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 for recreation. Understanding on species diversity of fish populations 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 named as station 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 results, 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, results for the fish diversity indices throughout the study period indicated that the Shannon-Wiener Index value was at 0.68±0.13, Margalef's Richness Index value was 3.82±0.95, and Pielou's Evenness Index value was 0.80±0.12. The results obtained in this study are believed to provide some baseline data for a better management of the 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 many more. However, the benefits of those reservoirs can become threats to the sustainability of the aquatic organisms. For example, a lake that provide recreational activities such as fishing, and jet skiing can suffer major impacts such as habitat destruction and aquatic species loss. Habitat destruction and defragmentation are the main causes of habitat loss (Fahrig, 2019). Similarly, agriculture activities around the wetland or lake can seriously impact the water conditions and its 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 threat the fish resources becoming overharvested. Other than that, invasion of alien species can affect the diversity of fish species (Rahim, Esa, & Arshad, 2013; Sharip, Suratman, & Shaaban, 2016). In fact, the threats on terrestrial aquatic habitats have been increased about two-thirds since the last few decades (Rodell et al., 2018). The destruction of freshwater ecosystem will lessen the species diversity of fish population in a wetland or lake habitats.

One of the main characteristics in determining the condition of fish community is 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 of species diversity are species richness and species evenness. Species diversity is a diversity measurement within an ecological community that related to the species richness and species evenness (McGinley, 2014).

Species richness is known as number of different species present in an ecological community, while species evenness refers to how close the number of each species within its environment.

Species richness often used as a benchmark for measuring the status of ecosystems as a sign of an intact and resilient system (D'agata et al., 2014). High number of fish population allows a variety of species interactions, such as those involving energy transferred (food webs), predation, competition, resource partition and niche apportionment. Conserving species diversity is important, especially to protect the most valuable fish species in the populations (Hurd et al., 2016). Furthermore, indigenous and threaten fish species are crucial to be protected due to every fish species has their own roles in the ecosystem. Therefore, species diversity will be able to sustain ecosystem functioning 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 which are 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 the stability of the community. Diversity increases the stability and the productivity in communities of higher organisms (Ptacnik et al., 2008).

Malaysia has been listed as the top 15 most diverse countries in term its biodiversity, with a biodiversity index of 0.33 and 5.8% of fish diversity (Butler, 2016). There were 470 species of fish available in Malaysia which comprise of 15 families in total (Chong, Lee, & Lau, 2010). However, the studies on species diversity of wetlands and lakes in Malaysia are still lacking. There were only 23.7% study of biodiversity documented in lakes in Malaysia, such as 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 is 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 as high for an urban landscape (Norhayati et al., 2016). However, the study 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 manage considerably 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 the construction was completed in August 1998. The 400 hectares of the Lake Putrajaya was 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 flow into the lake was originated from the Putrajaya wetland, while the remaining of 40.0% of the waters were flowing 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 months 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 designated as Station A, Station B and Station C (Figure 1). Station A located at the northwest part of the wetland, and it was the shallowest sampling station among all (depth of 0.95±0.37m). It was located at the source of water that flows into the lake. Meanwhile, Station B located in the middle of the islands that located in the central part of the wetland, and it was the deepest sampling station (depth of 2.63±1.01m). Finally, Station C located at the east part of the lake, where this station was located at the edge of the wetland, and it has 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 sizes for all stations. Each gill net measure 9.14 metres (30 feet) long and 1.83 metres (6 feet) depth with a stretched mesh size of 6.35 cm (2.5 inches), 8.89 cm (3.5 inches) and 11.43 cm (4.5 inches). The gill net was set up in the water in the evening and maintained in position for a night and 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 accordingly.

All fish caught were sorted according to stations and the mesh size of the gill nets. The fishes then were placed in containers that filled with ice for preservation, before sorting them at the shore. All fish samples were counted, and taxonomically identified to the species level, and were classified 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 using 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 was calculated using these formulas:

Percentage of species composition

$$PSC = (\text{Number of individuals of a species} / \text{Total number of individuals}) \times 100$$

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 each species 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 analyzed using statistical procedures. Descriptive statistic 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 analyzed using SPSS software version 24.0.

