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Ichthyofauna Biodiversity in Lake Kelari Within the Muaro Jambi National Cultural Heritage Area as a Basis for Establishing a Lubuk Larangan

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ABSTRACT

Lake Kelari is located in the Muaro Jambi National Cultural Heritage Area (KCBN) and has ecological and economic value as a habitat for various species of fish. This study aims to identify the biodiversity of the lake, conservation status, global distribution, and fish biodiversity index in the lake, which can be the scientific basis for the establishment of the proclamation pit as an in-situ conservation effort. The method used is a survey method including the collection of primary data through fishing using nets, bubu, and fishing rods in the 2023 rainy season and the 2024 dry season, as well as measuring water quality and habitat character. The results of the study show that the biodiversity of ikhtiofauna in Lake Kelari includes; 13 species, 13 genera and 7 families. The biodiversity index shows medium criteria. Lake Kelari has the potential as an insitu conservation area with the discovery of a species of senggiringan fish (*Hemibagrus planicep*) which has the status of Data Vulnerable in the IUCN Red List. Most of the species found are consumption fish, and some others are ornamental fish. The riparian vegetation found varied, the water quality was relatively maintained, and the absence of introduced fish showed the natural environment of Lake Kelari. In conclusion, Lake Kelari has medium fish biodiversity index with important conservation and economic value. The implementation of the ban can be a strategic step in maintaining fish populations and supporting the sustainability of the ecosystem and local economy.

INTRODUCTION

The Muaro Jambi National Cultural Heritage Area (KCBN) is one of the important cultural herritage of civilization as a cultural heritage from the 9th to the 13th centuries AD which is located in Jambi Province on the island of Sumatra, Indonesia, not only in terms of history and archaeology, but also in terms of environment and ecology. KCBN Muaro Jambi is a temple complex with an area of 3,981 ha, exceeding the area of Borubudur Temple by 2.5 ha (Gunawan *et al*., 2022). Existentially, KCBN is surrounded by several waters in the form of rivers, swamps and ditches. Some of the waters that flow in the KCBN area include the Jambi River, the Malay River, the Berembang River, the Johor Trench, the Lubuk Penyengat, the Telago Rajo Pond, the Tebat Patah Lake, and the Kelari Lake (Sukmono *et al.,* 2023).

Lake Kelari is the largest lake in KCBN located in Muaro Jambi Village, currently Lake Kelari is used by the community as a source of water in activities. Since 2020, Kelari Lake has been used as one of the BUMDes (tourist attractions) of Muaro Jambi Village. Lake Kelari has significant aquatic ecosystem potential, especially as a habitat for various species of ikhtiofauna. The fish that live in this lake not only have ecological value, but also have economic and social value for the local community, especially related to traditional fishing practices.

The use of Lake Kelari as a tourist attraction and household activities in the form of bathing and washing will have an impact on the quality of the waters, due to the entry of domestic waste in these waters. Based on Sukmono *et al*. (2023) Lake Kelari lives naturally with fish for consumption and ornamental fish with high economic value such as, Patin (*Pangasius pangasius*), Lampam (*Puntioplites waandersi*), Aji-aji (*Puntigrus tetrazona*), Susur batang (*Epalzeorhynchos kalopterus*). Pangasius pangasius that live in Lake Kelari reach a size of 2-5 Kg/head. Currently, the use of Lake Kelari for fisheries is still not regulated in the form of customary rules so that exploitation occurs without paying attention to the sustainability of Lake Kelari's fishery resources. One form of management that can be done is the establishment of a Lubuk Larangan, so research on fish biodiversity in the waters of Lake Kelari is crucial as a first step to maintain the balance of the ecosystem and its potential to be used as a Lubuk Larangan. One of the relevant conservation approaches is the implementation of prohibition loops that have proven effective in maintaining fish populations and regenerating aquatic ecosystems. According to Yuliaty (2014), the prohibition is very effective in limiting the behavior of residents in utilizing fishery resources.

