Ichthyofaunal community structure after restocking, in the Cacaban Reservoir, Tegal, Indonesia

Diana R. U. S. Rahayu, Agatha S. Piranti, Ani Widyastuti

Faculty of Biology, University of Jenderal Soedirman, Purwokerto, Banyumas, Jawa Tengah, Indonesia. Corresponding author: D. R. U. S. Rahayu, dianaretna.01@gmail.com

Abstract. Increased fishing activities can reduce the abundance of ichthyofauna populations in the Cacaban Reservoir. One effort to increase population abundance is through restocking. Selection of species that are not suitable for restocking will have an impact on the decline of native species. This study aimed to determine the community structure and wealth of native ichthyofauna species after increasing the stock in the waters of the Cacaban Reservoir, Tegal, Indonesia. Samplings were conducted periodically from June to September 2019. Fish samples were taken using gill nets measuring between 1.75 and 2.5 inches, which were installed from 17:00 to 05:00 and placed in 5 different sampling locations. The fish caught were identified and grouped according to the species. Water quality parameters were measured at the ichthyofauna sampling location. 17 species were found from 8 families consisting of 10 native species and 7 species of introduced fish, in a composition of introduced fish and native fish of 69% versus 31%, respectively. The native species were *Barbodes binotatus, Barbonymus gonionatus, Rasbora argyrotaenia, Puntius orphoide, Osteochilus vittatus, Oreochromis mosambicus, Channa striata, Clarias batrachus, Mystus nigrice*p, and *Tricogaster tricoptera*. The results of water quality measurements indicated that the Cacaban Reservoir is still suitable for fish life, based on the provisions of the Government of the Republic of Indonesia Number 82 per 2001 and on the Indonesian National Standard for fisheries and aquaculture activities.

Key Words: ichthyofauna, indigenous species, community structure, species richness.

Introduction. Cacaban Reservoir is one of the multifunctional waters: aside from being a source of agricultural irrigation and a tourist destination, it is also used as a means of capture fisheries. This activity is an effort to improve the local economy of the fisheries sector. Increased fishing activities that are not accompanied by wise management of resources will result in population decline and changes in the structure of water ichthyofauna communities. One effort to enrich fish populations in water is to do restocking, by entering new fish species into depopulated. According to Asyari (2011), the introduction of new fish species and efforts to enrich/increase fish stocks in public waters through stocking and restocking activities, among others, aim to increase fisheries production and maintain the sustainability of fish resources. However, the introduction (introduction) of new fish species can result in the decline or even loss of the native aquatic species (Leonardos et al 2008). Whereas the loss of a species will result in an overall diversity crisis (Modesto et al 2018). The main considerations used in selecting fish species for restocking purposes include having high economic value, growth, breeding and survival rates, and resistance to disease. It is also able to survive in eutrophic water conditions (Leonard & Mahengea 2022). Therefore, some of the species used for restocking are omnivorous and carnivorous fish, tending to be invasive. The introduction of new species into the waters will affect the balance of the ecosystem because introduced fish populations tend to produce overlapping niches, suppressing native species populations. This can affect the diversity of species in the waters.

Fishing activities in the Cacaban Reservoir have been developing for a long time. So far, a number of fish species were restocked, including 150,000 *Chanos chanos* in 2018 and 105,000 *Oreochromis niloticus* (sized 5-7 cm) in 2019. Previously, there was also the introduction of *Channa micropeltes* and *Pangasionodon hypopthalamus*. Both species have invasive abilities that can cause ecological disturbances due to the predation and competition. Both species of ichthyofauna also tend to be greedy and highly responsive to natural food in the waters, so the growth and reproduction rates tend to be higher than in native fish.

Increased fishing activities, related to an increased market demand, when performed without regard to the aspects of sustainability and species preservation, have the potential to threaten biodiversity of biological resources. Direct interviews with fishermen revealed that the number of species and the abundance of native ichthyofauna has decreased after the spread of new species in the Cacaban Reservoir. Based on the aforementioned information, this study aimed to determine the structure of the indigenous ichthyofauna community after restocking in the Cacaban Reservoir, as one source of scientific information that will support the direction of the management of capture fisheries in the Cacaban Reservoir, in a sustainable manner, based on the preservation of native species in local waters.

