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Plankton Diversity as a Natural Food Source for Milkfish (*Chanos chanos*) in Traditional Ponds of Pasuruan City, East Java

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Abstract: Traditional ponds in Pasuruan City are dominated by milkfish (*Chanos chanos*). Milkfish take food from the top layer of the seabed in the form of phytoplankton and zooplankton. This study aims to determine the abundance, diversity and dominance of plankton and water quality in traditional milkfish ponds in Pasuruan City. Sampling locations were selected based on the distance of the pond from the sea. Station 1 (near the sea), station 2 (1–3 km from the sea), and station 3 (furthest from the sea). The results showed the availability of natural food for milkfish in the form of phytoplankton and zooplankton. Phytoplankton was found more than zooplankton. The most common phytoplankton division was Bacillariophyta and the least was Euglenozoa with diversity index ranging from 1.64–1.82 and dominance index ranging from 0.24–0.31. The most common zooplankton phylum is Arthropoda and the least is Molluscs with diversity index ranging from 0–1.83 and dominance index ranging from 0.21–1.00. The measurement results of pond water quality parameters such as pH (8.51–9.02), temperature (30.1–32.5°C), brightness (25.5–29.6 cm), DO (3.7–5.7 ppm) and salinity (32.5–33.7 ppt) are still in accordance with the optimal standards of milkfish farming.

Keywords: Milkfish; Natural feed; Pasuruan City; Plankton diversity; Traditional ponds; Water quality

Introduction

Coastal areas have an attraction for a variety of human activities, including tourism and fisheries sectors, one of which is aquaculture activities (Murachman et al., 2010). Aquaculture is one of the many economic activities undertaken by coastal communities in Indonesia. Pond business activities have the potential to increase the number of jobs in the community (Dahuri et al., 1996).

Ponds are areas formed by humans as a medium for raising fish and shrimp. Ponds are divided into three, including layah ponds, ordinary ponds and inland ponds. Layah ponds are located close to the sea, on the shore or estuary. Ordinary ponds are located behind layah ponds and are usually filled with a mixture of sea water and fresh water from the river. Inland ponds are located far from the coast and are filled with freshwater only (Kordi & Tancung, 2010). Based on its management, ponds are divided into intensive, semi-intensive and traditional ponds. The difference in management is related to seed stocking, feeding and water management and the environment (Widigdo, 2000). One of the aquaculture biota that is often developed in traditional ponds is milkfish.

Milkfish is a type of fish that comes from brackish water and is eurihaline. This fish is able to grow well in fresh water (0 ppt) to high salinity (35 ppt) (Larasati &

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Budijastuti, 2022; Thalib et al., 2019). Previous studies have shown that ponds in Pasuruan city and regency have salinities that vary from 3-16 ppt (Surbakti, 2018), 0.2–35.87 ppt (Hendrajat & Sahrijanna, 2018), and 10–19.4 ppt (Arfiati et al., 2023).

Milkfish is a leading commodity in Pasuruan City. This commodity accounts for 49% of the total aquaculture production in Pasuruan City (Dinas Perikanan Kota Pasuruan, 2023). One of the areas in Pasuruan City that has a milkfish pond business is Blandongan village. This area is a producer of milkfish commodities located in Bugul Kidul District, Pasuruan City. Milkfish farmers in this area use a traditional farming system. According to Surbakti (2018) Traditional ponds in the feeding system do not add artificial feed, relying only on natural feed available in the pond.

The natural food favoured by milkfish is plankton. Plankton consists of phytoplankton and zooplankton. In the food chain, phytoplankton acts as a producer which then becomes food for zooplankton (Makmur et al., 2011). The results of previous studies showed the potential abundance of plankton as natural food for milkfish. The composition of phytoplankton that was found included Bacillariophyta, Chlorophyta, and Cyanophyta while zooplankton were Arthropoda and Rotifera (Surbakti, 2018). The abundance of Nitzschia in pond waters (Hendrajat & Sahrijanna, 2018). Added by Arfiati et al. (2023), milkfish eat more phytoplankton than zooplankton based on the composition in the stomach.

According to Isnawati et al. (2015), the conditions of the aquatic environment such as DO, BOD, pH, temperature, and salinity can affect the quality of food found in the upper layers of the water. Suitable waters can support the life of microorganisms as a source of natural food and energy for milkfish. The food will affect the morphometry, meristics, and growth patterns of fish. Added Triyanto et al. (2014) that the abundance of plankton as a natural food source affects water productivity. Based on previous research, differences in water environment conditions affect the diversity of plankton from both phytoplankton and zooplankton.

