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Diversity of phytoplankton in the whiteleg (*Litopenaeus vannamei*) shrimp ponds in the south coastal area of Pangandaran, Indonesia

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Abstract. *Palupi M, Fitriadi R, Wijaya R, Raharjo P, Nurwahyuni R. 2021. Diversity of phytoplankton in the whiteleg (*Litopenaeus vannamei*) shrimp ponds in the south coastal area of Pangandaran, Indonesia. Biodiversitas 23: 118-124.* Intensive shrimp farming in ponds is characterized by high stocking densities, complete feeding in quality and quantity, and good environmental control to produce the maximum quantity of shrimp in a fixed area. Phytoplankton is a bioindicator affecting the productivity of whiteleg shrimp in ponds. Currently, intensive shrimp farming activity is carried out on the south coast of Java, which utilizes sandy soil with a biofloc system, but the production has not been optimal. The objective of this study was to analyze the diversity and abundance of phytoplankton and water quality in the traditional and intensive whiteleg shrimp ponds in Pangandaran, West Java, to support sustainable pond management. The objective of the study was achieved by calculating the abundance, diversity index, evenness index and dominance index of planktons in intensive and traditional ponds. The study results showed that *Chrysophyta* division had the highest abundance and species number in both intensive and traditional ponds. The most abundant phytoplankton found in the intensive ponds was *Halosphaera viridis* (3143.88 ind/m^3), and that in the traditional ponds was *Rhizosolenia stolterfothi* (1414.746 ind/m^3). The phytoplankton diversity index (H') in the intensive ponds was 1.95 and that in the traditional ponds was 2.17. The dominance index value in the intensive ponds was 0.18 and in the traditional ponds 0.15. The abundance of phytoplankton is a limitation of the production success of whiteleg shrimp farming.

Keywords: Abundance, diversity, phytoplankton, shrimp ponds, water quality

INTRODUCTION

The shrimp farming business, which has been reviving along the North Coast of Java in recent years, apparently impacts the South Coast of West Java, precisely in Pangandaran (Husada et al. 2021) The presence of whiteleg shrimp, which is superior to giant tiger prawns, has caused the farming of this fishery export commodity to develop rapidly. The South Coast of Java Island is a potential area to be developed into a pond. Opening ponds in the area is an effort to increase shrimp production since the area is still wide open and has a good water quality. It is verified that general use of the area consists of (1) Pond Farming Fishery Zone with an area of 479.66 Ha located in Cijulang, Parigi, Sidamulih and Pangandaran Sub-districts and (2) Fishing Zone with an area of 22,778.66 Ha in all sub-districts (Kusuma et al. 2017).

The decreasing areas of mangrove forests will lead to habitat destruction, which is assumed to cause the decline of biodiversity in the aquaculture environment (Lisna et al. 2018; Nehemia et al. 2019; Islamy and Hasan 2020; Isroni et al. 2019; Nafisyah et al. 2018), including declined diversity of phytoplankton (Hilaluddin et al. 2020; Soedibya et al. 2021), which in turn has an impact on the decline in the pond production. Phytoplankton is autotrophic microorganisms able to produce their food with the assistance of sunlight, and they live floating in oceans, lakes, rivers, and other water bodies (Umami et al. 2018;). Phytoplankton is also used as indicators of the water's primary productivity since they can carry out photosynthesis resulting in oxygen which can be utilized by biota in the water (Wang et al. 2018). Phytoplankton has several types of chlorophyll, such as chlorophyll a, b, and c; thus, they can be used to measure water fertility which is also influenced by season and water quality (Arifin 2009; Singh and Kumar 2021). Phytoplankton diversity works in the balance of the aquaculture ecosystem and acts as natural food for the shrimp aquaculture in ponds (Sohel and Ullah 2012; Abualreesh 2021; Tulsankar et al. 2021).

