International Journal of Multidisciplinary Research and Growth Evaluation

International Journal of Multidisciplinary Research and Growth Evaluation
ISSN: 2582-7138
Received: 25-07-2021; Accepted: 10-08-2021
www.allmultidisciplinaryjournal.com
Volume 2; Issue 5; September-October 2021; Page No. 01-07

Phytoplankton diversity as natural feed of betutu fish larvae in Riam Kanan reservoir, South Kalimantan, Indonesia

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Abstract

The Riam Kanan reservoir is a freshwater reservoir that the public has long used, one of which is for fish farming. The aim of this study was to determine the presence and abundance of phytoplankton as natural feed for betutu larvae fish and an indicator of the environmental productivity of the Riam Kanan reservoir. The research was carried out in the Riam Kanan reservoir for 5 months (July-November 2020). Sampling was carried out at five different stations. Each sampling was taken about 20 liters of reservoir water. Furthermore, chemical measurements of reservoir water include dissolved oxygen (DO), carbon dioxide (CO_2), pH, NH_3, and physical measurements include temperature, brightness, and turbidity. Reservoir water also measured the abundance, diversity, evenness, and dominance of phytoplankton. The results showed that the average water quality values of the Riam Kanan reservoir during July-November 2020 were a value of 28.7ºC for temperature, the brightness of 1.8m, turbidity of 9.1 NTU, DO of 4.5 mg/L, CO_2 of 10.9 mg/L, pH of 8.2, and NH_3 of 0.3 mg/L. The phytoplankton found were phylum Chlorophyta (48%), Cynophyta (31%), Bacillariophyta (18%), and Euglenophyta (3%). The existence of phytoplankton was also very varied; in July, only 3 phyla existed, but from August to November, 4 phyla existed. Measurement of the diversity index showed that the phytoplankton in the Riam Kanan reservoir was in the medium category with high evenness and no species dominance. These findings indicate that the Riam Kanan reservoir is still provides a natural feed source for betutu fish larvae.

Keywords: Diversity, Dominance, Evenness, Fisheries

Introduction

One of the endemic fish found in the waters of the Riam Kanan reservoir, South Kalimantan, is the betutu fish (*Oxyeleotris marmorata* Bleeker). The population of betutu fish, both naturally living and farming in the Riam Kanan reservoir, has significantly decreased, caused by the very high mortality rate of betutu fish larvae [1]. One of the factors causing the mortality rate of cultured betutu fish larvae, namely the natural feed, is unknown. Phytoplankton is a natural feed for betutu fish larvae [2]. The quality of a water area is determined by the availability of natural feed such as phytoplankton. Phytoplankton is microscopic plant that can convert inorganic substances into organic substances through the process of photosynthesis and maintain the balance of an aquatic ecosystem [3, 4, 5]. These organisms can determine the fertility of marine waters, lakes, rivers, and reservoirs. Most of the aquatic ecosystems are filled with phytoplankton as primary producers of natural feed [6].

Riam Kanan reservoir is located in South Kalimantan and has long been used as a place for fish farming. Riam Kanan Reservoir is classified as a multifunctional reservoir because it is used for rice field irrigation, drinking-water sources, tourism activities, and fishing activities such as floating net cages (FNC) [7]. FNC activities dominate more than other activities. The number of fish farming activities causes the water quality degradation of this reservoir water because it contributes quite a lot of organic matter through the feed residue [8].

The increasing burden of using the Right Kanan reservoir, especially organic waste, will affect the quality and carrying capacity of the waters [7]. Indications of water quality degradation can be determined by the presence and abundance of phytoplankton. Phytoplankton can function as a natual feed for betutu fish larvae [9], monitoring tool [10] and an indicator of environmental conditions and changes [11]. Therefore, this study aims to determine the physicochemical quality of the waters and the presence and abundance of phytoplankton as natural feed for betutu fish larvae and an indicator of the productivity of the aquatic environment in the Riam Kanan reservoir.

Materials and Methods

Location

The research is located in Riam Kanan Reservoir, Tiwingan Lama, Banjar, South Kalimantan, Indonesia. The research location can be seen in Fig 1.

