Analiysis of Phytoplankton Diversity on the Productivity of Vannamei Shrimp (*Litopenaeus* vannamei) Intensive Pond, Jatisari Village, Banyuwangi

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Abstract

Phytoplankton can be used to estimate the potential for vannamei shrimp production. It can be used as a provider of nutrient sources and has an important role in improving water quality. This study aims to analyze the phytoplankton community structure on the productivity of intensive vannamei shrimp ponds. The research was conducted in Jatisari Village, Banyuwangi, East Java, Indonesia. Carried out parameters were the calculation of density, phytoplankton diversity index, culture performance (SR, FCR, ADG), and water quality (temperature, water transparency, salinity, pH, DO, NO_2, NO_3, PO_4, NH_4). The results showed that there were six classes and 33 genera from both ponds, Chlorophyceae (10 genera), Bacillariophyceae (8 genera), Cyanophyceae (9 genera), Dinophyceae (3 genera), Euglonophyceae (1 genus), Criptophyceae (1 genus). The index value of the two ponds shows moderate diversity, H' pond 1 is 1.76, and pond 2 is 2.02. The two plots' cultivation performance was SR 92% and 80%, FCR 1.08 and 1.13, ADG 0.31 g.day^{-1} and 0.35 g.day^{-1}, respectively. The physical and chemical parameters of the research showed a good enough value for the life of vannamei shrimp and phytoplankton.

Keywords: Cultivation performance, Phytoplankton, Vannamei shrimp.

INTRODUCTION

Indonesia is the third-largest seafood consumer country after China and Japan, Indonesia is the fourth largest shrimp exporter after India, Ecuador, and Argentina [1]. Vannamei shrimp is an aquaculture species whose production has increased the fastest over the past five years [2]. Indonesia can produce shrimp up to 919,959 tons [3]. Production of vannamei shrimp in East Java in 2017 was 156,139 tonnes. This value is higher than other provinces in Indonesia [3].

To increase production yields, many cultivators adopt an intensive cultivation system, characterized by probiotics, commercial feed with high protein content, and stocking densities ranging from 100-300 individuals.m^{-2} [4]. The higher the stocking density, the more metabolic waste will increase [5]. The distribution of feed that is used and not utilized by shrimp was controlled [4] so that shrimp feed in intensive cultivation systems becomes the main source of producing organic material, which can cause nutrient overload. Organic material in an amount suitable for carrying capacity has a positive impact because it can benefit aquatic organisms such as phytoplankton [6]. The organic material is decomposed by decomposer microbes to become nutrients (N and P) and can be used for microalgae growth [7]. On the other hand, if the organic material is not in accordance with the carrying capacity, it will have a negative impact because it will increase the rate of O_2 reduction and increase the O_2 requirement in the sediment, which will produce reduced compounds, such as NH_3, CH_4, and H_2S [6]. In addition, the effectiveness and amount of nutrients by phytoplankton depends on the availability of NO_3-N, PO_4-P absorption and organic materials, which are influenced by pH, dissolved oxygen, temperature, water transparency, salinity, NO_2-N and NH_3-N [8].

Phytoplankton is microorganisms that live hovering in the oceans, lakes, rivers, and other water bodies, are autotrophic microorganisms that can produce their own food with the help of sunlight [9]. The level of plankton production in an area of water can be used to estimate the potential for shrimp and fish production [10]. As well as providing a nutritional source for shrimp, phytoplankton is also very important in improving water quality [8]. The existence of phytoplankton can be used as a bioindicator of changes in the aquatic environment caused by an imbalance of an ecosystem due to pollution [11]. The high uniformity of plankton with the high number of individuals of each plankton and evenly distributed plankton will result in prime environmental conditions and can increase pond productivity [12]. The fluctuation in air quality parameters can cause a decrease in shrimp

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ISSN. 2087-2852
E-ISSN. 2338-1655

survival which continues to decrease in production [13]. This research was conducted to analyze the relationship between phytoplankton community structure in the waters and its relationship with the productivity of white shrimp (*Litopenaeus vannamei*) culture, by observing the diversity, density of phytoplankton, water quality during cultivation, and the productivity of the aquaculture pond.

