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Plankton Community Structure as a Bioindicator of Sustainable Water Quality in Koi (*Cyprinus carpio*) Ponds

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ABSTRACT

Koi (*Cyprinus carpio* L.) are a highly popular aquaculture commodity in Indonesia, particularly in Blitar District, where they are primarily cultivated using a semi-intensive system supported by natural plankton. This study aimed to identify the plankton community and to quantify its abundance as a bioindicator of water quality in Koi ponds. The research was conducted in March 2024, with a total of 20 water samples collected from 10 sampling stations—comprising both rearing and grow-out ponds—during the morning and afternoon. Several water quality parameters were measured both *in situ* and *ex situ*, including dissolved oxygen (DO), pH, and nitrite levels. The data were analyzed using canonical correspondence analysis (CCA). Results showed that the plankton community was dominated by the Chlorophyceae class, accounting for 48% of the total. Phytoplankton abundance reached 35,724 cells/L, significantly higher than the zooplankton abundance, which was 368 individuals/L. A total of 31 phytoplankton species and 9 zooplankton species were identified. The biological index indicated a medium to high diversity, with high evenness and low dominance. CCA analysis revealed a correlation between plankton abundance and various water quality parameters. Based on these findings, enhancing the presence of *Chlorella* and *Nitzschia* could support the natural diet of Koi and potentially enhance their body coloration.

INTRODUCTION

Ornamental fish commodities are known as one of the major contributors to the foreign exchange of Indonesia and it is placed as one of the largest exporter globally particularly freshwater commodities **(Satyani & Subamia, 2009)**. Among 750 freshwater ornamental fish species, Koi (*Cyprinus carpio* L.) are known as one of them **(Yanuhar *et al.*, 2019; Andriyono & Fitrani, 2021)**. Koi are very popular among other ornamental fish because of its color and body shape **(Tarihoran *et al*., 2023)**. This fish is also believed to be a bearer of good luck for some people **(Iskandar *et al*., 2021)**. Blitar district in the East Java is one of the most well-known areas of the Koi production, and it becomes the Koi cultivation center **(Rusda *et al*., 2023)**. Koi are widely cultivated in the Blitar area which is geographically suitable for developing Koi farming and is known to have good quality within country **(Kilawati *et al*., 2021)**. According to the **Central Statistics Agency of Blitar (2025)**, Koi production reached almost 203 million individual fish in 2023. They have various patterns and diverse body colors, such as red, white, black, and yellow. Genetic, nutritional, and environmental factors influence the color of Koi. Several ways have been tried to improve its color quality, such as the addition of roselle flower (*Hibiscus sabdariffa*) **(Amin *et al*., 2023)**. Another way could be done through an optimization of the natural feed such as plankton (*Daphnia* sp.) **(Laksono *et al.*, 2021)**.

The Koi farming in Blitar uses a semi-intensive cultivation system with a sediment substrate, in which this kind of pond is mainly supported by microorganisms such as plankton **(Patahiruddin *et al*., 2023)**. Plankton plays an important role as a natural food source for fish, both in nature and ponds, also it can be a bioindicator of water quality **(Khasanah *et al*., 2022)**. Koi farming is very susceptible to the changes of the water quality environment, so it has a range of tolerance to several parameters, such as temperature, pH, dissolved oxygen (DO), brightness, ammonia, nitrite, nitrate, and phosphate **(Ding *et al*., 2021)**. Water quality could determine the level of fertility through an observation of the abundance and diversity of phytoplankton and zooplankton **(Manickavasagam *et al.*, 2019)**. The presence of phytoplankton is very important for the survival of zooplankton and cultured fish. Zooplankton are animal plankton that feed on phytoplankton and as a food source for fish in their food chain **(Mondal & Samanta, 2022)**.

Plankton contain secondary metabolites that can affect the brightness of the fish's body color. **Rosada and Sunardi (2021)** explained that several phytoplankton contain chlorophyll *a* and *b*, and have additional pigments in the form of carotene and xanthophyll. Carotenoids have a role in ornamental fish coloring **(Kargın & Dikbaş, 2020)**. These pigments can affect the yellow and orange color pigments in the fish body. On the other hand, some plankton species might have a negative impact on the pond, such as Microcystis **(Yanuhar *et al*., 2019)**, particularly when it blooms.

Thus, observation of plankton in Koi ponds is necessary to be done in order to manage the water quality as well as maintain the natural feed for Koi growth and skin color. The diversity and numbers of plankton cells reflect the health of the aquatic ecosystem as well as being crucial for the growth of the cultured fish **(Tulsankar *et al*., 2021)**. Therefore, in this study, phytoplankton and zooplankton observations were carried out in Koi ponds at Blitar District to determine the important plankton species for Koi and to monitor the water quality in the closed system of rearing and enlargement stages.

MATERIALS AND METHODS

The research was conducted in March 2024 at Sumberingin, Blitar District (8°03'33"S 112°09'07"E). Ten stations with duplicate points consisting of five rearing ponds (TI.A ~ TV.A) and five enlargement ponds (TI.B ~ TV.B) were selected based on the availability of Koi culture (Table 1). Sampling was done twice for each station, in the morning and afternoon. Details of the sampling locations can be seen in Fig. (1).

