



Lake Batur Ichthyofauna in Bali, Indonesia

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ABSTRACT

The largest lake on the island of Bali is Lake Batur. Fish diversity in Lake Batur is still not well understood. In order to offer correct information on the diversity of species that occur there, this research intends to update the record of fish diversity in Lake Batur. Over the lake area, observations were made at five stations throughout the dry season of 2022, which ran from August 30 to September 5th. Nine indicators of water quality were measured across all stations. In order to gather samples, fishing rods, communal 2-3-inch nets, experimental gillnets with a mesh size of 1 inch, and scoops were used. For the purpose of identifying the species, all samples were kept in 10% formalin. There were 1,104 fish samples from the lake. Abangsongan Station 4 has the most fish. The outcomes demonstrated that the water is still of acceptable quality up to the seichi disk depth. 17 species were present, which were split into 14 genera and 9 families. According to this study, Lake Batur has a remarkable diversity of fish, including climbing perch (*Anabas testudineus*), snakeskin gourami (*Trichopodus pectoralis*), and blue gourami (*T. trichopterus*) and beardless barb (*Cyclocheilichthys apogon*), all of which were previously unknown. The Asian swamp eel (*Monopterus albus*) and milkfish (*Chanos chanos*) were not discovered, and several scientific names are inaccurate.

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Authors' Contribution

RG, GSH, IWA and SL designed the topic and method of this research. SA, TN and GRAK assisted in the field work and data collection. RG wrote the manuscript. HH and GW assisted in samples identification.

Key words

Lake Batur, Bali, Water quality, Fish, Indonesia

INTRODUCTION

The largest lake on Bali is Lake Batur. During the formation of this lake, Old Mount Batur, which is more than 3,000 meters above sea level, erupted twice (asl). Around 29,300 years ago, the Batur volcano erupted, destroying the mountain's summit. Lake Batur is a lake inside an active caldera and is located at an altitude of 1,050 meters above sea level. The lake has an average depth of 50.8 meters, a water surface area of 16.05 km², and a water volume of 815.38 million m³. The lake's water source comes from rainfall and seepage from the neighboring mountains, which have a catchment area of 105.35 km². The coastline

of Lake Batur is approximately 21.4 kilometers long and is comprised of two distinct topographies: Mountain Mount Batur, which is 1,717 meters above sea level, is in the west. In the north, east, and south, steep mountainous terrain leads to mountains (Mount Abang with an altitude of 2,172 m asl).

The variety of fish in Lake Batur is still not fully understood despite the fact that various investigations have been done there. Wijaya *et al.* (2012) conducted research on the lake's water quality and fish resource production potential, as well as a carrying capacity and feasibility analysis of the Lake Batur ecosystem (Budiasa *et al.*, 2018). Fish introduction through stocking is a common practice in Lake Batur, albeit the presence of imported fish at first is not known with certainty due to the lack of information on the condition of fish resources prior to their introduction (Umar and Suliaman, 2013).

Some of the fish species that are regularly stocked in Lake Batur are grass carp, common carp, Mozambique tilapia, silver barb, and Nile tilapia (Wijaya *et al.*, 2012). Tilapia, rasbora, guppy, swordtail, red devils, milkfish, eels, and spotted barb were found by Santosa and Wijaya

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(2013) and Juliawan *et al.* (2020). A thorough and integrated cross-disciplinary study must take into account the condition of the waters and the fish resources found there. In order to offer correct information regarding the diversity of existing species in Lake Batur, this research attempts to update the record of fish diversity in the lake.

MATERIALS AND METHODS

Five stations were selected for the observations based on prior work by Juliawan *et al.* (2020) (Fig. 1). Information about the stations can be found in Table I. The sampling was done between August 30 and September 5, 2022, which was the dry season.

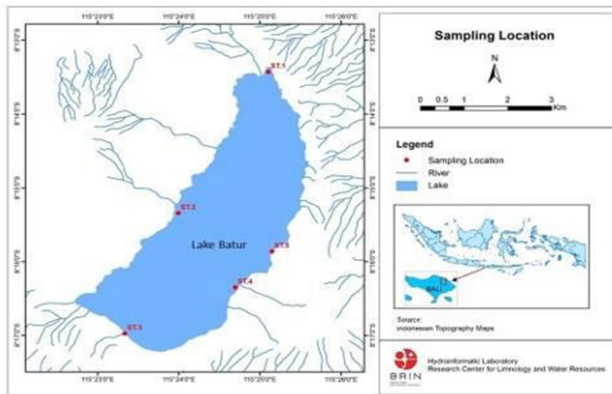


Fig. 1. Sampling location in Lake Batur, Bangli Regency, Bali province. Villages are represented as Station 1, Songan; 2, Toya bungkah; 3, Kedisan; 4, Abangsongan; 5, Cemara Landung.