MATERIAL AND METHOD

The research was conducted from 5th January – 5th February 2021. Samples were taken from two vannamei ponds in Jatisari Village, Banyuwangi Regency. Identification is carried out in the research location laboratory**.** We used plankton net, film bottle, water sampler, coolbox, hemocytometer, cover glass, dropper pipette, microscope, identification book, washing bottle, DO meter, refractometer, Secchi disk, and 5L bucket**.** We also used water samples, 70% alcohol, lugol, distilled water, test kits for NH_4, NO_3, NO_2, PO_4, and pH paper.

Parameters

The main parameters observed were phytoplankton density, diversity index, and performance of cultivation which included productivity, survival rate, FCR (Feed Conversion Ratio), and ADG (Average Daily Growth). The supporting parameters observed during the study were water quality. Water quality parameters observed during the study were temperature, water transparency, dissolved oxygen, pH, ammonia, nitrite, nitrate, and phosphate.

Phytoplankton sampling

The research samples were taken at four points, inlet, outlet, and two ancho shrimp ponds (*Litopaneaus vannamei*). Samples were taken every day at 13.00 WIB (West Indonesian Time). The collection was done using a bucket with a volume of 5 L for each point. The sample water is put into the plankton net, which has been given a 20 mL film bottle, then given four drops of lugol solution to preserve the phytoplankton and ensure that there is no eating process in the film bottle. Samples that have been taken are labeled and placed in the coolbox.

Phytoplankton identification and calculation

Calculation of phytoplankton density (cells. mL^{-1}) using the Big Block calculation formula [14] as follows:

$$\text{Phytoplankton density} = \frac{\text{nA} + \text{nB} + \text{nC} + \text{nD}}{4} \times 10^4$$

Description:

nA, nB, nC, nD	: Number of of phytoplankton cell in blocks A, B, C, D
4	: Number of blocks counted
10^4	: Conversion factor mm^3 to cm^3

The diversity index is calculated using the Shannon-Wiener method with the following formula:

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

Description:

H '	: Shannon-Wiener diversity index
Pi	: ni / N
ni	: Number of individuals of type i
N	: Total number of individuals

Aquaculture Performance Measurement

The formula used to measure the value of SR [15] is:

$$SR = \frac{N_t}{N_0} x\ 100\%$$

Description:

SR	: Survival (%)
Nt	: Amount of harvest
N0	: Total stocking

The Feed Conversion Ratio (FCR) is calculated using the formula according to [15] is:

$$FCR = \frac{F}{Wt + D}$$

Description:

FCR	: Feed conversion ratio
F	: Weight of feed given (g)
Wt	: Biomass at the end of maintenance (g)
W0	: Initial maintenance weight (g)
D	: Weight of dead fish (g)

Average Daily Growth (ADG) is calculated using the formula [16]:

$$ADG\ (g.day^{-1}) = \frac{(\text{Wt} - \text{W0})}{\text{t}}$$

Description:

ADG	: Daily weight gain
Wt	: Final weight (g)
W0	: Initial weight (g)
T	: Duration of maintenance (days)

Water Chemical Physics Parameters

Dissolved oxygen, temperature, pH, water transparency, salinity were measured every day during the study, while ammonia, nitrite, nitrate, and phosphate were measured every three days. Dissolved oxygen was measured at 06.00, 13.00, and 20.00 WIB (West Indonesian Time), water transparency, temperature, and pH were measured at 06.00 and 13.00 WIB, salinity was measured at 06.00 WIB. Ammonia, nitrate,

ISSN. 2087-2852
E-ISSN. 2338-1655

nitrite, and phosphate were measured every three days at 06.00 WIB.

RESULT AND DISCUSSION

Phytoplankton Identification

The results obtained in the two ponds, in pond 1, there were six classes with a total of 31 genera consisting of Cyanophyceae (10 genera), Chlorophyceae (9 genera), Bacillariophyceae (7 genera), Dinophyceae (3 genera), Euglenophyceae (1 genus), Cryptophyceae (1 genus). In pond 2, six classes were found, with a total of 31 genera. The classes found in pond 2 are Cyanophyceae (10 genera), Chlorophyceae (8 genera), Bacillariophyceae (8 genera), Dinophyceae (3 genera), Euglenophyceae (1 genus), Criptophyceae (1 genus). The highest number of genera in both ponds is Cyanophyceae.

