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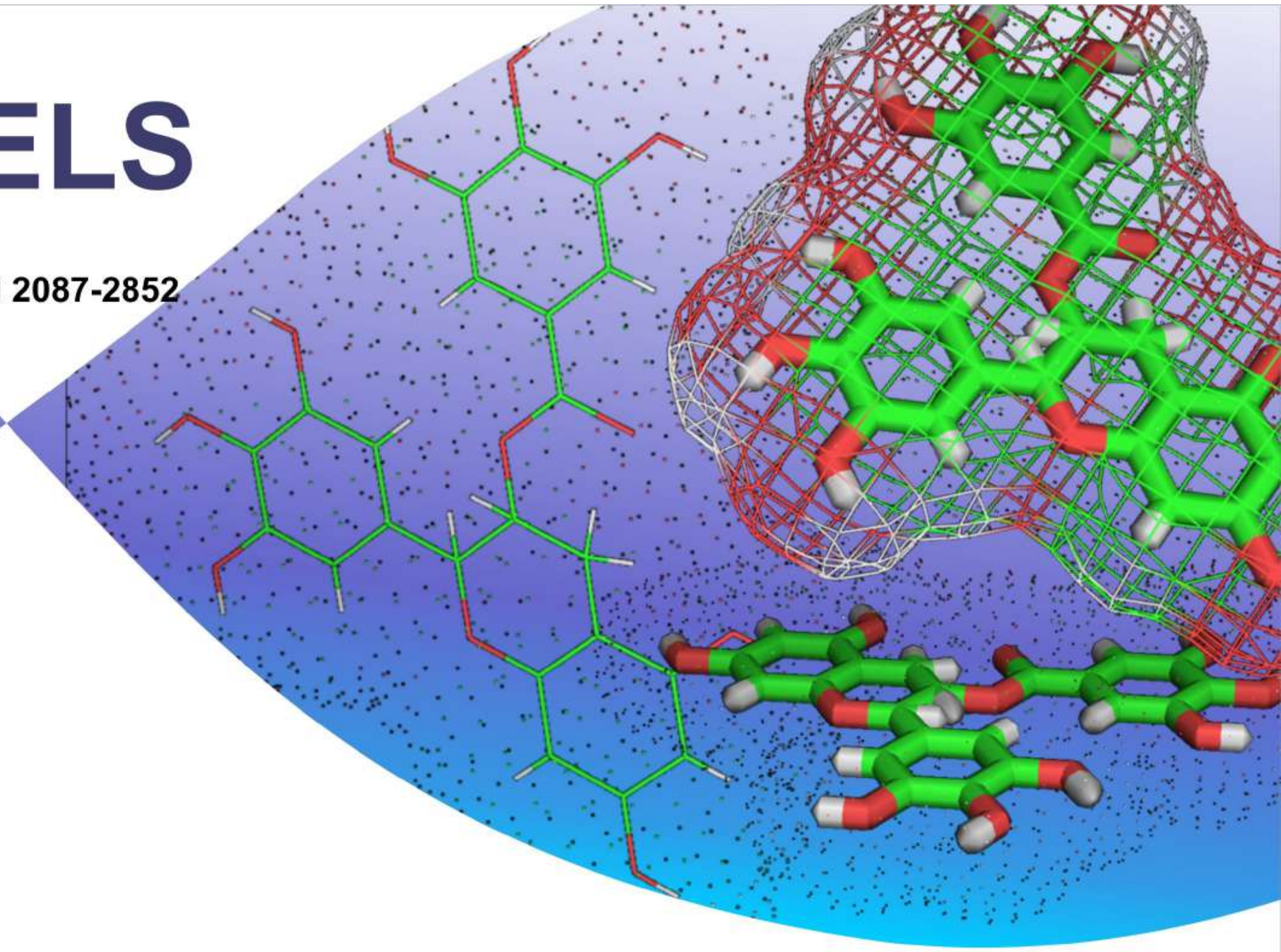

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Phytoplankton and Its Relationship to White Leg Shrimp (*Litopenaeus vannamei*) Culture Productivity in Alasbulu, Banyuwangi