This study aims to (1) identify the biodiversity of iktiofauna in Lake Kelari, (2) find out the conservation status of Lake Kelari, (3) know the global distribution of ikna in Lake Kelari, (4) find out the fish biodiversity index in Lake Kelari. The results of this research can be used by the village as a scientific basis in determining the prohibition pit in the area.

METHODS

Time and Place

The Iktiofauna Biodiversity Research was carried out on October 26-November 2, 2023 (rainy season) and July 16-21, 2024 (dry season) in Lake Kelari in the Mauro Jambi KCBN.

Sampling

This research method is a survey method. The survey research method is a type of research conducted to obtain facts or data found in the field (Ramdhan, 2021). The method

of sampling fish uses the census method where all caught fish are sampling. Fish biodiversity data collection in Lake Kelari Muara Jambi was carried out using several active and passive fishing tools, including nets, umbrella bubu, and fishing rods. Nets with nets (0.5 inches, 1 inches, and 1.5 inches) net lengths of 30 m, umbrella nets are installed using pellets and food baits, and fishing rods use fishing rods from 1, 3, 5, 9, and 12 as well as various types of bait such as; Crickets, small fish, worms and pellets. The determination of the location of the installation of the fishing gear was guided by the Fish Finder Lucky FF918-C fish detection device.

The research team conducted a flyng camp at the research station, so that each net can be installed for 24 hours, and can be used to catch fish at night (nocturnal) or daytime (diurnal). Net inspections are carried out in the morning (08.00-11.00 WIB), afternoon (13-16.00 WIB), and at night (19.00-21.00 WIB). Bubu and seo are installed in the afternoon (16.00-17.00) and lifted in the morning (07.00-08.00). Fishing using fishing gear with several popping bait, worms, crickets, pellets and small fish.

Fish Identification

Fish Identification and Preservation of Fish caught with nets will be collected and calculated based on type. The fish that are still alive are photographed in a mini aquarium using a Nikon D5200 camera and a mobile phone camera. If the fish is actively moving during the documentation, it will be anesthetized by using clove oil to give a limping effect. Dead fish samples were photographed with their heads facing left and black or red backgrounds and given the ICM code (Muara Jambi Temple Fish) and scaled. Fish identification was carried out in situ using 15 morphometric characters and 6 meristic characters (Figure 1).

The identification results will be compared with several fish identification books such as; Sukmono & Mira (2017), Kottelat *et al*. 1993, and online based on www.fishbase.org (Froose & Pauly, 2023). Each type of fish will be collected as many as 5 individuals to be preserved (preserved) using 10% formalin. Fish that are ≥ 15 cm in size will be injected with 70% alcohol first before being preserved in 10% formalin.

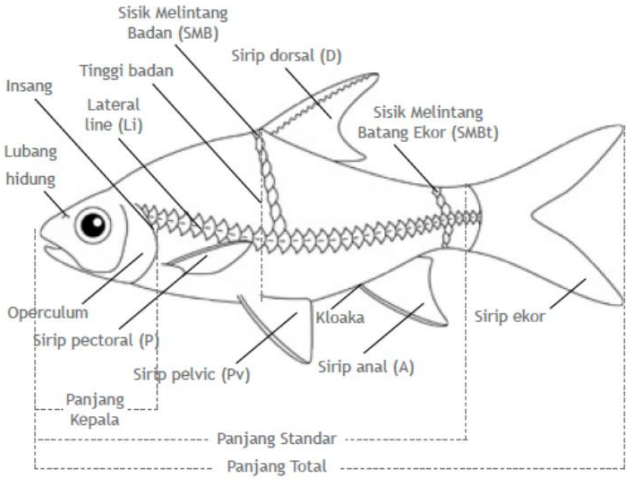


Figure 1. Morphometric Measurements of Fish (Sukmono & Margaretha, 2017). The Distribution of Fish Will Be Identified Based on www.Gbif.org.

Measurement of Habitat Character and Water Quality To determine the condition of fish habitat in the KCBN Regulation, morphometric measurements and water quality were carried out as well as identification of vegetation around the research station. The various parameters measured are presented in Table 1, the tools used are presented in Figure 2.