Table 1. Description of each station in this study

Station	Ponds	Pond area (m^2)	Koi density (fish/m^2)
TI.A	Rearing	938.8	60
TII.A		745.3	50
TIII.A		846.6	50
TIV.A		473.5	60
TV.A		490.4	60
TI.B	Enlargement	580.4	4
TII.B		221.9	2
TIII.B		431.4	3
TIV.B		369.0	3
TV.B		841.8	4

The filtered water was collected in a 250ml bottle and fixed with 4% formaldehyde for enlargement pond samples and 70% alcohol for rearing pond samples, as much as five drops and brought back to the laboratory for observation. Identification and enumeration of the density was done under the digital binocular light microscope (OPTIKA, B-190TBPL, Italy) equipped with camera (OPTIKA Proview Digital Camera).

Sampling was carried out by filtering 100L of water through a 20μm plankton net. Identification was done following several publications **(Shirota, 1966; Greeson, 1982; Botes, 2003; Van Vuuren, 2006; Suthers & Rissik, 2009; Sulastri, 2018; Thakar *et al.*, 2018)**. Confirmation of the nomenclature, locality, habitat was done through the Algae Base website **(Guiry & Guiry, 2025)**. Calculation of the number of plankton cells and individuals was conducted following the outlines of **APHA (2005)**.

Physical and chemical parameters were measured *in-situ*, such as dissolved oxygen (DO) (YSI, Pro 20, United States), pH (Hanna Instrument, HI 98107, Romania), water temperature (GEA, S-006, Indonesia), and water brightness (Secchi disc). Ammonia, nitrite, nitrate, and phosphate were measured *ex-situ* (Technical Implementation Unit of Fish and Environmental Health Laboratory, Pasuruan) by using the portable spectrophotometer (HACH, DR 1900, India) and portable colorimeter (HACH, DR/890, India) following the method of Indonesian National Standard SNI 06-6989.30-2005 (BSN, 2005) and SNI 06-2484-2002 (BSN, 2002).

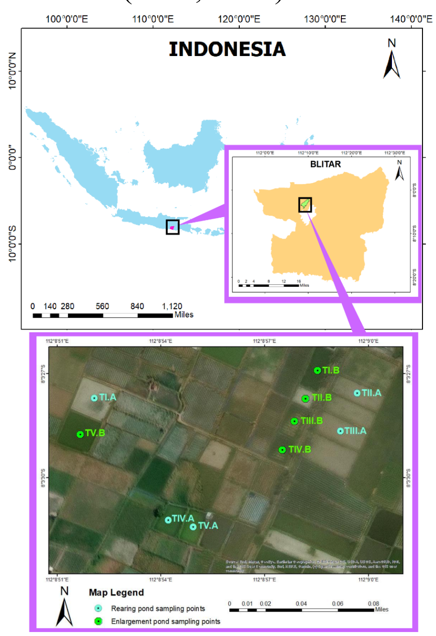

Fig. 1. Sampling site of this study located in Blitar District, Indonesia. TI.A to TV.A represents the rearing pond, and TI.B to TV.B represents the enlargement pond

The diversity (H'), evenness (E), and dominance index (C) were calculated after obtaining the plankton abundance value to determine the biological index value of plankton in the water. The relationship between the value of plankton abundance and the value of water quality parameters was analyzed by multivariate method using canonical correspondence analysis (CCA) with PAST Statistical Software.

RESULTS

1. Plankton composition

The general composition of the plankton community is shown in Fig. (2). Based on the results in the rearing pond (Fig. 2A), 34 genera belonging to 6 classes of plankton were obtained (4 phytoplankton and 2 zooplankton classes). Chlorophyceae was the highest composition compared to other classes at 47.83%, followed by Bacillariophyceae

(30.71%), Cyanophyceae (12.41%), Euglenophyceae (8.70%), and zooplankton namely Monogononta (0.32%) and Crustaceae 0.03%.

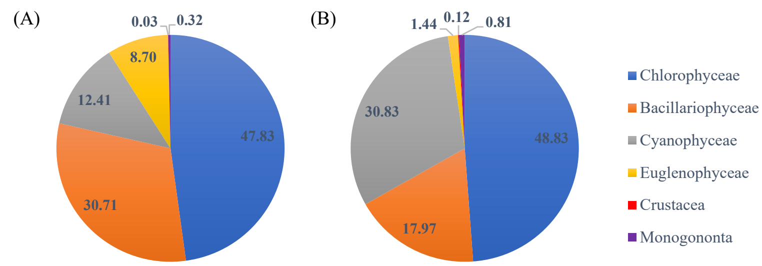

Fig. 2. Percentage of the plankton classes during the observation **(A)** Rearing ponds and **(B)** Enlargement ponds

In the enlargement pond (Fig. 2B), 26 genera of plankton were identified with the most dominant classes are Chlorophyceae (48.83%), Cyanophyceae (30.83%), Bacillariophyceae (17.97%), Euglenophyceae at 1.44%, Crustaceae (0.12%), and Monogononta (0.81%), resapectively. The plankton photographs are shown in Fig. (3).