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Abstract

Shrimp culture is related to phytoplankton's existence as a primary producer and water quality. Aside from their function as natural feed, phytoplankton has a role in maintaining the stability of the pond ecosystem. It is indicated by the high abundance and diversity of phytoplankton, as well as suitable water quality to support the productivity of shrimp culture. This research aimed to determine the correlation between phytoplankton structure community, water quality parameters, and shrimp productivity. This research used a descriptive method. This research was conducted in shrimp culture intensive system Alasbulu Village, Wongsorejo District, Banyuwangi on February-March 2020. The parameters observed are diversity and abundance of phytoplankton, water quality parameters, and production performance in each pond. Based on the results, six phytoplankton classes were identified: Bacillariophyceae (10 genera), Cyanophyceae (8 genera), Chlorophyceae (5 genera), Dinophyceae (2 genera), Euglenophyceae (1 genus), and Cryptophyceae (1 genus). Chlorophyceae dominated both ponds, followed by Cyanophyceae. Diversity index values on ponds 1 and ponds 2 were 1.39 and 1.50, respectively. Productivity of both ponds were 1.8 $kg.m^{-2}$ and 1.4 $kg.m^{-2}$; FCR (Feed Convertion Ratio) 1.1 and 1.3; ADG (Average Daily Growth) 0.3 $g.day^{-1}$ and 0.25 $g.day^{-1}$. It can be concluded from this research that high density of Chlorophyceae in phytoplankton community is one of the main causes that supported shrimp cultivation.

Keywords: Banyuwangi, *Litopenaeus vannamei*, phytoplankton, productivity.

INTRODUCTION

Aquaculture production from crustaceans or freshwater prawns had a percentage of 29.4% in 2010 and 70.6% for seawater commodities. The production of seawater commodities is dominated by the vannamei shrimp species (*Litopenaeus vannamei*), of which 77% is produced in Asian countries, including Indonesia [1]. Vannamei shrimp is one of the many shrimp species with high economic value and is an alternative type of shrimp that can be cultivated in Indonesia, aside from tiger shrimp (*Penaeus monodon*) and white shrimp (*Penaeus merguensis*). Vannamei shrimp is a superior shrimp commodity that began to be cultivated in Indonesia in 2002 [2].

Vannamei shrimp has various advantages in the cultivation aspect, such as high appetite, good market share, both nationally and internationally. It also has more resistance to disease infection compared to other shrimp species [3]. Intensive vannamei shrimp culture is inseparable from environmental aspects, such as the presence of phytoplankton as primary productivity and water quality. The interaction form of biological, physical, and chemical conditions of the waters will be determined through interrelated parameters. These parameters will affect primary productivity in the water. Aquatic ecosystems with low biodiversity are unstable and vulnerable to the influence of external pressures compared to ecosystems with high biodiversity. In this case, phytoplankton biodiversity needs to be controlled in order to have an ecosystem that remains in a stable condition [4].

Various biological agents in the aquaculture ecosystem can be used as a determinant of water quality, one of which is the presence of certain phytoplankton groups [5]. Phytoplankton act as a buffer for water quality by increasing dissolved oxygen content through photosynthesis and absorbing toxic substances, such as dissolved ammonia. In addition to functioning as natural food, phytoplankton also functions to maintain the stability of the pond ecosystem [6]. The effectiveness and magnitude of nutrient uptake by phytoplankton in pond water is strongly influenced by the availability of organic matter and other nutrient elements, which are influenced by dissolved oxygen, brightness, salinity, temperature, nitrite, nitrate, phosphate, and ammonia [7].

The environmental stability of the pond water is characterized by high diversity of phytoplankton, a high density of beneficial

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phytoplankton species, and suitable water quality parameters to support the growth of vannamei shrimp. Based on this background, a study was conducted to analyze the presence of phytoplankton in vannamei shrimp (*Litopenaeus vannamei*) ponds and their relationship to cultivation productivity.

MATERIAL AND METHOD

The type of method conducted in this study was descriptive qualitative. This study was carried out from February 16th to March 14th, 2020, in the vannamei shrimp culture pond, located in Alasbulu Village, Wongsorejo District, Banyuwangi, East Java. Sampling was carried out in two ponds (pond 1 and pond 2). The data collected in this study include phytoplankton community which consisted of composition, density, and diversity; cultivation performance which consisted of productivity, Survival Rate (SR), Feed Conversion Ratio (FCR), and Average Daily Growth (ADG); water quality parameters which consisted of temperature, brightness, dissolved oxygen (DO), pH, nitrate (NO_3), nitrite (NO_2), total ammonia-nitrogen (TAN), and phosphate.

Data Collection

The water quality observed consists of physical and chemical parameters. Physical parameters include water temperature and brightness measurements carried out every day at 6 am and 1 pm (West Indonesian Time-WIB). The chemical parameter of DO was measured at 6 pm, 1 pm, and 9 pm. Salinity was measured at 6 pm, while pH was measured at 6 am and 1 pm. Nitrite (NO_2), nitrate (NO_3), TAN, and phosphate were measured three days a week.

