

Freshwater fish diversity in semi-urban artificial lakes: A case study from IPB Dramaga Campus, Indonesia

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ABSTRAK

Keanekaragaman ikan merupakan indikator penting dalam menilai stabilitas dan kualitas ekosistem perairan tawar, terutama di kawasan semi-urban yang rentan terhadap tekanan antropogenik. Kajian ini menganalisis keanekaragaman ikan di tiga danau buatan di Kampus IPB Dramaga, yaitu Danau LSI, Danau SDGs, dan Telaga Inspirasi. Pengambilan sampel dilakukan pada April 2025 menggunakan metode penangkapan kombinasi aktif dan pasif. Seluruh spesimen ikan yang tertangkap diidentifikasi hingga tingkat spesies, kemudian keanekaragaman ikan pada setiap danau dianalisis menggunakan indeks Shannon, Simpson, dan Evenness. Dua belas jenis ikan dari sembilan suku berhasil diidentifikasi. Lima jenis diantaranya merupakan introduksi, dengan *Oreochromis niloticus* dan *Poecilia reticulata* sebagai jenis dominan. Telaga Inspirasi mencatat indeks Shannon tertinggi (1,390) dan nilai Simpson terendah (0,733), menunjukkan tingkat keanekaragaman relatif lebih tinggi dengan dominansi jenis yang lebih rendah. Danau LSI menunjukkan kekayaan jenis tertinggi (10 jenis), namun dominansi tinggi (Simpson 0,581). Sementara itu, Danau SDGs memiliki distribusi individu paling merata (Evenness 0,610). Seluruh parameter lingkungan berada dalam kisaran yang mendukung kehidupan ikan. Temuan ini menunjukkan bahwa keanekaragaman ikan di danau-danau Kampus IPB Dramaga dipengaruhi oleh variasi komposisi jenis serta dominansi beberapa jenis introduksi. Pemantauan ekologis secara kuantitatif berperan penting dalam pengelolaan biodiversitas ikan air tawar di ekosistem perairan semi-urban.

Kata kunci: danau buatan, ekosistem semi-urban, IPB Dramaga, keanekaragaman ikan.

ABSTRACT

Fish diversity is widely used as an indicator of freshwater ecosystem stability and environmental quality, particularly in semi-urban areas experiencing increasing anthropogenic pressure. This study assessed fish diversity in three artificial lakes on the IPB University Dramaga Campus: Lake LSI, Lake SDGs, and Telaga Inspirasi. Sampling was conducted in April 2025 using a combination of active and passive capture methods. Collected specimens were identified to species level, and diversity was evaluated using the Shannon, Simpson, and evenness indices. A total of 12 fish species from nine families were recorded. Five species were introduced, with *Oreochromis niloticus* and *Poecilia reticulata* identified as the dominant taxa. Telaga Inspirasi exhibited the highest Shannon index (1.390) and the lowest Simpson value (0.733), indicating relatively high diversity and low dominance. Lake LSI supported the greatest species richness (10 species) but showed relatively high dominance (Simpson index = 0.581). Lake SDGs displayed the highest evenness value (0.610), reflecting a more balanced distribution of individuals. Environmental parameters at all sites remained within suitable ranges for fish survival. These findings highlight differences in fish community structure among lakes and emphasise the importance of ecological monitoring for freshwater biodiversity management.

Keywords: artificial pond, fish diversity, IPB Dramaga, semi-urban ecosystem.

INTRODUCTION

Lakes represent one of the main freshwater ecosystems with an important ecological role in maintaining biodiversity and sustaining the stability of aquatic ecosystem functions (Heino et al., 2021). Lake ecosystems provide a wide range of habitats for aquatic organisms, including fish, which serve as key components of trophic networks and as biological indicators of changes in environmental conditions (Reshetnikov & Tereshchenko, 2019). Changes in fish composition and abundance within a water body can reflect underlying ecological dynamics and provide valuable information on ecosystem health status and community responses to environmental pressures, particularly those associated with anthropogenic activities (Pinna et al., 2023; Puspitarini, 2017). Fish diversity is therefore widely used as an indicator of aquatic ecosystem quality, as higher levels of fish diversity are generally associated with relatively stable ecosystems that can sustain their ecological functions effectively (Hazri & Noor, 2024). Studies on freshwater fish diversity are consequently essential as baseline data for conservation efforts and the management of aquatic ecosystems.

Fish diversity within aquatic ecosystems is shaped by a range of environmental factors, including both abiotic and biotic components. Abiotic variables such as temperature, pH, dissolved oxygen concentration, water transparency, and habitat characteristics play an important role in determining the distribution, abundance, and physiological tolerance of different fish species (Glińska-Lewczuk et al., 2016; Paller et al., 2017). In addition, biotic interactions, including interspecific competition, predation pressure, and the presence of introduced species, can also influence fish community composition (Gebrekiros, 2016). The introduction of non-native species into aquatic ecosystems is known to alter species diversity by increasing the dominance of certain taxa and intensifying competition for available resources with native species (Reid et al., 2019).