Water quality of the aquatic environment is always closely related to the development of fisheries, especially aquaculture, which has become a global concern today due to the emergence of several negative effects recorded in several locations (Landeman 1994; Landesman et al. 2005; De Lacerda et al. 2006; Kibria and Haque 2018). A common but important point is that water quality will affect optimal shrimp growth and harvest in the pond (Burford et al.2020; Leigh et al. 2020; Pertiwi et al. 2021). Classically, a water quality study will combine physicochemical parameters and biological indicators (Jones et al. 2001). The facts show that intensive pond cultivation involves the supplement of artificial feed (Fitriadi et al. 2020), fertilizers and other chemicals to stabilize the pond bottom; hence, the use of physicochemical parameters to accurately assess the pond and the surrounding environment is insufficient. It was further explained that there is an information shortage on the use of plankton communities as biological indicators related to water quality in aquaculture systems, especially in shrimp ponds. This study aimed to examine the diversity and abundance of phytoplankton in traditional and intensive ponds. The main finding that was targeted in this study was to analyze the types of phytoplankton in shrimp ponds to determine the types of potential phytoplankton in shrimp farming.

MATERIALS AND METHODS

Place and time of research

This study was carried out from February to July 2021. The research was conducted in traditional ponds and intensive ponds located on the coast of Pangandaran, West Java, Indonesia. The two research stations were selected because they represented the ponds in the areas which have always been successful in shrimp production in the last five harvest cycles. In both ponds, samplings were done at the inlet, outlet and middle of the waters. The intensive pond was located at a latitude of 7.6765250S, and the traditional ponds at 7.6800680S. The intensive ponds used HDFE plastics, and hence there was no wide factor that goes into shrimp farming, while the traditional ponds used natural soil as the pond bed. Feeding was done maximally using the commercial feed.

Sampling procedure

Samplings of phytoplankton and primary productivity measurement were carried out in a composite manner using a 30 L bucket, and the samples were filtered using a 25µm planktonet. 100 mL water samples used for phytoplankton identification were put in a bottle, and 4 drops of formalin were added. Afterward, sample bottles were put into an icebox to maintain the sample durability.

Identification of phytoplankton

Phytoplankton identification was carried out at the Laboratory of Fishery and Marine Science Faculty, Jenderal Soedirman University. Firstly, the sample bottle was shaken or stirred; next, 1 mL of water sample was taken using a micropipette. The water sample was dripped onto the Sedgewick Rafter; it was then observed under an Olympus microscope using a magnification of 10x10 (Amin et al. 2020). Phytoplankton observation was carried out based on the clean sweep method, and the observation under a microscope was done in 3 replications. Phytoplankton identification was carried out to the species level by referring to the plankton identification book (Yamaji 1986).

Data analysis

Phytoplankton abundance

Determination of the phytoplankton abundance was carried out based on the sweep method on a Segwick Rafter object-glass. The phytoplankton abundance was expressed quantitatively in the number of cells/ml (Fachrul 2007) calculated based on the following equation:

$$N = n\ x\ \frac{Vr}{Vo}\ x\ Vs$$

Where, N: Abundance (ind/mL); n: Number of observed cells (ind); Vr: Volume of filtered water (mL); Vo: Volume of observed water (mL); Vs: Volume of filtered water (L).

Margalef Diversity Index

$$(\mathrm{D}) = (\mathrm{S}-1)/\mathrm{Ln}(\mathrm{N})$$

Where, S: total number of phytoplankton species; N: total number of individual phytoplankton.

Diversity analysis

A species diversity index is a statement or mathematical description describing the community structure, and it enables information analysis about the species and number of organisms. Calculation of phytoplankton diversity index was carried out using the Shannon-Wiener formula (Basmi 1999), namely:

$$\mathrm{H'} = -\sum \mathrm{pi}\ \ln\ \mathrm{pi}$$

Where, H': Shannon-Wiener diversity index; pi: Number of individuals of species I; ln: Number of individuals; ∑: Total number of individuals.