Chlorophyceae and Bacillariophyceae are phytoplankton, which are expected in cultivation [17] as natural food and oxygen ponder [18], while Cyanophyceae are types that are avoided for cultivation because they contain toxins that will cause the organism to be susceptible to disease [19]. Bacillariophyceae are often found in the sea in large numbers [18], so that this class is commonly found in vannamei shrimp farming locations.

Phytoplankton Composition and Density

The percentage of phytoplankton composition in pond 1 is known to have three classes that dominate with high values, Cholophyceae, Cyanophyceae, and Bacillariophyceae, with the percentages that can be seen in Figure 1. The percentage of other classes found in both ponds is below 10%. The dominant phytoplankton classes found during the study were common in the white shrimp (*Litopenaeus vannamei*) cultivation location. The results of the research conducted previously have three dominant classes, which are the same as the results for which the study was conducted [8,18,20]. The phytoplankton that is expected to grow in pond waters is Bacillariophyceae and Chlorophyceae because these two classes can be used as natural food for shrimp other than as an oxygen enhancer in the water column [18].

Bacillariophyceae in both ponds had the same percentage. The genus of the class Bacillariophyceae can dominate in pond waters because of the availability of nutrients essential for growth in the form of ammonia, nitrite, and nitrate due to feeding [21]. Bacillariophyceae is a phytoplankton that can adapt to various environments and is cosmopolitan [22]. Generally, Bacillariophycea class has high nutritional value, is easy to digest, and is very good, especially for the survival of shrimp larvae, and this species is preferred by shrimp compared to other classes [8].

The high percentage of Cyanophyceae in both ponds could be due to the high phosphate value in both ponds. Phosphate levels greater than 0.01 mg.L^{-1} can lead to predominance in waters [18]. If there is a blooming of Cyanophyceae in the waters, it will cause the water to be green, blue, and even black, and it will be less profitable because Cyanophyceae releases toxins that are harmful to shrimp which can cause death before harvest [21].

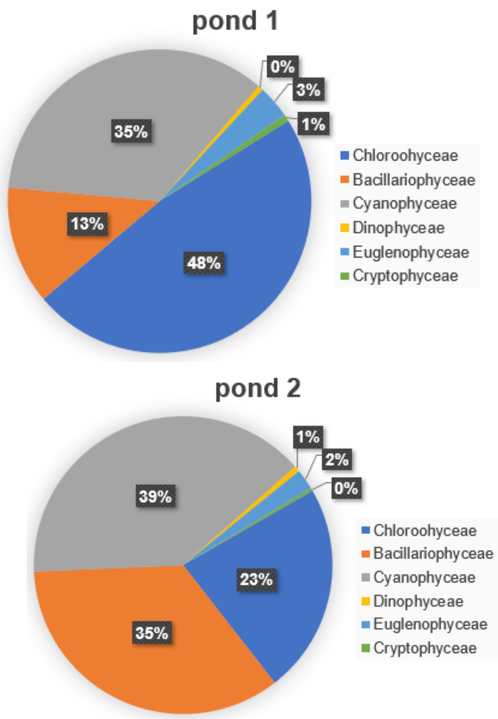

Figure 1. Composition of Phytoplankton

The diversity index value in the study can be seen in Table 1. The research diversity index has an index similar to the study by Umami *et al* [8] and Mansyah *et al* [19] and higher than the study by Hendrajat and Sahrijanna [23]. The index shows that the diversity value is moderate (1<H'<3), which means that pond water quality is still good to support the development and diversity of phytoplankton [19]. The greater the H', indicating that the more diverse life in water is [24]. If the diversity index is close to 1 (> 0.5), then the uniformity of organisms in the waters is in a balanced state, and there is no competition for both place and food, but these values indicate unstable biota [23].

