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Original Article

Species diversity of fish population in central wetland (south) of Lake Putrajaya, Malaysia

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Abstract

Wetland is one of the water bodies that play important roles in supplying different types of fish species for human consumption and other activities, including recreational activities. Understanding the species diversity of a fish population in a wetland or a lake is important to ensure the sustainability of the fisheries resources in the future. This study was conducted to determine the species composition and diversity of fish population in the central wetland (south) of Lake Putrajaya, Malaysia, from March to October 2019. Three sampling stations were designated and were labelled with A, B and C. The samplings were conducted using fish traps and gill nets with different mesh sizes (i.e. 2.5, 3.5 and 4.5 inches). As a result, a total of 303 fish individuals from 13 species were recorded. The most abundant species was *Notopterus notepterus* (bronze featherback) (41.25%), and this was followed by *Oxyeleotris marmorata* (marble goby) (15.51%), and *Oreochromis niloticus* (tilapia) (12.54%). Meanwhile, the fish diversity indices throughout the study period gave Shannon-Wiener Index of 0.68±0.13, Margalef's Richness Index of 3.82±0.95, and Pielou's Evenness Index of 0.80±0.12. The results obtained in this study provide some baseline data for improving the management of fisheries resources in the wetland.

Keywords: fish population, Lake Putrajaya, wetlands, species composition, species diversity

1. Introduction

Wetlands, reservoirs and lakes are some of the water bodies that play important roles in providing sources of water, food, hydroelectric power, agricultural activity, aquaculture activity, agrotourism, recreational activities, flood prevention, and in many more aspects. However, those reservoirs can also harbour threats to the sustainability of aquatic organisms. For example, a lake that supports recreational activities such as fishing and jet skiing can suffer major impacts, such as habitat destruction and aquatic species loss. Habitat destruction and fragmentation are the main causes of habitat loss (Fahrig, 2019). Similarly, agriculture activities around a wetland or lake can seriously impact the water conditions and the aquatic organisms.

Previous studies show that human activities may impact the fisheries resources through fish harvest. This includes subsistence, commercial, and recreational fish harvests, which can cause the fish resources to be overharvested. Other than that, invasions of alien species can affect the diversity of fish species (Rahim, Esa, & Arshad, 2013; Sharip, Suratman, & Shaaban, 2016). In fact, the threats

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on terrestrial aquatic habitats have increased by about two-thirds in the last few decades (Rodell *et al*., 2018). The destruction of a freshwater ecosystem will lessen the species diversity of fish population, in a wetland or a lake habitat.

One of the main characteristics in determining the condition of a fish community is its species diversity. Species diversity implies species richness and number of different fish species that live in a particular community (Nappi, Drapeau, & Leduc, 2015). Two concepts associated with species diversity are species richness and species evenness. Species diversity is a diversity measurement within an ecological community that relates to the species richness and species evenness (McGinley, 2014). Species richness is the number of different species present in an ecological community, while species evenness refers to how close the numbers of each species are within the environment.

Species richness is often used as a benchmark for measuring the status of an ecosystems as a sign of an intact and resilient system (D'agata *et al*., 2014). A numerous fish population allows a variety of species interactions, such as those involving energy transfer (food webs), predation, competition, resource partition, and niche apportionment. Conserving species diversity is important, especially to protect the most valuable fish species in the population (Hurd *et al*., 2016). Furthermore, indigenous and threatened fish species are crucial to be protected, as every fish species has its own role in the ecosystem. Therefore, species diversity helps to sustain ecosystem functions and the associated provision of ecosystem services (D'agata *et al*., 2014).

The species diversity of living organisms can be measured by using several indices, such as the Margalef index (Margalef, 1958), Menhinick's index (Menhinick, 1964), Simpson's index (Simpson, 1949) and Shannon-Wiener index (Shannon & Wiener, 1949). The diversity of fish species indicates stability of the community. Diversity increases the stability and the productivity in communities of higher organisms (Ptacnik *et al*., 2008).

Malaysia has been listed among the top 15 most diverse countries in term of its biodiversity, with a biodiversity index of 0.33 and 5.8% for fish diversity (Butler, 2016). There were 470 species of fish available in Malaysia, representing 15 families in total (Chong, Lee, & Lau, 2010). However, the studies on species diversity of wetlands and lakes in Malaysia are still lacking. There is only 23.7% study of biodiversity documented for the lakes in Malaysia, such as in Kenyir, Bera and Chini (Sharip *et al*., 2016).

