The diversity and abundance of phytoplankton in Lubuk Damar coastal waters, Aceh Tamiang, Indonesia

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Abstract. In the coastal ecosystem, mangroves play essential roles in biodiversity and energy flow, and phytoplankton functions as primary producers. This study aims to ascertain the diversity and abundance of phytoplankton in mangrove habitats at Lubuk Damar, Aceh Tamiang. Sampling was performed at Lubuk Damar in August 2017 and January 2018, Aceh Tamiang Regency, via a plankton net with a 20-micron mesh size. The outcome of this study will help to evaluate the phytoplankton contribution in mangrove estuarine ecosystems. In January 2018, the phytoplankton was more abundant than in August 2017. However, diversity was higher in August compared to January. The Index Diversity in August ranged between 1.24 – 2.83 and in January around 0.83 – 2.35. Furthermore, the Index Dominance in January was within 0.17 – 0.73, and in August around 0.08 – 0.48. Evenness Index in January was around 0.23 – 0.64, and in August, 0.11 – 0.87. In January, Chaetoceros sp. was dominant in water, followed by Bacillaria sp, and Biddulphia sp. In August, Leptocylindrus sp. was dominant in phytoplankton diversity, followed by Biddulphia sp. and Chaetoceros sp. In coastal water of Lubuk Damar, the presence of diatoms dominate the abundance phytoplankton.

1. Introduction
In the estuaries ecosystem, mangrove habitats are generally nutrient traps that support high primary productivity, promoting high levels of secondary production [1]. Mangrove is characterized by a complex interaction between biotic and abiotic components. They play essential roles in biodiversity and energy flow, with phytoplankton functioning as a primary producer. Phytoplankton is microscopic, single-celled organisms in the aquatic environment that fixes solar energy through the process of photosynthesis, assimilating carbon dioxide and water to produce carbohydrates [2] and important ecological niche in fisheries resources [3]. Among the phytoplankton groups, the Bacillariophyceae was the dominant class and can be used as a suitable bio-indicator for water quality [4-7], and phytoplankton community index can u access coastal water of health [8].

Abundance, distribution, and species composition are essential in determining the status of an estuarine ecosystem. This depends on some species of phytoplankton as their primary food source [9]. This phytoplankton initiates the marine food chain by serving as food to primary consumers such as...
zooplankton, shellfish, and finfish [10]. Their availability influences the distribution of consumer organisms, such as herbivore zooplankton. They also have high nutrient content, making them a valuable food item in the aquatic food chain [11]. Their abundance also influences the level of aquatic productivity. Hence, waters with high primary productivity are characterized by a correspondingly high abundance of phytoplankton [12].

Research on the abundance and diversity of phytoplankton in the Aceh Tamiang mangrove ecosystem is limited. In tropical regions, particularly in mangrove habitat, the information on the role of mangrove detritus in the estuary ecosystem in common but is highly limited in phytoplankton. Thus, this study investigates the diversity and abundance of phytoplankton in mangrove habitats at Lubuk Damar, Aceh Tamiang, Indonesia. The outcome will help to evaluate their contribution to the mangrove ecosystem.

2. Material and Methods

2.1. Description of the study sites

This research was carried out on the coast of the Lubuk Damar mangrove ecosystem, Seruway District, Aceh Tamiang Regency, and the sampling were performed at three stations. Station 1 was located in 98° 15' 44.544" E and 4° 18' 19.646" N. Station 2 in 98° 15' 32.880" E and 4° 17' 54.727" N. Station 3 was situated in 98° 15 21,138 E and 4° 17 29,756 N. Station 1 was dominated by Xylocarpus granatum, station 2 dominated by Soneratia alba and station 3 by Aegiceras floridum. The distance between stations is 800 m (Figure 1).

Figure 1. Map showing the location of Lubuk Damar, Seruway, Aceh Tamiang, Indonesia, where the sample was collected (the red dots).

Phytoplankton sampling was performed by filtering 100 liters of seawater twice. Filters with a 50 μm mesh size were placed above to prevent zooplankton from entering, while sieves with a 20 micron mesh size were below. Furthermore, the preservation process was carried out by dropping 20-30 drops of Lugol into the sample bottle.