Table 1. Measurement of Habitat Characteristics and Morphometry of Rivers

No	Parameter	Measuring Instruments	Unit
1	DO	Water quality Meter AZ86031	ppt
2	pH	Water quality Meter AZ86031	acidic - alkaline
3	Temperature	Water quality Meter AZ86031	^{0}C
4	Brightness	Disc buckets	cm
5	Coordinate Position	GPS Garmin	UTM
6	Conductivity	GPS Garmin	M

Figure 2. Fish Survey Supporting Equipment, a) Water Quality Meter AZ86031, b) Fish Finder Lucky FF918, c) Garmin GPS, d) Sacchi Disk Data Analysis

Data Analysis

The analysis of data related to fish biodiversity in this study includes: Diversity Index Shanon-Wiener (H'), Similarity Index (E), and, Dominance Index (C) calculated using the formula according to Odum (1971). The Diversity Index Shanon-Wiener (H'), Similarity Index (E), and, Dominance Index (C) index values are assessed using the criteria based on Krebs (1989). The results of measurement and calculation of morphometric data using a ruler and meristic data using a fish dissection kit are used to create a description as a determinant of the species character and will be compared with the species character from various fish identification books as well as online through the www.fishbase.org website (Froose & Pauly, 2017). All scientific names will be checked online at www.fishbase.org. The determination of conservation status refers to www.iucnredlist.org and www.fishbase.org. The determination of native species is based on Dewantara & Rachmatika (2016) and Wargasamita (2005). Determination of fish potential (Consumption and Ornamental) based on Haryono *et al*. (2015), and Sukmono & Mira (2017). The existence of fish and their habitat will be described to describe the relationship between fish and their habitat

RESULTS

The number of fish caught during the study in the rainy season (2023) and dry season (2024) was obtained 86 fish, 7 families, 13 species of fish were successfully identified. The

conditions of the waters in 2023 and the conditions of the waters in 2024 are not too different (Table 2).

Table 2. Morphological Condition and Water Quality of Lake Kelari

Name of Water: Kelari Lake	Station Location 1
Date: October 26, 2023 and July 17, 2024	Time: 2023: 08.30-1630 2024: 17.00-17.55 WIB
GPS (coordinates): Lat: -1.478703 Long: 103.675660	Kolektor: Tedjo Sukmono (TJS), Yoppie Wulanda (YPW), Lauura Hermala Yunita (LHY)
Weather: sunny, hot	
Location description: Kelari Lake is the largest lake in the KCBN area, the inlet of the Jambi River and the outlet of the Straits River. It is located in the people's neighborhood and is currently still used for bathing and washing the community. This lake has been prepared as a tourist lake with the construction of a floating hut, and a large signboard, which is the BUMDES of Muara Jambi Village. River Width: 65.45 m	
Water quality data 2023 River depth = 6-8 m Temperature = 28.80^{0}C DO = 5 ppt pH = 8.3 Conductivity =30.4 2024 River depth = 6.8 m Temperature = 31.6^{0}C DO = 4.1 ppt pH = 6.77 Conductivity =73.9	
Methods (fishing gear): Nets, umbrella bubu, and fishing rods Other Tools: Garmin GPS, DSLR Camera, Lucky FF918C Fish Finder, Water quality Meter AZ86031, Sacchi disk, specimen conservation kit	

Biodiversity of Ikhtiofauna Kelari Lake Muaro Jambi

Based on the results of the iktiofauna (fish) biodiversity research in Lake Kelari Muara Jambi on 2023-2024, 86 fish samples were successfully collected and given the sample code of Muara Jambi temple fish (ICM). The sample after the photo was preserved in 10% formalin. Overall, the diversity of fish in Lake Kelari Muara Jambi is as many as 13 species of fish.

The analysis results of the fish diversity index in Lake Kelari in 2023 and 2024 fall into the moderate category, with 1< H' < 3.