Assessments of fish communities in aquatic ecosystems commonly focus on several key components, including species richness, species diversity, evenness of individual distribution among species, and the dominance of particular species within the community (Muslim & Syaifudin, 2022). Ecological indices such as the Shannon–Wiener, Simpson, and evenness indices are widely applied to quantify these components. The Shannon index primarily reflects overall species diversity, whereas the Simpson index emphasises the degree of species dominance, and the evenness index describes how evenly individuals are distributed among species within a community (Muslim & Syaifudin, 2022). Together, these indices allow for a more comprehensive evaluation of fish diversity in aquatic ecosystems.

The IPB University campus in Dramaga, Bogor, is widely recognised as a biodiversity-oriented campus situated within a semi-urban landscape that supports high biodiversity potential, including freshwater aquatic ecosystems. Aquatic habitats at the IPB University Dramaga Campus consist of three artificial lakes—Lake LSI (situ Leutik and situ Perikanan), Lake SDGs, and Telaga Inspirasi—distributed across different areas of the campus and playing an important role in supporting ecological functions and biodiversity conservation within the semi-urban campus environment (Satria et al., 2023;

Ageriyanto, 2012). However, scientific studies addressing fish diversity in the aquatic environments of the IPB campus remain limited (Ageriyanto, 2012).

Among the three main lakes at the IPB University Dramaga Campus, only Lake LSI has previously been examined with respect to fish species diversity. Records of species introduction and earlier studies indicate that fish species richness in Lake LSI has shown considerable fluctuation between 1985 and 2011. These changes reflect not only variations in species richness but also an increasing contribution of introduced species to the lake's fish community (**FIGURE 1**). Surveys conducted between 1987 and 1992 recorded six fish species: *Clarias batrachus* (walking catfish), *Betta splendens* (Siamese fighting fish), *Channa striata* (snakehead), *Oreochromis mossambicus* (Mozambique tilapia), *Oreochromis niloticus* (Nile tilapia), and *Barbonymus gonionotus* (silver barb) (Ageriyanto, 2012). Three of these species—*C. batrachus*, *B. splendens*, and *C. striatus*—were identified as native species (Wijaya, 1991). A subsequent survey in 1992 recorded six species with a composition different from that observed in 1987, while studies conducted in 2010–2011 identified nine species, including four not previously reported: *Osteochilus hasseltii* (nilem), *Oxyeleotris marmorata* (marble goby), *Pterygoplichthys pardalis* (suckermouth catfish), and *Trichogaster trichopterus* (three-spot gourami) (Sulistiono et al., 1992). By 2012, species richness had declined to six species (Ageriyanto, 2012). This pattern indicates that the fish community in Lake LSI is highly dynamic and strongly influenced by interactions between natural ecological processes and human activities.

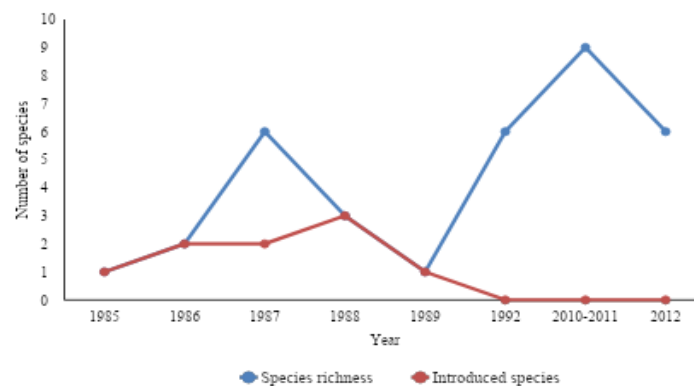


FIGURE 1. Temporal changes in fish species richness in Lake LSI, IPB University Dramaga Campus, based on introduction records and previous studies from 1985–2011 (Wijaya et al., 1991; Sulistiono et al., 1992; Ageriyanto, 2012).

Information on fish community structure in the other lakes within the IPB University Dramaga Campus remains very limited. The three main lakes in this area differ in several ecological characteristics, including water surface area, depth, water quality, and the extent of surrounding vegetation cover. Such variation in environmental conditions is likely to influence fish species composition and diversity in each lake. Similar patterns have been reported from tropical lake ecosystems, where differences in environmental conditions affect both species diversity and dominance within fish communities (Ardian et al., 2024; Suraya & Aunurafik, 2020).

In this context, the present study aims to analyse freshwater fish diversity in three lakes at the IPB University Dramaga Campus and to examine differences in species composition, dominance, and evenness of individuals among species within each lake ecosystem—Lake LSI, Lake SDGs, and Telaga Inspirasi—using the Shannon, Simpson, and evenness indices. The study also evaluates environmental parameters that may influence fish species composition and diversity within each lake. Differences in environmental characteristics among the three lakes are expected to result in distinct patterns of species composition and fish diversity. The findings of this study are intended to provide baseline information on fish community dynamics in lake ecosystems within the IPB University Dramaga Campus and to support ecologically informed management of campus freshwater ecosystems.