2.2. Plankton sampling and identification

The sample was collected in August 2017 and January 2018 with plankton net mesh size 28 μm and 30 cm. For each line, three repetitions were taken using a 10-liter volume bucket. The volume used in each line was 100 liters, and the sample was kept in a 250 ml volume bottle and preserved in 1% Lugol iodine.
The sample was identified in Biomicro Laboratory, Department of Aquatic Resources Management, Bogor Agricultural University, Indonesia. The identification of the specimens was conducted following the shape and morphology in [13]. In the laboratory, 1 ml of filtered water was dropped into Sedgwick Rafter Counting and using a light microscope (Olympus CH-2 at 10x magnification), plankton was identified as the possible lowest taxon. Phytoplankton diversity was determined based on the Shannon-Weaner Index.

3. Results and Discussion
In August 2017, a total of 42 species belonging to 29 families were identified: Bacillariophyceae (23 family and 34 species), Dinophyceae (3 family and five species), Cyanophyceae (1 family and one species), Chlorophyta (1 family and one species), Dictyochaceae (1 family, and one species) (Table 1). In January 2018, a total of 56 phytoplankton species belonging to 31 families were identified in Lubuk Damar: Bacillariophyceae (26 family and 42 species), Dinophyceae (3 family and six species), Cyanophyceae (1 family and one species), Dictyochaceae (1 family and one species). The overall composition, the presence above 5%, was found in the Bacillariophyceae and Chlorophyta divisions.

The results showed that 12 species were found in all stations, namely Amphipora sp., Bacteriatrium sp., Biddulphia sp., Chaetoceros sp., Coscinodiscus sp., Ditylum sp., Leptocylindrus sp., Nitzschia sp., Peridinium sp., Pleurogsima sp., Streptotecha sp., and Triceratium sp. In total, the phytoplankton found either in August or January were more than 40 species. This was higher than the research results in Darul Aman, Rupat, Bengkalis, Riau, which discovered a total of 25 species [14]. In both months, it was discovered that the Bacillariophyceae species were found more than other classes. It was also observed that this class had about 34 species in August and 42 in January. Furthermore, diatoms were dominant in this location. In the marine habitat, small-sized diatoms are the dominant groups in phytoplankton communities [15; 16; 17].

Table 1. Phytoplankton diversity at each station during the August 2017 and January 2018 research in Lubuk Damar, Seruway, Aceh Tamiang

| Station/Species | August 2017 | January 2018 |
|-----------------|-------------|-------------|
| Actinoptychus sp. | - | + |
| Amphipora sp. | + | + |
| Amphora sp. | + | + |
| Arachnoidiscus sp. | - | - |
| Asterionella sp. | - | - |
| Auliscus sp. | - | - |
| Bacillaria sp. | - | - |
| Bacteriatrium sp. | + | + |
| Bellerochea sp. | - | - |
| Biddulphia sp. | + | + |
| Campylodiscus sp. | + | + |
| Ceratium sp. | - | - |
| Chaetoceros sp. | + | + |
| Climacodium sp. | - | - |
| Cocconeis sp. | + | + |
| Corethron sp. | + | + |
| Coscinodiscus sp. | + | + |
| Dictyochta sp. | - | - |
| Dinophysis sp. | + | + |
| Diploneis sp. | + | + |
| Ditylum sp. | + | + |
| Eucampia sp. | - | - |
The comparative abundance between August 2017 and January 2018 is highly different (Table 2). In August, it ranged between 64,000 – 920,000 cell/m$^3$ and January, 23,484,311 – 190,315,789 cell/m$^3$. Hence, the abundance in January was 3x higher than August. This was due to the rainy season in January, which caused nutrients to float to the water's surface for consumption by phytoplankton. The nutrients were influenced by seasonal cycling, alongside the hydrodynamics of water acting as a driving factor for their abundance [18]. Changes in hydrodynamics and environmental conditions affect the production of phytoplankton [19]. Studies have revealed that nitrates, phosphate, salinity, and turbidity positively correlate with their abundance and distribution in tropical ecosystems [20].