Phytoplankton samples were obtained by taking water samples daily in pond 1 and 2 at 6 am. Water samples were taken using a plankton net and collected in a film bottle. Three drops of lugol 1% were added to lessen the movement of phytoplankton. Water samples were taken and dripped onto the hemocytometer surface, which had been closed with a cover glass through the well line. The identification was conducted with Microscope Olympus in 400 times magnification. The density of phytoplankton was measured using the Big Block method, and the diversity index was calculated using the Shannon-Wiener formula.

The data of vannamei shrimp productivity was collected at the end of the cultivation period. The survival rate values were obtained by collecting data of stocking density numbers and total individual numbers at the end of the rearing period. The ADG values were obtained by calculating both the final and initial weight of vannamei shrimp and comparing them with the rearing period. The FCR values were calculated based on the feed given during cultivation.

RESULT AND DISCUSSION

Phytoplankton Identification

The phytoplankton identified in this study is presented in Table 1. The phytoplankton found in pond 1 and pond 2 consisted of 6 classes with a total of 27 genera. The classes were Bacillariophyceae (10 genera), Cyanophyceae (8 genera), Chlorophyceae (5 genera), Dinophyceae (2 genera), Euglenophyceae (1 genus), and Cryptophyceae (1 genus).

Table 1. Phytoplankton Identified

Class	Genus	Pond 1	Pond 2
Chlorophyceae	*Chlorella*	35,000	28,393
	Cosmarium	-	2,500
	Oocystis	4,500	6,250
	Golenkinia	3,333	2,500
	Nannochloropsis	50,000	12,500
Bacillario-phyceae	*Skeletonema*	3,125	3,750
	Cyclotella	16,750	10,000
	Nitzchia	3,750	5,000
	Coscinodiscus	8,333	8,611
	Thalasiossira	-	4,500
	Navicula	3,333	4,167
	Amphiphora	-	2,500
	Bidduplhia	2,500	3,214
	Chaetoceros	8,000	8,594
	Amphora	2,500	2,917
Cyanophyceae	*Microcystis*	8,056	11,071
	Chrococcus	6,250	11,250
	Oscillatoria	13,854	13,182
	Anabaena	8,750	9,500
	Anabaenopsis	4,000	2,500
	Spirulina	4,167	2,500
	Synechococcus	6,667	4,000
	Pseudoanabaena	10,000	3,750
Dinophyceae	*Protoperidinium*	7,500	4,643
	Gymnodinium	2,500	4,167
Euglenophyceae	*Euglena*	4,821	4,531
Cryptophyceae	*Crypromonas*	8,750	7,813
Total		**226,439**	**155,909**
Diversity Index (H')		**1.39**	**1.50**

The results showed that phytoplankton genera obtained from both ponds were not much different, but pond 2 showed more variation compared to pond 1. Some of the genera that were only found in pond 2 were *Cosmarium*, *Thalassiosira,* and *Amphiphora*. The most genera found in this study were the Bacillariophyceae group. Bacillariophyceae has the ability to adapt to changes in water quality surrounding and has a wide distribution.

Water Quality

Differences in the composition of phytoplankton can be caused by water quality parameters in the pond [8]. Phytoplankton composition is influenced by various factors such as characteristics of the aquatic environment, physical parameters, and chemical parameters [9]. In this study, pond 2 showed a more diverse type of phytoplankton compared to pond 1. It could be attributed to the N:P ratio (Table 2.), where pond 2 showed a higher N:P ratio (0.79 – 32.6) compared to pond 1 (0.5 – 28.7). There is a strong positive correlation between the concentration of nutrients such as N and P with the potential emergence of phytoplankton at the cultivation site. The greater the ratio of N:P, the types of phytoplankton that appear will be more diverse, and their density will tend to increase [10].

Table 2. Water quality parameters

Parameters	Pond 1	Pond 2	Opt. Reference
DO ($mg.L^{-1}$)	3.95-11.85	3.68-9.4	>5 [25]
Temp (°C)	27.8-32.5	27.5-33	25-32 [26]
pH	7.1-8.4	6.8-8.3	7-8.5 [22]
Sal ($g.L^{-1}$)	19-24	22-30	10-30 [27]
WT (cm)	30-37	25-37	20-40 [28]
NO_2 ($mg.L^{-1}$)	0-1.92	0-2.25	0.1-1 [29]
NO_3 ($mg.L^{-1}$)	0-10	0-10	0.4-0.8 [30]
TAN ($mg.L^{-1}$)	0.1-2.25	0-2.85	<1.7 [31]
PO_4 ($mg.L^{-1}$)	0-1.7	0.25-1.0	<0.2 [32]
N:P Ratio	0.5-28.7	0.79-32.6	16:1 [33]

Based on the results obtained, it was shown that the Chlorophyceae group dominated with a percentage of 51% and 44% in pond 1 and 2, respectively. The pH obtained during this study in both ponds ranged from 7.4 – 8.4, where the pH range was optimum for the growth of the Chlorophyceae group. It is known that Chlorophyceae can grow well in the pH range of 7.35 – 8.84 [11].