The decline in milkfish production in 2021 and 2022 in Pasuruan City and the lack of information on plankton diversity in traditional ponds in Pasuruan City are important concerns for stakeholders. It is necessary to conduct research on plankton diversity as a natural food source in traditional ponds in Pasuruan City to determine the availability of natural food for milkfish.

Method

Research Location

This study was conducted in milkfish ponds Blandongan Village, Bugul Kidul District, Pasuruan City, East Java. This traditional pond is located at coordinates 7°37'19.29"–7°39'6.58" South latitude and 112°56'55.38"–112°56'31.21" East longitude. Samples were collected at 3 different stations (Figure 1).

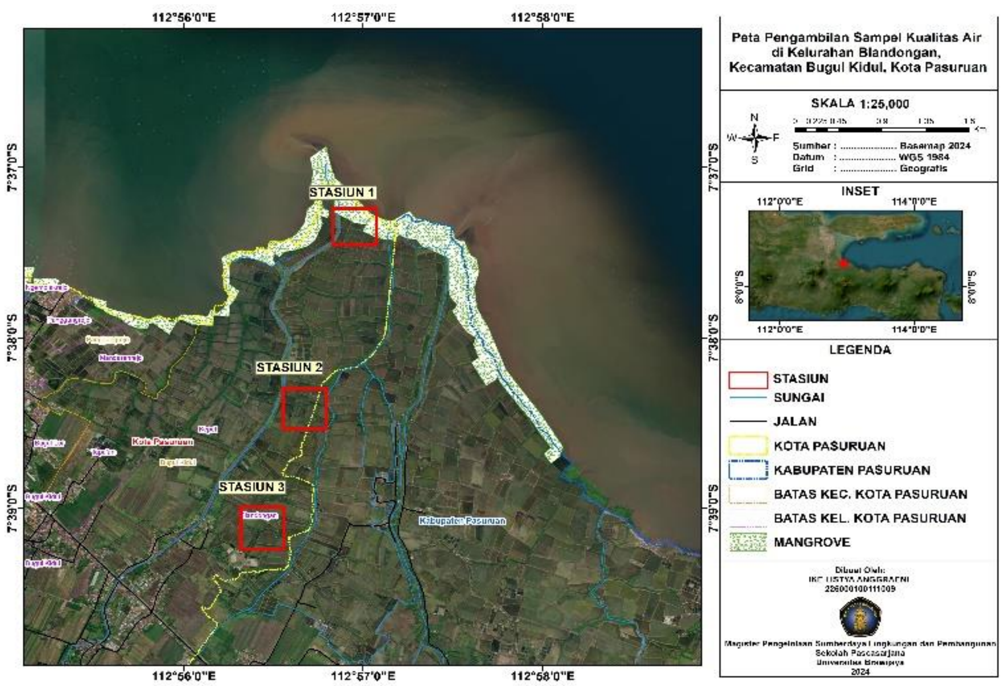

Figure 1. Sampling location

Sampling sites were selected based on the distance of the ponds to the sea and estuary. Station 1 was located near the sea and estuary (< 1 km), station 2 was 1–3 km from the sea and estuary, and station 3 was furthest from the sea and estuary (> 3 km).

Sampling and Laboratory Observations

Sampling was carried out using the pour method. Each sampling point was taken as much as 25 litres (Rahmawati et al., 2023) and filtered using plankton net no. 25 size 65 μm (Espinasse et al., 2023). Sample collection and measurement were carried out as many as 4 (four) replicates at each station. The filtered water was put into a 35 ml sample bottle and given 1% lugol using a drop pipette (Gronseth et al., 2017; Jiang et al., 2024). The sample bottles were labelled according to the station and placed in a cool box. The cool box was given ice cubes to keep the temperature cool during sample storage. Samples were analysed and identified phytoplankton and zooplankton species using a microscope at the Integrated Science and Technology Laboratory, Graduate School of Universitas Brawijaya, Malang. Plankton identification refers to (Prescott, 1954).

Water quality parameters (temperature, pH, salinity, DO, and brightness) were measured three times at each sampling point. Sample measurements used portable measuring devices to ensure precise data were taken. Digital thermometer brand LUTRON series DO-5510 to measure water temperature, secchi disk as a brightness measurement tool, digital pH meter brand Lutron PH-208 to measure acidity, salinometer brand Atago to measure salinity and DO meter brand LUTRON series DO-5510 to measure dissolved oxygen (Prasasti et al., 2022). Aquadest helps calibrate the equipment before and after use. GPS determines the coordinate point of sampling.