In most cases, diatoms dominate the phytoplankton composition, such as Malaysia's mangrove estuary, which constitutes over 80% [21]. In the Kuantan coast, 63 genera of diatoms and seven genera of dinoflagellates were recorded [22]. In August 2017, *Leptocylindrus sp.* was dominant in phytoplankton diversity, followed by *Biddulphia sp.* and *Chaetoceros sp.* (Figure 2). In January 2018, the *Chaetoceros sp.* was dominant in water, followed by *Bacillaria sp.*, and *Biddulphia sp.* (Figure 3). Diatoms dominated in August and January, as nitrates, silicates, and phosphates were abundant, constituting the primary nutrients required by phytoplankton. Diatoms especially need silicate for

| Month | August 2017 | January 2018 |
|-------|------------|-------------|
| Station/Species | St1 | St2 | St3 | St1 | St2 | St3 |
| **Fragilaria sp.** | - | - | - | + | + | + |
| **Gomphonema sp.** | - | - | - | - | - | - |
| **Gonyaulax sp.** | - | - | - | - | - | + |
| **Gossleriella sp.** | - | - | - | + | + | + |
| **Guinardia sp.** | + | + | + | + | + | + |
| **Gyrosigma sp.** | - | - | - | + | + | + |
| **Halosphaera sp.** | + | + | + | - | - | - |
| **Hemiaulus sp.** | + | + | + | + | + | + |
| **Lauderia sp.** | + | + | + | + | + | + |
| **Leptocylindrus sp.** | + | + | + | + | + | + |
| **Melosira sp.** | - | - | - | + | + | + |
| **Mestogloia sp.** | + | + | + | + | + | + |
| **Navicula sp.** | - | - | - | + | + | + |
| **Nitzschia sp.** | + | + | + | + | + | + |
| **Omnithocercus sp.** | - | - | - | + | - | - |
| **Oscillatoria sp.** | + | + | + | - | - | - |
| **Peridinium sp.** | + | + | + | + | + | + |
| **Planktoniella sp.** | - | - | - | + | + | + |
| **Pleurosigma sp.** | + | + | + | + | + | + |
| **Protoperidinium sp.** | + | + | + | + | + | + |
| **Rhabdonema sp.** | - | - | - | + | + | + |
| **Rhizosolenia sp.** | + | + | + | - | + | + |
| **Skeletonema sp.** | - | - | - | - | - | - |
| **Stephanophysis sp.** | - | - | - | + | + | + |
| **Streptotheca sp.** | + | + | + | + | + | + |
| **Surirella sp.** | - | - | - | + | + | + |
| **Thalassionema sp.** | - | - | - | + | + | + |
| **Thalassiosira sp.** | + | + | + | + | + | + |
| **Thalassiothrix sp.** | - | - | - | + | + | + |
| **Triceratium sp.** | + | + | + | + | + | + |
| **Trichodesmium sp.** | - | - | - | - | + | + |
building their cell. Therefore, the availability and concentrations of nutrients in water affect their diversity and abundance.

Table 2. Phytoplankton abundance profiles in Lubuk Damar in August 2017 and January 2018

| Station | August 2017 | January 2018 |
|---------|-------------|--------------|
|         | Abundance (cell/m³) | (H') | (D) | (E) | Abundance (cell/m³) | (H') | (D) | (E) |
| St1L1   | 399.398     | 2.04 | 0.00 | 0.62 | 45.946.065 | 2.05 | 0.33 | 0.51 |
| St1L2   | 176.401     | 1.72 | 0.08 | 0.58 | 39.793.534 | 2.12 | 0.27 | 0.58 |
| St1L3   | 407.018     | 1.40 | 0.43 | 0.48 | 30.568.020 | 2.04 | 0.27 | 0.52 |
| St1L4   | 250.226     | 2.45 | 0.14 | 0.78 | 23.484.311 | 1.62 | 0.48 | 0.42 |
| St1L5   | 327.218     | 2.74 | 0.08 | 0.87 | 44.216.942 | 1.29 | 0.45 | 0.34 |
| St1L6   | 309.654     | 2.54 | 0.13 | 0.77 | 26.967.368 | 1.47 | 0.52 | 0.38 |
| St2L1   | 193.123     | 1.59 | 0.37 | 0.59 | 29.765.614 | 1.52 | 0.39 | 0.41 |
| St2L2   | 260.491     | 2.04 | 0.21 | 0.71 | 63.837.393 | 1.12 | 0.52 | 0.30 |
| St2L3   | 98.165      | 1.86 | 0.25 | 0.73 | 136.616.541 | 1.21 | 0.43 | 0.31 |
| St2L4   | 165.774     | 2.83 | 0.08 | 0.86 | 43.684.211 | 2.35 | 0.17 | 0.64 |
| St2L5   | 208.281     | 2.36 | 0.17 | 0.73 | 18.866.165 | 2.34 | 0.20 | 0.62 |
| St2L6   | 920.301     | 1.45 | 0.48 | 0.43 | 21.858.647 | 0.83 | 0.73 | 0.23 |
| St3L1   | 342.135     | 1.89 | 0.25 | 0.61 | 108.160.000 | 1.63 | 0.42 | 0.41 |
| St3L2   | 111.519     | 1.82 | 0.27 | 0.11 | 190.315.789 | 1.28 | 0.55 | 0.33 |
| St3L3   | 144.361     | 1.24 | 0.43 | 0.54 | 49.962.105 | 1.37 | 0.49 | 0.35 |
| St3L4   | 206.997     | 1.76 | 0.28 | 0.62 | 183.758.596 | 1.06 | 0.63 | 0.27 |
| St3L5   | 89.664      | 1.81 | 0.26 | 0.69 | 154.491.228 | 1.00 | 0.67 | 0.26 |
| St3L6   | 64.000      | 1.39 | 0.42 | 0.60 | 26.287.519 | 1.23 | 0.58 | 0.32 |