The classification of biota community condition based on H' (Basmi 1999) are, H' < 2.30: Low diversity; 2.30 < H'< 6.91: Medium diversity; H' > 6.91: High diversity.

Evenness analysis

The distribution of the number of individuals of each species can be determined by comparing the diversity index value to the maximum value. The evenness index of phytoplankton can be analyzed using the following formula (Odum 1993):

$$E = H'/\ Hmax$$

Where, E: Evenness Index; H': Diversity Index; Hmax: $\log_2$ S; S = Number of Species.

Criteria according to Krebs (1985), E < 0.4: Low category; 0.4 < E < 0.6: Medium category; E > 0.6: High category.

The maximum value of E (E: 1) means that every species in the community has the same number of individuals, and minimal value of E (close to 0) means that every species has different number of individuals (Odum 1993; Basmi 1999).

Dominance Index

A dominance index is used to determine whether certain species dominate a community. The dominance index for phytoplankton was calculated using the Simpson dominance index formula as follows (Odum 1993):

$$C = \sum_{i=1}^{s} (ni/N)2$$

Where, C: Simpson dominance index; ni: Number of individual of each species; N: Total number of individual; s: Number of species.

The value of C ranges between 0 and 1; if the C value is close to 0, it means that there is no dominant species, while if the C value is close to 1, it means that there is a species dominating the community (Odum 1993; Basmi 1999).

RESULTS AND DISCUSSION

Composition

The study results showed that there were different species of phytoplankton in the intensive and traditional shrimp ponds. The composition of phytoplankton is presented in Table 1.

Table 1 shows that the phytoplankton in intensive ponds consisted of 5 divisions, namely Chrysophyta (5 genera), Ochrophyta (2 genera), Chromista (2 genera), Pyrophyta (1 genus) and Chromatophyta (1 species). It can be concluded that the most dominating species in the intensive ponds was Chrysophyta and the least dominating were Pyrophyta and Chromatophyta. The Chrysophyta dominance was presumably due to their wide distribution and high tolerance to environmental changes. Chrysophyta can reproduce sexually and asexually in one life cycle, enabling them to spread rapidly. This finding was contrary to the results of a study by Yuni and Mustaqim (2020), which showed that the species of the highest abundance in intensive shrimp ponds was Chyanophyta (26 Ind/L) and the least one was Chrysophyta (19 Ind/L). Furthermore, the study by Samadan et al. (2020) analyzing the phytoplankton abundance in intensive shrimp ponds found that the highest abundance was *Bacillariophyta* or Diatom with 6 species.

There were 7 divisions of phytoplankton in traditional ponds, i.e., Chrysophyta (4 genera), Chromista (4 genera), Ochrophyta (2 genera), Bacillariophyta (2 genera), and Chlorophyta, Eukaryota, Chromatophyta, each having 1 genus. In the traditional ponds, like in the intensive ponds, Chrysophyta also had the highest number of species. However, the traditional ponds had 7 divisions of phytoplankton, while the intensive ponds had only 5 divisions. The water quality, influenced by nutrients, significantly affect the abundance and diversity of phytoplankton in shrimp pond (Domitrovic et al. 2007; Prabhudessai et al. 2019). Plentiful nutrients in the traditional shrimp ponds allow the presence of more phytoplankton. In addition, Tilahwatih et al. (2019) reported that plankton density in traditional ponds was higher than that in semi-intensive ponds. Phytoplankton diversity in traditional ponds was 0.119-0.159 ind/L, while in semi-intensive ponds was 0.121-0.159 ind/L. Two factors affecting the quality of nutrients in the water are the availability of mangrove forests at the farming sites (Musa et al. 2020; Maurya and Kumari 2021) and water contamination (Jonah and Etteokon 2020).

Phytoplankton abundance

The abundance of phytoplankton in intensive ponds and traditional ponds based on the samples calculation is presented in Table 2.