MATERIALS AND METHODS

Study area and period

This study was conducted at Lake SDGs, Lake LSI, and Telaga Inspirasi, located within the IPB University campus in Dramaga District, Bogor, West Java (FIGURE 2). Field sampling was carried out on 11–12 and 16–19 April 2025.

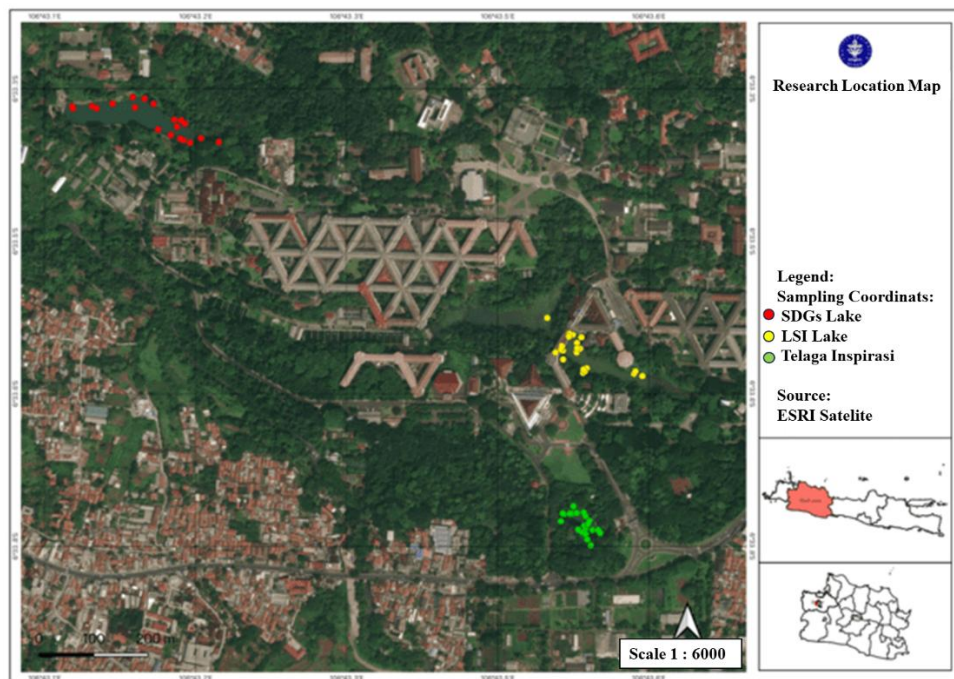


FIGURE 2. Map of fish sampling locations at IPB University

Fish sampling

Fish were collected using a purposive approach, focusing on sites considered most representative of fish presence within each lake (Nyimbili & Nyimbili, 2024). To capture a broad range of species and size classes, both active and passive sampling techniques were applied (Walter, 2020).

Active sampling relied on a hand net with a 35 cm diameter, used to collect fish directly from shallow water along lake edges and near the surface (Cabacinha et al., 2019). Sampling was carried out at multiple shoreline points by repeatedly sweeping

shallow areas of the littoral zone. Each lake was sampled at several points, with three repetitions per point, to improve the representativeness of the catch.

Passive sampling involved the use of six-entrance umbrella traps (*bubu payung*) and stationary fishing lines (*pancing tajur*). The umbrella traps were commercially available units made of nylon netting comparable to polyethylene (PE) and supported by collapsible metal frames. Each trap had six funnel-shaped entrances arranged in a double-layer configuration, an umbrella diameter of approximately ± 60 cm, and an estimated mesh size of $\pm 1-1.5$ cm. Four traps were installed in each lake, spaced about ± 100 cm apart. Two traps were baited with oil palm fruit, while the remaining two used a mixture of chicken intestines and pellets. Stationary fishing lines were set using size-12 hooks and 0.5 mm nylon line, baited with chicken intestines. These lines were left in place for a fixed period to allow fish to be captured without continuous human intervention (Walter, 2020). All traps were installed at 17:00 and checked twice daily, at 07:00 and again at 17:00. Catches were examined each afternoon, after which traps were rebaited and reset. The process of fish specimen collection follows recognised standard protocols designed to minimise stress and harm to the animals. All procedures are carried out in compliance with animal welfare regulations and ethical best practices, ensuring that the collection is both scientifically rigorous and humane.

Environmental variables

Environmental variables recorded at each lake included air temperature, water temperature, dissolved oxygen, pH, water transparency, and depth. Measurements were taken at each sampling plot along the lake margins (littoral zone) during trap installation and inspection to maintain consistent environmental records throughout the sampling period. The littoral zone was targeted because it represents a key habitat for fish and strongly influences species distribution and abundance in lake ecosystems (Matern et al., 2021).

Air temperature was measured using a thermohygrometer, which was installed at approximately 1 m above ground level and positioned in a shaded area to minimise direct solar radiation effects. Measurements were recorded simultaneously with other environmental parameters. Water temperature and dissolved oxygen were measured using a digital DO meter, pH was recorded with a digital pH meter, water transparency was assessed with a Secchi disc, and water depth was measured using a measuring tape. All instruments were standard tools commonly applied in freshwater ecological studies.