Table 3. Fish Diversity Index in Lake Kelari

Year	Diversity Index Value	Criterion
2023	1.63	Medium
2024	1.60	Medium

The analysis results of the fish Similarity Index in Lake Kelari in 2023 and 2024 fall into the High species high category, with an E value of <1.

Table 4. Fish Similarity Index in Lake Kelari

Year	Similarity Index Value	Criterion
2023	0.84	High
2024	0.77	High

The analysis results of the fish dominance index in Lake Kelari for the years 2023 and 2024 fall into the category of no dominant species, with a value of $0.5 < C < 1$.

Table 5. Fish Dominance Index in Lake Kelari

Year	Dominance Index Value	Criterion
2023	0.23	No fish dominate
2024	0.25	No fish dominate

The research results indicate that the IUCN status of fish in Lake Kelari includes a species classified as Vulnerable (VU), namely *Hemibagrus planiceps*.

Table 6. Types of Fish, Conservation Status and Potential in Lake Kelari in the Rainy and Dry Season

No	Family	Local Name	Species	IUCN	Potential
I	Bagridae	Senggiring	*Hemibagrus planicep*	VU	Ornamental Consumption
II	Chanidae	Gabus	*Channa gachua*	LC	Consumption
III	Cyprinidae	Sitam	*Labeo chryssophedion*	LC	Ornamental
		Aji-aji	*Tetrazone pointigrus*	LC	Ornamental
		Kepras kecil	*Anematichthys repason*	LC	Consumption
		Bentulu	*Barbichytys levis*	LC	Consumption
		Susur Batang	*Epalzeorhynchos kalopterus*	LC	Ornamental
		Seburuk Perut	*Osteochilus spylurus*	LC	Consumption
		Bengalan/ lampam	*Puntioplites waandersi*	LC	Consumption
IV	Danionidae	Seluang	*Rasbora dusonensis*	LC	Consumption
V	Pangasidae	Patin	*Pangasius pangasius*	LC	Consumption
VI	Siluridae	Lais	*Cryptopterus limpok*	LC	Consumption
VII	Xenocyprididae	Parang-arang	*Oxygaster anomalura*	LC	Consumption

The research results in 2023 recorded seven fish species caught in Lake Kelari, with a total of 38 fish classified under the IUCN status of Least Concern (LC).

Table 7. Types of Fish Caught in Lake Kelari in the 2023 Rainy Season

No	Famili	Local Name	Species	IUCN	Fish Abundance
1	Cyprinidae	Kepras kecil	*Anematichthys repason*	LC	9
2	Cyprinidae	Bentulu	*Barbichytys levis*	LC	1
3	Cyprinidae	Susur batang	*Epalzeorhynchos kalopterus*	LC	12
4	Cyprinidae	Seburuk perut	*Osteochilus spylurus*	LC	1
5	Pangasidae	Patin sungai	*Pangasius pangasius*	LC	9
6	Cyprinidae	Ikan Elang/Aji-aji	*Tetrazone pointigrus*	LC	2
7	Cyprinidae	Bangalan/lampam	*Puntioplites waandersi*	LC	4

The 2024 research results show that the number of fish species caught was higher than in 2023, with a total of 8 fish species recorded in Lake Kelari. The total number of fish caught was 48, including one species classified as Vulnerable (VU) according to the IUCN.

Table 8. Types of Fish Caught in Kelari Lake in the Dry Season in 2024

No	Famili	Local Name	Species	IUCN	Fish Abundance
1	Chanidae	Gabus	*Channa gachua*	LC	1
2	Bagridae	Senggiring	*Hemibagrus planicep*	VU	3
3	Siluridae	Lais	*Cryptopterus limpok*	LC	15
4	Cyprinidae	Sitam	*Labeo chryssophedion*	LC	15
5	Xenocyprididae	Parang-arang	*Oxygaster anomalura*	LC	2
6	Pangasidae	Patin	*Pangasius pangasius*	LC	1
7	Cyprinidae	Aji-Aji	*Tetrazone pointigrus*	LC	1
8	Danionidae	Seluang	*Rasbora dusonensis*	LC	10