The effectiveness and uptake of nutrients by phytoplankton in pond waters depend on the availability and absorption rate of NO_3-N, PO_4-P, and organic matter which is influenced by pH, dissolved oxygen, temperature, water transparency, salinity, NO_2-N, and NH_3-N [25]. Optimal water conditions will spur the absorption rate of nutrients by phytoplankton so that it can improve the structure of the plankton community. The N:P value in both ponds ranged from 1.91-13.79, and the average N:P value in pond 1 was 6.59 and in pond 2 was 7.28. Cyanophyceae were found to be more dominant at low N:P ratios below 10: 1 [26].

Cultivation Performance

Based on Table 2, yields and SR of both ponds have a higher value than the study by Aridin *et al* [20], the SR value in pond 1 is 92%, with a yield of 5636 kg for a pond area of 2000 m^2 and in pond 2 is 80%, with a yield of 7688.5 kg for a pond area of 2500 m^2. The high SR value indicates that the environmental conditions in the water for the production process are quite good [13].

The FCR value for pond 1 is 1.08, and pond 2 is 1.13. The FCR value in this study is greater than Budiardi *et al* [13]. The lower the FCR value, the better condition, which shows that the optimal feeding for cultivation. Generally, the FCR value in vannamei shrimp culture is 1.4-1.8 [27]. In addition, water quality also affects shrimp appetite, which will affect the FCR value. Temperature, salinity, and alkalinity have a close relationship with the FCR value of vannamei shrimp [28].

Table 1. Phytoplankton Genera and Average Density

No	Genus name	Class	Pond 1		Pond 2	
			Average density ($cell.mL^{-1}$)	Average genus (%)	Average density ($cell.mL^{-1}$)	Average genus (%)
1	*Oocystis*	Chlorophyceae	3,666	1.02	4,750	1.85
2	*Nanochloropsis*		159,916	44.8	48,333	18.8
3	*Cosmarium*		83	0.02	166	0.06
4	*Tetreselmis*		416	0.11	0	0
5	*Golenkinia*		250	0.07	83	0.03
6	*Closterium*		166	0.04	83	0.03
7	*Tetraselmis*		0	0	1,000	0.39
8	*Tetraedron*		83	0.02	0	0
9	*Dictyosphaerium*		83	0.02	166	0.06
10	*Gleocystis*		683	1.91	3,833	1.49
11	*Skeletonema*	Bacillariophyceae	14,750	4.14	31,666	12.36
12	*Cyclotella*		11,916	3.34	12,750	4.9
13	*Nitzchia*		166	0.04	833	0.3
14	*Coscinodiscus*		666	0.18	666	0.26
15	*Navicula*		166	0.04	500	0.19
16	*Bidulphia*		0	0	83	0.03
17	*Chaetoceros*		16,750	4.70	27,000	10.54
18	*Thallasiosira*		750	0.21	15,666	6.11
19	*Microcystis*	Cyanophyceae	14,750	4.14	23,000	8.9
20	*Chrococcus*		40,750	11.44	1,4750	5.7
21	*Oscillatoria*		28,416	7.97	27,166	10.6
22	*Merismopedia*		666	0.18	1,000	0.39
23	*Anabaenopsis*		916	0.25	916	0.35
24	*Anabaena*		30,083	8.44	22,833	8.91
25	*Gleocapsa*		666	0.18	1,416	0.55
26	*Pseudanabaena*		666	0.18	2,000	0.78
27	*Synechochoccus*		3,250	0.92	2,500	0.97
28	*Spirulina*		2,166	0.60	4750	1.85
29	*Protoperidinium*	Dinophyceae	250	0.07	166	0.06
30	*Gymnodinium*		1,083	0.30	1,166	0.45
31	*Noctiluca*		666	0.18	250	0.09
32	*Euglena*	Euglenophyceae	2,000	3.55	566	2.2
33	*Criptomonas*	Criptophyceae	2,500	0.7	833	0.3
	Total		**356166**	**100**	**256000**	**100**
	H'		**1.7602442**		**2.0218753**	

ISSN. 2087-2852
E-ISSN. 2338-1655

The ADG value in pond 1 ranged from 0.19-0.48 g.day^{-1}, with an average of 0.31 g.day^{-1}, and in pond 2, it ranged from 0.19-0.55 g.day^{-1} with an average of 0.357 g.day^{-1}. The highest ADG in the study had a higher value than the study [16]. The lowest ADG value of the two ponds was caused by the adjustment period of the vanmamei shrimp from natural feed to artificial feed.