Material and Method

Description of the study sites. Sampling was carried out for 4 months (June - September 2019), in the Cacaban Reservoir, Tegal Regency, Central Java with the geographical location at: 109º 11' 28" E - 109º 14' 58" E and 7º 1' 31" S - 7º 2' 18'' S. (Figure 1). The waters function primarily as a source of irrigation in the agricultural area, which reaches 17,500 ha, with an inundation area at a maximum of 928.7 ha. Whereas the secondary function is for tourism and fishery purposes Capture fisheries and aquaculture co-exist. Aquaculture is done with a floating net karamba system, which is managed semi-intensively in 12 ponds with sizes varying from 6 x 6 m^2 to 8 x 8 m^2. Capture fishing is carried out by freelancers and fishermen who are members of several groups of more than 100 people, both permanently or seasonally active.

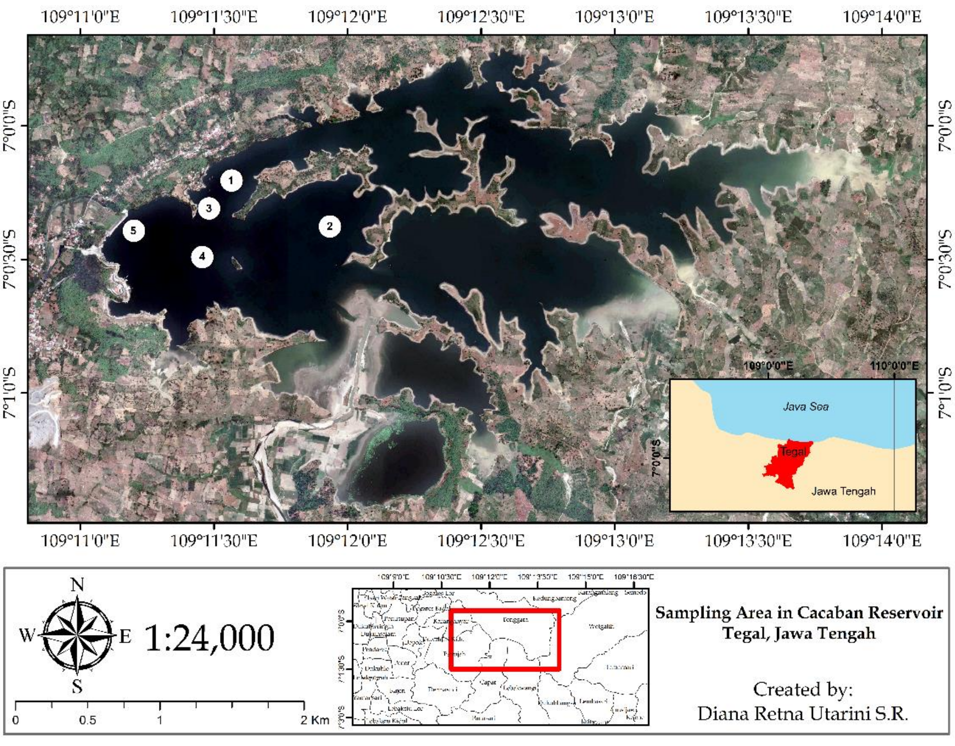

Figure 1. Map of the Cacaban Reservoir: location of the study sample.

Method of collecting data. The research approach is descriptive. Sampling of ichthyofauna was carried out using a survey method (FAO 2002) which was carried out 4 times within an interval of one month. Sampling was conducted at 5 stations. Station I was located at Station I at S 7°0'12.29" E 109°11'33.95", Station II at S 7°0'22.59" E 109°11'56.0", Station III at S 7°0'18.54" E 109°11'28.88", Station IV at S 7°0'29.48" E

109°11'27.36", Station V at S 7°0'23.55" E 109°11'12.02". The next station determination is done using a Garmin 45 XL GPS. Ichthyofauna samples were taken using fishing gear commonly used by local fishermen, with mesh sizes of 1.75-2.50 inches, widths of 2.5-2.5 m and lengths of 20-30 m, which were placed at 17.00-17.30 PM and lifted at 05.00-06.00 AM Samples of ichthyofauna caught were grouped according to their morphological characters and then identified using Kotellat et al (1993) and the fishbase (http://fishbase.org). Supporting data included physico-chemical factors: pH, temperature, DO, transparency/brightness, BOD, N-NH3 and TDS, which referred to the Government Regulation of the Republic of Indonesia Number 82, Year 2001, class 2, in accordance with the requirements for the fishery activity designation. Water sampling was carried out at the subsurface, at a depth of 0.2 m, using a 5 L water sampler. Water sampling and testing were carried out based on Standard Methods for The Examination of Water and Waste Water (APHA 1992).