Data Analysis

Plankton abundance is the number of plankton found and then calculated as the number of individuals per litre. The calculation uses the Lackey Drop Macrotransect Counting method (Herawati et al., 2019; Akbar et al., 2021) with equation 1.

$$\text{Number of Cell/L} = \frac{T}{L} \times \frac{V_0}{V_1} \times \frac{1}{P} \times \frac{1}{W} \times N \quad (1)$$

Where:
N = Number of Diatom cells found per preparation
T = Area of cover glass $(mm)^2$
L = Microscope field of view $(mm)^2$
V_0 = Volume of sample water in sample bottle (ml)
V_1 = Volume of sample water under the cover glass (ml)
P = Number of field of view observed
W = Volume of filtered water (litres)

The plankton diversity index was calculated using the Shannon-Weaver diversity index (Magurran, 2004; Shannon & Weaver, 1964). The diversity index formula is calculated by equation 2.

$$H' = -\Sigma \text{pi} \ln pi \text{ where pi} = \frac{\text{ni}}{\text{N}} \quad (2)$$

Where:
H = Diversity Index
ni = Number of individuals-i
N = Total number of individuals in the sample
The diversity index criteria are as follows:
H < 1 = Low diversity
1 < H < 3 = Medium diversity
H > 3 = High diversity

The dominance index was calculated to determine the dominating plankton species based on Simpson's dominance index (Simpson, 1949; Dash & Dash, 2009). The calculation of dominance is calculated by equation 3.

$$C = \sum_{i=1}^{s} \text{pi}^2 \text{ where pi} = \frac{\text{ni}}{\text{N}} \quad (3)$$

Where:
C = Dominance Index
ni = Number of individuals-i
N = Total number of individuals in the sample

Dominance index values range from 0 to 1. If the C value is close to 0, it means that there is no dominant species and vice versa, a C value close to 1 means that there is a dominant species. The greater the dominance index value, the lower the diversity.

Water quality parameters measured were brightness, temperature, salinity, pH and dissolved oxygen. The data obtained were processed and analysed descriptively. The observed water quality data were then compared with several references (Table 1).

Table 1. Standard water quality parameters for milkfish farming

Criteria	Optimum standard	Reference
Temperature (°C)	22–35	Beltran et al. (2018)
Brightness (cm)	20–40	Kordi & Tancung (2010), SNI 01-6150 (1999)
Salinity (ppt)	5–35	SNI 01-6150 (1999)
pH	7.0–9.0	Kordi & Tancung (2010)
DO (ppm)	4–7	Kordi & Tancung (2010)

Result and Discussion

Phytoplankton

The percentage of phytoplankton abundance in traditional ponds, Blandongan, Pasuruan City consists of 5 divisions. The five divisions include Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta and Euglenozoa. The most common phytoplankton division is Bacillariophyta while the least is Euglenozoa (Figure 2).

The variety of phytoplankton divisions found at all stations can be used as natural food for milkfish. This is in accordance with the results of research from Cermeño et al. (2014) and Tian et al. (2021), that Chlorophyta, Bacillariophyta, Cyanophyta, Dinophyta and Euglenozoa were found, with the Bacillariophyta division found the highest at 67.9% among other divisions. Added by Arfiati et al. (2023) The phytoplankton of Chlorophyta, Bacillariophyta and Cyanophyta divisions are the main food of milkfish. Bacillariophyta is a group of algae that are qualitatively and quantitatively found in various types of waters (Kristiansen & Pavel, 2016). According to Diniarti et al. (2021) Bacillariophyceae are natural food for biota that live in the sea and have high populations in brackish and marine waters and are known as diatoms.