The Central wetland (south) of Lake Putrajaya is one of the man-made wetlands that can be found in Malaysia. The purpose of the construction of the Lake Putrajaya was to increase the aesthetic appeal of Putrajaya and also to act as tourist attraction by providing recreational activities, fishing and water sports (Nurliyana, Normaliza, Roslan, Yahzam, & Akashah, 2010). The wetland also provides natural ecosystem and habitats for terrestrial and aquatic species including fishes, aquatic plants, molluscs, reptiles, amphibians, insects, and birds. The species abundance in this area can be considered high for an urban landscape (Norhayati *et al*., 2016). However, studies on the diversity of fish species in the wetlands are currently scarce.

Therefore, the aim of this study was to determine the species composition and diversity of the fish population in the central wetland (south) of Lake Putrajaya, Malaysia. This study hopes to provide some baseline data and information about the wetlands, so that the fisheries resources can be managed considerably better in the future.

2. **Materials and Methods**

The study was conducted in the central wetland (south) of Lake Putrajaya, Malaysia (Figure 1). The Lake Putrajaya is located in the middle of the city of Putrajaya, which is the centre of the administration of the Malaysian government. Putrajaya houses most of the offices and administration buildings of the Malaysian government agencies.

The construction of the Lake Putrajaya started in March 1997 and was completed in August 1998. The 400 hectares of the Lake Putrajaya were established by inundating the lower parts of the river valleys of Chuau River and Bisa River. It is estimated that 60.0% of the water that flows into the lake originates from the Putrajaya wetland, while the remaining of 40.0% of the water flows from the drainage system and shoreline areas of the lake (Nurliyana *et al*., 2010). This lake was inundated for flood mitigation, conservation of nature, ecotourism, recreation, research, education, and soil erosion protection.

In this study, the sampling was conducted in the central wetland (south) of the Lake Putrajaya. The central wetland (south) is located in the most southern part of the wetland system, before entering to the lake system.

The sampling was carried out from March to October 2019. The eight-month duration was established to obtain a temporal analysis of fish population in the wetland. Spatially, the sampling was conducted monthly at three sampling stations. These stations were labelled as Station A, Station B and Station C (Figure 1). Station A was located at the northwest part of the wetland, and it was the shallowest among these sampling stations (depth of 0.95±0.37 m). It was located at the source of water that flows into the lake. Meanwhile, Station B was located in the middle of the islands that are in the central part of the wetland, and it was the deepest sampling station (depth of 2.63±1.01 m). Finally, Station C was located at the east part of the lake, at the edge of the wetland, and it had a bay-like shape, and was dominated by submerged aquatic macrophytes (depth of 1.67±0.76 m).

Fish sampling was conducted using gill nets of same specification and size at all the stations. Each gill net measured 9.14 metres (30 feet) long and 1.83 metres (6 feet) in depth with a stretched mesh size of 6.35 cm (2.5 inches), 8.89 cm (3.5 inches) or 11.43 cm (4.5 inches). The gill net was set up in the water in the evening, was maintained in position for the night, and was hauled in the next morning. Other than that, fish traps were also utilized as another method of fish sampling. A boat was used in placing and hauling the gill nets and the fish traps.

All fish caught were sorted according to station and mesh size of the gill net. The fishes then were placed in containers filled with ice for preservation, before sorting them on the shore. All fish samples were counted, and taxonomically identified to the species level, and were classified as to their family, scientific name, and common name. The standard length (cm) of each fish was measured by using a measuring board, and the weight (g) was measured by