Data analysis. Data analysis was performed descriptively. Calculations were carried out using the following formulae:
The Relative Abundance (RA) is calculated as the ratio between the number of individuals of certain species and the total number of individuals of all species (Yunianto et al 2012).

$$RA\ (\%) = (ni / N) \times 100$$

Where:
ni - number of individuals of species i;
N - the sum of all individuals.

The Local Distribution (LD) is calculated as the ratio between the number of locations where a species is found and the total number of locations (Rusdianto & Sauri 2021).

$$LD\ (\%) = (Ni / N) \times 100$$

Where:
Ni - number of species found at the location i;
N - the total number of sampling locations.

The Shannon-Wiener diversity index (H') represents the uncertainty in predicting the species identity of a uncertainty in predicting the species identity of an individual randomly from the dataset (Begon et al 1990):

$$H' = \sum \left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right)$$

Where:
H' - the Shannon-Wiener diversity index;
ni - number of individuals in each species;
N - the sum of all individuals;
H'<1 low level of species diversity;
1<H'<3 moderate species diversity level;
H'>3 high species diversity level.

The Evenness similarity index (E) is used as a measurement of the distribution of the total number of individuals between species in a community (Brower et al 1990).

$$E = \frac{H'}{H'Max} = \frac{H'}{Ln\ S}$$

Where:
H' - the Shannon-Wiener diversity index;
H'Max - maximum diversity;
S - number of species;

E=0 evenness between low species, or wealth the individuals of each species differ greatly; E=1 evenness between species is relatively evenly distributed, or in number individuals of each species are relatively the same.

The Simpson Dominance Indices (C) determines whether there is species dominance (Magurran 1988):

$$C=\sum_{i=1}^{S}\left(\frac{ni}{N}\right)^{2}$$

Where:
C - Simpson dominance index;
ni - number of individuals in each species;
N - the sum of all individual number;
C - 0.01-0.30 low dominance;
C - 0.31-0.60 moderate domination;
C - 0.61-1.00 high dominance.

Statistical analysis. The indices of species richness, heterogeneity and evenness was analyzed using PAST3 (Paleontological Statistics Software Package).

Results and Discussion

Ichtyofauna community structure in the Cacaban Reservoir. The total number of Ichthyofauna that were captured during the study were 438 individuals based on the identification results grouped into 7 families, 13 genera and 17 species (Table 1, Figure 2).

Table 1

Ichthyofaunal community structure in the Cacaban Reservoir

No	*Species*	*Number of individuals in a month*				*RA (%)*	*Origin*	*LD (%)*
		June	*July*	*August*	*Sept*			
		Family: Cyprinidae						
1	*Barbodes binotatus*	8	11	15	8	9.59	*	60
2	*Barbodes gonionotus*	3	0	9	0	2.74	*	40
3	*Rasbora argyrotaenia*	2	4	7	2	3.42	*	40
4	*Puntius orphoides*	4	0	5	4	2.97	*	40
5	*Osteochilus vittatus*	0	3	7	1	2.51	*	40
		Family: Cichlidae						
6	*Oreochromis* sp	0	0	2	0	0.46	***	20
7	*Oreochromis niloticus*	15	43	40	33	29.91	**	100
8	*Oreochromis mosambicus*	1	0	5	2	1.83	*	40
9	*Hemichromis elongatus*	2	4	11	6	5.25	***	60
		Family: Channidae						
10	*Channa micropeltes*	7	6	5	8	5.94	**	60
11	*Channa striata*	3	2	10	7	5.02	*	40
12	*Chanos chanos*	1	2	0	0	0.68	**	40
		Family: Claridae						
13	*Clarias batrachus*	0	1	0	2	0.68	*	20
14	*Clarias gariepinus*	1	2	1	0	0.91	***	20
		Family: Bagridae						
15	*Mystus nigricep*	1	0	3	3	1.60	*	40
		Family: Anabantidae						
16	*Trichogaster trichopterus*	1	0	1	2	0.91	*	40
		Family: Pangasidae						
17	*Pangasionodon hypopthalamus*	10	27	31	44	25.57	**	60
Total abundance (individual)		59	105	152	122	100		
Total species (species)		14	11	15	13			
Total native species (species)		8	5	9	9			

*native species; **introduced; ***accidentally introduced.