At each location, water was measured and sampled both above the surface and at the sechi depth. Temperature, pH, conductivity, dissolved oxygen (DO), total dissolved solid (TDS), and salinity were measured in situ to determine the water quality. In the meantime, measurements of total suspended solid (TSS), chlorophyll a, total nitrogen (T-N), total phosphorus (T-P), and chemical oxygen demand were made in water samples (COD). The samples were placed in a 250 ml sample tube, preserved by refrigeration,

and then sulfuric acid was added to bring the pH down to 2. Fish were sampled using fishing rods, community nets with a mesh size of 2-3 inches, experimental gillnets with a mesh size of 1 inch, and fish scoops in floating net cages.

On a particular specimen of the observed species, pictures were taken. If there isn't a suitable photo representation, an image from another source will be used in its place. All materials were stored in 10% formalin for observation and identification. Fish samples were rinsed under running water in the lab to get rid of formaldehyde. After sorting them, they were put in a collection bottle that contained 70% alcohol. For identification, manual books written by Kottelat *et al.* (1993) is used.

RESULTS AND DISCUSSION

To provide a summary of each station that was observed both on the water's surface and at the depths of Seichi, the nine water quality metrics are displayed as bars. While the many fish species will be described and given a useful key to make it easier to identify fish in Lake Batur.

Water quality

The range of brightness values obtained with the Sechi disk, as illustrated in Figure 2, is 1.5 to 2.0 meters. Due to the abundance of phytoplankton, suspended materials, and

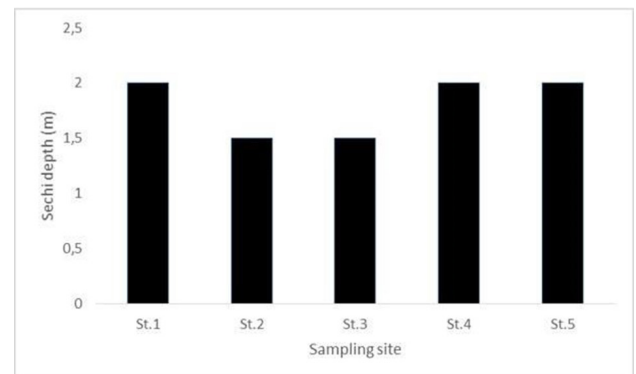


Fig. 2. Seichi disk brightness value in Lake Batur, Bali, Indonesia.

Table I. Details of station sampling locations in Lake Batur, Bali

Station	Sampling sites/ Villages	S	E	Altitude	Land use types
1	Songan	08° 13,624'	115° 24,910'	1033 m a.s.l	Agricultural area
2	Toya Bungkah	08° 15,111'	115° 24,924'	1057 m a.s.l	Floating net cage activities and tourism
3	Kedisan	08° 16,520'	115° 22,816'	488 m a.s.l	Dock area and community activities
4	Abangsongan	08° 16,415'	115° 24,528'	1200 m a.s.l	Water plant area
5	Cemara Landung	08° 15,458'	115° 25,882'	1200 m a.s.l	Floating net cage activity and fishing areas

