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Phytoplankton in the Anchialine Habitat of Red Shrimp (*Parhippolyte uveae*) at Mangrove Ecosystem Waters

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Abstract

The anchialine habitat waters of this study is located at mangrove ecosystem around Koguna Beach area, Buton Island, Indonesia. It is a closed water, isolated from the sea, and inhabited by *Parhippolyte uveae* red shrimp. The existence of phytoplankton in this habitat can be used to determine the availability of natural food and the water quality of this shrimp's habitat. This study was conducted to examine the presence of phytoplankton in the anchialine habitat of red shrimp. Phytoplankton samples were obtained by filtering water using Plankton Net. Meanwhile, several biological indexes such as the diversity index, evenness index, and dominance index were used to analyze the phytoplankton community. The result showed that this habitat was dominated by phytoplankton from the classes Bacillariophyceae, Florideophyceae, and Globothalamea with a total of 13 genera in September 2021 and Bacillariophyceae, Cyanophyceae, Dinophyceae, and Globothalamea with a total of 18 genera in December 2021. The most common type of phytoplankton found in the red shrimp habitat during the study was *Navicula* sp. with a ban of 1436 cells L^{-1} and 479 cells L^{-1} in September 2021 and December 2021, respectively. The diversity index of phytoplankton in this habitat was low, meanwhile, the index of evenness and dominance indicated that this habitat was of good quality (evenness index was high and dominance index was low). This study can be used as a basic information for further research on the management control for this species habitat.

Keywords: *anchialine habitat, community structure, Parhippolyte uveae, phytoplankton*

1. Introduction

The anchialine habitat at mangrove ecosystem waters around Koguna Beach area is a closed water, not directly connected to the sea on the surface, and overgrown with mangrove vegetation on the edges. Administratively, this area is included in Mopaano Village, Lasalimu Selatan District, Buton Regency, Southeast Sulawesi, Indonesia. This village is one of the fisheries access management areas (Pengelolaan Akses Area Perikanan-PAAP) and has a no-take zone (Kawasan Larang Ambil-KLA) which was stipulated based on the Decree of the Governor of Southeast Sulawesi Number 126 year of 2022 concerning the Determination of Access Management for Fisheries Areas in Siotapina District and Lasalimu Selatan District, Buton Regency, Southeast Sulawesi Province [1]. This habitat is inhabited by red shrimp which have very interesting colors and their identity is still a mystery to the local people. However, the previous study revealed that the red shrimp is a type of Parhippolyte uveae which is a typical shrimp that inhabits anchialine habitat [2].

P. uveae, the sugarcane shrimp, is a type of shrimp belonging to the Barbouriidae family and order Decapoda [3]. It has also been reported to be found in similar habitats in several places in Indonesia, such as Kakaban Island and Maratua Island, East Kalimantan [4,5], Tanjung Sanjangan, Tolitoli, Central Sulawesi [6], Lake Sombano, Wakatobi [7], Halmahera, North Maluku [8], and several islands in West [5].

P. uveae has very attractive colors that has the potential to be developed as an ornamental shrimp for aquariums. They have been traded at quite expensive prices ranging from 23.63 to 62.70 €, depending on the size [9]. Taking from nature certainly has the potential to put pressure on the population, therefore domestication and conservation efforts are needed to ensure its sustainability. Efforts to manage aquatic organisms for both domestication and conservation require information from various aspects [10–15]. One aspect that can be further investigated is the presence of phytoplankton in the anchialine habitat of red shrimp.

The existence of phytoplankton was used to determine the availability of natural food in water and determine the water quality of an ecosystem [16–18]. An investigation reported that the intestinal contents of P. uveae consisted of foraminifera, algae, mucus, and chyme [19]. This shows that one of its natural foods is algae. Studies on algae (phytoplankton) in this habitat have never been carried out. Up to now, studies that have been conducted on this habitat include characteristics of red shrimp habitat [20], growth patterns and condition factors for red shrimp [21], and molecular identification of the shrimp [2]. Therefore, this study aims to examine the presence of phytoplankton in the anchialine habitat of red shrimp at Koguna Beach area, Buton Island, Southeast Sulawesi, Indonesia.