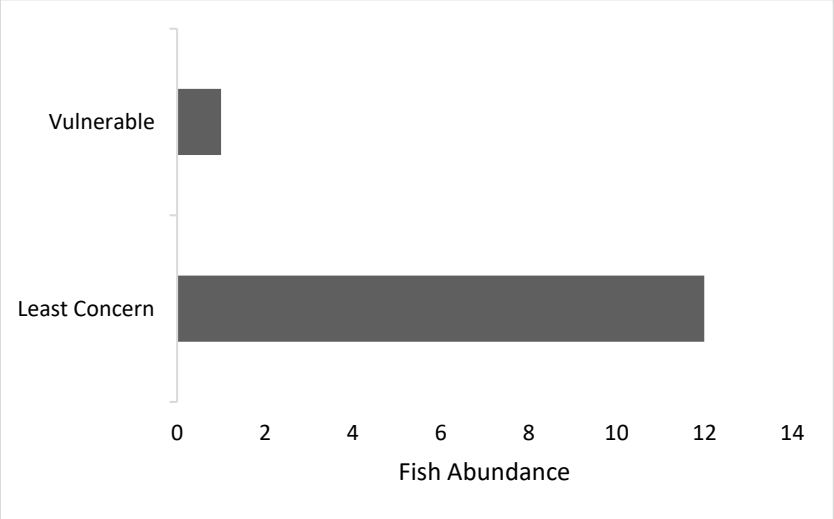


Figure 3. IUCN Red List Fish Category in Lake Kelari

Most of the fish found in Lake Kelari are consumption fish. A total of 9 species are consumption fish, 3 species are ornamental fish, and one type of ornamental consumption fish. Based on this survey data, it shows that the economic potential of fish in Lake Kelari is quite high (Figure 4).