The study of Miftahurrohman et al (2016) in the Cacaban Reservoir, conducted in April 2016, reported only four species of ichthyofauna, captured with a 3-inch gill net, namely: *O. niloticus, Barbodes gonionatus, Ophiochepalus striatus* and *Hemichromis elongatus*. Differences in the number of species of ichthyofauna in the Cacaban Reservoir are likely due to differences in the types of fishing gear used. Fish were grouped based on their presence in the Cacaban reservoir: introduced, native species and accidentally introduced. Accidentally introduced are species that accidentally enter together with the entry of water into a water body (Karpova 2016). Of the 17 species of ichthyofuna caught in the Cacaban Reservoir, 3 species were accidentally introduced, 4 species were deliberately introduced species, while 10 species were native species. The analysis of Local Distribution (LD) showed that most of the species only had a value of 40%, meaning that they were only found at two research stations, Claridae were only found at one station (LD 20%). This indicates that most of the species only have limited distribution capabilities. Only *O. niloticus* from Cichlidae has the ability to spread widely (found in five research stations) with an LD value of 100%.

The results of the calculation of relative abundance (RA) showed that *O. niloticus* and *P. hypopthalamus* are the two species that have the highest relative abundance levels of 29.91 and 25.57, respectively. The two species are intentionally introduced to increase the capture fisheries productivity in the Cacaban Reservoir. *O. niloticus* is a superior species that is often used for restocking. According to Linde-Arias et al (2008), *O. niloticus* is an invasive species having more ecological abilities, at various trophic levels, compared to native species, especially in terms of tolerating various diets, so that it has the potential to threaten the preservation of native species (Zambrano et al 2010). In the Cacaban Reservoir there were 10 native species (Table 1) found, which have varying relative abundance levels. *Barbodes binotatus* is the indigenous species (insect, zooplankton and phytoplankton eater) with the highest relative abundance (9.59%), and therefore it has an economic potential to be developed. According to Trijoko et al (2016), members of the Cyprinidae Family are found in calm and clear waters. This species is also an environmental indicator used to assess the habitat quality or the health of the aquatic environment (Pratama et al 2018).

Ichthyofauna composition found in the Cacaban Reservoir during the study is presented in Figure 2. The highest was from the Cichlidae by 37% and the lowest was from the Anabantidae by 1%. Chichlidae have high adaptability, even in low water quality conditions (Ford et al 2015; Faradiana et al 2018).

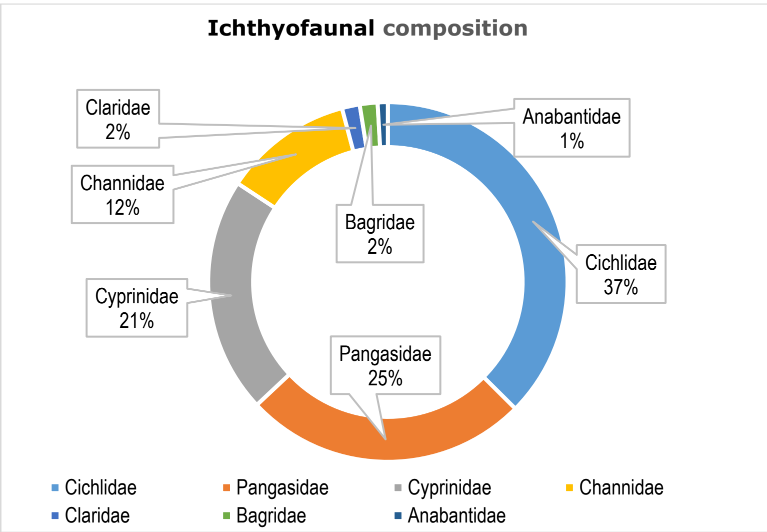

Figure 2. The composition of the ichthyofauna in the Cacaban Reservoir.