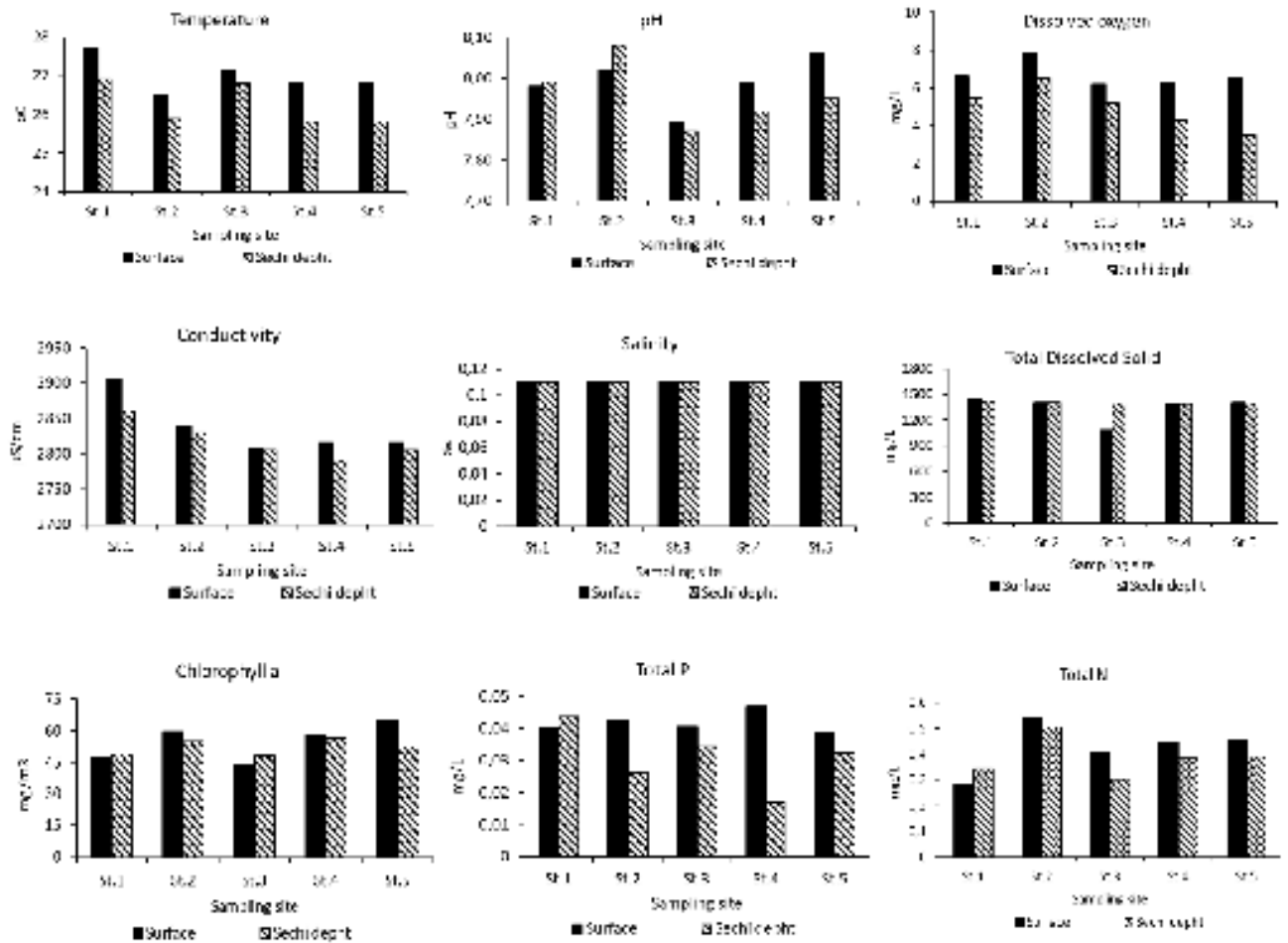


Fig. 3. Water qualities measurement at five observed stations in Lake Batur, Bali, Indonesia.

dissolved compounds, the lake's water condition at the time this research was done seemed greenish and slightly cloudy. The spatial distribution of the observed parameters is depicted in Figure 3. When compared to the other stations, station 1's water temperature has the highest value. According to Boyd (1990), the temperature range in Lake Batur is still within the ideal range for growth, which is between 18°C and 34°C. Both at the surface and at sechi depth, the water's acidity (pH) value at the study According to Boyd (1990), the temperature range of Lake Batur is still within the range of 18°C to 34°C, which is the ideal temperature range for growth. Both at the surface and at sechi depth, the water's pH value at the study site ranges from 7.9 to 8.1. The value is still within the range of 6.5 to 9.0, which is considered to be a good pH for finfish existence (Boyd and Tucker, 1998).

The dissolved oxygen content at the surface of the water is higher than at sechi depth. Dissolved oxygen is an important environmental parameter for the respiration of

lake fauna. During respiration, or consuming oxygen and expelling carbon dioxide while absorbing food molecules to obtain energy for growth and maintenance (Kulkarni, 2016). The conductivity, salinity, and TDS values at the study site are included in group D which indicates the condition of the water has not been polluted based on the quality standard Government Regulation No. 22 of 2021. The value of this water quality parameter is no different from the water quality value of Lake Batur 12 years ago (Wijana, 2016). In comparison to Sulawesty and Satya (2013) study, conductivity is higher but TDS is lower.

