern of *L. anatina* from all locations was similarity. The habitat conditions of the four locations are slightly different, namely Alue Naga Beach and Syiah Kuala Beach have the same habitat so that they are separated from Ujong Pancu Beach and Kuala Cangkoi due to differences in environmental parameters.

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