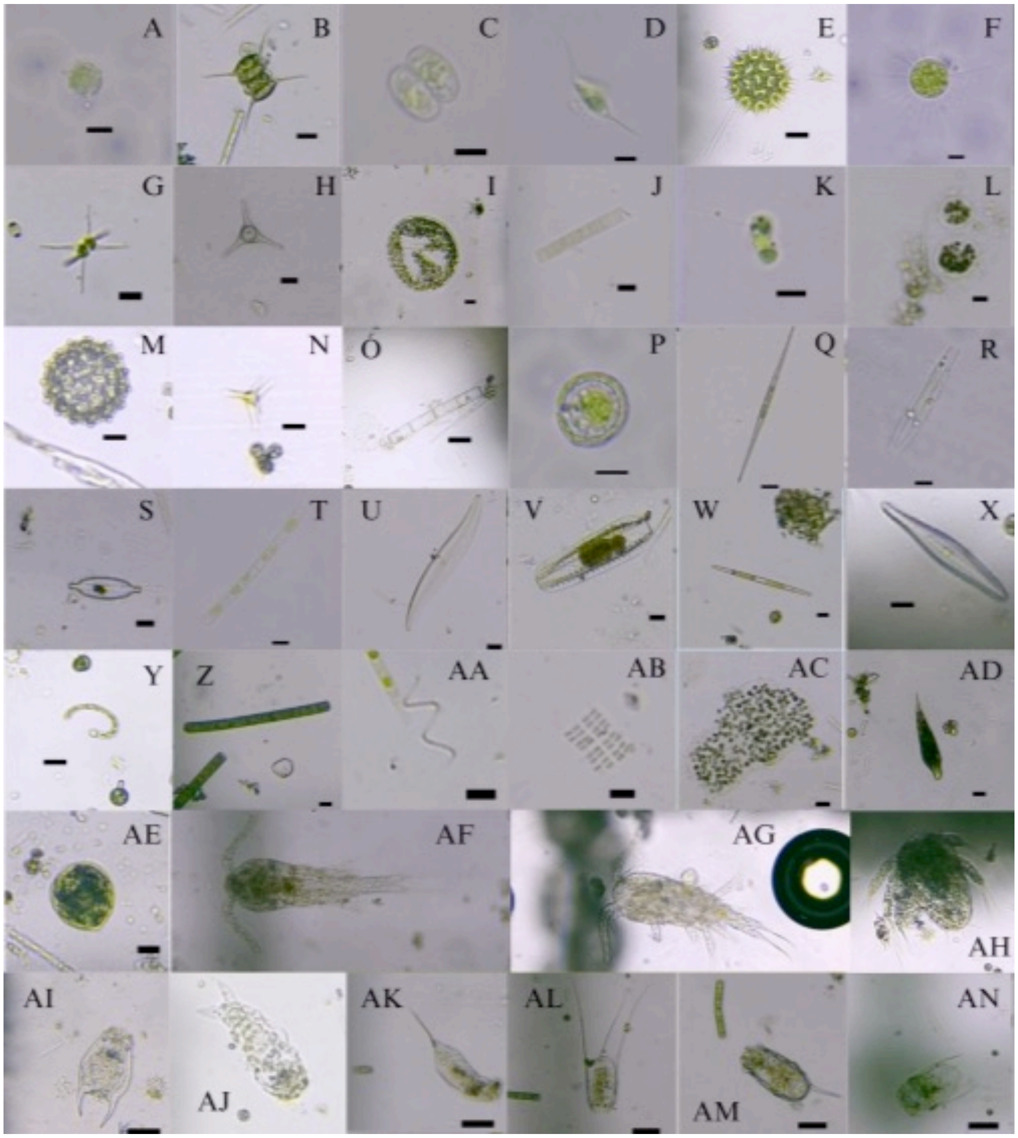

Fig. 3. Observed plankton in this study (A) *Chlorella,* (B) *Scenedesmus,* (C) *Didymocytis,* (D) *Schroederia,* (E) *Pediastrum,* (F) *Golenkinia,* (G) *Staurastrum,* (H) *Pachycladella,* (I) *Pleodorina,* (J) *Spirogyra,* (K) *Westella,* (L) *Eudorina,* (M) *Coelastrum,* (N) *Tetraedron,* (O) *Oedogonium,* (P) *Cyclotella,* (Q) *Nitzschia,* (R) *Navicula,* (S) *Frustulia,* (T) *Aulacoseira,* (U) *Gyrosigma,* (V) *Surirella,* (W) *Synedra,* (X) *Gomphonema,* (Y) *Anabaena,* (Z) *Oscillatoria,* (AA) *Spirulina,* (AB) *Merismopedia,* (AC) *Microcystis,* (AD) *Euglena,* (AE) *Trachelomonas,* (AF) *Diacyclops,* (AG) *Cyclops,* (AH) *Nauplii copepod,* (AI) *Brachionus,* (AJ) *Cephalodella,* (AK) *Trichocerca,* (AL) *Filinia,* (AM) *Keratella,* (AN) *Polyarthra*

2. Plankton abundance

Phytoplankton abundance in the morning and afternoon (Fig. 4A) ranged from 21,354 – 30,066 cells/L in the morning and 26,694 – 35,724 cells/L in the afternoon. In contrast, zooplankton (Fig. 4B) in the morning was 81 - 235 ind/L and in the afternoon 84 - 368 ind/L. Table (2) shows the range of abundance values of each genus found in this study.