The Shannon Wiener (H') diversity index calculation results of all ichthyofauna captured during the study ranged from 1.74 to 2.26 (Figure 1), whereas spatially, at the individual level of each research station, it ranged from 1.17 to 2.17 (Figure 3), these conditions indicate that the diversity level of ichthyofauna Cacaban Reservoir is included in the medium category. This value also shows that the productivity and stability of the aquatic ecosystem in the Cacaban Reservoir is included in the medium category. Basically, there are seven factors that affect the species diversity, namely: competition (Maynard et al 2017), ecological (Félix et al 2020) and environmental stability (Chícharo et al 2006), predation, productive habitat, habitat time and heterogeneity. Differences in the diversity indices at each research station can be caused by the habitat selection behavior. Ichthyofauna will tend to look for habitats that are rich in food sources and safe.

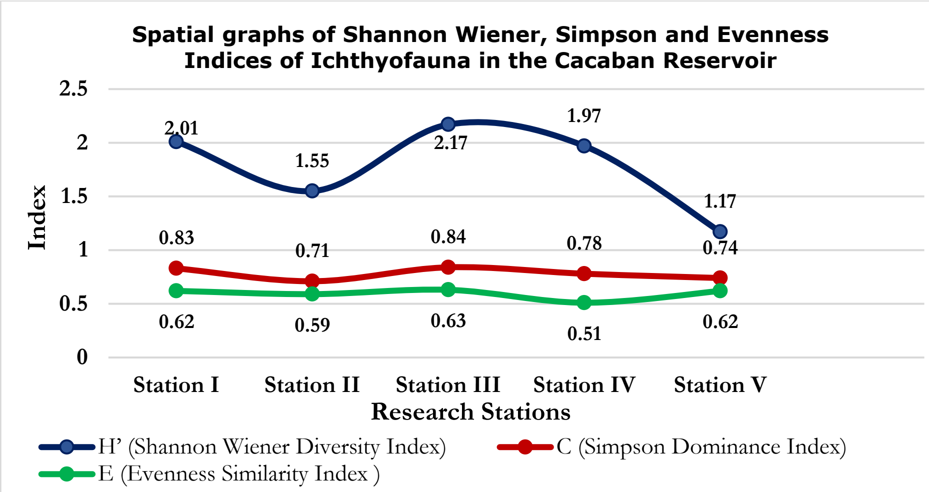

Figure 3. Spatial graphs of Shannon Wiener, Simpson and Evenness Indices of Ichthyofauna in the Cacaban Reservoir.

The calculation results of the Simpson dominance index for the Cacaban Reservoir's ichthyofauna showed a temporal range of values of 0.75-0.86 (Figure 4), while spatially it ranged from 0.71 to 0.84 (Figure 4), meaning that there were ichthyofauna that dominated in these waters. Two species had the highest relative abundance, namely *O. niloticus* and *P. hypopthalamus*, which can threaten the stability of the Cacaban Reservoir ecosystem, meaning that restocking can result in changes in the structure of aquatic biota communities. According to Insani et al (2020), *O. niloticus* shows a very omnivorous habit, is very tolerant of salinity and new habitats, this species can be found in the highlands to the estuaries, can have a negative impact on freshwater and brackish water communities through competition for food and other resources, its distribution in Indonesia is caused by cultivation activities.