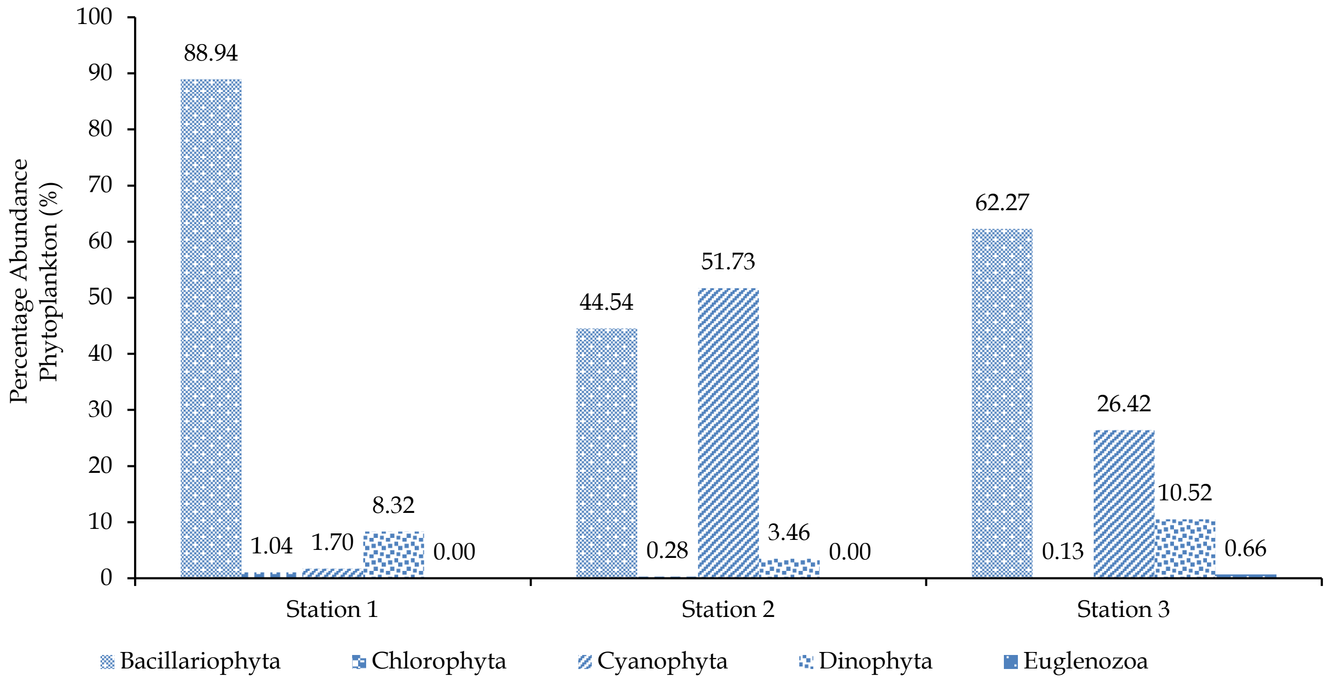

Figure 2. Percentage of phytoplankton abundance

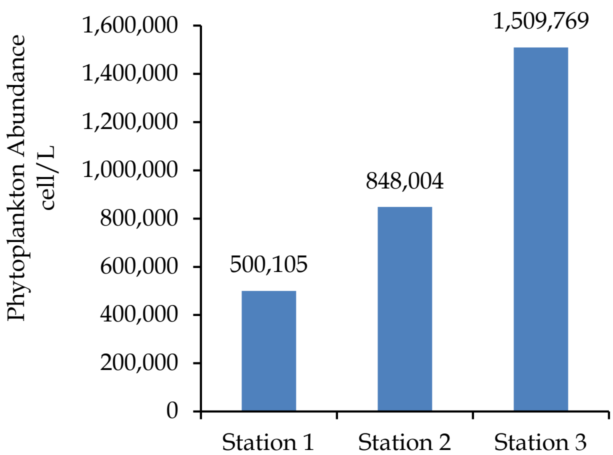

Figure 3. Total abundance of phytoplankton

Total phytoplankton abundance ranged from 500,105 to 1,509,769 cells/L. The highest total phytoplankton abundance was obtained at station 3 and the lowest at station 1 (Figure 3). Based on the amount of phytoplankton abundance, the pond is categorised as eutrophic. According to Siagian & Simarmata (2018) and Geng et al. (2022), phytoplankton abundance of > 15,000 cells/L is called eutrophic waters.

The most common phytoplankton genus is Nitzschia at 629,149 cells/L at station 3 from the Bacillariophyta division. In addition, still from the same division (Bacillariophyta) was Cyclotella at 183,403 cells/L found mostly at station 1. The genus Plectonema at 433,456 cells/L from the Cyanophyta division was found mostly at station 2 (Table 2).

Nitzschia has a high lipid content. Lipid content can fulfil the energy needs of milkfish (Djumanto et al., 2017). Another phytoplankton that dominates in the pond is Cyclotella. It is suspected that pond waters experience eutrophication. Cyclotella live in colonies and are commonly found in fresh waters. These phytoplankton have good nutritional value for many aquaculture species. In addition, this species is one type of plankton that can indicate the level of water quality.

The development of Cyclotella indicates the influence of human activities (Boyd, 2014; Putriani, 2018; Yang et al., 2020).

Table 2. Individual abundance of phytoplankton in traditional ponds

Station	Abundance Phytoplankton (Cell/L)	Phytoplankton dominance Genus	Division
1	183,403	Cyclotella	Bacillariophyta
2	433,456	Plectonema	Cyanophyta
3	629,149	Nitzschia	Bacillariophyta

Phytoplankton diversity index in traditional ponds Blandongan, Pasuruan City ranged from 1.64–1.82. The highest diversity index was obtained at station 3 and the lowest at station 3 (Figure 4).