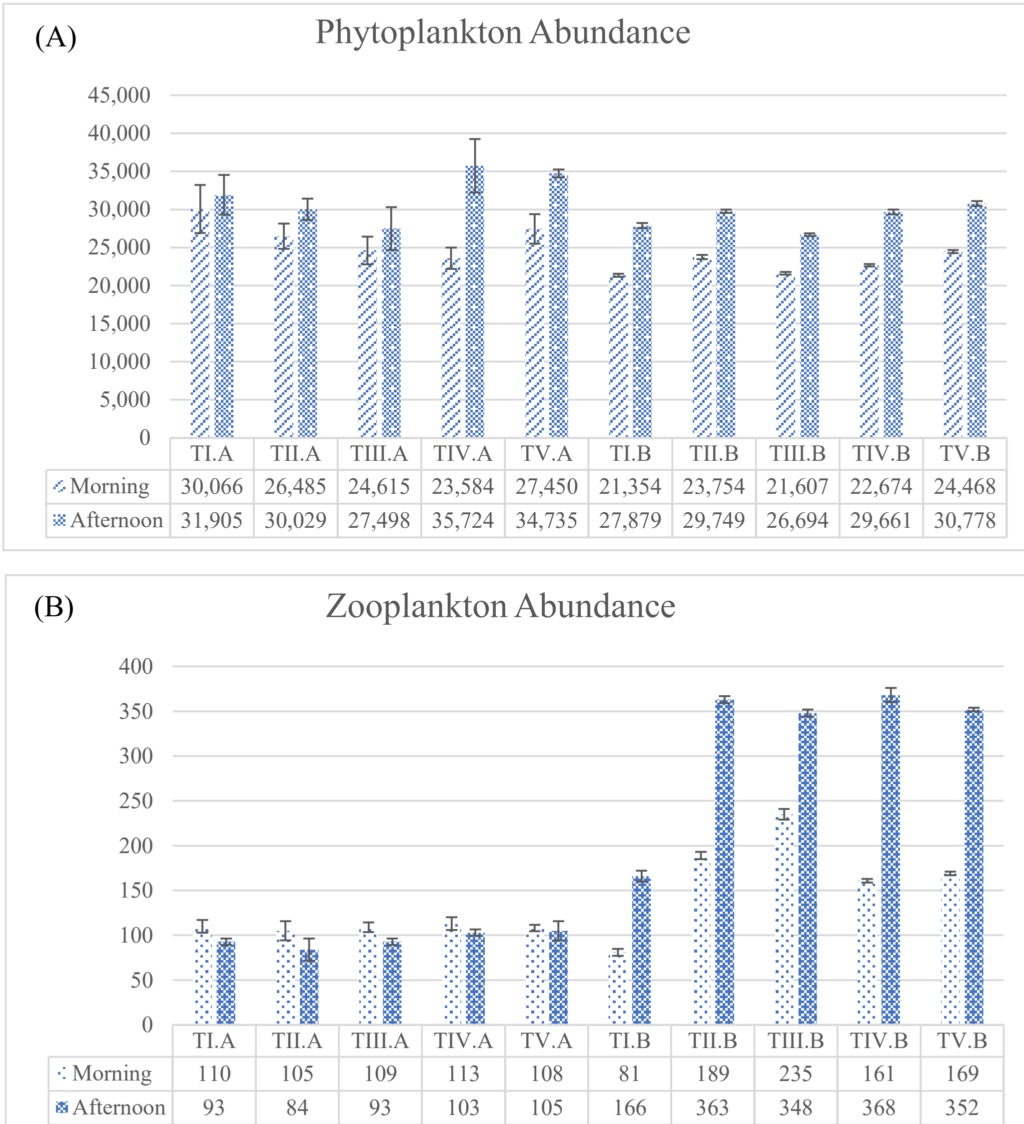

Fig. 4. Plankton abundance both in rearing (TI.A-TV.A) and enlargement (TI.B-TV.B) ponds during study in the morning and afternoon

Table 2. The distribution and abundance of plankton during the observation

	TI.A	TII.A	TIII.A	TIV.A	TV.A	TI.B	TII.B	TIII.B	TIV.B	TV.B
Chlorophyceae										
Chlorella*	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Scenedesmus	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Didymocystis	++++	++++	++++	+++	+++	-	-	-	-	-
Schroederia	++++	++	-	+++	-	-	-	-	-	-
Pediastrum	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Golenkinia	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Staurastrum	++++	+++	++++	+++	+++	+++	+++	++++	+++	+++
Pachycladella	-	++	-	++	-	-	-	-	-	-
Pleodorina	++	+	+	+	+	-	-	-	-	-
Spirogyra	-	++	++	-	-	-	-	-	-	-
Westella	+++	++++	++++	++++	+++	-	-	-	-	-
Eudorina	++++	++++	++++	++++	++++	-	-	-	-	-
Coelastrum	-	-	-	-	-	+++	+++	+++	+++	+++
Tetraedron	-	-	-	-	-	+++	+++	+++	+++	+++
Oedogonium	-	-	-	-	-	+	+	+	+	+
Bacillariophyceae										
Cyclotella	++++	++++	++++	++++	++++	-	-	-	-	-
Nitzschia*	++++	++++	++++	++++	++++	++++	+++	++++	++++	++++
Navicula	++++	++	++++	++++	++++	++	++	+++	++	++
Frustulia	++++	-	-	-	++++	-	-	-	-	-
Aulacoseira	++++	++++	++++	++++	++++	++	++	++	+++	+++
Gyrosigma	-	-	++	++	-	-	-	-	-	-
Surirella	+++	+++	+++	++	+++	++	++	++	++	++
Synedra*	++++	++++	-	++++	++++	++++	++++	++++	++++	++++
Gomphonema	-	-	-	-	-	+	+	+	++	++
Cyanophyceae										
Anabaena	++++	-	-	-	++++	++++	++++	++++	++++	++++
Oscillatoria*	++++	++++	+++	-	+++	+++	+++	+++	++++	++++
Spirulina*	-	+++	++++	-	++++	++++	++++	++++	++++	++++
Merismopedia	-	++	-	+++	++	-	-	-	-	-
Microcystis	+++	+++	-	++++	++++	++++	++++	++++	++++	++++
Euglenophyceae										
Euglena*	-	++++	++++	-	+++	++	++	++	++	++
Trachelomonas*	+++	++++	++++	++++	++++	-	-	-	-	-
Crustaceae										
Diacyclops	+	+	-	+	-	-	-	-	-	-
cyclops	-	-	-	-	-	+	+	+	+	+
Naupli copepoda	-	-	-	-	-	+	+	+	+	+
Monogononta										
Brachionus*	+	+	+	+	+	+	+	+	+	+
Cephalodella	+	+	+	+	+	+	+	+	+	+
Trichocerca	+	+	+	+	+	+	+	+	+	+
Filinia	-	+	-	+	+	+	+	+	+	+
Keratella	-	+	+	+	+	+	+	+	+	+
Polyarthra	-	+	+	-	+	-	-	-	-	-