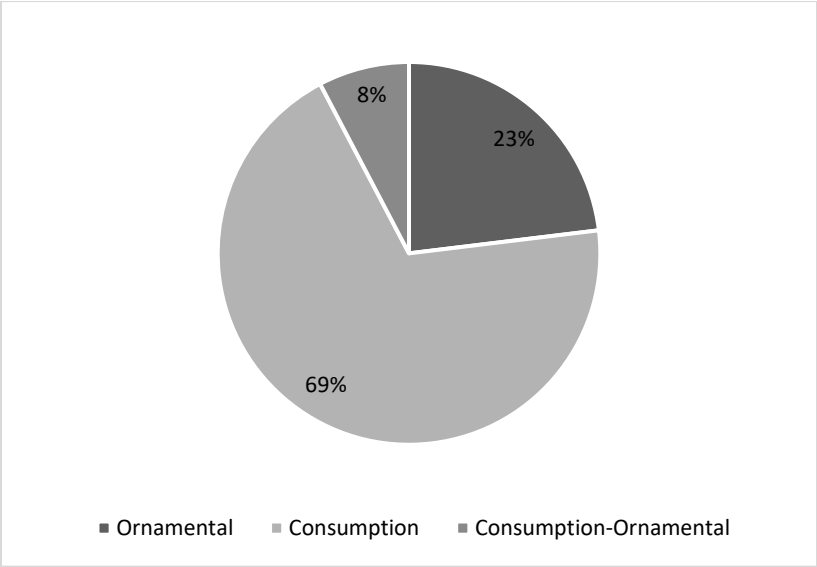


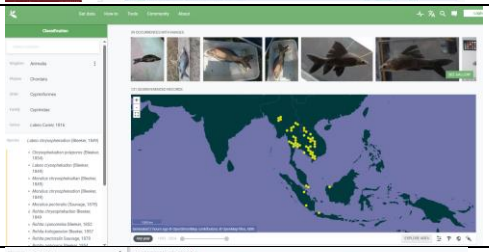
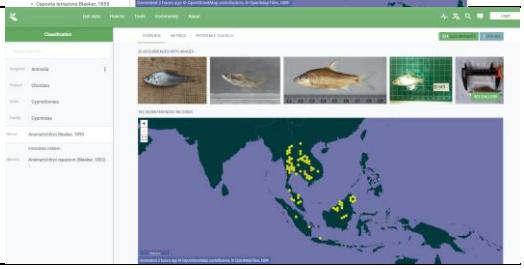
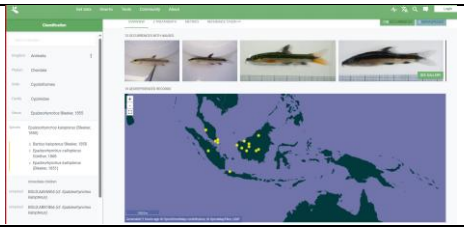
Figure 4. The Potential of Kelari Lake Fish

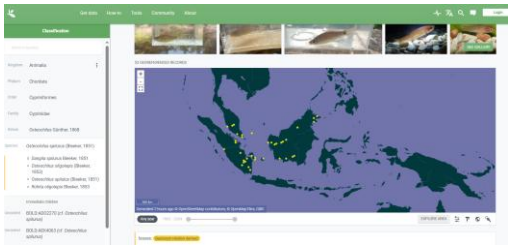
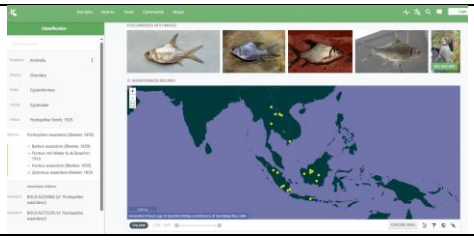
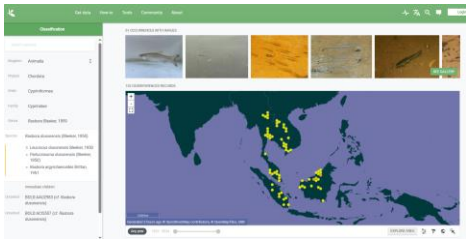
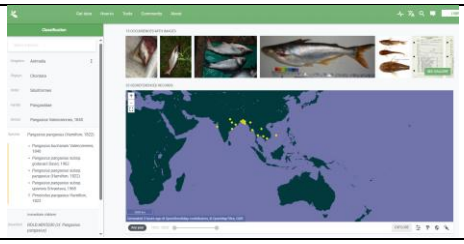
Some of the Lake Kelari Muara Jambi Fish have the potential for consumption and ornamental are presented in Figure 5.

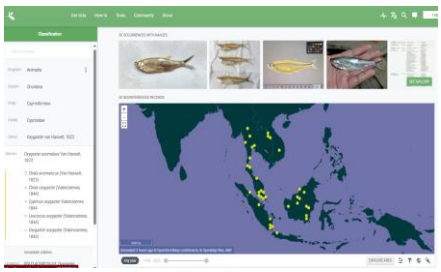
Figure 5. Consumption Fish and Ornamental Fish in Lake Kelari

The results of this study were analyzed for fish distribution using the Global Biodiversity Information Facility (GBIF).

Table 9. Lake Kelari Fish Spark Plug Distri Based on GBIF

No	Species	Status	Global Distribution	GBIF
1	*Hemibagrus planicep*	Endemic Sumatra, Kalimantan	Not Recorded	
2	*Channa gachua*	Endemic	Afghanistan in the west to Indonesia through South and Central Asia.	
3	*Labeo chryssophedion*	New Record	Southeast Asia: Sundaland to Vietnam.	
4	*Tetrazone pointigrus*	Endemic to Indonesia	Southeast Asia	
5	*Anematichthys repason*	New Record	Mekong and Chao Phraya basins, Malay Peninsula, Sumatra, Java and Borneo.	
6	*Barbichthys laevis*	New Record	Asia: Malay Peninsula, Sumatra, Borneo and Java (Ref. 26580); Mekong and Chao Phraya basins (Ref. 43281).	
7	*Epalzeorhynchos kalopterus*	New Record Jambi	lower half of the Malayan/Thail and peninsula, Borneo, Java	