Phytoplankton Diversity

Based on the observation, it is shown that *Chlorella* dominated the Chlorophyceae group in both ponds. Salinity is one of the water quality parameters that play an important role in the growth and metabolism of *Chlorella*. The population of *Chlorella* will increase along with salinity. *Chlorella* can live in an environment with a salinity value of up to 50 $g.L^{-1}$ [12]. At the research site, the water used in the cultivation process has a relatively high salinity value, up to 30 $g.L^{-1}$. It can be one of the reasons for *Chlorella* dominance in both ponds. *Chlorella* can improve the growth performance of shrimp in cultivation if consumed as much as 3% of body weight every day [13].

The diversity index (H') values obtained from pond 1 and 2 are above 1 (1<H'<3), which indicates that the level of phytoplankton diversity is average, with moderate community stability [14]. The moderate level of phytoplankton diversity obtained in this study is related to water quality conditions, where there are several parameters with values that exceed the threshold in the water, namely TAN (2.85 $mg.L^{-1}$), nitrate (10 $mg.L^{-1}$), nitrite (2.25 $mg.L^{-1}$) and phosphate (1.7 $mg.L^{-1}$). In addition, the category of moderate water stability is supported by data on the composition of phytoplankton where there is a group that tends to dominate in both ponds, namely Chlorophyceae.

Cultivation Productivity

The results regarding vannamei shrimp (*Litopenaeus vannamei*) culture production in pond 1 and 2 with indicators such as day of culture, yield, survival rate, food conversion ratio, and average daily growth are presented in Table 3. Pond 1 has a higher production yield compared to pond 2 based on the ratio between harvest tonnage (1.8 $kg.m^{-2}$) and pond area (1.4 $kg.m^{-2}$). The high and low production of vannamei shrimp culture depends on various supporting factors, namely growth rate, food that consumed, and density of seed stocking that carried out at the beginning of the cultivation period [15]. This statement is in accordance with the results of this study, where pond 1 has an ADG value of 0.3 $g.day^{-1}$ with a stocking density of 208 $ind.m^{-2}$ so that the productivity results in pond 1 are higher than pond 2.

The high yield value in pond 1 can be associated with phytoplankton density, where pond 1 has a higher value compared to pond 2. The correlation between yield and phytoplankton density in both ponds showed in Fig. 1. Moreover, the amount of production is assumed to be related to the dominance of Chlorophyceae, where pond 1 has a higher percentage of Chlorophyceae density compared to pond 2, which is 51% with a percentage of the genus *Chlorella* at 44.6%. The productivity of vannamei shrimp in Chlorophyceae-dominated pond is relatively higher compared to ponds that are dominated by other phytoplankton groups [16]. One of the genera of Chlorophyceae, namely *Chlorella*, has an omega-3 fatty acid content of 5.52%, which is relatively higher compared to other phytoplankton genera.

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Unsaturated fatty acids are good for the growth of organisms so that they can support increasing cultivation productivity [17]. The availability of *Chlorella* as a natural feed can improve the growth performance of shrimp. *Chlorella* contains 80% of protein, eight essential amino acids, vitamins, carbohydrates, fiber, chlorophyll, enzymes, minerals that are useful in supporting growth performance, and the antioxidant compound lutein, which can prevent tissue damage [18].

Table 3. Cultivation Productivity

No	Indicator	Pond 1	Pond 2
1	Pond Area (m^2)	3,514	3,595
2	Stock. Density (ind)	700,408	697,025
3	Day of culture (days)	55	55
4	Yield ($kg.m^{-2}$)	1.8	1.4
5	SR (%)	80	85
6	FCR	1.1	1.3
7	ADG ($g.day^{-1}$)	0.3	0.25

The survival rate value in pond 2 (85%) is higher than pond 1 (80%). The high survival rate in pond 2 is assumed to be influenced by the high diversity index value obtained. Ecologically, phytoplankton has an important function as a primary producer that can be used as an indicator of water fertility. In addition, the biodiversity of phytoplankton shows the level of water stability. The more diverse types of phytoplankton that grow, the more stable the water will be so that it is beneficial for aquaculture activities. Stable water conditions, which include water quality and primary productivity, will support shrimp growth [19].