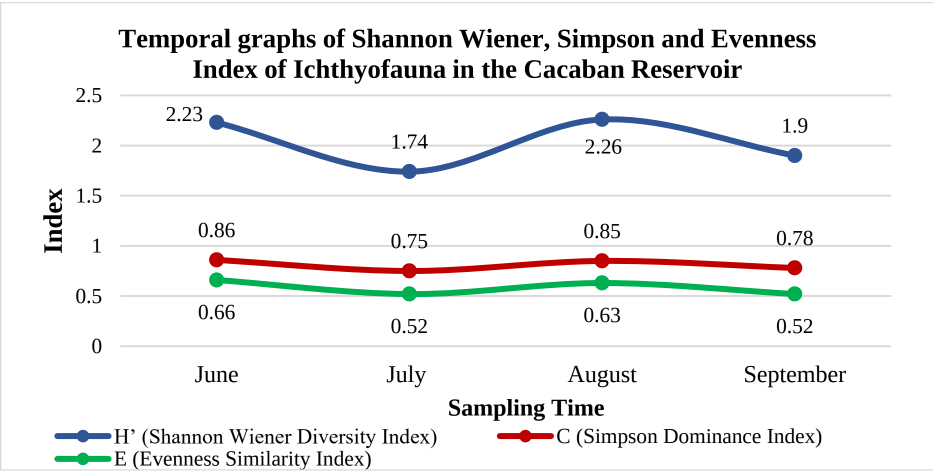

Figure 4. Temporal graphs of Shannon Wiener, Simpson and Evenness Indices of Ichthyofauna in the Cacaban Reservoir.

The Evenness index values temporally ranged from 0.52 to 0.66 (Figure 3), while spatially it ranged from 0.51 to 0.63 (Figure 4), which reflect the individuals' distribution differences between species. The ichthyofauna in the Cacaban Reservoir is still relatively normally distributed, showing the good quality of the aquatic environment.

Indigenous ichthyofaunal community structure in the Cacaban Reservoir. The composition between introductions and indigenous ichthyofauna was 69% versus 31%. The 31% native fauna were composed of 10 species, namely *Barbodes binotatus, Barbonymus gonionatus, Rasbora argyrotaenia, Puntius orphoides, Osteochilus vittatus, Oreochromis mosambicus, Channa striata, Clarias batrachus, Mystus nigricep* and *Tricogaster tricopterus*, which come from 6 families (Figure 5). Some native species of the Cacaban Reservoir show relative abundances below 10%, which indicates overlapping niches; species that have a wide range of niches will dominate the habitat. Sampling results in these waters indicate that all members of the Cyprinidae family found are native species, and some of them became less abundant. Figure 4 presents the Shannon diversity Indices (H'), Simpson Dominance Indices (C), and Evenness Indices (E) of ichthyofauna in the Cacaban Reservoir.

Based on Figure 6, Station 3 is the best habitat for indigenous ichthyofauna in the Cacaban Reservoir, according to the diversity index (H') value at station 3, which is the highest of all stations. A high level of species diversity means that the condition of the ecosystem is quite balanced, with a high productivity and a low ecological pressure on the ecosystem. Although the five stations are still in the category of moderate diversity, the number of species that dominate is moderate. Differences in diversity index at each station and time of study can be caused by habitat selection behavior. Ichthyofauna will tend to look for habitats that are rich in food sources and safe. One type of shock that affects the level of species diversity is a change in water quality parameters. According to Jenkins & Jupiter (2011), the temporal distribution of fish is more influenced by changes in water quality. In a balanced ecosystem, community diversity is high, while ecosystems that often experience shocks from both physic-chemical and biological factors will tend to have low diversity.

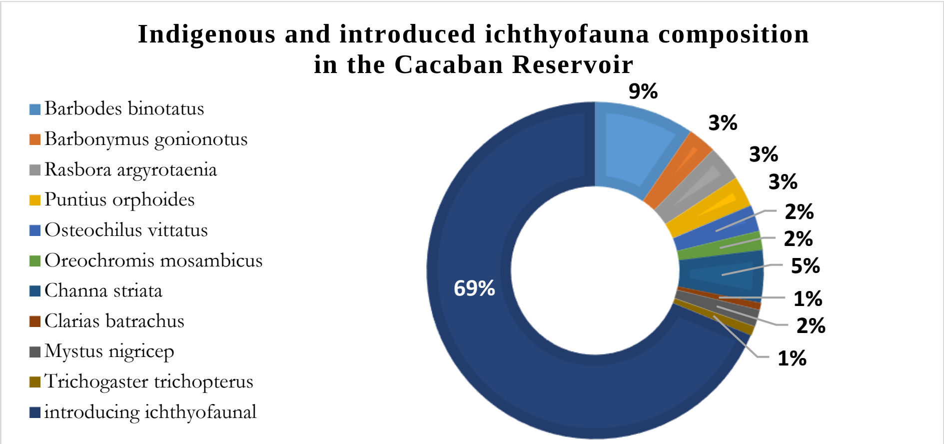

Figure 5. Indigenous and introduced ichthyofauna composition in the Cacaban Reservoir.