Table 1. The composition of phytoplankton in the study sites

Location	Division	Class	Ordo	Genus
Intensive Pond	Chrysophyta	Chrysophyceae	Centrales	*Rhizosolenia*
		Bacillariophyceae	Rhizosoleniales	*Rhizosolenia*
			Rhizosoleniales	*Rhizosolenia*
			Biddulphiales	*Biddulphia*
			Centrales	*Chaetoceros*
	Ochrophyta	Coscinodiscaceae	Coscinodiscales	*Coscinodiscus*
		Chlorodendrophyceae	Chlorodendrales	*Halospaera*
	Chromista	Bacillariophyceae	Biddulphiales	*Biddulphia*
			Coscinodiscales	*Coscinodiscus*
	Pyrophyta	Dinophyceae	Prorocentrales	*Prorocentrum*
	Chromatophyta	Coscinodiscophyceae	Leptocylindrus	*Leptocylindricus*
Traditional Pond	Chrysophyta	Bacillariophyceae	Rhizosoleniales	*Rhizosolenia*
			Rhizosoleniales	*Rhizosolenia*
			Pennales	*Fragilaria*
			Centrales	*Skeletonema*
	Chromista	Bacillariophyceae	Coscinodiscales	*Coscinodiscus*
			Biddulphiales	*Biddulphia*
	Ochrophyta	Coscinodiscaceae	Coscinodiscales	*Coscinodiscus*
		Bacillariophyceae	Rhizosoleniales	*Rhizosolenia*
	Bacillariophyta	Bacillariophyceae	Fraggilariales	*Nitzschia*
		Mediophyceae	Thalassiosirales	*Lauderia*
	Chlorophyta	Chlorodendrophyceae	Chlorodendrales	*Halospaera*
	Eukaryota	Prymnesiophyceae	Coccolithales	*Cocolithus*
	Chromatophyta	Coscinodiscophyceae	Leptocylindrales	*Leptocylindrus*