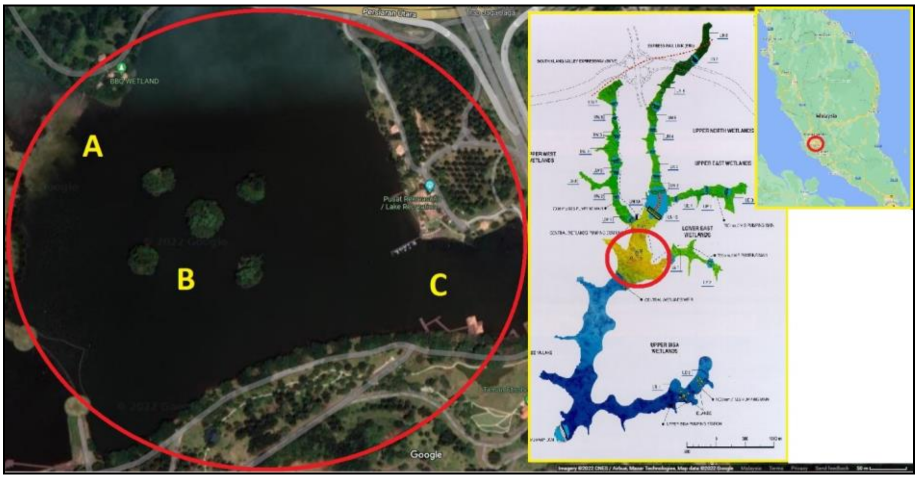

Figure 1. The location of the Central Wetland (south) of Lake Putrajaya, Malaysia, including the sampling stations within the wetland area (sources: Google maps and https://www.ppj.gov.my/second-page/tasik-dan-wetland)

using an electronic digital balance.

To determine the species composition and diversity of fish population in the study area, the number of fish species and the number of individuals of each species were calculated using these formulas:

Percentage of species composition:

PSC = (Number of individuals of a species / Total number of individuals) x 100

Shannon-Wiener Index (1949) – Species diversity:

$$H' = (N \log N - \Sigma\, n_i \log n_i) / N$$

where n_i is the number of individuals in species 'i' and N is the total number of individuals.

Margalef's Richness Index (1958) – Species richness:

$$D = (s - 1) / \log N$$

where s is the number of species and N is the total number of individuals.

Pielou's Evenness Index (1969) – Species evenness:

$$E' = H' / H'\,max$$

where H' is the number derived from Shannon-Wiener Index and H' max is the maximum value of H' or log (S).

All data were analysed using statistical procedures. Descriptive statistics such as percentage, mean, standard deviation and standard error of fish were calculated for standard length (cm) and weight (g), total landings (g), and catch-per-unit-effort (CPUE). All data were analysed using SPSS software version 24.0.

3. Results and Discussion

A total of 303 individual fish consisting of 13 species from eight families were recorded at the central wetland (south) of Lake Putrajaya, Malaysia, during the study period from March to October 2019 (Table 1). The dominant species among those recorded was *Notopterus notopterus* (bronze featherback) represented by 125 individuals at 41.25% of the total fish count sampled. This was followed in rank order by *Oxyeleotris marmorata* (marble goby) comprising 47 individual fish (15.51%), *Oreochromis niloticus* (tilapia) comprising 38 individual fish (12.54%), *Hemibagrus nemurus* (river catfish) comprising 24 individual fish (7.92%), and *Hampala macrolepidota* (hampala barb) comprising 19 individual fish (6.27%). The rest of the species contributed less than 20.0% of the total fish landing (Table 1).

Regarding the fish families, the dominant family observed during the study period was Notopteridae (two species) which comprised 41.91% of the total fish recorded. This was followed in rank order by the families Cyprinidae (17.49%), Cichlidae (15.84%), Butidae (15.51%), Bagridae (7.92%), and Loricariidae (0.66%). Meanwhile, Pangasiidae and Channidae both contributed 0.33% of the total recorded. On the other hand, in terms of the diversity indices, the Shannon-Wiener Index mean value was 0.68±0.13, while the Margalef's Richness Index was at 3.82±0.95, and the Pielou's Evenness Index was at 0.80±0.12 (Table 2).

The results on spatial distribution of the fish species indicated some distinctive trends. Station A contributed nine species with 142 fish individuals. Station B contributed five species with 28 fish individuals, while station C recorded 12 species with 133 fish individuals. In terms of fish indices based on stations, the Shannon-Weiner index for station A had the highest value of 0.80, followed by station C (0.72) and station B (0.68) in decreasing order. Meanwhile, the Margalef's Richness Index had its highest value 5.18 in station C, followed by station A (3.72) and station B (2.76). The Pielou's Evenness Index for station B was the highest at 0.97, followed by station A and station C at 0.84 and 0.67, respectively.