3. Results and Discussion

A total of 303 individual fish comprised 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 most dominant species recorded was *Notopterus notopterus* (bronze featherback) consisting of 125 individuals at 41.25% of the total fish sampled. This was followed by *Oxyeleotris marmorata* (marble goby) comprising of 47 individual fish (15.51%), *Oreochromis niloticus* (tilapia) comprising of 38 individual fish (12.54%), *Hemibagrus nemurus* (river catfish) comprising of 24 individual fish (7.92%), and *Hampala macrolepidota* (hampala barb) comprising of 19 individual fish (6.27%). The rest of the species comprised less than 20.0% of the total fish landing (Table 1).

In terms of fish families, the most dominant family landed during the study period was Notopteridae (two species) which comprises of 41.91% from the total fish families recorded. This was followed by the family of Cyprinidae (17.49%), Cichlidae (15.84%), Butidae (15.51%), Bagridae (7.92%), and Loricariidae (0.66%). Meanwhile, Pangasiidae and Channidae, both comprise of 0.33% from the total families recorded. On the other hand, in terms of the diversity indices, the results indicated that the Shannon-Wiener Index mean value was at 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 for the spatial distribution of the fish species indicated some distinctive trends. Station A comprises of nine species with 142 fish individuals. Station B comprise of five species with 28 fish individuals, while station C recorded with 12 species with 133 fish individuals. In terms of fish indices based on stations, results for the Shannon-Weiner index recorded that station A was having the highest value of 0.80, and this was followed by station C (0.72) and station B (0.68). Meanwhile, the Margalef's Richness Index indicated that the highest value was recorded in station C with 5.18, followed by station A (3.72) and station B (2.76). The value of the Pielou's Evenness Index recorded that station B was the highest with 0.97, and followed by station A and station C with 0.84 and 0.67, respectively.

The highest number of fish individual was recorded in Station A, where it is 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 high abundance of aquatic plants, mainly *Hydrilla*, which provides suitable refuge for fishes. Macrophytes provide microhabitats for zooplankton, other than safe spaces and food sources for aquatic organisms (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 lead to the benthic primary production (Pettit, Ward, Adame, Valdez, & Bunn, 2016). Light penetration in profundal zone was not sufficient for the primary production than the littoral zone, which sometimes contain different fish communities (Hayden, Myllykangas, Rolls, & Kahilainen, 2017).

For the temporal data, the highest number of fish species landed was recorded in the month of October with 10 species and 40 fish individuals. Meanwhile, the lowest 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 values for the Shannon-Wiener Index ranged between 0.42 (in May) and 0.88 (October). The rest of the months 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 values 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. As results, there were seven species of fish classified as 'native species' including *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 comprises of 78.55% with a total number of 238 fish individuals. Meanwhile, the non-native species comprises of 21.45% with a total of 65 fish individuals.

Among them, *Puntius bulu* was 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* was very low (Farinordin et al., 2016). However, the results of the study revealed on the existence of large individual samples (mean weight of 1,104.98±451.22 g), with 17 (5.61%) fish individual captured.

Six species of fish were classified as 'non-native' or 'alien' species which include *Oreochromis niloticus*, *Barbonymus gonionotus*, *Geophagus* sp., *Chitala ornata*, *Hypostomus plecostomus*, *Pangasius hypophthalmus* (Figure 2). The presence of the non-native or alien species in water bodies is not uncommon to be reported around the world. These species were introduced for certain purposes including for aquaculture (Khan et al., 2016), for sport fishing and for ornamental purpose (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 known as aquaculture species which include *Oreochromis niloticus*, *Barbonymus gonionotus*, and *Pangasius hypophthalmus*. Meanwhile, fish species such as *Chitala ornata*, *Geophagus* sp., and *Hypostomus plecostomus* were known as ornamental fishes. The report on the existence of *Geophagus* sp. in water bodies in Malaysia is currently scarce.