Notes: (-): 0 Ind/L, (+): 1-99 Ind/L, (++): 100-499, (+++): 500-999, (++++): 1000-4999, (*): dominant genus with high abundance

3. Plankton biological index

The average value of the rearing ponds (T.A) and enlargement ponds (T.B) diversity index of both phytoplankton and zooplankton included in the category of moderate diversity or the diversity was not found overwhelming, because the value is within 1≤ H'≤3 (Table 3). The evenness index of phytoplankton and zooplankton (Table 3) included in the high category, because the value is within 0,6 ≥ E, which means that the level of evenness or distribution of individual plankton throughout the pond is high or extensive. The average dominance index both of phytoplankton and zooplankton included the low category since the value is 0 ≤ C or there is no dominant genus in the plankton community.

Table 3. The biological index of the Koi ponds based on the plankton communities

Station	Diversity (H')		Evenness (E)		Dominance (C)	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Phytoplankton						
T.A	2.75±0.07	2.91±0.02	0.97±0.01	0.97±0.02	0.07±0.01	0.06±0.01
T.B	2.63±0.09	2.67±0.04	0.89±0.03	0.90±0.01	0.09±0.02	0.14±0.01
Zooplankton						
T.A	1.49±0.15	1.46±0.17	0.94±0.06	0.97±0.01	0.24±0.03	0.25±0.04
T.B	1.66±0.10	1.70±0.06	0.85±0.05	0.87±0.03	0.21±0.02	0.20±0.01

4. Statistical analysis

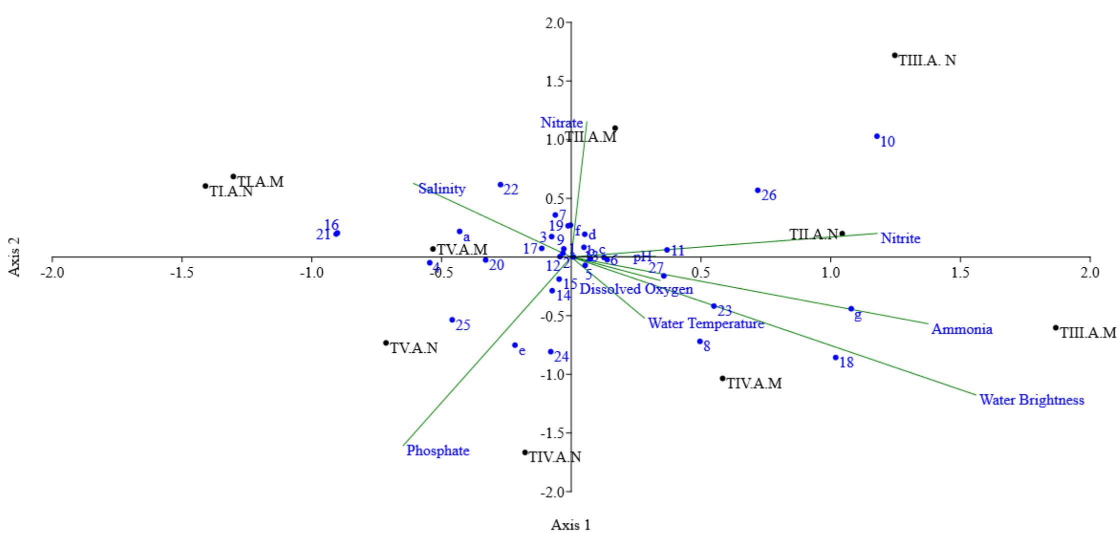

Fig. 5. Tri-plot representing the two axes of CCA of the environmental variables and the planktons along different stations in the rearing Koi ponds Koi (1) *Chlorella*, (2)

Scenedesmus, (3) *Didymocystis*, (4) *Schroederia*, (5) *Pediastrum*, (6) *Golenkinia*, (7) *Staurastrum*, (8) *Pachycladella*, (9) *Pleodorina,* (10) *Spirogyra,* (11) *Westella,* (12) *Eudorina,* (13) *Cyclotella,* (14) *Nitzschia,* (15) *Navicula,* (16) *Frustulia,* (17) *Aulacoseira,* (18) *Gyrosigma,* (19) *Surirella,* (20) *Synedra,* (21) *Anabaena,* (22) *Oscillatoria,* (23) *Spirulina,* (24) *Merismopedia,* (25) *Microcystis,* (26) *Euglena,* (27) *Trachelomonas,* (a) *Diacyclops,* (b) *Brachionus,* (c) *Cephalodella,* (d) *Trichocerca,* (e) *Filinia,* (f) *Keratella*, (g) *Polyarthra*