2. Research Methodology

Phytoplankton sampling was carried out in the anchialine habitat at mangrove ecosystem waters around Koguna Beach area in Mopaano Village, Lasalimu Selatan District, Buton Regency, Southeast Sulawesi, Indonesia (Figure 1). The red shrimp habitat has a size of ± 70×25 m^2, so the determination of the research station was determined based on the representativeness of the location, i.e., center, left, and right sides. Sample analysis was carried out at the Aquatic Productivity and Environment Laboratory, Faculty of Fisheries and Marine Sciences, Halu Oleo University. This research was conducted from September to December 2021.

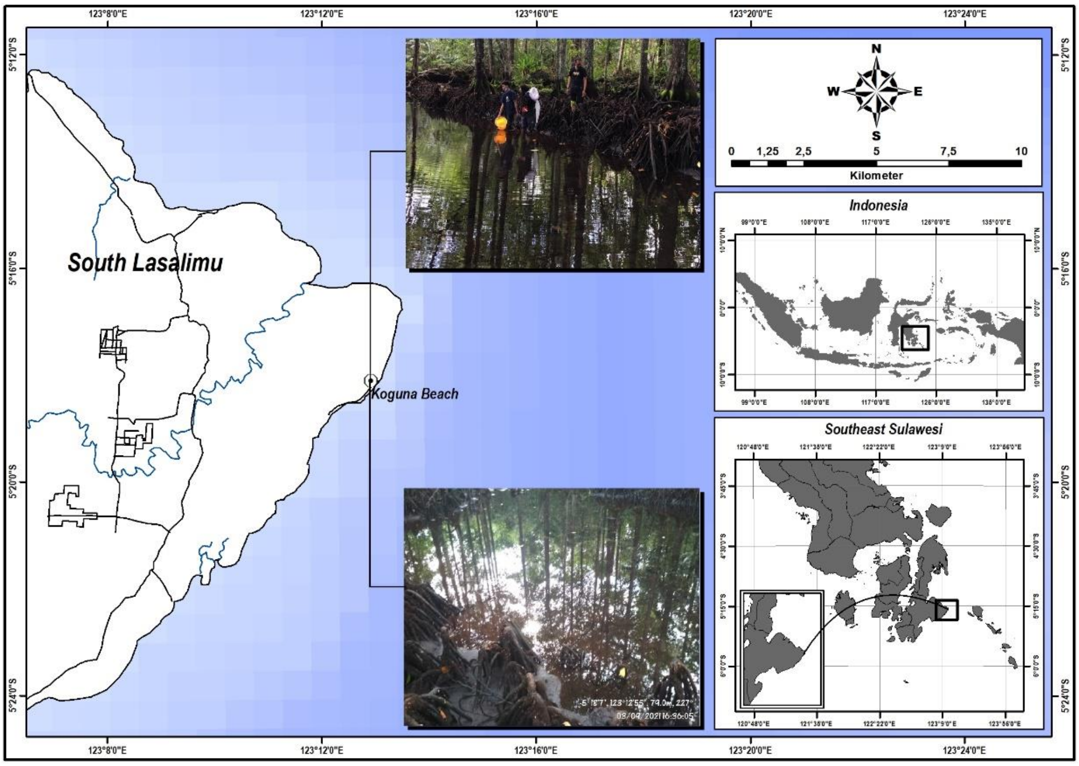

Figure 1. Sampling sites in the anchialine habitat of red shrimp at Koguna Beach area, Buton Island

Phytoplankton samples were obtained by filtering 100 liters of water using Plankton Net No. 25. These water samples that have been filtered in the bucket were poured into sample bottles and preserved by adding Lugol's solution. Phytoplankton identification method was carried out by census using a 10×10 magnification microscope and a 50×20×1 mm^3 Sedgwick-Rafter Counting Cell (SRC), by observing the entire area of sedgewick rafter Lackey drop microtransect counting [22]. Meanwhile, the identification of genus level was done based on various identifying phytoplankton books [23–25]. The following formula was used to calculate the phytoplankton abundance:

$$N = \frac{1}{A} \times \frac{B}{C} \times \frac{D}{E} \times n \quad (1)$$

Notes:

N = Phytoplankton abundance (cell L^{-1})
n = Total number of individuals of a specific species (cells)
A = Filtered water volume (L)
B = Volume of filtered water (ml)
C = Observed volume of water (ml)
D = Cover glass area (mm^2)
E = Area of Sedgwick Rafter (mm^2)

The phytoplankton community was analysed using several biological indexes such as the diversity index, evenness index, and dominance index. The following Shannon-Wiener index equation was used to calculate the species diversity:

$$H' = -\sum \frac{n_i}{N} \ln \frac{n_i}{N} \quad (2)$$

Notes:

H' = Diversity Index
n_i = Number of individuals of genus i
N = Total number of individuals

Furthermore, the evenness index (E) was calculated using the following formula:

$$E = \frac{H'}{H'_{max}} \quad (3)$$

Notes:

E = Evenness Index
H' = Diversity Index
H'_{max}= Maximum diversity value (Ln S)
S = Number of genera

The evenness index ranges from 0 to 1. Within this range, the smaller E value indicates the distribution of the individual number of each species is different, there is a tendency for dominance by certain species. Meanwhile, the greater E value indicates the number of individuals of each species is the same or no species dominates [26].

The dominance index was determined based on the Simpson's Dominance Index (C), calculated by the following formula:

$$C = \sum \left[\frac{n_i}{N}\right]^2 \quad (4)$$

Notes:

C = Dominance Index
n_i = Number of individuals of genus i
N = Total number of individuals

The dominance index also ranges from 0 to 1. This index is used to determine the dominance of a particular species in a population. A value close to 0 indicates no dominant species, while a value close to 1 indicates a dominant species.

3. Results

3.1. Result

3.1.1. Phytoplankton Composition and Abundance

The phytoplankton genera found in the red shrimp habitat in September 2021 were from the classes Bacillariophyceae, Florideophyceae, and Globothalamea with a total of 13 genera; while the genera discovered in December 2021 came from the classes Bacillariophyceae, Cyanophyceae, Dinophyceae, and Globothalamea with a total of 18 genera. The abundance of phytoplankton obtained during the study period can be seen in Tables 1 and 2.

Table 1. The abundance of phytoplankton found in the red shrimp habitat in September 2021.

Genus		Station					
		1.1	1.2	2.1	2.2	3.1	3.2
BACILLARIOPHYCEAE							
1	Cocconeis	34	41	42	27	7	-
2	Coscinodiscus	5	-	16	7	4	4
3	Diatoma	1	4	-	-	-	-
4	Eunotia	-	-	-	-	2	-
5	Licmophora	4	-	-	3	-	-
6	Melosira	-	-	44	56	-	-
7	Navicula	25	30	139	28	50	1164
8	Nitzschia	-	5	-	-	-	-
9	Pinnularia	-	-	-	-	1	-
10	Surirella	5	17	-	-	-	-
11	Synedra	-	-	-	-	6	-
FLORIDEOPHYCEAE							
12	Batrachospermum	54	44	33	-	-	-
GLOBOTHALAMEA							
13	Globigerina	21	30	21	5	-	-
	Total abundance (cells L^{-1})	147	170	294	125	71	1168

Table 2. The abundance of phytoplankton found in the red shrimp habitat in December 2021.