No	Species	Status	Global Distribution	GBIF
			and Sumatra in Indonesia.	
8	*Osteochilus spilurus*	Endemic	Southeast Asia. Isthmus of Kra (southern Thailand), Malaya (Malaysia), Sumatra (Indonesia) and Borneo (Brunei, Indonesia, Malaysia).	
9	*Puntioplites waandersi*	New Record	Southeast Asia	
10	*Rasbora dusonensis*	Endemic to Indonesia	Southeast Asia: Malaya (Malaysia), Sumatra and Borneo (Indonesia); Yunnan (China)	
11	*Pangasius pangasius*	New Record	INDIA	
12	*Cryptopterus limpok*	Endemic Sumatra, Kalimantan	Southeast Asia: Malaya (Malaydia), Sumatra (Indonesia), western Borneo (Indonesia, Malaysia)	

No	Species	Status	Global Distribution	GBIF
13	*Oxygaster anom alura*	New Record Jambi	Cambodia, southern Thailand, Malaya (Malaysia), Sumatra (Indonesia), Borneo (Indonesia, Malaysia).	

DISCUSSION

The quality of the waters in Lake Kelari obtained in 2023 and 2024 is no different. In 2023 the DO value of 5ppt is higher than the DO value of 4.1 ppt in 2024. Riparian vegetation found in Lake Kelari includes: 1) Ganefo / Kiambang *(Salvinia molesta*) 2) Kiambang thorns (*Trapa natans*), 3) Apu-Apu (*Pistia stratiotes*), 4) Hidrilla (*Hydrilla verticillate),* 5) Kale (*Ipomea batatas*).

Biodiversity of Ikhtiofauna Kelari Lake Muaro Jambi

The Diversity Index value obtained in 2023 (1.63) and in 2024 (1.60). Every year shows the value of the medium category diversity index because 1 < H' < 3 = Medium type diversity. This indicates that the habitat conditions in Lake Kelari are still optimal. This is in line with Erika (2028), who stated that a medium diversity criterion suggests that the fish habitat remains in an optimal state and is still suitable for biota. Diversity index (H') and similarity index (E) are indices commonly used to evaluate the condition of an aquatic environment (Muhammad, 2020). Diversity index in Lake Kelari show there are still many types of fish species, this is suspected to be due to habitat conditions that are very supportive of fish life such as the existence of migration routes that can be passed by fish from the Batanghari River to the lake or vice versa. Ridho & Patriono (2020) stated that the inflow and exit of the lake function to maintain the existence of aquatic macrophytes as microhabitats, providing nutrients to plant-eating fish. It is suspected that these ecological conditions cause more types of fish than ecological conditions with limited microhabitats and sources of nutrients.

The results of the analysis of the Similarity Index values in 2023 (0.84) and 2024 (0.77) show high population similarity, because the value of E < 0.6. The high value of the fish similarity index in Lake Kelari shows that the distribution of individuals between fish species is evenly distributed. This is in accordance with the opinion of Pariyanto *et al.* (2021) that if the value of the similarity index is close to the value of one, the distribution will be evenly distributed with the wealth of each individual equal.

Based on the results of the analysis of the Dominance Index, the values obtained in 2023 (0.23) and 2024 (0.25) show a value of 0<D≤0.50 criterion that no fish species dominate this indicates that the fish in Lake Kelari do not exhibit specific or temporal dominance and remain in a stable condition. A stable environment is characterized by a balanced state and diverse life forms without any dominant species (Aprilia *et al*., 2023). This occurs because the pattern of distribution of fish species occurs evenly or uniformly in Dana Kelari, in accordance with the opinion of Kiki *et al.,* (2018) that a uniform distribution pattern occurs due to individual

competition so as to encourage an even distribution of space. The Dominance Index (C) is low, indicating no fish species dominates. This proves that fish in each station remain stable in an environment that supports diversity without the dominance of a specific species (Manullang *et al*.,2020; Purba *et al*., 2024).