The largest number of fish individuals was recorded at Station A, located at one of the wetland's inlets which is shallower (depth of 0.95±0.37m) than the other areas. Station A also has a high abundance of aquatic plants, mainly *Hydrilla*, which provides suitable refuge for the fishes. Macrophytes provide microhabitats for zooplankton, aside from being safe spaces and food sources for aquatic organisms

Table 1. Family, species, common name, number of individuals, mean length and mean weight of fishes caught in Central Wetland (South) of Lake Putrajaya, Malaysia from March 2019 to October 2019.

Family	Fish species	Common name	No. of individuals (%)	Mean standard length (cm±SD)	Mean weight (g±SD)
Notopteridae	*Notopterus notopterus*	Bronze featherback	125 (41.25)	21.14±2.16	89.61±23.06
Butidae	*Oxyeleotris marmorata*	Marble goby	47 (15.51)	15.01±6.05	84.42±136.74
Cichlidae	*Oreochromis niloticus*	Tilapia	38 (12.54)	23.01±4.56	403.07±228.15
Bagridae	*Hemibagrus nemurus*	River catfish	24 (7.92)	23.73±7.43	271.98±224.93
Cyprinidae	*Hampala macrolepidota*	Hampala barb	19 (6.27)	19.91±7.96	191.08±122.47
Cyprinidae	*Puntius bulu*	Crossbanded barb	17 (5.61)	32.72±5.11	1104.98±451.22
Cyprinidae	*Barbonymus gonionotus*	Silver barb	14 (4.62)	17.11±2.65	146.42±46.17
Cichlidae	*Geophagus* sp.	Earth eater cichlid	10 (3.30)	14.66±0.99	88.55±13.57
Cyprinidae	*Barbonymus schwanenfeldii*	Tinfoil barb	3 (0.99)	4.93±0.38	3.46±0.56
Notopteridae	*Chitala ornata*	Clown featherback	2 (0.66)	36.75±3.32	322.00±24.04
Loricariidae	*Hypostomus plecostomus*	Suckermouth catfish	2 (0.66)	34.15±3.75	712.50±24.75
Pangasiidae	*Pangasius hypophthalmus*	Sutchi Catfish	1 (0.33)	58.00±0.00	3297.00±0.00
Channidae	*Channa micropeltes*	Giant Snakehead	1 (0.33)	21.50±0.00	130.00±0.00
Total			303		

Table 2. Species diversity indices of fish population for each station and month in Central Wetland (South) of Lake Putrajaya, Malaysia from March 2019 to October 2019

Station and month	No. of species	No. of individuals	Shannon-Wiener Index	Margalef's Richness Index	Pielou's Evenness Index
Mean ± SD	-	-	0.68±0.13	3.82±0.95	0.80±0.12
Station					
Station A	9	142	0.80	3.72	0.84
Station B	5	28	0.68	2.76	0.97
Station C	12	133	0.72	5.18	0.67
Month					
March	6	27	0.62	3.49	0.80
April	6	16	0.69	4.15	<u>0.89</u>
May	6	42	<u>0.42</u>	3.08	<u>0.54</u>
June	8	55	0.72	4.02	0.80
July	5	44	0.46	<u>2.43</u>	0.66
August	7	32	0.72	3.99	0.85
September	7	47	0.73	3.59	0.86
October	10	40	<u>0.88</u>	<u>5.62</u>	0.88

(Choi, Jeong, Kim, La, Chang, & Joo, 2014). Fish that live in a lake prefer the limnetic or shallow littoral areas (Nelson, Grande, & Wilson, 2016). The littoral zone with high light penetration promotes the availability of nutrients and leads to primary benthic production (Pettit, Ward, Adame, Valdez, & Bunn, 2016). Light penetration in the profundal zone was insufficient for the primary production of the littoral zone, and can sometimes contain different fish communities (Hayden, Myllykangas, Rolls, & Kahilainen, 2017).

In temporal analysis, the largest number of fish species landed was recorded in the month of October, with 10 species and 40 fish individuals. Meanwhile, the least number of species landed was recorded in July with five species and 44 fish individuals (Table 2). *Notopterus notopterus* and *Oxyeleotris marmorata* were present every month during the sampling period. The Shannon-Wiener Index ranged between 0.42 (in May) and 0.88 (October). The rest of the months it ranged between 0.60 and 0.80. Meanwhile, the Margalef's Richness Index ranged between 5.62 (October) and 2.43 (July). Finally, the Pielou's Evenness Index ranged between 0.54 (May) and 0.89 (April) (Table 2).