Overall, the most 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 reported that Cyprinidae was the most 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 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 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* (2^{nd} most dominant) and *Hemibagrus nemurus* (4^{th} most dominant) were classified as carnivore 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 was dominated by those predatory species. Carnivorous fishes are considered as 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 conflict of sampling techniques with the tourists and anglers. This can be examined from visual observation where fish species such as *Barbonymus schwanenfeldii* was 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 feeding activity by human. The behaviors of fishes change due to fish feeding activity by human, including the distribution of the fish species (Paula, Schiavetti, Sampaio, & Calderon, 2018).

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

4. Conclusion

In conclusion, the most dominant species inhabited the central wetland (south) of Lake Putrajaya during the study period was *Notopterus notopterus* (bronze featherback), and this was followed by *Oxyeleotris marmorata* (marble goby), and *Oreochromis niloticus* (tilapia). The most dominant family recorded during the study period was Notopteridae, where this finding was different when compared to most studies about species diversity of fish in lakes and reservoirs. On the other hand, the carnivorous species was dominant, which indicate that the carnivorous fishes may play big roles in the food chain and food cycle of the wetland. The native fish species was also dominant, comprise 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 individual fish samples. The non-native or alien fish species were mainly found in Malaysia waters for aquaculture purpose, such as *Oreochromis niloticus* and ornamental purpose such as *Geophagus* sp. Future study in the wetland should focus on utilizing other fishing gears 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 at the near 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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Figure

Total: 3 Figures

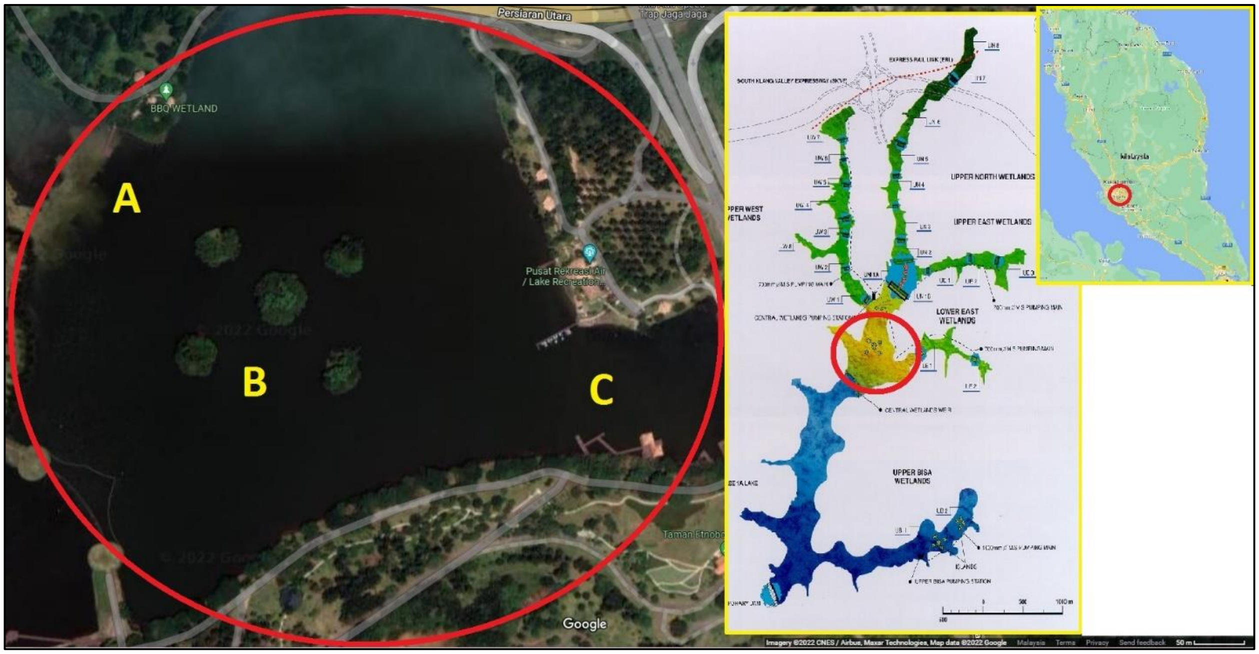

Figure 1 The location of the Central Wetland (south) of Lake Putrajaya, Malaysia, including the sampling stations within the wetland area (sources: Google maps and https://www.ppj.gov.my/second-page/tasik-dan-wetland).