Fish identification

All captured fish were counted, photographed, preserved, and identified to species level. Identification was based on morphometric and meristic characteristics, following standard taxonomic keys and references (Kottelat et al., 1993; Skelton, 2001; Habibie et al., 2018).

Data analysis

Fish diversity was quantified using the Shannon, Simpson, and evenness indices, calculated with the vegan package (version 2.6-10) in R (Kang et al., 2018). Species

occurrence across the three lakes was visualised through Venn diagrams generated using the ggVennDiagram package (Gao et al., 2024), highlighting similarities and differences in species presence among sites. The analyses were descriptive in nature and aimed to compare patterns of fish diversity between lakes. Environmental parameters were likewise summarised descriptively to characterise the physicochemical conditions of each lake.

RESULTS AND DISCUSSION

Species composition

The fish community is dominated by non-native species collected from the IPB lake ecosystems, representing nine families and twelve species, with a total of 1192 individuals (57.2%), while native species account for 891 individuals (42.8%) of the total 2083 individuals recorded. Three families were represented by two species each: Cichlidae (*Amphilophus amarillo*, *Oreochromis niloticus*), Cyprinidae (*Barbodes binotatus*, *Osteochilus hasseltii*), and Osphronemidae (*Trichopsis vittata*, *Trichopodus trichopterus*). Each of the remaining six families was represented by a single species: Clariidae (*Clarias batrachus*), Zenarchopteridae (*Dermogenys cf. pusilla*), Eleotridae (*Oxyeleotris marmorata*), Poeciliidae (*Poecilia reticulata*), Loricariidae (*Pterygoplichthys pardalis*), and Danionidae (*Rasbora aprotaenia*) (TABLE 1, FIGURE 3).

Five species were identified as introduced or invasive fish: *Amphilophus amarillo*, *Oreochromis niloticus*, *Poecilia reticulata*, and *Pterygoplichthys pardalis*. Among these, Nile tilapia (*O. niloticus*) and guppy (*P. reticulata*) occurred in the highest numbers (TABLE 1). This finding is consistent with reports from Sermo Reservoir, Yogyakarta, where cichlids dominated the fish community (Suryandari et al., 2021). The presence of Nile tilapia in the lakes of IPB Dramaga is attributed to human-mediated translocation and has been documented since 1986 (Ageriyanto, 2012). *Pterygoplichthys pardalis* is known to frequently dominate fish communities in tropical waters due to its broad environmental tolerance (Orfinger & Goodding, 2018). However, in our study, which employed a collapsible trap (*bubu payung*) as the sampling gear, the dominance of *Pterygoplichthys pardalis* was not significantly observed (0,1% from total individual fish caught, TABLE 1). This suggests that the choice of sampling gear plays a crucial role in accurately detecting species dominance.

Guppy (*Poecilia reticulata*) is commonly found in the Cisadane River system due to its high tolerance of polluted conditions, temperature variation, and salinity (Allibhai et al., 2023; Hamilton et al., 2016; Hadiaty, 2011). Guppy (*Poecilia reticulata*) is commonly associated with tolerance to a wide range of environmental conditions, including polluted waters, temperature fluctuations, and varying salinity. However, its presence in the IPB lake ecosystems does not necessarily indicate degraded environmental conditions. Based on the measured parameters (TABLE 2), the lakes exhibit dissolved oxygen values ranging from 6.54 to 7.40 mg/L, water temperature between 26.36 and 29.01°C, and pH from 6.74 to 8.37, which are all within suitable ranges. The introduction of guppy often occurs for disease-vector control, as this species preys on mosquito larvae. Native to freshwater systems in Latin America, *P. reticulata* has been introduced widely across West Java (Sentosa et al., 2015). Introduced fish species can

suppress trophic functional diversity and reduce dietary niche breadth of native species, ultimately destabilizing aquatic ecosystems (Shuai & Li, 2022). Native species such as wader (*B. binotatus*) and snakeskin gourami (*T. trichopterus*) may also enter these lakes through intentional release following declining interest in aquaculture or ornamental keeping (Sentosa et al., 2015). Native species were present but not numerically dominant, which may reflect their relatively narrower ecological tolerance compared and trophic niche to non-native species (Constantini et al., 2023; Wei et al., 2021).

TABLE 1. Fish species composition in IPB lake ecosystems.