Physico-chemical and biological factors of water. The results of average water quality measurements in the Cacaban Reservoir during the study are presented in Table 2. These results indicate a range that is still within the quality standard provisions of the Government of the Republic of Indonesia Regulation Number 82 of 2001, concerning the management of water quality and water pollution control, in accordance with class 2 designations for fishery activities and the Indonesian National Standards for fisheries and aquaculture activities. Environmental factors which include physical-chemical and biological factors, are one of the factors that influence the value of species diversity in an ecosystem. The most influential factors include brightness (Faradina et al 2018) and chlorophyll concentration. The level of brightness will affect the energy production process through photosynthesis, while the chlorophyll concentration is an indicator of the abundance of phytoplankton in these waters, which plays a role in energy production and oxygen availability in the water (Rahayu et al 2020). The results of water quality measurements at each station did not show any ecological pressure that could determine changes in species diversity. All physical-chemical factors of water were within the range of quality standards for fishery activities and aquaculture standards.

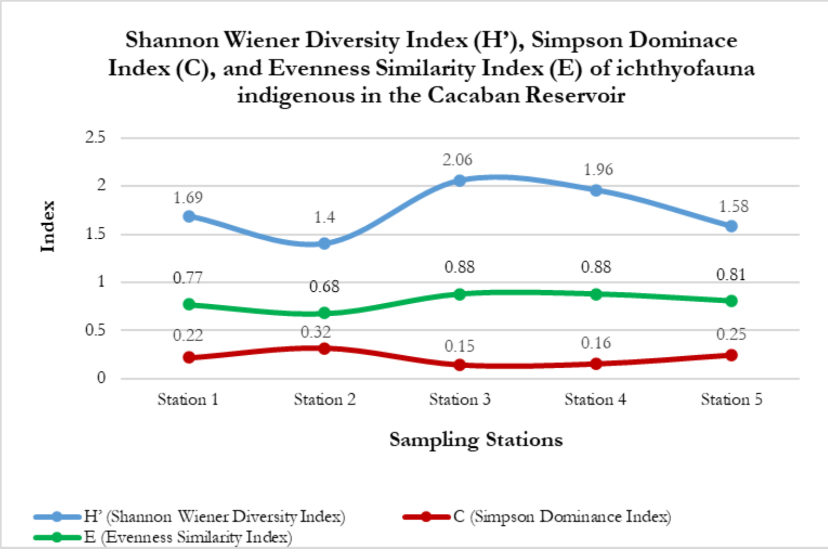

Figure 6. Shannon Wiener Diversity (H'), Simpson Dominance (C), and Evenness Similarity (E) indices, indigenous ichthyofauna in the Cacaban Reservoir.

Table 2

Physico-chemical and biological factors during the research

Parameter	*June*	*July*	*August*	*Sept*	*Standard limit*	*Quality criteria*
Depth (m)	16.2	12.7	7.8	5.2	-	*
Water temperature (°C)	30.1	29.8	29.2	30.2	Range+3 (in the range of 3 points above and/or below measurement)	*
Transparency (m)	0.62	0.67	0.72	0.59	>0.50	**
TDS (mg L^{-1})	150	149	148	150	<100	*
pH	6.6	6.8	6.7	6.8	6-9	*
DO (mg L^{-1})	4.38	5.21	5.37	4.53	>4	*
BOD (mg L^{-1})	5.87	6.72	6.77	6.21	>3	*
N-NH_3 (mg L^{-1})	0.019	0.017	0.016	0.018	<0.02	*
Chlorophyll (mg m^{-3})	0.23	0.28	0.32	0.26	-	-

* Government Regulation Number 22 of 2021, Concerning Implementation of Environmental Protection and Management (National Water Quality Standards), allotment of fisheries (class 2).

Figure 7 shows the relationship between the level of penetration and the indigenous ichthyofauna diversity index, at each research station. A positive R value indicates a positive correlation, a value of R=0.5703 means that the relationship between the diversity index values indicates a moderate correlation. Figure 8 illustrates the relationship between the diversity of indigenous fauna at each station is positively correlated with the chlorophyll concentration.