The non-native (alien) fish species were classified based on Rahim *et al*. (2013), who listed alien species that can be found in freshwaters of Malaysia. In these results, there were seven species of fish classified as 'native species' namely *Notopterus notopterus, Oxyeleotris marmorata, Hemibagrus nemurus, Hampala macrolepidota, Puntius bulu, Barbonymus schwanenfeldii,* and *Channa micropeltes* (Figure 2). These are some of the most commonly found species in inland water bodies throughout Malaysia, either in rivers, lakes, or dams. In terms of fish composition, the native fish species comprised 78.55% with a total number of 238 fish individuals. Meanwhile, the non-native species comprised 21.45% with a total of 65 fish individuals.

Among these species, *Puntius bulu* is classified internationally as 'least concerned' and their availability in freshwater sources is declining (Lumbantobing, 2019). This species has been categorized as threatened (Hashim *et al*., 2015). A diversity study in Sat River and Kelapah River in Malaysia revealed that the proportions of *P. bulu* were very low (Farinordin *et al*., 2016). However, the results of this study revealed large sized individuals in the samples (mean weight 1,104.98±451.22 g), with 17 (5.61%) fish individuals captured.

Six species of fish were classified as 'non-native' or 'alien' species, namely *Oreochromis niloticus*, *Barbonymus*

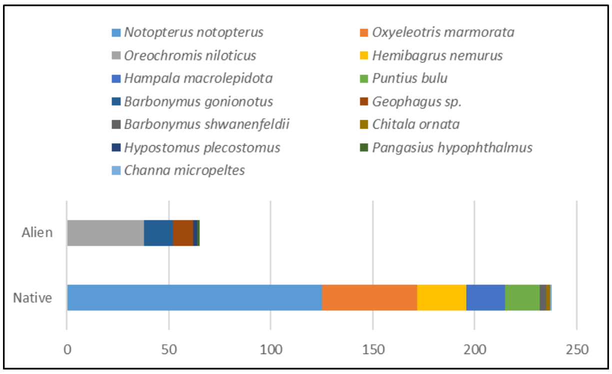

Figure 2. Number counts of individual fishes split to native and alien species that were caught during the study period in the Central Wetland (south) of Lake Putrajaya, Malaysia

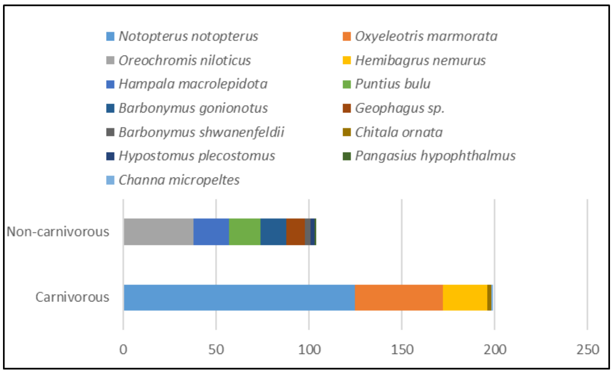

Figure 3. Number counts of individual fishes split between carnivorous and non-carnivorous species that were caught during the study period in the Central Wetland (south) of Lake Putrajaya, Malaysia

gonionotus, *Geophagus* sp., *Chitala ornata*, *Hypostomus plecostomus*, and *Pangasius hypophthalmus* (Figure 2). The presence of non-native or alien species in water bodies is not uncommon and has been reported around the world. These species were introduced for certain purposes, including for aquaculture (Khan *et al*., 2016), for sport fishing, and for ornamental purposes (Esmaeili, Teimori, Feridon, Abbasi, & Brian, 2015). Sometimes they were introduced to maintain and control the fisheries ecosystem (Piria *et al*., 2016). From here, there were three non-native species that are known as aquaculture species, namely *Oreochromis niloticus*, *Barbonymus gonionotus*, and *Pangasius hypophthalmus*. Meanwhile, fish species such as *Chitala ornata*, *Geophagus* sp., and *Hypostomus plecostomus* are known as ornamental fishes. Reports on the existence of *Geophagus* sp. in water bodies of Malaysia are currently scarce.