A high abundance of the *Chaetoceros* sp. is presumably due to this type of diatom being highly tolerant of changing environmental conditions [23]. Its abundance in both months is also due to it being one of the most species-rich and cosmopolitan genera of planktonic diatoms [24]. From the composition and abundance in January 2018 in the waters of Lubuk Damar, the *Bacillariophyceae* class was more numerous than other classes, which was around ± 80%. The high abundance is due to its adaptation to the environment compared to other classes [25]. In addition to the results of this study, the relatively high abundance of this class was reported by several other studies, which showed that its composition was higher, precisely 90% in the waters of Tangerang [26]. In August 2017, the highest composition discovered was *Leptocylindrus* sp., although according to [27], this is a chain-shaped diatom found in estuaries and coastal waters in rarely abundant states. If abundance occurs, it may be due to high silicate concentrations and low N: P ratios. Furthermore, it may occur in high abundance, as this centric diatom is commonly found in marine waters worldwide in relation to its trigger factors such as nutrient level, temperature, rainfall, and salinity [28].

The Shannon-Weaver Index results further showed that phytoplankton in Lubuk Damar is categorized as low to moderate in August 2017 and January 2018. It also showed that in August, its level was around 0.83 – 2.35 and in January, 1.24 – 2.83. Therefore, it is concluded that diversity in August was higher than in January. The Index Dominance in August was around 0.08 – 0.48, and in January 0.17 – 0.73. There was a higher abundance in January 2018 than in August 2017 and a higher diversity in August 2017 than in January 2018. The Evenness Index in January 2018 was around 0.23.
– 0.64 and in August 2017 between 0.11 – 0.87. Hence, in August 2017, phytoplankton was more evenly distributed, although its abundance in August 2017 was lower than in January 2018.

Furthermore, the Lubuk Damar mangrove ecosystem is presumed to have contributed to the pattern of species abundance in the research location. The existence of mangroves also helps in the provision of nutrients during the decomposition process. This is in line with the opinion of [29], which stated that there is a symbiotic relationship between the roles of phytoplankton and mangroves in the estuary because they enrich the water as an ideal medium for their succession. Simultaneously, their presence plays a vital role in the estuary food web, which is influenced by mangrove waters' nutrition. Other effects include its role in fish diversity, [30] stated that seasonal changes influence phytoplankton's presence in nutrition.

4. Conclusions
Phytoplankton types were dominated by diatoms. In January 2018, the Chaetoceros sp was dominant in water, followed by Bacillaria sp., and Biddulphia sp. In August 2017, Leptocylindrus sp was the most dominant, followed by Biddulphia sp. and Chaetoceros sp. Its abundance in January 2018 was higher than in August, but its diversity higher in August than in January. The Shannon-Weaner Index in August 2017 ranged between 1.24 – 2.83 and in January 2018 around 0.83 – 2.35. Furthermore, in August, the Dominance Index was around 0.08 – 0.48, and in January, around 0.17 – 0.73. The Evenness Index in January was between 0.23 – 0.64 and in August around 0.11 – 0.87. Therefore, suggestions for future research are geared toward the justification of the number of nutrients from the mangrove ecosystem to the coastal waters of Lubuk Damar, for phytoplankton communities.

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