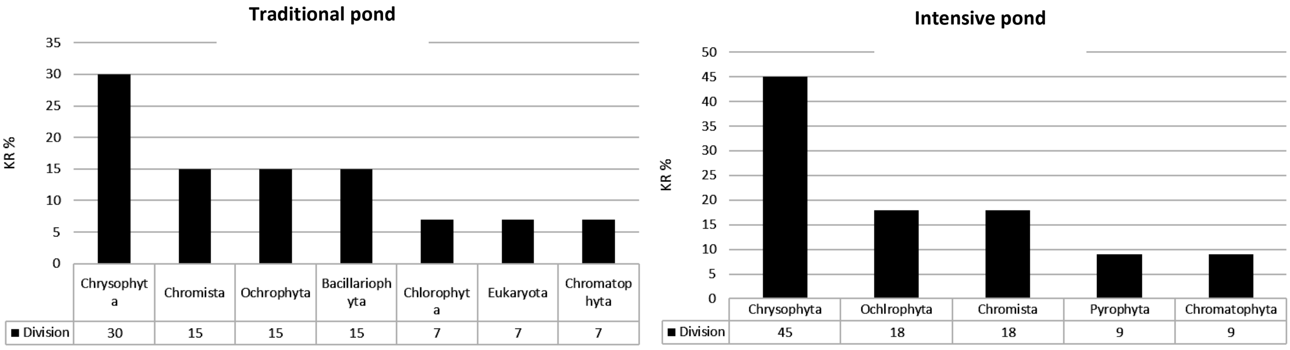

Figure 2. Phytoplankton abundance

Table 2. Phytoplankton abundance

Location	Species	Abundance (indi/m^3)	Amount
Intensive Pond	*Rhizosolenia stliformis*	314.388	2
	Rhizosolenia shrubsolei	2357.91	15
	Rhizosolenia stolterfothi	471.582	3
	Prorocentrum micans	314.388	2
	Leptocylindricus danicus	314.388	2
	Coscinodiscus excentricus	2515.104	16
	Biddulphia alternans	157.194	1
	Chaetoceros densum	314.388	2
	Coscinodiscus lineatus	628.776	4
	Halosphaera viridis	3143.88	20
	Biddulphia aurita	785.97	5
	Total		72
Traditional Pond	*Coscinodiscus excentricus*	1257.552	8
	Rhizosolenia stolterfothi	1414.746	9
	Rhizosolenia shrubsolei	314.388	2
	Cocinodiscus lineatus	157.194	1
	Biddulphia aurita	157.194	1
	Fragilaria ocearica	157.194	1
	Skeletonema costatum	157.194	1
	Halospeira viridis	943.164	6
	Rhizosolenia alata	314.388	2
	Nitzchia closterium	628.776	4
	Cocolithus pelagicus	157.194	1
	Leptocylindricus danicus	157.194	1
	Lauderia borealis	157.194	1
	Total		38

Table 3. Diversity, homogeneity and dominance indexes

Location	Diversity index (H')	Evenness index (E)	Dominance index (C)
Intensive pond	1.95	0.81	0.18
Traditional pond	2.17	0.84	0.15

The abundance of phytoplankton in a shrimp pond is influenced by the physical and chemical properties of water quality which is affected by nutrient content discharged from aquatic waste around the farming site (Adhikari et al. 2017; Emabye and Alemayo 2020) nitrogen and phosphorus (Arofah et al. 2021). This result corresponds to the study by Samocha and Lawrence (1997), stating that the water quality index is strongly influenced by effluent from the pond itself, especially ponds that are close to the disposal area. The presence and growth of phytoplankton in the pond water is influenced by environmental conditions such as light, temperature and concentration of nutrients in the water (Yusoff et al. 2002).

Phytoplankton with the highest abundance found in the intensive ponds was *Halosphaera viridis* (3143.88 ind/m^3), and that found in the traditional ponds was *Rhizosolenia stolterfothi* (1414.746 ind/m^3). On the other hand, the lowest abundance in the intensive ponds was *Biddulphia alternans* (157.194 ind/m^3), and those of the traditional ponds were *Cocinodiscus lineatus*, *Biddulphia aurita*, *Fragilaria oceanica*, *Skeletonema costatum*, *Leptocylindrus danicus*, *Lauderia borealis* with the equal abundance value of 157.194 ind/m^3. *Halospaera viridis* is included in Chlorophyta division, namely green algae commonly found in shrimp aquaculture waters. This result is in line with Leliaert's (2019) statement that Chlorophyta is unicellular planktonic algae living superbly in brackish and seawater; its shape varies from unicellular to multicellular and complex Chlorophyta found in many marine and terrestrial habitats. Chlorophyta lives in cold waters with low salinity (Tragin and Vaulot 2018). Based on its habitat, *Halosphaera viridis* is very likely to breed well in the *vannamei* shrimp ponds. Samadan et al. (2020) reported that phytoplankton species found in intensive *vannamei* shrimp aquaculture ponds were 4 genera of Chlorophyta, namely *Chlamydomonas, Tetraselmis, Chlorella* and *Oocytis.*

Halosphaera viridis has two stages of growth, namely motile and non-motile, with relatively short grow yet it can perform asexual reproduction (Sym and Pienaar 1997). This is a super alga species as it contains nutrients, especially fatty acids. Acxur et al. (1970) state that fatty acid in *Halosphaera viridis* has a structure similar to that of fatty acid in *Tetraselmis* sp*.*, an alga widely used in *vannamei* shrimp farming.

Diversity

Fine aquatic ecological condition is necessary to obtain high-quality aquatic production. Therefore, water quality and phytoplankton diversity are important factors to be analyzed and considered (Qiao et al. 2020). The establishment of phytoplankton diversity is strongly influenced by biotic and abiotic factors of a pond; those might affect the aquaculture ecosystem and health of the cultured shrimp (Yang et al. 2020). Phytoplankton diversity index in the intensive ponds was 1.95, and that in traditional ponds was 2.17. Basmi (1999) states that a diversity index value below 2.3 is categorized as low. This result corresponds the that of research by Ni et al. (2018), showing that the diversity index of phytoplankton in the intensive ponds was very low (1.93-2.49) and that of research in Western Harbor, showing the diversity index of 1.0 and 2.50 (Gharib and Dorgham 2006). It was explained that the water of the shrimp pond was slightly polluted.