Family/species	Native/ alien	Local name	Number of individuals			Σ	%
			Telaga Inspirasi	LSI	SGDs		
Cichlidae							
<i>Amphilophus amarillo</i>	A	Red devil	0	24	263	285	14
<i>Oreochromis niloticus</i>	A	Nila	515	1	5	523	25
Clariidae							
<i>Clarias batrachus</i>	N	Lele	4	0	0	4	0,2
Cyprinidae							
<i>Barbodes binotatus</i>	N	Wader	163	14	8	185	9
<i>Osteochilus hasselti</i>	N	Nilem	3	0	0	3	0,1
Danionidae							
<i>Rasbora aprotaenia</i>	N	Seluang	0	8	0	8	0,4
Eleotridae							
<i>Oxyeleotris marmorata</i>	N	Betutu	0	3	0	3	0,1
Loricariidae							
<i>Pterygoplichthys pardalis</i>	A	Sapu-sapu	0	2	0	2	0,1
Osphronemidae							
<i>Trichopodus trichopterus</i>	N	Sepat rawa	2	19	113	134	6
<i>Trichopsis vittata</i>	N	Cupang	0	130	422	552	27
Poeciliidae							
<i>Poecilla reticulata</i>	A	Guppy	371	5	6	382	18
Zenarchopteridae							
<i>Dermogenys cf. pusilia</i>	N	Cucut	0	2	0	2	0,1
Total			1058	208	817	2083	

The red devil cichlid (*A. amarillo*) exhibited two phenotypes—orange and black (FIGURE 3E–F). This colour variation results from loss of melanophores responsible for black band formation (Geiger, 2011). The term “Midas cichlid” refers to brightly coloured *Amphilophus* individuals commonly found in several lakes in Nicaragua, Central America (Geiger, 2011).

Nilem (*O. hasseltii*) and catfish (*C. batrachus*) were found exclusively in Telaga Inspirasi (FIGURE 3). Three individuals of *O. hasseltii* and four of *C. batrachus* (TABLE 1) were monitored in Telaga Inspirasi, with the corresponding environmental parameters presented in TABLE 2. Compared to the other lakes, Telaga Inspirasi exhibited the lowest dissolved oxygen levels and water temperature, the highest pH (above 7), and moderate transparency, while the air temperature was not significantly different (TABLE 2). These

environmental parameters were suitable for the two exclusive fish species found in Telaga Inspirasi. This is consistent with the understanding that catfish possess a broad range of adaptive capabilities across diverse aquatic conditions (Sharma et al., 2023).

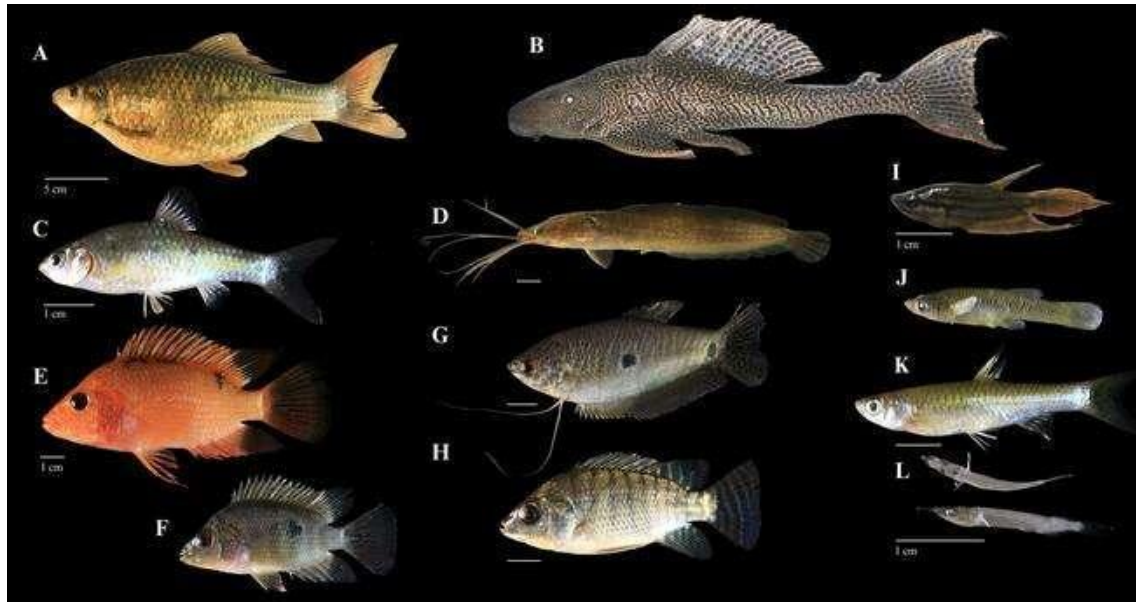


FIGURE 3. Fish species recorded in IPB lake ecosystems: A. Nilem (*Osteochilus hasseltii*); B. Armored catfish (*Pterygoplichthys pardalis*); C. Wader (*Barbodes binotatus*); D. Catfish (*Clarias batrachus*); E–F. Red devil (*Amphilophus amarillo*); G. Snakeskin gourami (*Trichopodus trichopterus*); H. Nile tilapia (*Oreochromis niloticus*); I. Croaking gourami (*Trichopsis vittata*); J. Guppy (*Poecilia reticulata*); K. Seluang (*Rasbora aprotaenia*); L. Halfbeak (*Dermogenys cf. pusilla*). Scale bars: A–B = 5 cm; C–L = 1 cm.

O. hasseltii is a freshwater species endemic to West Java, typically inhabiting rivers and swampy areas (Syamsuri et al., 2017). This herbivorous fish feeds on phytoplankton, zooplankton, algae, and periphyton growing on submerged surfaces (Iskandar et al., 2020). Its presence in Telaga Inspirasi may be supported by suitable food resources and limited human-mediated translocation restricted to this lake.