Sampling

Sampling was carried out at 5 different stations around the Riam Kanan reservoir in July-November 2020 (Fig 1). Each station was sampled three times. 20 L of water were taken at each sampling. Then the water was filtered by a plankton net and bottles as storage containers. Furthermore, 4% formalin is added to the water in the bottle.

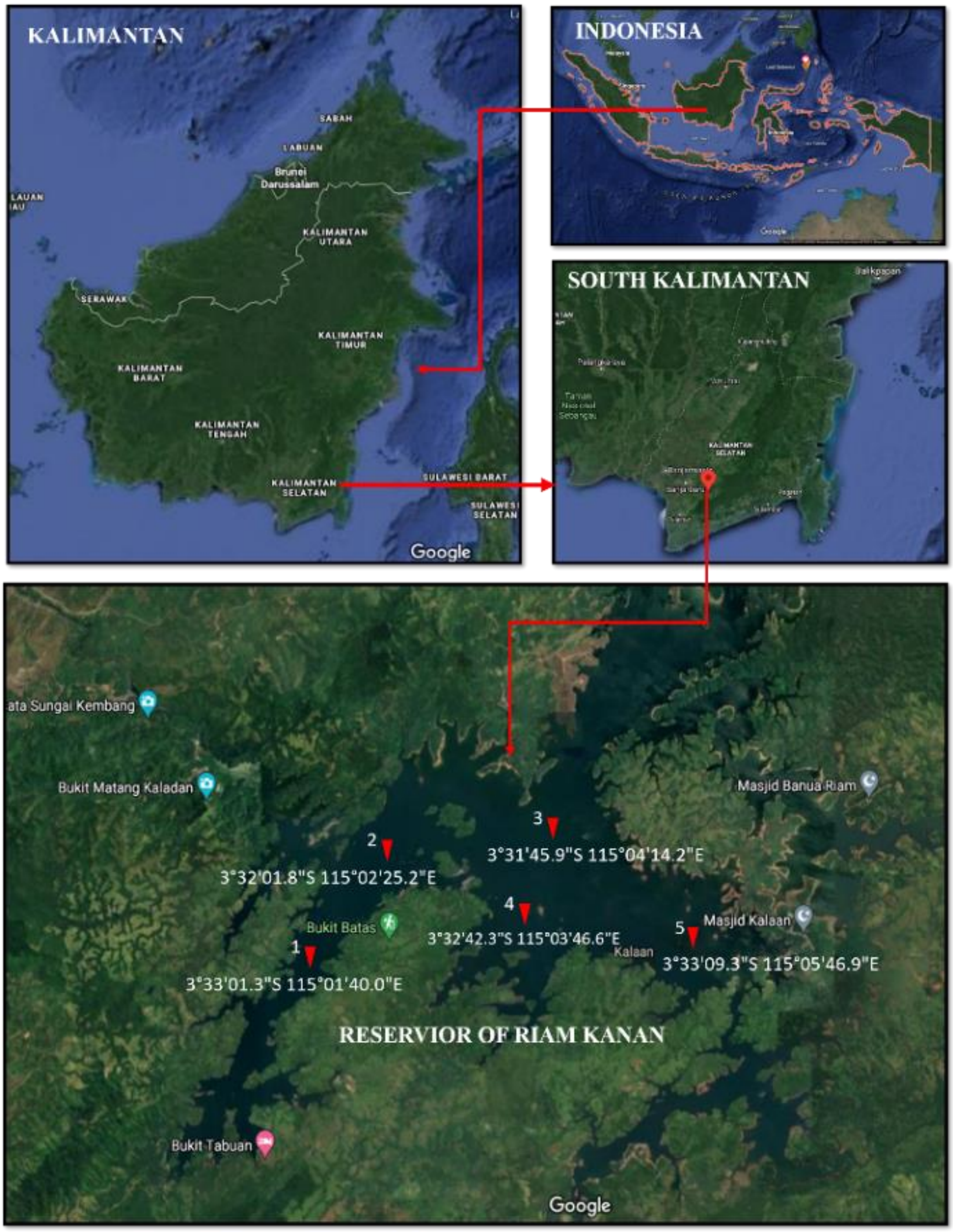

Fig 1: Riam Kanan Reservior in South Kalimantan, Indonesia

Analysis of Water Quality

Parameters for water quality testing of Riam Kanan reservoir include physical parameters such as temperature was measured by a portable thermometer, brightness was measured by a Secchi disk, and turbidity was measured by a turbidity meter; while chemical parameters such as dissolved oxygen (DO), carbon dioxide (CO_2) and pH which was measured by a portable multi water quality brand Horiba and the measurement of ammonia (NH_3) using spectrophotometry salicylate method.