Table 6 shows that 7 fish families in Lake Kelari are 100% native and native to Indonesia, Introduced and invasive fish that have been popularly cultivated such as: carp (*Cyprinus carpio*), dumbo catfish (*Clarias gariepinus*), tilapia (*Oreochromis niloticus*), mujair (*Oreochromis mossambicus*), (Dewantoro & Rachmatika, 2016), not found in the Kelari Lake area. This shows that the habitat of Lake Kelari is still very well maintained. The number of fish caught in Lake Kelari in the 2023 Rainy Season (Table 7) and the number of fish caught in the 2024 dry season (Table 8) are not much different. A total of 38 fish with 7 species of fish were caught in the 2023 dry season and 48 fish with 7 species were caught in the 2024 rainy season.

The most catch in the 2023 rainy season is the stem tree (*Epalzeorhynchos kalopterus*) which is a species native to Indonesia that has a Data Deficient status in the IUCN Red List. It has a very high commercial value (Shaykh & Hidayat, 2021), meaning that data on its population in the wild is still limited, so it is vulnerable to the risk of undetected population decline. As an endemic fish, its existence in Lake Kelari shows the importance of this area as a natural habitat that supports the survival of rare species. By making Lake Kelari a *forbidden spot*, the protection of this species can be increased by restricting fishing activities in Lake Kelari, so that the stem fish (*Epalzeorhynchos kalopterus*) can breed and maintain population stability. It also supports efforts to conserve biodiversity in Indonesian waters and provides an opportunity for further studies related to the ecology and population status of the stem fish (*Epalzeorhynchos kalopterus*) in its natural habitat. According to Sukmaningrum *et al.,* (2022); Sukmono *et al.,* (2017) stated that through conservation, the diversity of endemic fish species can be maintained in their natural habitats.

The results of this study can be a strong enough basis to consider the establishment of a prohibition pit in Lake Kelari, especially to protect the diversity of species of consumption fish and ornamental fish. Considering that fish consumption dominates the population (69%) and has an important role in meeting the food needs of the community, the establishment of a prohibition pit in Lake Kelari will help preserve Lake Kelari fish from overexploitation. In addition, the existence of a significant ornamental fish population (23%) also requires protection so that economic potential and biodiversity are maintained. This is supported by the statement of Dani *et al*. (2016) which stated that the prohibition helps provide a safe environment for fish to breed naturally and maintain long-term stocks, supporting the economic sustainability of the surrounding community. The establishment of the prohibition pit is expected to support sustainable fisheries management, maintain the natural habitat of fish, and provide time for species of consumption and ornamental value to breed, thereby increasing long-term fish stocks for the surrounding community.

GBIF is a data information system that collects, integrates, and distributes data on plant species, animals, and microorganisms, including information about their habitat, distribution, and conservation status. GBIF supports the importance of collaboration between countries and organizations to improve the accuracy of global biodiversity data, including data from high-biodiversity regions such as Indonesia. This collaboration plays an important role in improving data management standards in various countries (Hobern & Miller, 2019).

The results of the study show the existence of a species *of Pangasius pangasius* in Lake Kelari, which is documented as one of the consumption fish with significant economic

potential for the local community. However, an analysis of global distribution based on Global Biodiversity Information Facility (GBIF) data shows that this species is not officially registered in Indonesia. This creates discrepancy, considering that *Pangasius pangasius* or catfish is widely found and even cultivated in Indonesia. According to Nevriansyah *et al.* (2022) catfish (*Pangasius* sp.*)* is very popular in Indonesia because of its high economic value and easy to cultivate.

CONCLUSION

The results of this study give a conclusion that the catch in Lake Kelari in the rainy season is 7 and the dry season is 8 species of fish. The conservation status of fish in Lake Kelari has one species with Vulnerable status, namely the senggiringan fish (*Hemibagrus planicep*). The biodiversity index shows a medium criterion. Based on global distribution, there are still catfish that are not recorded in GBIF in Indonesia, but these fish are widely distributed in most of Indonesia. Based on the potential of Lake Kelikari, this area can be recommended for management by designating it as a Lubuk Larangan area.

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