Genus		Station					
		1.1	1.2	2.1	2.2	3.1	3.2
BACILLARIOPHYCEAE							
1	Chaetoceros	5	4	2	-	-	-
2	Cocconeis	13	66	16	16	24	15
3	Coscinodiscus	5	9	2	3	-	-
4	Cymbella	1	-	-	-	-	-
5	Diatoma	1	-	-	-	-	-
6	Eunotia	-	-	1	-	-	-
7	Gomphonema	-	-	-	-	-	-
8	Gyrosigma	1	-	-	-	-	-
9	Licmophora	1	-	2	-	4	4
10	Melosira	-	-	102	29	-	-
11	Navicula	341	36	8	28	33	33
12	Nitzschia	-	-	-	-	4	4
13	Surirella	26	12	5	21	11	11
14	Synedra	1	1	-	-	4	3
CYANOPHYCEAE							
15	Oscillatoria	36	-	10	-	-	-
DINOPHYCEAE							
16	Dinophysis	-	-	-	-	-	-
17	Peridinium	1	-	-	-	-	-
GLOBOTHALAMEA							
18	Globigerina	-	-	4	-	18	8
	Total abundance (cells L^{-1})	432	128	154	97	98	78

3.1.2. Phytoplankton Community Structure

Analysis of the phytoplankton community structure in the form of diversity index, evenness index, and dominance index can be seen in Tables 3 and 4.

Table 3. Phytoplankton community structure in the red shrimp habitat in September 2021

Station	Diversity Index	Evenness Index	Dominance Index
1.1	1.62	0.78	0.24
1.2	1.72	0.89	0.20
2.1	1.50	0.84	0.29
2.2	1.40	0.78	0.30
3.1	1.03	0.57	0.52
3.2	0.02	0.03	0.99

Table 4. Phytoplankton community structure in the red shrimp habitat in December 2021

Station	Diversity Index	Evenness Index	Dominance Index
1.1	0.85	0.34	0.64
1.2	1.29	0.66	0.35
2.1	1.28	0.51	0.47
2.2	1.47	0.82	0.25
3.1	1.66	0.85	0.22
3.2	1.62	0.83	0.25

3.2. Discussion

3.2.1. Phytoplankton Composition and Abundance

The total abundance of phytoplankton among stations ranged from 71-1168 cells L^{-1} with the highest abundance at Station 3.2 in September 2021. Whereas, it ranged from 78-432 cells L^{-1} with the highest abundance at Station 1 in December 2021. These results showed the differences in the total abundance of phytoplankton among stations and time. This could be caused by different water quality. The abundance of phytoplankton in the waters can be influenced by several water quality variables including temperature and nutrients. Temperature plays an important role in determining the presence of phytoplankton in the waters [27]. The uneven distribution of phytoplankton abundance is caused by the presence of nutrients and different water quality [28]. Waters close to river mouths will have a high abundance of phytoplankton due to the large input of nutrients including nitrate and phosphate [29].

Bacillariophyceae was the most common class of phytoplankton found during the study with a total of 11 genera in September 2021 and 14 genera in December 2021. Bacillariophyceae is a class of phytoplankton that is cosmopolitan in nature and has high tolerance and adaptability to environmental conditions [30]. This result is in line with another study in Ujung Kartini waters which are located on the west side of Jepara Regency [31] which showed that the highest abundance of phytoplankton came from the class Bacillariophyceae which reached 91.23%. The investigation in Muara Sungai Kakap waters, Kubu Raya also stated that Bacillariophyceae was the dominant class, commonly found in waters and able to adapt well to surrounding environmental conditions [32]. Overall, phytoplankton in this study was lower than in other studies, including those reported in the Ujung Kartini waters. It showed that the abundance of phytoplankton in these waters at high and low tide ranges between 6,375 – 13,725 cells L^{-1} [31].

The most common type of phytoplankton found in the red shrimp habitat during the study was *Navicula* sp. With a total abundance of 1436 and 479 cells L^{-1} in September and December 2021, respectively. They can be found at all stations in the first and second sampling. This species is a type of phytoplankton from the class Bacillariophyceae or Diatom which is found in all types of fresh and marine waters [33]. The habitat of this species is oligotrophic to eutrophic waters with a temperature of 18.23-27.44°C and a pH of 7.16-7.23 [34].