The results of statistical analysis of plankton in the morning and afternoon in Blitar Koi rearing ponds in Fig. (5) show the relationship of several plankton genera with water quality parameters. *Didymocystis, Staurastrum, Pleodorina, Aulacoseira, Anabaena, Oscillatoria*, and *Diacyclops* are known to have a high correlation with salinity. *Chlorella, Spirogyra, Westella, Cyclotella, Surirella, Euglena, Trichocerca*, and *Keratella* are highly associated with nitrate, nitrite, and pH. *Pediastrum, Golenkinia, Pachycladella, Gyrosigma, Spirulina, Trachelomonas, Brachionus, Cephalodella,* and *Polyarthra* are highly associated with pH, ammonia, brightness, and temperature. *Schroederia, Eudorina, Nitzschia, Navicula, Synedra, Merismopedia, Microcystis,* and *Filinia* were highly associated with phosphate.

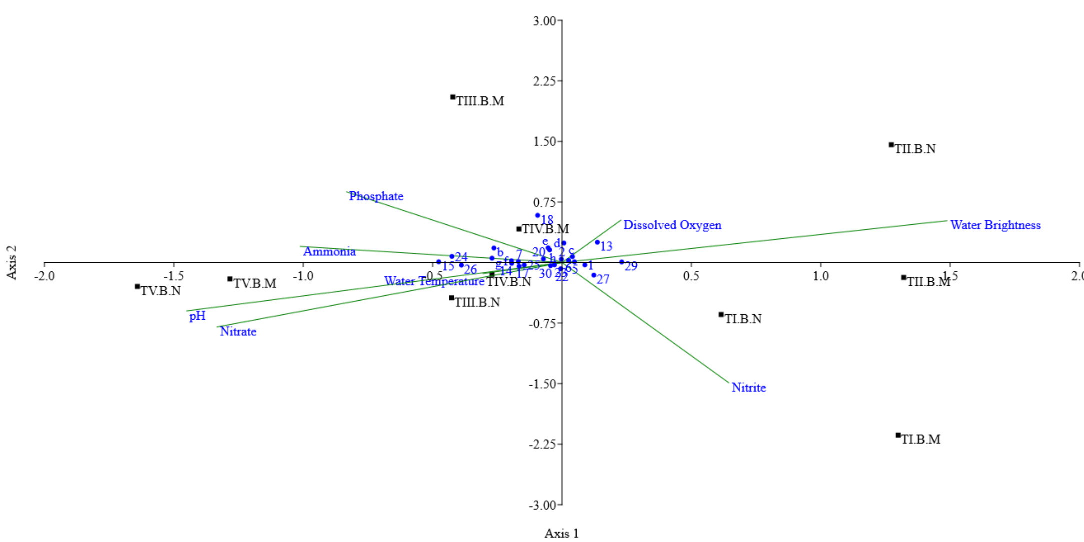

Fig. 6. Tri-plot representing the two axes of CCA of the environmental variables and the planktons along different stations in the enlargement Koi ponds (1) *Chlorella,* (2) *Scenedesmus,* (5) *Pediastrum,* (6) *Golenkinia,* (7) *Staurastrum,* (13) *Coelastrum,* (14) *Tetraedron,* (15) *Oedogonium,* (17) *Nitzschia,* (18) *Navicula,* (20) *Aulacoseira,* (22) *Surirella,* (23) *Synedra,* (24) *Gomphonema,* (25) *Anabaena,* (26) *Oscillatoria,* (27) *Spirulina,* (29) *Microcystis,* (30) *Euglena,* (b) *Cyclops,* (c) *Nauplii copepod,* (d) *Brachionus,* (e) *Cephalodella,* (f) *Trichocerca,* (g) *Filinia,* (h) *Keratella*

The results of the analysis in Fig. (6) show a positive correlation between plankton and the measured water quality parameters. *Scenedesmus*, *Navicula*, *Brachionus*, *Keratella*, and *Cephalodella* were positively correlated or influenced by DO and phosphate. Ammonia and pH affected the abundance of *Tetraedron*, *Staurastrum*, and *Oscillatoria* species. The abundance of *Chlorella*, *Microcystis*, and *Spirulina* was influenced by nitrite and water brightness. The water brightness affected the abundance of *Pediastrum* species while *Coelastrum*, and *Nauplii copepod* were positively correlated with the DO parameter. *Golenkinia* species abundance was influenced by DO and water brightness. *Surirella*, and *Euglena* abundance were influenced by nitrite and nitrate. Ammonia affected the abundance of *Oedogonium*, *Gomphonema*, *Trichocerca*, and *Filinia* species. The total abundance of *Anabaena* species was influenced by pH, while *Synedra* species were influenced by the nitrate. The water pH parameter also affects the abundance of *Nitzschia* species. The abundance of *Aulacoseira* and *Cyclops* species is influenced by the phosphate.