Abundance of Phytoplankton

The abundance of phytoplankton was determined by the Hardy method [12] using equation 1.

$$N = \frac{n}{m} \times \frac{s}{a} \times \frac{1}{v} \quad (1)$$

Where,

N = Number of individuals per liter (cells or individuals/L)

N = Number of individuals found (cells or individuals)

M = Number of drops of sample checked
S = Volume of the sample with preservative (mL)
A = Volume of each drop of the sample (mL)
V = Volume of filtered water (L)

Diversity Index (H')

Diversity index (H') states the circumstances of the organism's population mathematically. Phytoplankton species diversity can be calculated by the Shannon-Wiener diversity index using equation 2.

$$H' = -\sum_{t=1}^{s} Pi \ln Pi \quad (2)$$

Where,

Pi = ni/N H' = Shannon-Wiener diversity index
ni : the number of individuals in species I N: Total number of species

The diversity index criteria: Low category = $0 \leq H' < 1$
Moderate category = $1 \leq H' < 3$
High category = $H' \geq 3,0$

Evenness Index (E)

Evenness is the composition of the number of individuals in each genus in a community. The evenness index used was based on the Shannon-Wiener function to determine the distribution of each type of phytoplankton in the observation area. The evenness index was calculated using equation 3.

$$E = \frac{H'}{H'_{max}} = \frac{H'}{\ln(S)} \quad (3)$$

Where,
E = Evenness index
S = Number of species or species richness
H' = Shannon-Wiener diversity index
ln = Natural log
H'_{max} = Maximum diversity possible

The evenness index criteria: High category = $E > 0,6$
Moderate category = $0,4 < E < 0,6$
Low category = $E < 0,4$

Dominance Index (D)

The dominance index was used to obtain information about the dominant family in a community. The dominance index can be calculated by Simpson's formula using equation 4.

$$D = \sum (Pi)^2 \quad (4)$$

Where,
$P_i = n_i/N$
n_i = the number of individuals in species *i*
N = the total number of species
D = dominance index

The dominance index criteria:D approaches 0 (zero) = no species dominance
D approaches 1 (one) = species dominance

Results

Water Quality

The presence and abundance of phytoplankton in the waters are influenced by the water quality. The results showed that the water quality in the waters of Riam Kanan reservoir did not change significantly during the study. The average water quality values of Riam Kanan reservoir during July-November were a value of 28.7ºC for temperature, brightness of 1.8m, turbidity of 9.1 NTU, DO of 4.5 mg/L, CO_2 of 10.9 mg/L, pH of 8.2, and NH_3 of 0.3 mg/L. The results of water quality measurements based on stations in July – November can be seen in Table 1.

Table 1: Water Quality in Riam Kanan Reservior on July to November 2020

Parameter	Month				
	July	**August**	**September**	**October**	**November**
Temperature (°C)	28.65	28.24	28.56	28.51	28.73
Brightness (m)	1.84	1.83	1.84	1.85	1.83
Turbidity (NTU)	9.12	9.09	9.11	9.08	9.11
DO (mg/L)	4.51	4.53	4.53	4.43	4.63
CO_2 (mg/L)	10.70	10.90	10.82	10.85	10.91
pH	8.16	8.21	8.19	8.16	8.16
NH_3 (mg/L)	0.32	0.31	0.30	0.31	0.32

Types and presence of phytoplankton

Research conducted on the waters of Riam Kanan reservoir for 5 months showed that this reservoir was very rich in phytoplankton. The types of phytoplankton found in Riam Kanan reservoir were phylum Chlorophyta, Cyanophyta, Euglenophyta, and Bsacillariophyta. Phylum Cholophyta dominates almost all waters of Riam Kanan reservoir. In this phylum, 9 genera were found, one of which was the genus *Staurastrum*, which had the most presence in Riam Kanan reservoir. This genus was found at all stations from July to November. In addition to this genus, there were 2 genera from the phylum Cyanophyta, namely *Anabaena* and *Chroococcus* which can also be found every month. The data on the type and presence of phytoplankton can be seen in Table 2. The percentage of phytoplankton presence by phylum can be seen in Fig 2.