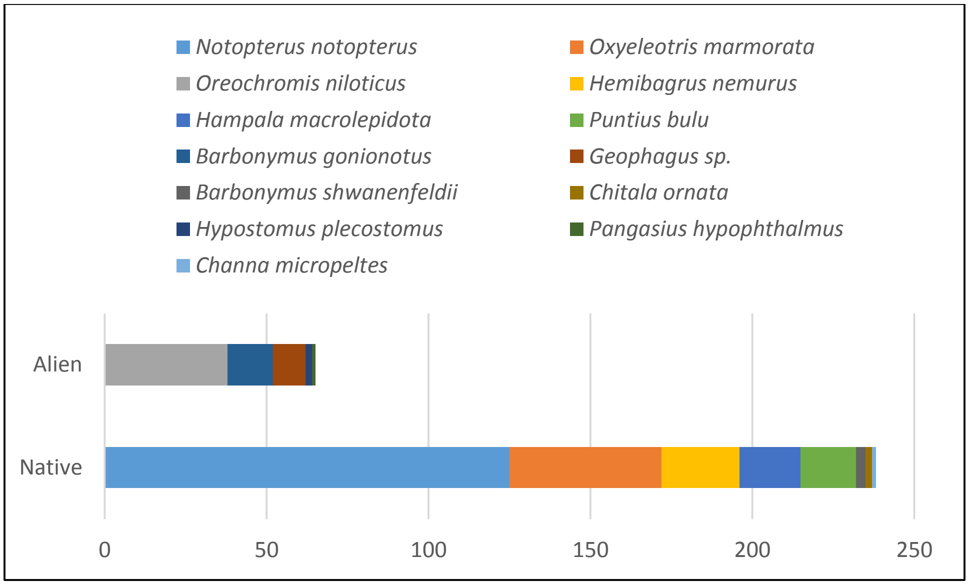

Figure 2 Number of individual fishes between native and alien species that were caught during the study period in the Central Wetland (south) of Lake Putrajaya, Malaysia.

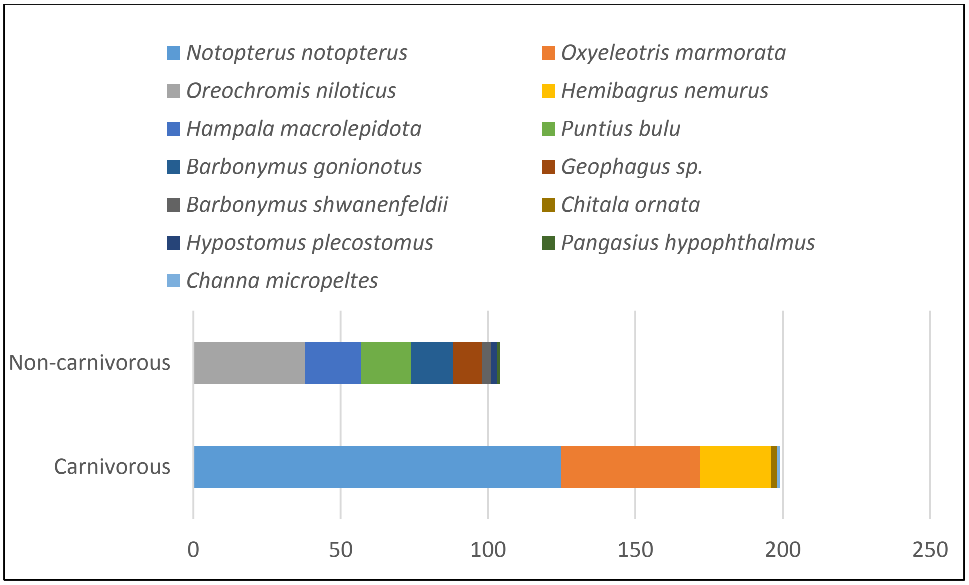

Figure 3 Number of individual fishes between carnivorous and non-carnivorous species that were caught during the study period in the Central Wetland (south) of Lake Putrajaya, Malaysia.

Table

Total: 2 Tables

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

Family	Fish species	Common name	No. of individual (%)	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