DISCUSSION

The overall plankton abundance observed in this study was relatively high compared to the findings of **Hossen *et al.* (2022)**, who reported phytoplankton abundance at 5,983 ± 273 cells/L and zooplankton abundance at 1,681 ± 41 individuals/L in polyculture system ponds without fertilizer application. Phytoplankton abundance in this study was higher than zooplankton due to their different growth phases. **Adharini and Probosunu (2021)** reported that phytoplankton can reproduce relatively quickly and can adjust to changes in water physics and chemistry compared to zooplankton. In the rearing pond, the abundance of phytoplankton in the morning was found to be less than in the afternoon and inversely proportional to the abundance of zooplankton. Based on **Sthepani *et al*. (2014)**, phytoplankton have positive phototaxis properties, while zooplankton have negative properties. According to **Rusdiyani and Purnomo (2021)** negative phototaxis properties in zooplankton can cause daily vertical migration, hence there are fewer zooplankton during the day than in the morning. Therefore, phytoplankton as primary producers are more abundant than zooplankton.

Sellami *et al*. (2011) explained that the increase in zooplankton abundance is influenced by several factors, such as primary production, which comes from phytoplankton. Thus, an increment of phytoplankton abundance in the enlargement pond is always followed by an increment of zooplankton, as happened in this study. Based on water quality measurements, the Koi pond, particularly in the enlargement pond, had high levels of nitrate, nitrite, phosphate, and low ammonia levels. **Surya *et al*. (2024)** reported that high phosphate concentrations were utilized by algae as nutrients for growth, resulting in an increase in algal abundance.

The phytoplankton classes found in this study was consisted of Chlorophyceae, Cyanophyceae, Bacillariophyceae, and Euglenophyceae. **Hammadi *et al.* (2024)** reported phytoplankton classes in the common carp ponds with similar composition, i.e. Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae. Chlorophyceae is the most common type of phytoplankton in freshwaters, and it is known to determine a good condition of the pond **(Diatin *et al.*, 2018)**. Zooplankton found in this study include the Monogononta and Copepod classes. **Kishor *et al.* (2023)** reported that zooplankton found in common carp ponds include Copepod, Rotifer, Cladocera, Protozoa, and Ostracod. Based on **Adadu *et al.* (2019)**, Copepod, Monogononta, and Branchiopoda, are the most common zooplankton found in freshwaters with *Brachionus* as the common genus.

Among Chlorophyceae, *Chlorella* was known as the most abundant genus both in the rearing and enlargement pond with an average value of 2,206±516 cells/L and 2,364±286 cells/L, respectively. *Chlorella* is a cosmopolitan plankton that can easily multiply in various seasons **(Soeprapto *et al.*, 2023)**. Based on the CCA results (Fig. 5), it is known that *Chlorella* in the rearing pond has a high correlation to nitrate, nitrite, and pH. This is consistent with the findings of **Maulidhya *et al.* (2024)**, which showed that nitrate levels and pH have a strong influence on the abundance of *Chlorella*.

Similar result was found in the enlargement pond (Fig. 6), at where the abundance of *Chlorella* was mainly influenced by nitrite. Based on **Liang *et al.* (2015)**, *Chlorella* absorbs nitrite as a source of nitrogen for the photosynthesis process.

Spirulina, as the most dominant Cyanophyceae, was found in the enlargement pond (2,933±620 cells/L), while in the rearing ponds *Oscillatoria* was found to be dominant (1,118±617 cells/L). Based on the CCA data (Fig. 6), the abundance of *Spirulina* was influenced by the nitrite parameter. The increase in *Spirulina* abundance can be caused by their ability to absorb nutrients such as ammonia, nitrate, and phosphate as a food source **(Damanik *et al.*, 2022)**. *Oscillatoria* has a relationship with salinity (Fig. 5), which is known to be correlated with the nitrification process in freshwater. High salinity level may inhibit the growth of nitrifying bacteria **(Pariakan & Rahim, 2021)**.

Among the Bacillariophyceae, *Synedra* and *Nitzschia* were respectively dominant in the enlargement (2,033±171 cells/L) and rearing pond (1,943±1,007 cells/L). Positive correlation was found between the abundance value of *Synedra* and the nitrate parameter (Fig. 6). The results of the CCA analysis of *Nitzschia* have a high correlation with phosphate (Fig. 5). **Rahmah *et al.* (2022)** stated that *Nitzschia* has a positive correlation with phosphate and temperature. **Abdullah *et al.* (2017)** reported the common existence of *Nitzschia* in waters with high fertility levels that are rich in nutrients. **Aritonang *et al.* (2022)** explained that the nitrate parameter shows a strong correlation to diatom abundance, which explains why the two genera have the same correlation with nitrate.

Among the Euglenophyceae, *Euglena* was found dominantly in the enlargement pond (376±81 cells/L), while in the rearing pond, *Trachelomonas* was found in a high number of cells (1,747±743 cells/L). Based on the analysis of the enlargement pond CCA data (Fig. 6), the abundance of *Euglena* was influenced by nitrite and nitrate parameters. **Emalya *et al.* (2023)** described the high abundance of *Euglena* sp. along with the absorption of nitrate and nitrite of 74.58 and 73.52%, respectively. The results of the study are in accordance with the value of *Euglena* abundance influenced by nitrite and nitrate parameters in the waters. Based on the results of the CCA analysis (Fig. 5), *Trachelomonas* has a high correlation with DO, ammonia, brightness, and temperature. During the rainy season, the environmental temperature decreases which causes bacterial activity and the nitrification process to run slowly, so that ammonia in the environment can increase. Conversely, if the temperature increases in summer, it can cause bacterial activity and the nitrification process can increase, so ammonia decreases **(Wahyuningsih & Gitarama, 2020)**.