Table 2. Cultivation Performance

No	Indicator	Pond 1	Pond 2
1	Cultivation age (day)	72	73
2	Yields (kg)	5,636	7,688.5
3	Survival rate (%)	92	80
4	FCR	1.08	1.13
5	ADG (gr.day^{-1})	0.316	0.357

Water Quality

Water quality during the study can be seen in Table 3. The temperature range during the study was 27.5-31°C. Bacillariophyceae and Chlorophyceae are found in many stable water conditions. The optimum temperature for the growth of phytoplankton from Bacillariophyceae is 30-35°C and Chlorophyceae 20-30°C, Cyanophyceae can tolerate higher temperatures (above 35°C) than the Chlorophyceae and Bacillariophyceae classes [5].

The temperature has an influence on the oxygen consumption, growth, survival rate of shrimp in a cultured environment [29]. In addition, the temperature has a direct influence in controlling the rate of various metabolic processes of microalgae cells [21]. The temperature tolerated by vannamei shrimp [30] ranges from 23-30°C and grows optimally at temperatures of 30°C (for small shrimp, 1g) and 27°C (for large shrimp, 12-18g). Vannamei shrimp can also tolerate temperatures below 15°C and above 33°C, but their growth will be stunted.

Water transparency is a condition that describes the ability of sunlight to penetrate the water layer to a certain depth [31]. The range of water transparency measured during the study in the two ponds was 20-53 cm. The highest water transparency is in pond 1, which is 48 cm in the morning, and the lowest is 20 cm during the day. The highest water transparency is in pond 2, which is 53 cm during the day and the lowest is 27 cm during the day. The lower the water transparency value, the increased phytoplankton abundance [13], besides that, turbidity or low water transparency can be caused by nutrient content and sludge [31]. Good pond water transparency for shrimp rearing is 35-45 cm [32].

The pH range values obtained in the two ponds were 7.6-8.5. The pH value range of 7.17-8.98 in ponds does not harm cultivation organisms, including plankton [3]. The optimum pH range for cultivation activities is between 7.0-9.0 [33]. The limit of tolerance of organisms to pH varies and is influenced by temperature, dissolved oxygen, alkalinity, the type of organism, and its place of life [33].

Salinity is a reflection of the amount of salt dissolved in water [21]. Vannamei shrimp can tolerate a wide range of salinity, 0.5-45 ppt, can grow well in the range of 7-34 ppt [30], and grow optimally at 25-30 ppt [32]. The diatom class group was able to adapt to salinity up to 90 ppt [12]. So that the salinity obtained during the study is in the optimal range for the growth of shrimp and phytoplankton in water. Salinity during the study ranged from 25-31 ppt.

Oxygen has an important role in the survival of aquatic organisms. The lowest DO (dissolved oxygen) value was in pond 1, 2.9 ppm at night, and the highest was 8.7 ppm during the day. The lowest DO (dissolved oxygen) value was in pond 2, 2.5 ppm at night, and the highest was 9 ppm during the day. Marine species will die if DO levels are below 1.25 mg.L^{-1} for several hours. DO values between 2.5-3 mg.L^{-1} result in reduced swimming speed, and DO levels of 5.3-8 mg.L^{-1} are good for the survival and growth of marine organisms [34]. Plankton can live well at oxygen concentrations of more than 3 mg.L^{-1} [35].