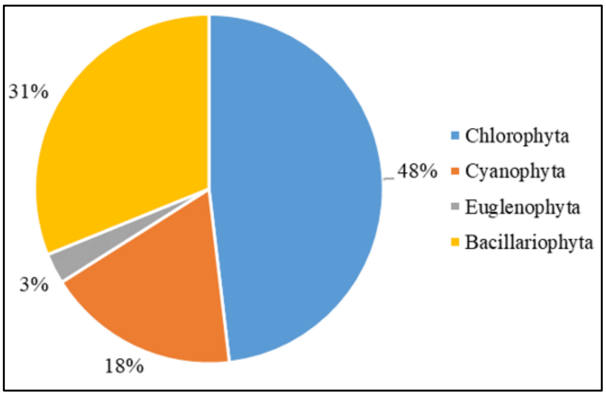

Fig 2: The percentage of phytoplankton by phylum

Table 2: Types and presence of phytoplankton in Riam Kanan reservoir from Jul-Nov 2020

Phylum	Genus	Month																								
		July					August					September					October					November				
Station		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Chlorophyta	*Ankistrodesmus*	√	-	√	-	-	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√
	Tetrastrum	√	-	-	√	-	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√
	Kirchneriella	-	-	-	-	-	-	√	-	-	-	-	√	-	-	-	-	√	-	-	-	-	√	-	-	-
	Haematococcus	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√
	Coelastrum	√	√	√	√	√	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√
	Cosmarium	-	-	-	-	-	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√
	Pleurotaenium	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√
	Pediastrum	√	-	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Scenedesmus	√	√	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Closterium	-	√	√	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Staurastrum	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Cyanophyta	*Pseudoanabaena*	-	-	-	-	-	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√
	Microcystis	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√
	Anabaena	√	√	√	√	-	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Chroococcus	√	-	-	√	-	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Oscillatoria	-	-	-	-	-	-	√	-	-	-	-	√	-	-	-	-	√	-	-	-	-	√	-	-	-
	Cylindrospermopsis	-	√	-	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euglenophyta	*Trachelomonas*	-	-	-	-	-	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√	-	√	√	-	√
Bacillariophyta	*Navicula*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Synedra	√	√	√	√	√	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√	√	-	√	√	√
	Diatoms	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√
	Aulacoseira	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√
	Pinnularia	-	-	-	-	-	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√	-	-	√	-	√

The results also showed that the presence of phytoplankton in Riam Kanan reservoir in July had fewer species compared to August-November. In July there were only 3 phyla, namely Chlorophyta which consisted of 7 genera, Cyanophyta which consisted of 3 genera, and Bacillariophyta which consisted of 2 genera. In August-November there were 4 phyla namely Chlorophyta which consists of 8 genera, Cyanophyta which consists of 5 genera, Euglenophyta which consists of 1 genus, and Bacillariophyta which consists of 5 genera. The number of phytoplankton in Riam Kanan reservoir can be seen in Fig 3.