The exclusive occurrence of catfish (*C. batrachus*) in Telaga Inspirasi is notable, given the species' high tolerance to varied environmental conditions and its opportunistic feeding behaviour (Sharma et al., 2023). However, this pattern may partly reflect methodological constraints, as catfish were captured only using fishing lines baited with chicken intestines and umbrella traps baited with pellets. In Lake LSI and Lake SDGs, fishing lines did not yield *C. batrachus*.

Halfbeak (*D. cf. pusilla*), armoured catfish (*P. pardalis*), marble goby (*O. marmorata*), and seluang (*R. aprotaenia*) were recorded only from Lake LSI (FIGURE 3). A total of two individuals of *D. cf. pusilla*, two of *P. pardalis*, three of *O. marmorata*, and eight of *R. aprotaenia* (TABLE 1) were monitored in Lake LSI. The environmental parameters for the lake are summarised in TABLE 2. Compared to the other two lakes, Lake LSI exhibited moderate dissolved oxygen levels and water temperature, the lowest pH (below 7), and the lowest transparency, while its air temperature showed no significant

difference. These environmental conditions were found to be suitable for the four exclusive species inhabiting Lake LSI.

D. cf. pusilla was captured exclusively using hand nets and is characterised by a pointed snout. This species feeds on phytoplankton and mosquito larvae and relies on shoreline vegetation (Elinah et al., 2016). The physical characteristics of Lake LSI, including shoreline structure and vegetation, likely supported both its habitat requirements and effective sampling via hand nets.

The armoured catfish (*P. pardalis*), an introduced species from South America, is commonly used in aquaria as an algae cleaner (Elfidasari et al., 2022). Its high reproductive capacity and tolerance of polluted conditions enable rapid population growth and dominance in freshwater systems. Overabundance often results from aquarium owners releasing unwanted fish into natural waters (Avhad et al., 2025), a pathway likely responsible for its presence in campus lakes.

Marble goby (*O. marmorata*) is a predatory fish capable of cannibalism when prey availability is low (Kambey et al., 2019). It inhabits muddy-bottom freshwater systems such as lakes, rivers, and swamps, preferring vegetated habitats for spawning (Liang et al., 2022). Its presence in Lake LSI is supported by abundant small fish prey and aquatic vegetation, and individuals were captured using fishing lines baited with chicken intestines. Sampling limitations may explain the absence of this species from other lakes with similar substrate and vegetation.

Seluang (*R. aprotaenia*) is endemic to Java and typically inhabits upstream freshwater systems with moderate to fast currents (Rahmayanti et al., 2021). Individuals recorded in Lake LSI were captured using umbrella traps deployed near dam inflow areas, suggesting that localised current conditions likely facilitated their presence.

Historical records of fish communities at the IPB Dramaga Campus remain largely limited to *Situ* Leutik and *Situ* Perikanan, now collectively known as Lake LSI. Native species previously documented include catfish (*C. batrachus*), Siamese fighting fish (*Betta splendens*), and snakehead (*Channa striata*) (Wijaya et al., 1991). In the present study, *C. batrachus* was found only in Telaga Inspirasi, while *B. splendens* and *C. striata* were not observed. The absence of native species such as *B. splendens* and *C. striata* in the current study is likely driven by the existence of invasive alien species (IAS) in Lake LSI, specifically the *O. niloticus*, *A. amarilo*, and *P. pardalis*. These invasive taxa are known for their high ecological resilience and aggressive competition for resources. *A. amarilo*, in particular, exhibits high territoriality and predatory behaviour, which can suppress smaller native populations. Furthermore, the presence of *P. pardalis* often leads to habitat degradation through the disturbance of benthic substrates and the consumption of eggs from native nest-building species (Sumanasinghe & Amarasinghe, 2013). The environmental conditions in Lake LSI, characterised by moderate dissolved oxygen and water temperature (TABLE 2), appear to favour these resilient invasive species, allowing them to outcompete more sensitive native fishes. This shift in community structure suggests that biological pressure from multiple invasive species, combined with physical habitat changes, is a primary driver of the decline in native ichthyofauna in the IPB campus lakes.

Environmental conditions in Lake LSI (TABLE 2) fall within ranges suitable for *Betta* spp., with water temperatures between 23.7 and 31.9 °C and pH values from 5.24 to 8.51 (Nur et al., 2022). Similar environmental parameters suggest that *Betta* spp. could still be present but were not detected due to sampling constraints. *Betta* species typically inhabit calm or slow-flowing freshwater with dense vegetation or hanging roots, such as ponds, peat swamps, rice fields, and low-flow rivers (Subriyanto et al., 2025). Their narrow ecological niche reduces detection probability when sampling is designed to cover a broad range of species.