The lower survival rate obtained in pond 1 can be caused by the high density of antagonistic phytoplankton, one of which is Cyanophyceae. The average total density of Cyanophyceae in pond 1 was 61.744 cells $m.L^{-1}$, while pond 2 was 57.753 cells $m.L^{-1}$. Cyanophyceae is a phytoplankton that is detrimental because because of their ability to produce secondary metabolites in the form of toxins that are harmful to shrimp. Cyanophyceae can reduce water quality which will affect the decline in shrimp production. Cyanophyceae can produce various toxins such as microcystins (MCYs), anatoxin-a, anatoxin-a(s), cylindrospermopsin (CYN), and saxitoxin (STX). These toxins have specific target organs, causing organ damage to mortality if present in the body of aquatic organisms at high levels [20]. Besides their ability to produce toxins, Cyanophyceae is a group of phytoplankton that has lower nutrient content than other phytoplankton groups [21].

The food conversion ratio (FCR) value in pond 1 is 1.1, while in pond 2 is 1.3. Both FCR values are classified as good for cultivation activities. In vannamei shrimp culture, generally, the FCR value ranges between 1.4 – 1.8 [22]. FCR is a ratio between the amount of feed consumed and the weight gain of shrimp. High FCR indicates that more feed is not converted into shrimp biomass. In addition, high FCR also indicates that the treatment given is increasingly ineffective and inefficient [23]. In this study, it was found that the FCR value of pond 1 was lower compared to pond 2. The results indicated that shrimp in pond 1 had a better feed utilization efficiency compared to pond 2. Allegedly, this is supported by the role of natural feed availability in the pond, which can help to reduce the need for artificial feed. Chlorophyceae and Bacillariophyceae are phytoplankton groups that have high nutrient content, so that they are beneficial for shrimp growth. The average total density of Chlorophyceae and Bacillariophyceae in pond 1 was higher than in pond 2. It shows that phytoplankton has the ability to support the fulfillment of nutrients in shrimp.

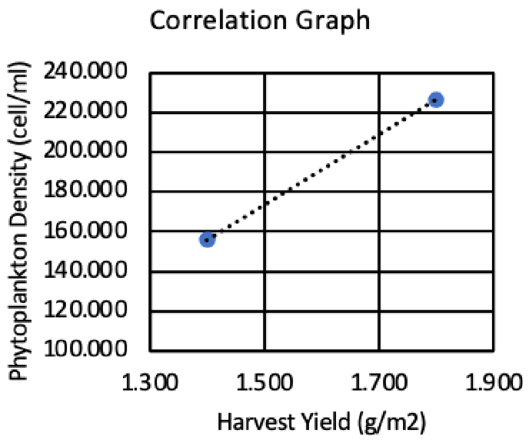

Figure 1. Correlation between total phytoplankton density and harvest yield in linear regression graph.

Average daily growth (ADG) results in pond 1 is 0.3 g day^{-1}, while in pond 2 is 0.25 g day^{-1}. Cultivated organisms in ponds with low stocking densities showed a greater body weight gain. There is less competition in utilizing phytoplankton as natural food in ponds with lower stocking densities [24]. This statement contradicts the result of this study, where pond 2 has a lower ADG value compared to pond 1, but the stocking density in pond 2 (697,025 ind) is lower than pond 1 (700,408 ind). It can be attributed to the difference in phytoplankton density, where the average total phytoplankton density in pond 1 was higher than pond 2. Based on these results, it can be concluded that although the stocking density in pond 1 is higher than in pond 2, the need for natural feed for shrimp growth in pond 1 is still fulfilled with the abundance of phytoplankton. It shows that shrimp will be able to grow optimally when the need for nutrients is fulfilled.

CONCLUSION

The high and low values of physical and chemical water quality parameters are correlated to the growth of phytoplankton and the survival of vaname shrimp. The phytoplankton found in pond 1 and pond 2 consisted of six classes with a total of 27 genera. The diversity index is in the category of average or moderate water stability. Water quality parameters of temperature, brightness, DO, salinity, pH were in the optimal range, while TAN, nitrite, nitrate, and phosphate exceeded the threshold of the optimal range for cultivation. The productivity of vannamei shrimp culture in pond 1 was higher compared to pond 2 based on the harvest yield, ADG, and FCR values obtained. The high phytoplankton density and dominance of Chlorophyceae that occurred is suspected to be the main cause of the high productivity of cultivation.

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