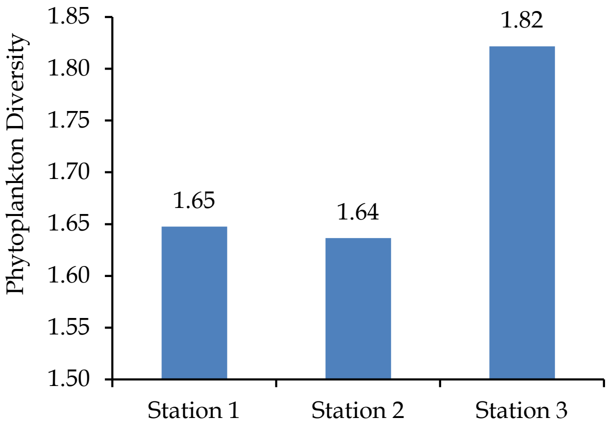

Figure 4. Phytoplankton diversity index

Based on the results of diversity analysis, it can be seen that the phytoplankton diversity index in the pond is moderate. According to Odum (1959), the diversity of organisms (H) is said to be low if $H < 1$, moderate if $1 < H < 3$ and high if $H > 3$. Phytoplankton diversity is largely influenced by the interaction of a number of physico-chemical and biological factors that work simultaneously. A healthy aquatic ecosystem depends on the physico-chemical and biological diversity of the ecosystem.

The dominance index of phytoplankton in traditional ponds, Blandongan, Pasuruan City ranged from 0.24–0.31. The lowest dominance index value is found at station 3 and the highest is found at station 2 (Figure 5). The analysis showed that the dominance of an individual in the pond is categorised as low. The results of the analysis indicate that there is no dominating phytoplankton species in pond waters. Dominance index value close to 1 indicates the dominance of certain species (Dash & Dash, 2009).

The dominance index of phytoplankton in traditional ponds, Blandongan, Pasuruan City is different from the results of research from (Nasmia, 2022), that the dominance index value of phytoplankton in ponds in Lalombi and Tolongano villages ranged from 0.4227–0.9033, close to the value of one, which indicates that there are certain types that dominate the phytoplankton community structure in ponds.

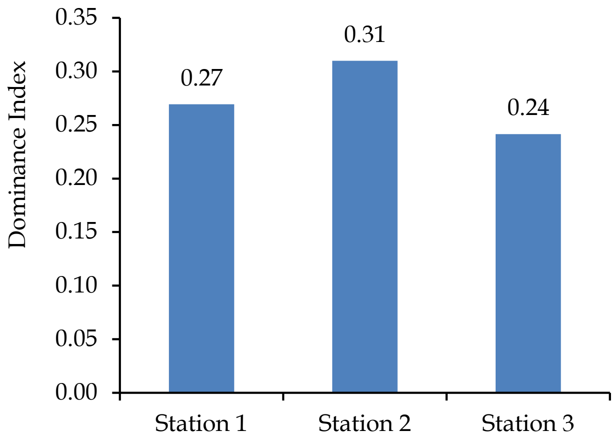

Figure 5. Phytoplankton dominance index

Zooplankton

The percentage of zooplankton abundance in traditional ponds, Blandongan, Pasuruan City consists of 4 phylum. The four phyla include Arthropoda, Ciliophora, Molluscs, and Rotifera. The percentage of zooplankton abundance found in the pond is the phylum Arthropoda while the least found is the phylum Mollusca (Figure 6).

The variety of zooplankton found in ponds can be utilised as natural food for milkfish. Research results Arfiati et al. (2023) found that zooplankton found in the stomach of fish came from the phylum Rotifera and Arthropoda. The lack of variation in the genus of zooplankton found at station 1 is thought to be due to tides. Based on research from Gultom (2018) and Firmansyah et al. (2021) plankton include microorganisms whose lives float in water and many or few plankton communities are determined by the discharge of water entering from seawater sources into the pond through the frequency of water changes.

The total abundance of zooplankton in traditional ponds, Blandongan, Pasuruan City ranged from 2,836–43,487 individuals/L. The highest abundance value was obtained at station 3 and the lowest at station 1 (Figure 7).

Based on the analysis of the total abundance of zooplankton, shows that the majority of traditional ponds, Blandongan, Pasuruan City is still classified as trophic. Zooplankton found in this study in accordance with research conducted by Fernandes et al. (2019), Lien et al. (2022) and Moreira et al. (2024) which also found zooplankton from the Protozoa (Ciliophora) group such as Acineta, Euplotes and Zoothamnium, the Copepoda, Nauplius group and also Rotifera Brachionus. The presence of Protozoa, especially Euplotes, indicates high organic matter in the water. Rotifera is a natural food for milkfish due to its high protein content.