The following variables were total N, total P, and chlorophyll a. At Lake Batur's surface and seichi depth, Station 5 had the highest concentration of chlorophyll a (65.3 mg/m³) and station 3 had the lowest (43.6 mg/m³). The comparatively high amount of phytoplankton and the existence of blooms at numerous observation sites suggest that the observed area is quite productive, which is supported by the value of chlorophyll a concentration. The

high nutrient concentrations shown by total N and total P, which range between 0.2840.546 mg/L and 0.0170.047 mg/L, respectively, provide support for the phytoplankton findings. The waters of Lake Batur are categorized as eutrophic based on fertility criteria (eutrophication) and the three indicators stated above (Radiarta and Sagala, 2012). The availability of oxygen in the water can be disrupted by water fertility that exceeds the tolerance limit, which can impact the sustainability of aquatic biota, particularly fish. The values of chlorophyll a, N, and P are higher in this study than in a previous one by Suwesty and Satya (2013).

Fish diversity

The survey resulted in the collection of 1,104 fish samples from five distinct sites. Comparatively speaking, Station 4, Abangsongan, has the most fish. The findings indicated that there were 17 species, 14 genera, and 8 families. Figure 4 displays the diversity of fish at each location in Lake Batur.

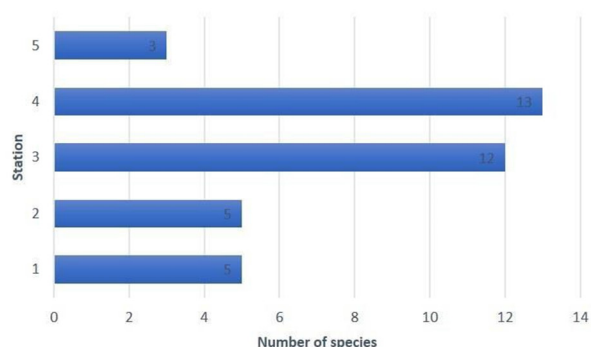


Fig. 4. Number of species at each station. 1, Songan; 2, Toya Bungkah; 3, Kedisan; 4, Abangsongan; 5, Cemara Landung.

Below is a description of the specific fish species that were obtained for this investigation (Fig. 5). Only seven of the nine species were recorded compared to the Santosa and Wijaya (2012) investigation, which was the preceding one. Two species of Asian milkfish (*Chanos chanos*) and swamp eels (*Monopterus albus*) were not discovered in the investigation. The different species that can be found in Lake Batur are described below, along with helpful tips.

Family: Cichlidae

One nostril is present on each side of the head of this family. The lateral line is separated into two halves; the front is curled parallel to the dorsal fin's base, while the back is straight. These traits describe the members of this family that can be found in Lake Batur:

1. Body is grayish-black with vertical stripes, and the fins are more acute than those of a Mosambique tilapia fish. *Oreochromis niloticus*

2. The body is blackish, the outer dorsal and tail fins are reddish in color; the mouth is bigger and wider than the Nile tilapia *Oreochromis mosambicus*

3. Head shape tapered at the mouth, body thin, red/gray-black, plain/vertical line from back to belly/blotch on body/patched on dorsal side..... *Amphilopus citrinellus*