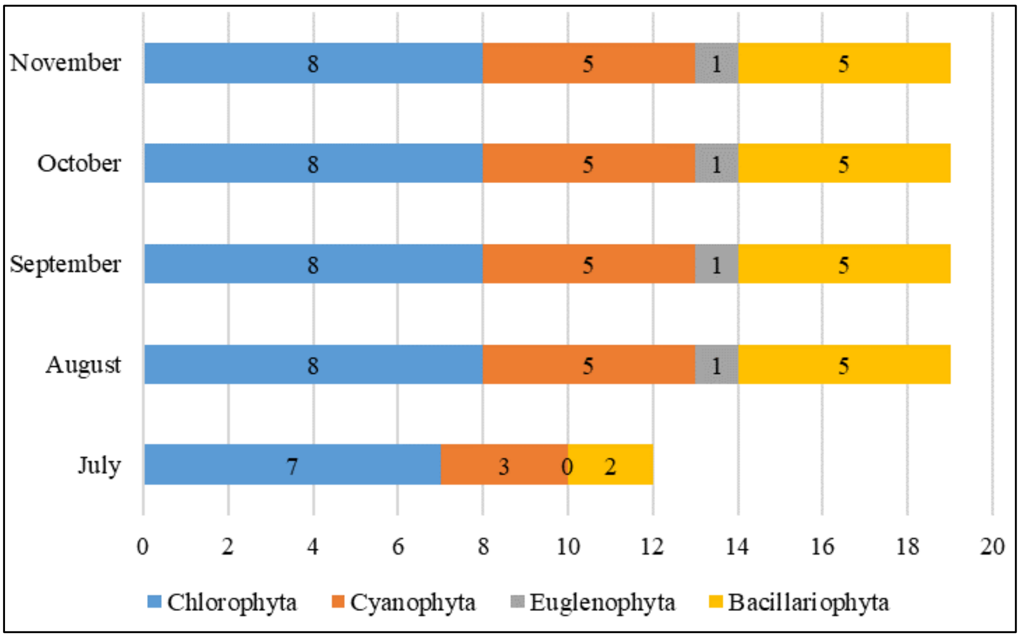

Fig 3: Total of genus phytoplankton based on a family in Riam Kanan reservoir from July-November 2020

Abundance of Phytoplankton

Based on Table 3, the genus *Staurastrum* was the most abundant phytoplankton in the waters of Riam Kanan reservoir. This genus can be found on all stations from July-November. In addition to this genus, genera that were also abundant and can be found at all stations from July-November were the genus *Ankistrodesmus*, *Tetrastrum*, *Coelastrum*, *Anabaena*, *Chroococcus*, *Navicula*, and *Synedra*.

Table 3: The phytoplankton abundance in Riam Kanan reservior from July-November 2020

Phylum	Genus	Total of phytoplankton (10.000 Ind/L)				
		July	August	September	October	November
Chlorophyta	*Ankistrodesmus*	21.0	6.5	6.5	6.5	6.5
	Tetrastrum	6.2	7.0	8.5	8.5	8.5
	Kirchneriella	0	1.0	1.0	1.0	1.0
	Haematococcus	0	1.0	1.0	1.0	1.0
	Coelastrum	49.1	2.5	2.5	2.5	2.5
	Cosmarium	0	26.0	23.5	23.5	23.5
	Pleurotaenium	0	1.0	1.0	1.0	1.0
	Pediastrum	9.0	0	0	0	0
	Scenedesmus	44.1	0	0	0	0
	Closterium	8.7	0	0	0	0
	Staurastrum	302.8	18.0	20.5	20.5	20.5
Cyanophyta	*Pseudoanabaena*	0	4.5	7.5	7.5	7.5
	Microcystis	0	3.0	4.0	4.0	4.0
	Anabaena	17,2	23.0	25.5	25.5	25.5
	Chroococcus	23.7	13.5	12.5	12.5	12.5
	Oscillatoria	0	1.0	1.0	1.0	1.0
	Cylindrospermopsis	22.0	0	0	0	0
Euglenophyta	*Trachelomonas*	0	9.5	10.5	10.5	10.5
Bacillariophyta	*Navicula*	21.4	27.0	27.0	27.0	27.0
	Synedra	138.5	5.0	8.0	8.0	8.0
	Diatoma	0	5.0	5.0	5.0	5.0
	Aulacoseira	0	31.0	33.0	32.2	28.0
	Pinnularia	0	1.0	3.0	3.0	3.0
Total phytoplankton each month		663.7	186.5	201.5	200.7	196.5
	%	45.81	12.87	13.91	13.85	13.56

Table 3 shows in July, several genera were very abundant, namely the genus *Ankistrodesmus*, *Coelastrum*, *Staurastrum*, and *Synedra*. However, in August-November, these genera experienced a significant decrease. There was even a genus *Scenedesmus* which was abundant in July but in August-November it was not found anymore. On the other hand, in August-November, new genera such as the *Cosmarium*, *Trachelomonas*, and *Aulacoseira* appeared which were quite abundant.