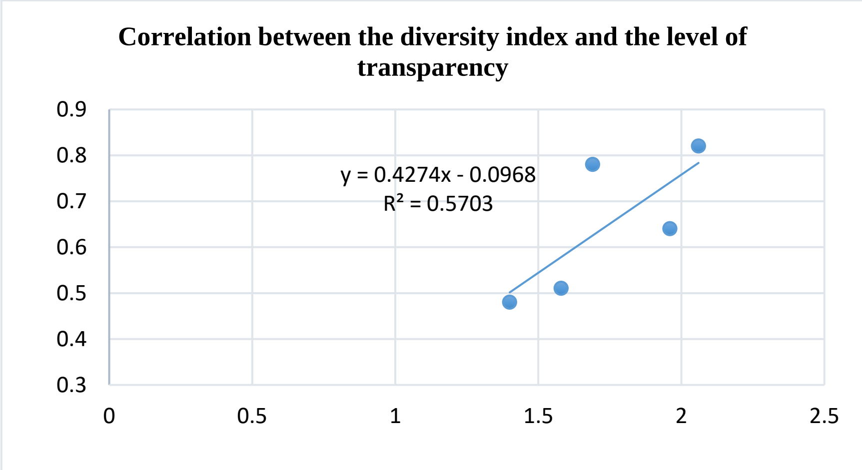

Figure 7. Correlation between diversity index and the level of transparency.

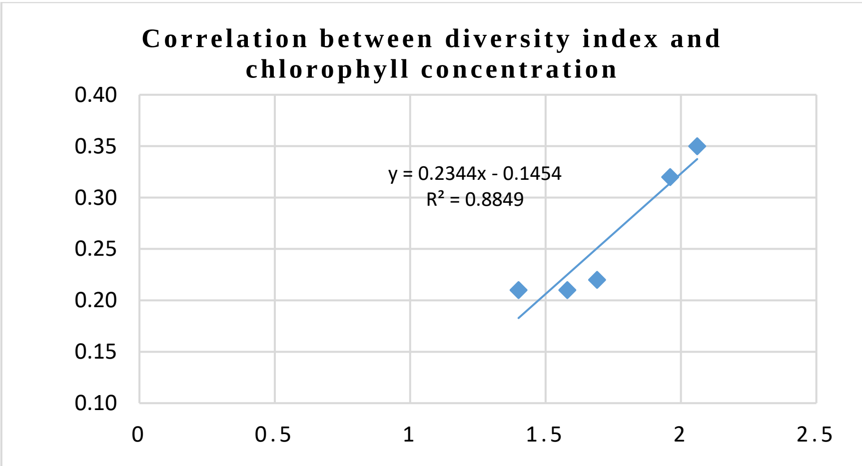

Figure 8. Correlation between the diversity index (H') with chlorophyll concentration.

Conclusions. Ichthyofauna caught were 438 individuals grouped into 7 families, 13 genera and 17 species. Three species were introduced accidentally, four species were introduced species intentionally while 10 species were native species. Most species have limited distribution capabilities, only *O. niloticus* has the ability to spread widely. The two species that had the highest relative abundance were *O. niloticus* and *P. hypopthalamus*. Based on the level of diversity, the ichthyofauna in the Cacaban Reservoir is included in the moderate category, with the level of evenness between species included in the low category because there are ichthyofauna that dominate. While the condition of the waters based on physical-chemical factors of water is still within the range of quality standards for fishery and aquaculture activities.

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Conflict of interest. The authors declare no conflict of interest.

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Authors:
Diana Retna Utarini Suci Rahayu, Faculty of Biology, University of Jenderal Soedirman, Jalan dr. Soeparno no 63, Purwokerto, Banyumas, Central Java 53122, Indonesia, e-mail: dianaretna.01@gmail.com
Agatha Sih Piranti, Faculty of Biology, University of Jenderal Soedirman, Jalan dr. Soeparno no 63, Purwokerto, Banyumas, Central Java 53122, Indonesia, e-mail: agatha.piranti@gmail.com
Ani Widyastuti, Faculty of Biology, University of Jenderal Soedirman, Jalan dr. Soeparno no 63, Purwokerto, Banyumas, Central Java 53122, Indonesia, e-mail: widyass36@gmail.com

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