Nile tilapia (*O. niloticus*), wader (*B. binotatus*), guppy (*P. reticulata*), and snakeskin gourami (*T. trichopterus*) occurred in all three campus lakes (TABLE 1, FIGURE 4). Their widespread distribution likely reflects undocumented dispersal pathways. Although lakes are often considered isolated aquatic systems, flood events and water-level variation can create temporary connections that allow fish movement between lakes, rivers, floodplains, or even via subsurface channels. In addition, human-mediated introductions further facilitate species exchange (Qin et al., 2019).

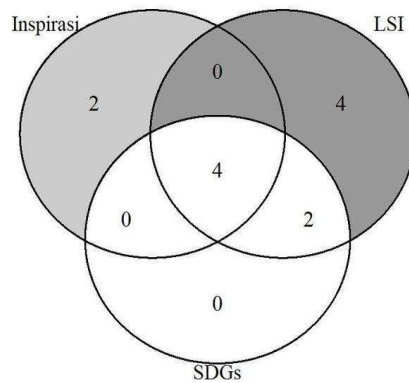


FIGURE 4. Species distribution in the ecosystems of IPB University lakes

The distribution of fish species across the three lakes, as illustrated in FIGURE 4, reveals distinct patterns of occupancy. Lake LSI exhibited the highest number of unique species (4 species), whereas Lake SDGs lacked any exclusive species. Although TABLE 2 provides a snapshot of the environmental conditions at each site, these parameters should be interpreted as supporting data rather than direct drivers of species richness. Without further statistical modelling, such as Canonical Correspondence Analysis (CCA), it is not possible to establish a definitive correlation between individual water quality factors and the presence of unique species.

However, the exclusivity of species in Lake LSI may be more closely related to its unique physical characteristics, such as the presence of water currents and potentially higher habitat heterogeneity, which were not as prominent in SDGs or Telaga Inspirasi. Conversely, the lack of unique species in Lake SDGs suggest that its environment may primarily support generalist taxa that are also capable of inhabiting the other two lakes. Furthermore, the absence of shared species between Telaga Inspirasi and the other lakes in certain categories (FIGURE 4) highlights a fragmented distribution that likely reflects

localised habitat suitability and the pressure from invasive alien species (IAS) rather than broad water quality trends.

Fish diversity indices

Analysis of ecological indices revealed clear variation in fish diversity among the three lakes (FIGURE 5). These indices, including species richness, Shannon–Wiener diversity, Simpson dominance, and evenness, are commonly used to evaluate ecological condition and community stability (Muslim & Syaifudin, 2022; Heino et al., 2021). The diversity values observed in this study fall within the range commonly reported for Indonesian freshwater lakes. For example, fish diversity in Lake Toba showed a Shannon index of 1.83, indicating moderate diversity typical of tropical lentic ecosystems (Qomaria, 2023). Similarly, urban lakes such as Lake Cilodong show that environmental pressure and anthropogenic activities can influence fish community structure, resulting in moderate diversity levels and varying dominance patterns (Prihatini, 2018).

Telaga Inspirasi supported six species and showed the highest Shannon index ($H' = 1.39$), indicating moderate diversity (Konopinski, 2020). The Simpson value (0.73) indicates low dominance, suggesting no single species strongly prevails (Heino et al., 2021). The relatively high evenness further indicates balanced distribution of individuals among species (Suraya & Aunurafik, 2020).

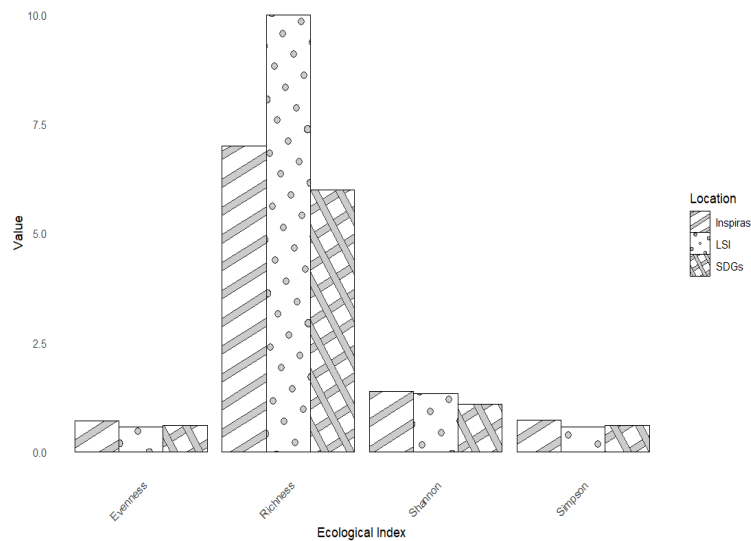


FIGURE 4. Ecological indices of fish communities in IPB lake ecosystems.

Lake LSI had the highest species richness (10 species), exceeding Telaga Inspirasi and Lake SDGs. Despite moderate Shannon diversity, the relatively higher Simpson value (0.58) suggests greater dominance by certain species (Konopinski, 2020). Similar patterns have been reported in Indonesian lakes, where habitat differences and environmental conditions influence species dominance and community structure (Prihatini, 2018). The lower evenness indicates uneven abundance distribution, with some species occurring at much higher densities than others (Suraya & Aunurafik, 2020).