Phytoplankton diversity in aquaculture can be established with good aquaculture management, especially in shrimp feeding allowing control of the waste disposal to the aquaculture ponds. A study by De et al. (2020) showed that feeding shrimp using fish waste hydrolyzate combination increased the abundance and diversity of phytoplankton in pond water; one of the phytoplankton was *Isochrysis galbana,* which is a beneficial alga for shrimp farming. Lukwambe et al. (2019) said that giving probiotics supplement significantly affected the growth of algae. Probiotics supplement can reduce the growth of Cyanobacteria species (Oscillatoria and Anabaena) and increase the growth of *Nannochloropsis, Chlorella* of Chlorophyta species, Oocystics and Navicula of Bacillariophyta species.

Species evenness

The phytoplankton evenness index of the intensive ponds was 0.81, and that of the traditional ponds was 0.85 (high homogeneity). A high evenness index in a community indicates that the individual abundance of each species was relatively equal; in other words, there was no domination of certain species. In contrast, the research conducted by Makmur et al. (2011) on shrimp ponds in Tanjung Jabung Barat, Jambi, found a very low evenness index of around 0.53. Phytoplankton evenness index ranged from 0.773 to 0.889 (high evenness) and zooplankton evenness index was 0.740-0.908 (high evenness).

The research location, either intensive ponds or traditional ponds, used paddlewheel as oxygen supply and phytoplankton dispersion. Even distribution of individuals at each depth during the observation was caused by sufficient light intensity and water current. Cao et al. (2011) said that the wind affects the homogeneity of phytoplankton which leads to the accumulation of phytoplankton in certain locations. There were 11 species of phytoplankton in intensive ponds and 13 species in traditional ponds.

Dominance index

The dominance index in this study was low, i.e., 0.18 in the intensive ponds and 0.15 in the traditional ponds was 0.15, which means that there was no dominant species of phytoplankton in the ponds. According to Odum (1993), if the value of C is close to 0, it means that there are no dominant species, but if the value of C is close to 1, there is a dominant species. There were no dominant phytoplankton species at the research location because natural habitats such as mangrove forests are still maintained around the intensive and traditional shrimp ponds. Some mangroves are still in the planting process, and thus natural habitats are still well preserved (Lisna et al. 2018). It was further explained that the domination of plankton was due to the use of probiotics in intensive and traditional shrimp ponds according to the required dose. Inappropriate use of probiotics and damaged mangrove habitats will affect the domination of phytoplankton in the water (Pirzan 2008). A beneficial density and domination of phytoplankton are indicated by the growth of Chlorophyceae, Cyanophyceae, and Bacillariophyceae. It can be established by the inoculation of green algae from other ponds. Green algae are highly favored for shrimp growth; therefore, the availability of green algae during the farming process is important to consider (Cremen et al. 2007).

Results of this study is in contrast with those of the research conducted in the north coast of Java, precisely in Rembang, which found that there were dominant phytoplankton in both traditional and intensive ponds with dominance value ranging from 0.02 to 0.68 and 0.01 to 0.75 (Umami et al. 2018). Thus, ponds in these areas can be categorized as degraded shrimp farming ponds. The followings are several issues to be considered in order to avoid domination: applying the supplement of probiotic bacteria, dolomite, shrimp stocking density, feed, organic and inorganic fertilizers and balanced pest control based on the standard operating procedures (SOP) in accordance with the carrying capacity of the land and the characteristics of the local environment (Mitra 2019).

In conclusion, the phytoplankton in shrimp ponds in Pangandaran had a low diversity index and high evenness index, indicating that there was no species dominating the community. The abundance of phytoplankton is an indication for the successful production of *vannamei* shrimp farming.

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