The results of zooplankton diversity analysis in traditional ponds, Blandongan, Pasuruan City ranged from 0–1.83. The highest diversity index obtained at station 3 and the lowest at station 1 (Figure 8).

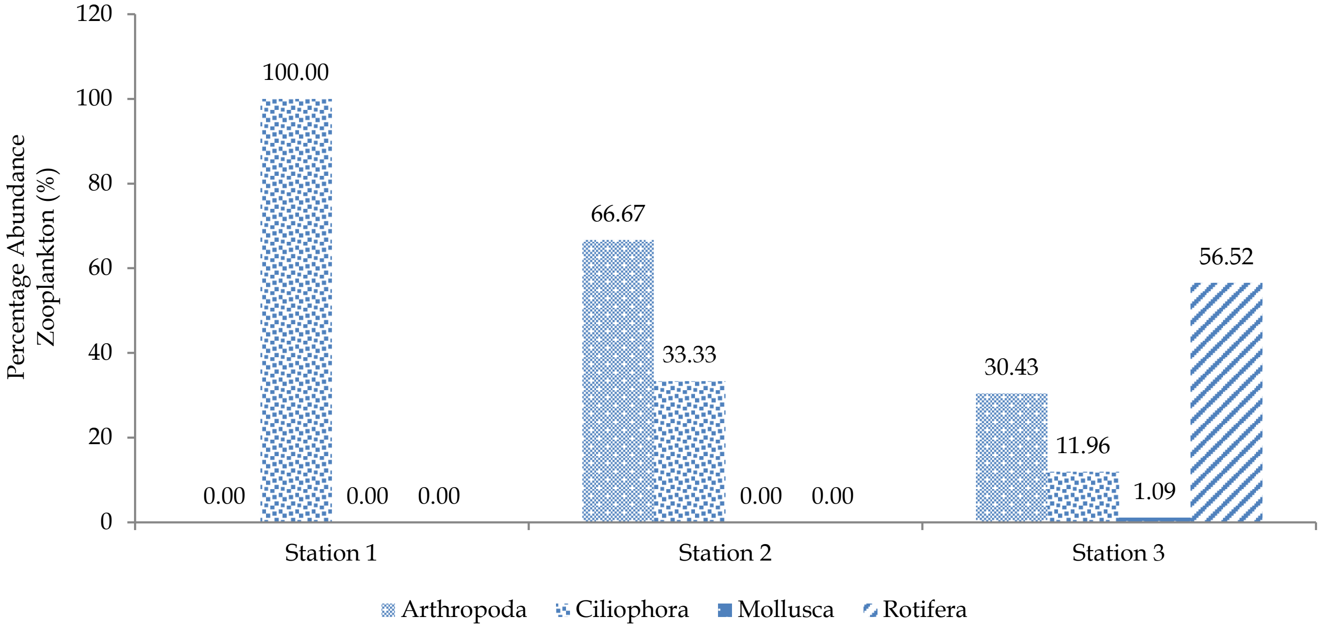

Figure 6. Percentage of zooplankton abundance

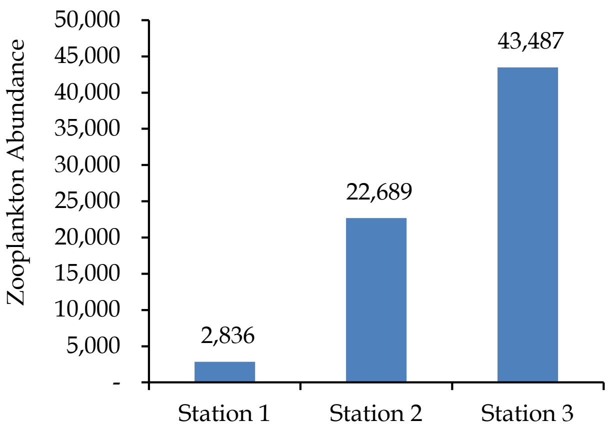

Figure 7. Total zooplankton abundance

Based on the results of diversity index analysis, zooplankton diversity at station 1 is low. At stations 2 and 3 the diversity index is in the medium category. According to Odum (1959), the diversity of organisms (H) is said to be low if $H < 1$, moderate if $1 < H < 3$ and high if $H > 3$. The difference in diversity index at station 1 with stations 2 and 3 is thought to be a factor of environmental change in the coastal area. According to Utojo (2015), the diversity and stability of plankton in the traditional ponds are also influenced by plankton habitat and commodities cultivated in addition to the need to leave mangrove plants as a green belt and natural filters along the river, the main channel and between the ponds.