The highest abundance of zooplankton both in the rearing pond and the enlargement pond is that of *Brachionus* (26±9 and 57±26 ind/L, respectively). Based on the results of the CCA analysis of the enlargement pond (Fig. 6), it is known that the abundance value is influenced by DO and phosphate. **Adadu *et al.* (2019)** found that the abundance of zooplankton species such as *Brachionus falcatus* and *Brachionus angularis* has a positive correlation with DO, BOD, CO_2 and pH. Optimal DO parameters can impact the growth and metabolism of organisms in the water **(Chilmawati *et al.*, 2020)**. *Brachionus* in rearing ponds correlates with DO, ammonia, brightness, and temperature (Fig. 5). Temperature is correlated with the brightness, if the brightness increases, the temperature might increase due to penetration of sunlight that facilitates the phytoplankton photosynthesis process **(Ariadi *et al.*, 2023)**.

Biological indexes in Table (3) show a moderate diversity (H') phytoplankton both in rearing (mean value 2.80±0.09) and enlargement ponds (mean value 2.65±0.07), while the zooplankton diversity was lower in both rearing (mean value 1.49±0.16) and enlargement ponds (mean value 1.68±0.08). In concomitant with this, study of **Othman *et al.* (2024)** reported similar trend with a moderate diversity of phytoplankton. On the other hand, **Deka *et al.* (2022)** reported low value of diversity index (H') for the zooplankton. This diversity index can also determine the level of pollution status in the waters. **Balloch *et al.* (1976)** found that diversity index can be an indicator of water quality. The scale of the pollution status based on the diversity value as greater than 4 for unpolluted water condition, 1-3 as moderate polluted water condition, and less than 1 for highly polluted water conditions **(Wilhm & Dorris, 1966)**. The evenness index (E) of phytoplankton both rearing and enlargement ponds consecutively shows an average of morning and afternoon time 0.97±0.02 and 0.90±0.02, while the zooplankton in both ponds shown mean value 0.96±0.04 and 0.86±0.04, respectively. This value (E) categorized as high uniformity because indicating the stability distribution of plankton community (>0.6) **(Cahyonugroho *et al.*, 2022)**. Dominance index (C) of the phytoplankton in rearing and enlargement ponds was counted as low as the average value 0.07±0.01 and 0.12±0.02, respectively. The zooplankton in both rearing and enlargement ponds categorized same as the phytoplankton with average values of 0.25±0.04 and 0.21±0.02, respectively. According to **Samadan *et al.* (2020)** the dominance index value close to the value of 0 indicates the absence of plankton genus that dominates the pond water area. This reflects that the plankton community structure is relatively diverse.

Based on this study, the abundance of plankton in the Koi pond at Blitar, Indonesia is classified as relatively high with fluctuating number of zooplankton, which is mainly caused by unstable climatic variables such as humidity, rainfall, solar intensity, and air temperature **(Siddique *et al.*, 2024)**. Therefore, maintenance of water quality through the stabilization of plankton community in the fish pond is strongly recommended to improve the availability of natural feed as well as triggering the brightness of fish skin color. According to **Panjaitan (2023)**, ornamental fish particularly Koi, need plankton as their natural feed for increasing the color intensity due to the pigment carotenoids that can give red and yellow colors. This study recommends several plankton that are beneficial for Koi ponds, namely Chlorophyceae and Bacillariophyceae. **Pantami *et al.* (2020)** found that *Chlorella* sp. (Chlorophyceae) contains violaxanthin, astaxanthin, neoxanthin, lutein, and β-carotene with some amounts of fatty acids, especially omega fatty acids, which constitute over 60% of total fatty acids, so it can help the fish grow and potentially increases the skin color. Based on **Won *et al.* (2023)**, *Nitzchia palea* (Bacillariophyceae) have the Fucoxanthin pigment, a brown pigment that belongs to xanthophyll category of carotenoids. From this study, it can be concluded that *Nitzschia* may help increase the brightness of the Koi body color. **Atici (2022)** informed that phytoplankton from Bacillariophyceae class contains chlorophyll-*a* and β-carotene. However, there is one genus in this study that may become a bad indicator of water quality in fish ponds, one of which is *Oscillatoria* sp. Based on **Soetignya *et al.* (2021)**, the dominance of *Oscillatoria* could reflect polluted waters.

CONCLUSION

The value of overall phytoplankton abundance in this study was extremely high compared to the abundance of zooplankton, both in the morning and afternoon. Plankton abundance in this study is known to be enough to support the growth of fish in the cultured pond. Several classes of phytoplankton (Chlorophyceae, Cyanophyceae, Bacillariophyceae, and Euglenophyceae) were found in the rearing and enlargement ponds, while the zooplankton found were Monogononta and Copepoda. The dominant genus that occurred in this study varied depending on the classes. Among those genera, *Chlorella* (Chlorophyceae) and *Nitzschia* (Bacillariophyceae) should be triggered in the

Koi pond to support the enhancement of skin color. However, there is a threat from *Oscillatoria* (Cyanophyceae) which is abundantly found in the pond, thus, maintaining the community of plankton is necessary in terms of water quality management of Koi ponds.

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