The abundance of phytoplankton can be seen from the number of phytoplankton in the Riam Kanan reservoir. Table 3 shows the total number of each phytoplankton by genus. The genus *Staurastrum* has the highest number (382.3×10^4 Ind/L) while the genus with the least number is *Haematococcus*, *Kirchneriella*, *Pleurotaenium*, and *Oscillatoria* (each of which was 4×10^4 Ind/L). In addition, several genera have quite a lot, namely Genus *Synedra* (167.5×10^4 Ind/L), *Navicula* (129.4×10^4 Ind/L), *Aulacoseira* (124.2×10^4 Ind/L), and *Anabaena* (116.7×10^4 Ind/L). The morphology of phytoplankton found in Riam Kanan reservoir can be seen in Fig 4.

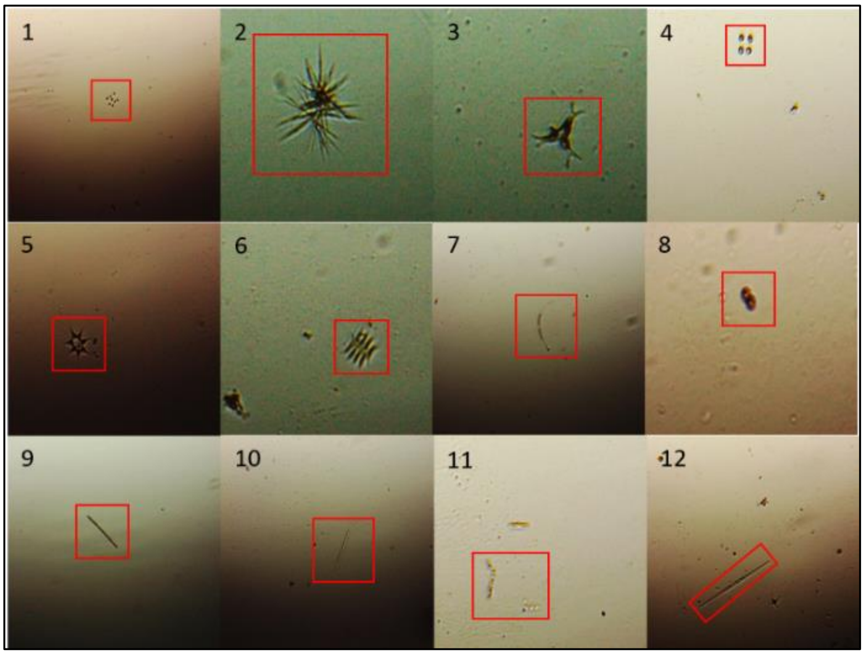

Fig 4: Phytoplankton in Riam Kanan reservior. 1. *Ceolastrum*; 2. *Ankistrodesmus*; 3. *Staurastrum*; 4. *Tetrastrum*; 5. *Pediastrum*; 6. *Scenedesmus*; 7. *Closterium*; 8. *Chorococcus*; 9. *Anabaena*; 10. *Oscillatoria*; 11. *Cylindrospermopsis*; 12. *Synedra*

After calculating the abundance of phytoplankton in Riam Kanan reservoir, then the calculation of the diversity index, evenness index, and dominance index was carried out. It was done to find out the type of phytoplankton that dominates the waters of Riam Kanan reservoir. The calculated results can be seen in Table 4.

Tabel 4: Diversity index, evenness index, and dominance index at Riam Kanan reservoir during July – November 2020

Parameter	Month				
	July	August	September	October	November
H'	1.763	2.467	2.524	2.526	2.540
E	0.710	0.838	0.857	0.858	0.863
D	0.267	0.106	0.099	0.098	0.096