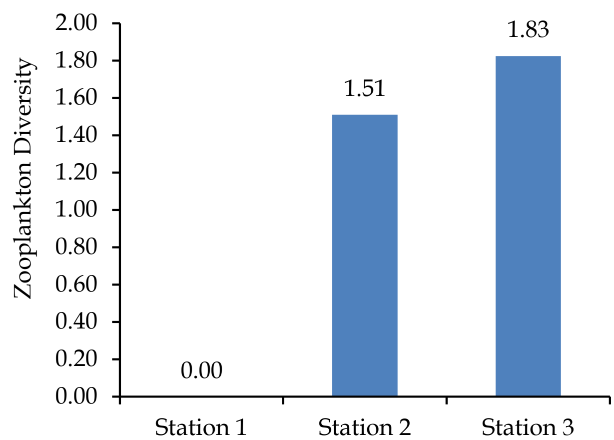

Figure 8. Zooplankton diversity index

The high susceptibility of zooplankton to environmental change, especially to human impacts in catchment areas of aquatic systems, means that they are often used to determine various environmental features.

Knowledge of zooplankton responses to change is highly practical and important for habitat quality assessment as well as the establishment of conservation criteria (Kippen, 2020). Factors responsible for zooplankton irregularities arise from a wide variety of physical and biotic processes, such as predation and competition (Takahashi et al., 2014).

The dominance index of zooplankton in traditional ponds, Blandongan, Pasuruan City ranged from 0.21–1.00. The lowest dominance index value was found at station 3 and the highest was found at station 1 (Figure 9).

Based on the dominance index analysis, it shows that the dominance of an individual at stations 2 and 3 is categorised as low while at station 1 it is categorised as high. According to Dash & Dash (2009), the dominance index value that is close to 1 indicates the dominance of certain species. At station 1, the dominance of Bursaridium from the Ciliophora division was found.

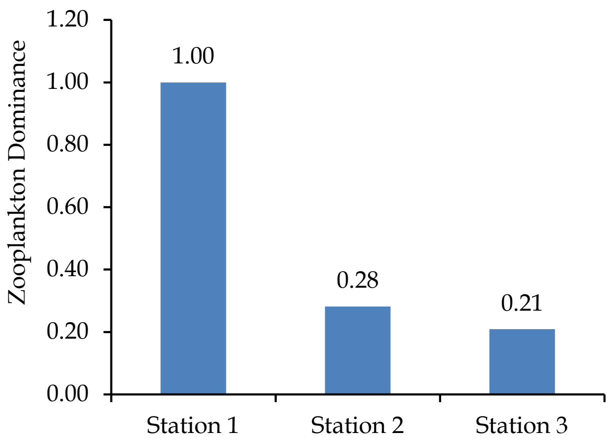

Figure 9. Zooplankton dominance index

Water Quality

The results of water quality measurements in traditional ponds, Blandongan, Pasuruan City include temperature, brightness, dissolved oxygen (DO), acidity (pH) and salinity. Based on the results of the study, it was found that the temperature value in the pond is still in the optimum standard range of 30.1–32.5 °C. The value of DO (dissolved oxygen) is still within the optimum standards at station 1 (closest to the sea), while at stations 2 and 3 below the optimum standards ranging from 3.7–3.8 ppm. The pH value in the pond is still within the optimum standard at stations 1 and 2, while at station 3 is not optimal at 9.02. Salinity measured in the pond is still in the range of optimum standards ranging from 32.5–33.7 ppt. Brightness in the pond is still in the optimum standard range of 25.5–29.6 cm (Table 3).

The physical and chemical conditions at each research station were different depending on weather and tidal factors. According to Hirai et al. (2015) and Dewanti et al. (2018) the physico-chemical characteristics of a habitat will support the structure of the biota community that lives in it, including plankton.

The measurement results of temperature parameters from the three stations varied between 30.1–32.5 °C. The existence of an upward trend in temperature from station 1 to station 3 is influenced by the measurement time factor. This is in accordance with research conducted by Sulistiawati et al. (2020) which states that time differences such as morning and afternoon can affect temperature. The sampling time was carried out between 09.00–14.00 WIB sequentially from station 1 to 3.