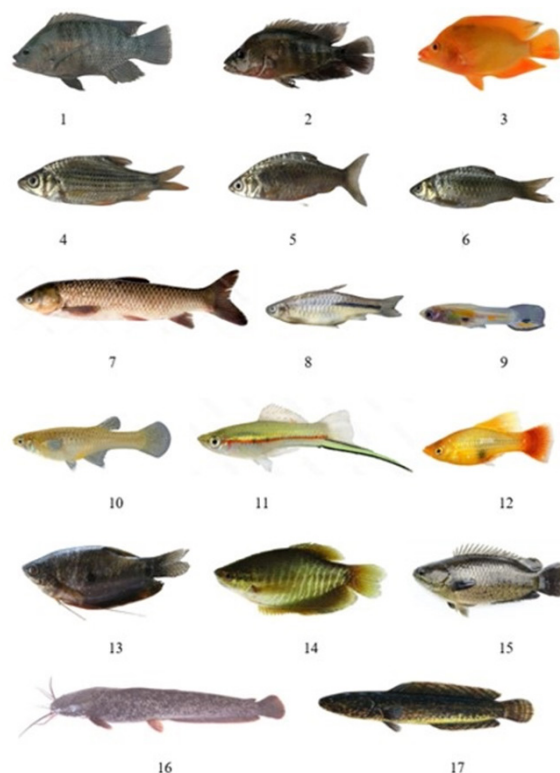


Fig. 5. Lake Batur fish species in Bali, Indonesia. 1, *Oreochromis niloticus*; 2, *Oreochromis mosambicus*; 3, *Amphilopus citrinellus*; 4, *Cylocheilichthys apogon*; 5, *Barbonymus goniotus*; 6, *Barbodes binotatus*; 7, *Ctenopharyngodon idella*; 8, *Rasbora lateristriata*; 9, *Poecilia reticulata*; 10, *Gambusia affinis*; 11, *Xiphophorus hallery*; 12, *Xiphophorus maculatus*; 13, *Trichopodus trichopterus*; 14, *Trichopodus pectoralis*; 15, *Anabas testudineus*; 16, *Clarias gariepinus*; 17, *Channa striata*.

Family: Cyprinidae

The largest family of freshwater fish, which is dispersed throughout practically the entire globe. Members of this family are distinguished by the presence of pharyngeal teeth that serve as food chews at the top of the throat. Members of this family that have been identified in Lake Batur have the following characteristics:

1. Perfect lateral line, lots of pores lined up parallel to head, no barbel, black spot at base of tail, row of black dots along scales..... *Cyclocheilichthys apogon*

2. Perfect lateral line, the scale structure on the lateral line is parallel or curved backwards, and it contains two pairs of barbels that are frequently small and inconspicuous, and they are higher in the back than *Barbodes*.....*Barbonymus gonionotus*

3. Perfect lateral line, the scale structure on the lateral line is parallel or curved backwards, and it contains two pairs of barbels, there is a round spot in front of the dorsal fin and the base of the tail or the tip of the anal fin*Barbodes binotatus*

4. Perfect lateral line, body elongated with relatively low back..... *Ctenopharyngodon idella*

Family: Danionidae

Elongated flat body, mouth generally pointing upwards, some have a knob at the end of the lower jaw, caudal fin is forked. The characteristics of members of this family found in Lake Batur are as follows:

1. Complete black stripe from operculum to base of caudal fin, 29-33 scales on lateral line, caudal fin with blurred black margin *Rasbora lateristriata*

Family: Poeciliidae

Slightly cylindrical body in the front and flattened to the back, there is a color pattern depending on the species. The characteristics of members of this family found in Lake Batur are as follows:

1. Males are light-colored with black spots above the anal fin and below the dorsal fin; has several color patterns *Poecilia reticulata*

2. Origin of dorsal fin opposite the anal-fin seventh weak spine, anal-fin base less than half of tail length, tip of ventral fin before anal fin *Gambusia affinis*

3. The caudal fin in males is long and pointed at a slightly lower angle; color patterns vary..... *Xiphophorus helleri*

4. Male fish do not have a notch in the lower corner of the caudal fin, the color pattern varies and sometimes the body has spots..... *Xiphophorus maculatus*

Family: Osphronemidae

Body flattened or rounded, snout short, mouth opening oval and small, caudal fin rounded or sickle-shaped, mains line complete and unbroken, second pelvic-fin rays long and filamentous. The characteristics of members of this family found in Lake Batur are as follows:

1. The pelvic fins are elongated and almost the same as the body length, the caudal fin is sickle-shaped and slightly concave, there are irregular black stripes across the body,

the body color is yellowish..... *Trichopodus pectoralis*

2. The pelvic fins are elongated and almost the same as the body length, the caudal fin is sickle-shaped, slightly concave, there is a dark oblique band and three black spots on the body, the body is bluish *Trichopodus trichopterus*

Family: Anabantiidae

It has hard scales, sharp dorsal and anal fin spines; operculum, suboperculum, and interoperculum serrated. The characteristics of members of this family found in Lake Batur are as follows:

1. Body shape is flat and oval with hard scales, large head, yellowish body sides, upper part of the body is dark black/brown/greenish, has vertical stripes; 15-19 spines on the dorsal fin and 9-11 spines on the anal fin *Anabas testudineus*

Family: Clariidae

Body without scales, slightly cylindrical in shape at the front and flattened backward, with two pair barbels, long dorsal and anal fins, pectoral fin with spine The characteristics of members of this family found in Lake Batur are as follows:

1. Dorsal fin, caudal fin, and anal fins are not united, head length 2.9-3.8 shorter than standard length, anterior crown reaches middle of eye, dorsal spine not sharp *Clarias gariepinus*

Family: Channidae

Body elongated, mandible prominent, dorsal and anal fins long, no pelvic fins in some species, no spines on all fins

1. Dorsal fin rays 38-43, anal 23-27, lateral line 52-57, color pattern in ‘<’ shape on body, stripes curved towards head on dorsal fin *Channa striata*

Geographically, the Wallace Line, whose western end is on the island of Lombok, lies immediately next to the easternmost tip of the Sunda Shelf, the island of Bali. As a result, it is thought that Java is where the flora and fauna of Bali are most likely to have originated. According to a prior study by Voris (2000), the islands of Java and Bali are frequently connected, which leads the Java Island's flora and fauna to become Bali Island's, or vice versa, resulting in the island of Bali having a low percentage of unique flora and fauna (Tanzler *et al.*, 2014). According to Freoese and Pauly (2022), there are 1263 native freshwater fish species in Indonesia, 247 alien species (Dina *et al.*, 2022), and 400 endemic species (Hubert *et al.*, 2015). According to Kottelat *et al.* (1993) and Kottelat (2013), two species of aquatic fish are endemic to the island of Bali, *Lentipes whittenorum* and *Rasbora baliensis* (Brittan, 1954), which surround the forgotten Gitgit waterfalls (Brittan, 1954).

Dahrudin *et al.* (2017) reported new discoveries of several other endemic freshwater fish species found on the island of Bali, although it is a Bali-Java endemic species, *Lentipes ikeae* and *Sicyopus rubicundus*, as well as a Bali-Lombok-Java endemic species, *Stiphodon aureofuscus*.

In order to prevent the introduction of foreign fish from contaminating their habitats, it is necessary to maintain these endemic fish species. Taxonomically, study on Bali-specific or Bali-Lombok-Java-specific fish is still in its infancy. This condition may be brought on by the size of the fish and the comparatively small number of endemic species, which makes it challenging to study and less appealing to researchers.

Keep in mind that only six of the 17 fish species collected are indigenous to Indonesia, with the remainder having been introduced. *Cyclocheilichthys apogon*, *Barbonymus goniotus*, *Barbodes binotatus*, *Rasbora lateristriata*, *Channa striata*, and *Anabas testudineus* are the names of the species. In the meantime, only three native fish species (*Osteochilus vittatus*, *Barbodes binotatus*, and *Rasbora argyotaenia*) have been identified in three other lakes in Bali (Taradihpa *et al.*, 2018; Parawangsa *et al.*, 2019; Pertamina *et al.*, 2019). In Lake Bratan, seven species have been reported (*Osteochilus hasselti*, *Rasbora* sp., *Tor tambra*, *Clarias batrachus*, *Ophiocephalus striatus*, *Anabas testudineus*, *Trichogaster pectoralis*) (Restu *et al.*, 2018). Until now, there have been very few related studies with endemic species on the island of Bali, particularly endemic to freshwater fish, where these studies have only been carried out by a few researchers with limited sampling point locations. As a result, the possibility of discovering new endemic species on the island of Bali remains very high.

Based on the observational data of the nine observed parameters, the water quality in Lake Batur remains good for fish survival. However, with the massive development of tourism as a source of income/foreign exchange for Bali, many land conversion activities are unavoidable in order to support this sector. Furthermore, tourism increases anthropogenic activities such as clearing land for agricultural, fishing, and animal husbandry activities, which will contribute to Lake Batur's water quality deterioration. Overall, Lake Batur has a high level of fish diversity when compared to other freshwater areas in Bali. Despite the fact that native Indonesian fish account for only 30% of the species in Lake Batur. However, Lake Batur has a higher percentage of native fish than Lakes Buyan, Tambiingan, Bratan. In terms of fish diversity, the types and species composition of fish populations must be measured on a regular and accurate basis to ensure that no species dominates, resulting in invasive species, as is often the case in Indonesian fresh waters (Dina *et al.*, 2022).

CONCLUSIONS

The water quality in Lake Batur remains good for fish survival. We discovered 17 species in Lake Batur, belonging to 14 genera and 8 families, six of which were indigenous to Indonesia. It is hoped that the water quality and fish diversity in Lake Batur will be documented and used as material for recommendations for Lake Batur management and utilization that will be more optimal for regional income, community welfare, and providing nutrition for Lake Batur residents.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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