Discussion

Good ecological quality will support the production of aquatic organisms such as the availability of natural feed (phytoplankton) for fish farming [13, 14, 15]. Measurement of water quality is important because it helps to control environmental damage and detects the presence of aquatic organisms such as phytoplankton as one of the determinants of water quality. In fish farming areas, water quality measurements are very important to be carried out periodically [16, 17]. Periodic water quality measurements in Riam Kanan reservoir showed that the physical (temperature, brightness, turbidity) and chemical (DO, CO_2, pH, NH_3) water quality did not change during the July-November 2020 period (Table 1). However, the water quality of Riam Kanan reservoir has changed physically and chemically compared to 2012. In 2012, this reservoir had an average temperature of 30.4 ºC, a brightness of 2.27 m, pH of 7.44, and DO of 6.86 mg/L [18]. Water quality parameters are closely related to one another. If the level of CO_2 increases in water, it is certain that the pH will increase and DO will decrease [19, 20]. The decrease in the brightness level will increase the turbidity and the presence of NH_3 in the waters of Riam Kanan reservoir is thought to be caused by feed residue that accumulates in the reservoir. Study literature explained that the uneven entry of organic materials into the waters will increase turbidity, reduce light penetration and affect the diversity of phytoplankton [21, 22]. This change in water quality will cause changes in the composition of phytoplankton as a natural feed source in Riam Kanan reservoir.

Phytoplankton organisms are important indicators for detecting fertility and health due to environmental changes [23], and have the ability to tolerate different environments [24]. Phytoplankton is also a natural feed for organisms in the waters. The presence of phytoplankton in the Riam Kanan reservoir is quite abundant. There are 4 types of phyla and Chlorophyta dominates 48% of the phytoplankton population in this reservoir, followed by phylum Cyanophyta (31%) (Fig 2). The previous research explained that phytoplankton populations that dominate in the freshwater ecosystems such as reservoirs and rivers are Chlorophyta, Cynophyta, and Bacillariophyta [25, 26]. This results also supported by Ni et al. which found that the phytoplankton species Chlorophyta, Cyanophyta, Euglenophyta, and Bacillariophyta were the most dominant in the waters [15]. Furthermore, another research in 2012 showed that the Riam Kanan reservoir also found that the phyla Chlorophyta and Cyanophyta was dominated the waters of these reservoirs. [18].

The presence of phytoplankton is quite abundant in Riam Kanan reservoir. As seen in Table 2 and Table 3, in July there were only phyla Chlorophyta, Cyanophyta, and Bacillariophyta with a small number of genera (10 genera) but with a very high number of 45.81% of the total phytoplankton during the study compared to August-November which had a high diversity (there were 4 phyla, increasing the phylum Euglenophyta with 19 genera) but the number is low and stable. Although there are differences in the number between genera, the calculation of the diversity index showed that the abundance of phytoplankton in Riam Kanan reservoir is in the moderate category (<3) with high evenness (E>0.6) and no species dominance the Riam Kanan reservoir during the July-November 2020 period. This indicates that the waters of Riam Kanan reservoir are still in good condition. Study literature explained that the phytoplankton may indicate environmental pollution [11, 27, 28]. If the waters are only dominated by 1 species then the waters are referred to as polluted, otherwise, if the number and diversity of the population are balanced then the waters are not polluted.

The appearance of the phylum Euglenophyta (genus *Trachelomonas*) is due to a large number of organic matter which is a source of nutrition for this species. The phylum Euglenophyta can live in fresh water and several species in seawater, especially in areas that contain a lot of organic matter [29]. The large number of phylum Chlorophyta (genus *Staurastrum*) and phylum Bacillariophyta (genus *Synedra*) is due to this species having high adaptability to physical and chemical changes in the aquatic environment. Bacillariophyta is a type of phytoplankton that has high adaptability to changes in waters [30], and lives in waters that contain lots of nutrients such as nitrate and phosphate [31]. The genus *Staurastrum* can live in waters that are poor and rich in nutrients, while the genus *Synedra* can tolerate water quality and waters rich in organic matter [32].

Conclusion

The findings of this study can be understood as the waters of Riam Kanan reservoir are in good condition despite the higher usage load. It is proven by measuring the quality of water chemically and physically for five months which is still in good condition and the diversity of phytoplankton is classified as moderate with high evenness and no dominance. This indicates that the waters of Riam Kanan reservoir are still in good condition. This condition needs to be maintained and conserved so that the Riam Kanan reservoir still provides a natural feed source for fish farming, especially for betutu fish larvae.

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