3.2.2. Phytoplankton Community Structure

Phytoplankton community plays an important role in aquatic ecosystems. The diversity, abundance and distribution of phytoplankton depend on adaptation to ecosystem changes [35]. The diversity index in September 2021 ranged from 0.02-1.72; while in December 2021 ranged from 0.85-1.66. These results indicated a low diversity index (<2.30). A low diversity index indicates that the condition of an ecosystem in water is unstable and does not support biota [36]. The phytoplankton diversity index is influenced by environmental conditions where the better the environmental conditions, the higher the species diversity [37]. The diversity of biota that live in anchialine habitats is low due to the unstable characteristics of the environment. In some anchialine habitats, low biota diversity is reported, especially anchialine ponds with small, shallow basins containing brackish water [5]. The red shrimp habitat on Buton Island is such a habitat with a relatively small size.

The evenness index results ranged from 0.03-0.89 in September 2021; while it ranged from 0.34-0.85 in December 2021. Based on the results, most of these indexes were close to 1, which indicated that the distribution of individuals between species was even. A high evenness index indicates an equal distribution of the number of individuals of each genus and there tends to be no dominant genus [38]. However, a low evenness index (0.03) was counted at Station 3.2, which indicated that the distribution of individuals between species was uneven and there was ecological pressure in the waters.

The dominance index results ranged from 0.20-0.99 in September 2021; while it ranged from 0.22-0.64 in December 2021. The dominance index obtained during the study was mostly included in the low category. This showed that the red shrimp habitat was in good quality and there was no pressure from certain types of phytoplankton that dominate. A dominance index closes to 0 indicates that there is no dominance of certain types of phytoplankton in that community [39]. However, there was a station that had a very high dominance index (>0.9), which indicated that there was a dominating genus. The dominant type of phytoplankton can affect the population balance of a species in the water [40].

3.2.3. Management Implications

The anchialine habitat needs to be given special attention in its management so that unexpected things do not happen due to anthropogenic influences. Excessive tourism development and other activities that do not consider the ecological impact will cause serious damage. Uncontrolled tourism development and the introduction of foreign species in marine lakes in Palau and Vietnam resulted in ecological chaos [5]. Lakes in Vietnam are no longer natural, having been used for fisheries, mollusc harvesting, and aquaculture. In addition, a large number of lakes have been introduced to sea turtles for various reasons such as consumption and animist rituals. The presence of turtles may disrupt the anchialine habitat, while for turtles it can also have a negative impact because there is little food available to ensure their long-term survival.

Many species are rare and endemic to anchialine habitats and are highly vulnerable from anthropogenic influences [2,5,20,41]. The anchialine habitat of red shrimp is a small body of water, so it is very easy to degrade if not managed properly. Likewise with the resources in it, both red shrimp, phytoplankton, and other resources.

Phytoplankton as autotrophic organisms have an important role in the food chain in the waters. They are able to convert inorganic materials into organic matter through the process of photosynthesis. Meanwhile, the organic matter from the phytoplankton is used by zooplankton and other aquatic organisms as a food source. Therefore, the abundance of phytoplankton is important in natural habitats.

4. Conclusion

In order to identify the availability of natural food and water quality of the anchialine habitat of red shrimp, the presence of phytoplankton was investigated using Plankton Net and identified using census methods during September-December 2021 at Koguna Beach area. Based on the study outcomes, phytoplankton can be found in the anchialine habitat of red shrimp which were dominated by the classes Bacillariophyceae, Florideophyceae, and

Globothalamea with a total of 13 genera in September 2021; while the phytoplankton discovered in December 2021 were dominated from the classes Bacillariophyceae, Cyanophyceae, Dinophyceae, and Globothalamea with a total of 18 genera. The most common type of phytoplankton found in the red shrimp habitat during the study period was Navicula sp. with an abundance of 1436 and 479 cells L^{-1} in September and December 2021, respectively. Meanwhile, the phytoplankton diversity index was low, but in general, the evenness and dominance indexes indicated that the distribution of individuals between species was even. This study can be used as a basic information for further research on the management control for this habitat.

Author Contributions

MNF: Conceptualization, Methodology, Investigation, Writing - Review & Editing; **AR:** Writing - Review & Editing; **LS:** Writing - Review & Editing**, WSC:** Investigation, Writing**;** and **LM:** Writing - Review & Editing.

Conflicts of interest

There are no conflicts to declare

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