Table 3. The average value of water quality during study

Parameters	Pond 1			Pond 2			Optimum value	References
	06.00	13.00	20.00	06.00	13.00	20.00		
Temperature (°C)	28.1	29.2	-	29.3	30.45	-	23-30°C	[30]
Water transparency (cm)	31.8	30.4	-	35.4	34.2	-	35-45 cm	[32]
pH	7.7	8.17	-	7.7	8.2	-	7.0-9.0	[33]
Salinity (ppt)	28	27.9	-	28.5	28.3	-	25-30 ppt	[32]
DO (ppm)	3.8	6.4	3.6	4.0	7.1	3.8	5.3-8 ppm	[34]
NH_4 (mg.L^{-1})		1.25			1.3		< 1.7 mg.L^{-1}	[39]
NO_2 (mg.L^{-1})		6.47			7.2		< 0.05 mg.L^{-1}	[40]
NO_3 (mg.L^{-1})		14.9			14.8		< 0.5 mg.L^{-1}	[41]
PO_4 (mg.L^{-1})		2.75			2.7		0.27-5.51 mg.L^{-1}	[41]

The DO value of the two ponds at night is lower than the optimum value for phytoplankton and vannamei shrimp. The high DO content during the day in both ponds was caused by oxygen intake produced by phytoplankton [18] and waterwheels [34]. The availability of windmills provides dissolved oxygen is always available, and the pond is always in aerobic conditions. It is the response to the decomposing bacteria that accelerate the decomposition process of organic waste into N and P nutrients, which are fixed into NO_3-N and PO_4-P. These conditions can effectively accelerate nutrient uptake of phytoplankton growth [25]. Dissolved oxygen dynamics in aquatic ecosystems are determined by the balance between oxygen production and consumption [36].

In intensive ponds, ammonia is mostly in the form of NH_4^+, which can be ionized due to the availability of dissolved oxygen, and the N source from NH_4^+ is not toxic to aquatic organisms and can be utilized directly by phytoplankton [25]. NH_4^+ is required for phytoplankton to form protein and cell formation [37]. The range of NH_4^+ values during the study in pond 1 was 0.4-2.5 mg.L^{-1}, and in pond 2, it was 0.2-2.5 mg.L^{-1}. This value was higher than that of the study [38]. Concentrations <1.7 mg.L^{-1} are not hazardous for aquaculture activities [39].

Nitrite (NO_3) levels should not exceed 0.05 mg.L^{-1} because they can be toxic to aquatic organisms [40]. Meanwhile, the range in the two ponds was 0.75-11.25 mg.L^{-1}. This value is certainly higher than Effendi [40] and the result is higher than the study of Utojo and Mustafa [25].

Based on measurements during the study, it was known that the nitrate value in pond 1 ranged from 3-25 mg.L^{-1} with an average of 14.8 mg.L^{-1}. In pond 2, nitrate values ranged from 3-40 mg.L^{-1} with an average of 14.9 mg.L^{-1}. The nitrate concentration for vannamei shrimp culture is <0.5 mg.L^{-1}, while the optimal nitrate level for phytoplankton growth is 3.9-15.6 mg.L^{-1}. If it is lower than 0.114 mg.L^{-1}, nitrates will be a limiting factor for phytoplankton [41]. Nitrate content above 0.5 mg.L^{-1} is feared to cause eutrophication in the waters. So that both ponds are good enough for phytoplankton but too high for vannamei shrimp cultivation.

The optimal phosphate content for phytoplankton growth is in the range 0.27-5.51 mg.L^{-1} [41], while the phosphate content less than 0.02 mg.L^{-1} will be a limiting factor. Based on measurements during the study and additional data from the study location, it was found that in pond 1, the phosphate values ranged from 2.5-3 mg.L^{-1} with an average of 2.75 mg.L^{-1}. In pond 2, the phosphate values ranged from 2.2-3 mg.L^{-1} with an average of 2.7 mg.L^{-1}, so that the results obtained during the study have an optimal range for cultivation and phytoplankton.

The higher NH_4, PO_4, and NO_3 content with the support of high water temperature and water transparency will result in increased chlorophyll biomass content [38] so that the abundance of phytoplankton biomass increases. The process of decomposing organic matter into mineral salts is faster when the pH range is in the alkaline range [32].

CONCLUSION

The performance value of vannamei shrimp culture in this study shows a good value. It can be caused by the optimal aquatic environment so that the shrimp's appetite can be maintained. Phytoplankton stability during the study also affected the cultivation performance value. ADG and FCR values indicate that the shrimp make good use of the feed.

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ISSN. 2087-2852
E-ISSN. 2338-1655

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ISSN. 2087-2852
E-ISSN. 2338-1655