Lake SDGs supported six species and had a Shannon index of 1.092, also indicating moderate diversity (Konopinski, 2020). The relatively low dominance and fairly high

evenness ($E = 0.610$) indicate balanced species distribution and stable community structure (Suraya & Aunurafik, 2020). Comparable patterns have been reported in Indonesian tropical lakes, where moderate diversity levels commonly reflect environmental variability and habitat heterogeneity (Qomaria, 2023).

Relationships between water quality and fish occurrence

Environmental conditions measured across the three IPB lakes were generally within ranges suitable for freshwater fish communities (TABLE 2). Dissolved oxygen concentrations ranged from 6.54 to 7.40 mg L⁻¹, exceeding the minimum requirement for respiration and metabolic processes in most freshwater fish species (Kulla et al., 2020). Water temperature ranged from 26.38 to 29.01 °C, which falls within the optimal range for growth and physiological performance of tropical freshwater fishes (Fatma & Ahmed, 2020). Similarly, pH values (6.74–8.37) were within the tolerance limits commonly reported for freshwater organisms (Sulastri et al., 2016). These conditions indicate that water quality did not strongly limit fish survival across the studies lakes.

Variation in water transparency may partly explain differences in fish occurrence among lakes. Lake LSI showed the highest water transparency (69.92 cm), allowing greater light penetration that can enhance primary productivity and increase food availability (Setiawati et al., 2020). Higher productivity can support more complex food webs and habitat structure, which may contribute to higher species richness (Bogotá-Gregory et al., 2020).

The relatively low occurrence of *Pterygoplichthys pardalis* may be related to habitat characteristics rather than general water quality. This species is a benthic detritivore feeding on algae and organic matter attached to substrates (Lujan et al., 2012). It is also known for its high environmental tolerance, including survival under low oxygen conditions due to accessory air-breathing (Orfinger & Goodding, 2018). However, differences in substrate composition, food availability, and habitat structure among lakes may limit its abundance despite suitable water quality.

TABLE 2. Environmental parameters at fish sampling sites in IPB University Dramaga.

Parameter	Locations		
	SDGs	Telaga Inspirasi	LSI
Dissolved Oxygen (mg/L)	7,40±0,81	6,54±0,92	7,17±0,70
Water Temperature (°C)	29,01±1,01	26,38±6,05	28,40±0,54
Water pH	6,90±0,31	8,37±6,27	6,74±0,29
Water transparency (cm)	58,71±8,36	52,00±12,86	69,92±10,05
Air temperature (°C)	26,81±1,17	26,97±1,03	26,86±1,07

Similarly, the low occurrence of *Amphilophus amarillo* may reflect habitat preferences and ecological behaviour rather than physicochemical constraints. Cichlid fishes are strongly associated with substrate type, territoriality, and feeding niche, which influence their spatial distribution (Lehtonen, et al., 2023). Variation in habitat complexity and ecological interactions among lakes may therefore explain the low abundance of this species.

Air temperatures remained relatively stable (26.81–26.97 °C), indicating consistent climatic conditions during sampling. Stable thermal conditions may help maintain water

temperature balance, which is important for fish physiological processes (Kayame et al., 2020). Overall, although environmental parameters were within suitable ranges, differences in habitat characteristics and species-specific ecological preferences likely contributed to variation in fish occurrence among the three lakes.

CONCLUSIONS

This study revealed variation in fish diversity among the three lakes at the IPB University Dramaga Campus, where a total of 12 fish species were recorded. *Oreochromis niloticus* was the dominant species in Telaga Inspirasi, while *Trichopsis vittata* dominated Lake LSI and Lake SDGs. Ecological indices indicated differences in fish diversity among lakes: Telaga Inspirasi exhibited the highest Shannon index (1.390) and lower dominance (Simpson index 0.733), Lake LSI showed the highest species richness (10 species) but higher dominance (Simpson index 0.581), and Lake SDGs displayed a relatively higher evenness of individuals among species (Evenness 0.610). Despite these differences, variation in index values among lakes was not pronounced, suggesting that fish diversity in the three lakes, particularly Telaga Inspirasi and Lake SDGs, is generally comparable, with differences mainly reflected in species composition and dominance patterns. Measured environmental parameters showed variation in physicochemical conditions among lakes during the sampling period. Overall, the results demonstrate that ecological indices are effective tools for describing variation in fish diversity in lake ecosystems within semi-urban campus environments.

AUTHOR CONTRIBUTIONS

W.E.P., A.H.I., M.R., N.A., R.R.H., and D.P.F. contributed to the research ideas and conceptual design; W.E.P., N.A., and R.R.H. developed the methodology; A.H.I., M.R., and W.E.P. performed the data analysis; D.P.F. reviewed and edited the manuscript.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest associated with this study, whether financial, personal, or professional, that could have influenced the results or interpretations of the research.

ETHICAL COMPLIANCE

Fish specimens are collected using standard protocols that reduce stress and harm, following animal welfare and ethical guidelines to ensure humane, rigorous practices

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