Table 3. Average measurement results of water quality

Parameters	Unit	Station			Optimum Standard
		1	2	3	
Temperature	°C	30.1	30.8	32.5	22–35 [a]
DO	ppm	5.7	3.8	3.7	4–7 [b]
pH	-	8.51	8.91	9.02	7.0–9.0 [b]
Salinity	ppt	33.5	32.5	33.7	5–35 [c]
Brightness	cm	29.6	28.9	25.5	20–40 [b,c]

Description:
[a]: Beltran et al. (2018); [b] : Kordi & Tancung (2010);
[c]: SNI 01-6150 (1999)

DO (Dissolved Oxygen) levels at stations 2 and 3 ranged from 3.7–3.8 ppm. This is thought to be the presence of relatively high temperature organic matter in the waters. According to Kordi & Tancung (2010), temperature is very influential on oxygen levels. Oxygen is inversely proportional to temperature, meaning that when the temperature is high, the solubility of oxygen decreases. Added by Effendi (2003) that low DO concentrations will affect the cultivation diet. DO levels of less than 4 mg/L can have an unfavourable impact on aquatic organisms.

The results of pH (acidity) measurements at station 3 (furthest from the sea) were not optimal. This is due to the lack of fresh water, both rainwater and river water. Some rivers that are usually flooded are still dry due to the dry season. This is supported by the salinity at station 3 which is the highest of the other stations. According to Kordi & Tancung (2010), the pH of water affects the fertility of waters. pH above 9.0–9.5 makes fish growth inhibited. At station 3 (furthest from the sea) the abundance of plankton is more than other stations. Salinity at this station is also high, making the pH more alkaline. According to Kordi & Tancung (2010), high pH (9.0–9.5) causes an increase in ammonia levels and usually occurs during the day which is characterised by an explosion of plankton.

Salinity measurements in traditional ponds in Blandongan Village, Pasuruan City ranged from 32.5–33.7 ppt. According to Kordi & Tancung (2010), milkfish can live in a wide range of salinity. However, optimal growth of fish can occur in a fixed salinity range. According to Kordi & Tancung (2010) and SNI 01-6150 (1999), the optimal salinity value range is 5-35 ppt. The results of brightness measurements in traditional ponds Blandongan village Pasuruan still in the range of optimum value of water quality in aquaculture ranging from 25.5–29.6 cm. According to Kordi & Tancung (2010) and SNI 01-6150 (1999), the optimal range of brightness is 20–40 cm.

Based on the results of research in Blandongan traditional pond, Pasuruan City, the total abundance of phytoplankton was found to be more than zooplankton, indicating that the pond waters contain the composition of natural food needed by milkfish. Such plankton description can be utilised as natural food for milkfish with phytoplankton composition more than zooplankton. According to Diniarti et al. (2021) The main diet of adult milkfish consists of benthic and planktonic organisms consisting of gastropods, lamellibranchia, foraminifera, filamentous algae, diatoms, copepods, nematodes and detritus. The phytoplankton can be utilised by zooplankton or other herbivores. Added by Arfiati et al. (2023), phytoplankton are more eaten than zooplankton. The composition of plankton in the stomach of milkfish is around 99.8% phytoplankton and 0.2% zooplankton. The higher abundance of plankton also affects the growth of milkfish. According to Herawati et al. (2019), the higher the abundance of plankton, the higher the growth rate by 83%.

Conclusion

The results showed the availability of natural food for milkfish farming. plankton in the pond in the form of phytoplankton and zooplankton. The abundance of phytoplankton is the most compared to zooplankton. Plankton abundance was highest at station 3 (furthest from the sea). At that station, the highest phytoplankton abundance was 1.509.769 cells/L and zooplankton as many as 43.487 individuals/L. The most abundant phytoplankton division found was Bacillariophyta and the least was Euglenozoa. The phytoplankton diversity index in the medium category ranged from 1.64–1.82. The dominance index of phytoplankton in the low category ranged from 0.24–0.31. The most common zooplankton phylum is Arthropoda and the least is Mollusca. The zooplankton diversity index at station 1 (near the sea) is in the low category (0) while stations 2 and 3 are in the medium category ranging from 1.51–1.83. At station 1 (near the sea) there is a dominance of the genus Bursaridium of the division Ciliophora while stations 2 and 3 zooplankton dominance index low category. The results of water quality measurements in pond waters are suitable for milkfish cultivation. Temperature parameters ranged from 30.1–32.5°C. DO ranged from 3.7–5.7 ppm. pH ranged from 8.51–9.02. salinity ranged from 32.5–33.7 ppt. and brightness ranged from 25.5–29.6 cm. The results of DO and pH measurements at station 3 (furthest from the sea) were less than optimal for milkfish growth. This is thought to be due to the high abundance of plankton. Further research needs to be done on the effect of plankton abundance on milkfish growth.

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Author Contributions

I.L.A. contributed as a researcher and article writer; H.K. contributed as a supervisor of research ideas and article writing; A.P.W.M. contributed as a supervisor in research data processing. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

In writing this article, we sincerely declare that there is no conflict of interest that may affect the objectivity and integrity of the results.

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