Overall, the dominant species found in this study was *Notopterus notopterus* from the family of Notopteridae. The results were different when compared to most results of lake studies in Malaysia. Most previous fisheries studies have reported Cyprinidae as the dominant family, in Lake Kenyir (Kamaruddin, Mustafa-Kamal, Christianus, Daud, & Yu-Abit, 2011), Lake Pergau (Alias *et al*., 2019), Chenderoh Reservoir (Kah-Wai & Ali, 2001), Lake Subang (Chai *et al*. 2021), Lake Raban (Piah, *et al*., 2021), Lake Temenggor, and Lake Bersia (Abd-Hamid, Mansor, Hashim, & Mohammad, 2012). *Notopterus notopterus* was recorded as the second most dominant species landed in Lake Kenyir (Kamaruddin *et al*., 2011) and Lake Subang (Chai *et al*., 2021). Meanwhile, only a small proportion of the species was recorded in Lake Temenggor and Lake Bersia (Abd-Hamid *et al*., 2012).

The *N. notopterus* is classified as indigenous to Malaysia, and is also distributed in Thailand, Sumatera, India, Philippines, Pakistan, and Vietnam. *Notopterus* sp. is a carnivore and usually feeds within the lake's water column (Yanwirsal, Bartsch, & Kirschbaum, 2017). Similarly, *Oxyeleotris marmorata* (2nd most dominant) and *Hemibagrus nemurus* (4th most dominant) were classified as carnivores due to their feeding regimes and stomach structures (Figure 3). The dominance of the carnivorous species can be a sign that the top species in the food chain were dominated by those predatory species. Carnivorous fishes are predatory species that feed on other fishes (Gerking, 1994) and they are usually positioned at the top of the food pyramid.

However, the abundance of cyprinids in this study might have been underestimated. It is notable that the wetland was also occupied by many cyprinids, especially at the shore area of the lake. It was impossible to conduct fish sampling at the shore area of the wetland, due to a conflict of these sampling techniques with the tourists and anglers. However, from visual observations there where fish species such as *Barbonymus schwanenfeldii* colonizing the water surface along the shore areas. This was due to feeding activities conducted by the tourists and anglers who visited the wetland. They feed the fishes with food items such as bread, pellets, and leftover baits. Fish tend to get aggregated in one area due to the feeding activity by humans. The behaviors of fishes change due to fish feeding activity by humans, including the distribution of the fish species (Paula, Schiavetti, Sampaio, & Calderon, 2018).

Creating awareness on utilization of the fisheries resources, especially among the tourists and anglers, is crucially important (Rayan, Chartchumni, Kaewdonree, & Rayan, 2020). Furthermore, the availability and diversity of the fish species needs to be sustained through a well-planned fish release or stocking program, with appropriate monitoring activities (Rayan *et al*. 2020). Alien species introduced in a lake or wetland system, aside from other anthropogenic activities such as overexploitation of the fisheries resources, can induce severe losses to diversity of the fish species (Rahim *et al*., 2013). Therefore, information about species diversity and its distribution is critically important, in order to support the appropriate management of the social and biological aspects of the fisheries resources.

4. Conclusions

In conclusion, the dominant species that inhabited the central wetland (south) of Lake Putrajaya during the study period was *Notopterus notopterus* (bronze featherback), followed by *Oxyeleotris marmorata* (marble goby), and *Oreochromis niloticus* (tilapia) in rank order. The dominant family recorded during the study period was Notopteridae, and this finding differed from most prior studies on the species diversity of fish in lakes and reservoirs of Malaysia. On the other hand, the carnivorous species were dominant, which indicates that the carnivorous fishes may play key roles in the food chain and food cycle of the wetland. The native fish species were also dominant, comprising 78.55%, when compared to the non-native or alien fish species. Some of the native fish species were classified as endangered, such as *Puntius bulu*, which was represented by large sized individual fish. The non-native or alien fish species in Malaysian waters have been mainly introduced for aquaculture purposes, such as *Oreochromis niloticus;* and for ornamental purposes such as *Geophagus* sp. Future studies in the wetland should focus on utilizing other sampling gear and techniques, such as hook-and-line technique, cast net, and electrofishing equipment. More stations can also be included to represent different locations of the wetland, including near the shore area of the lake. This study revealed the fish species inhabiting the wetland, which is useful as baseline data for a better management of the central wetland (south) of Lake Putrajaya, Malaysia.

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