# A desktop study on fish assemblages in Malaysian lotic habitats

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Abstract. A desktop study on freshwater fish in Malaysian lotic habitats was conducted to provide an overview of the freshwater fish assemblages in Malaysia. Secondary data was extracted from literature that retrieved from major scientific databases including Google Scholar, ScienceDirect, and SpringerLink. A total of 385 fish species from 49 families were documented in Malaysian lotic habitats based on secondary data analysis. The Cyprinidae family is the most abundant fish family in Malaysia with 88 species recorded, followed by Danionidae (44), Bagridae (27), and Osphronemidae (21). The Cyprinidae family has the top five fish species recorded most frequently in Malaysian lotic habitats, which are present in the majority of Malaysia's states. Approximately 47% of fish species are restricted to just one state of Malaysia, demonstrating endemism of freshwater fish is high in Malaysian lotic habitats. Fish assemblages were found to be similar in Kedah, Kelantan, Pahang, Perak, Terengganu, and Johor, but very different in Sabah, Sarawak, Penang, Negeri Sembilan, and Selangor. Connectivity between lotic habitats in each state, land use, endemism, and invasive species may all influence the fish assemblages in each Malaysian state. This study revealed that ichthyofaunal research is lacking in several Malaysian states. More research should be done in those states to fill in the research gaps and present the most up-to-date information on Malaysia's ichthyofaunal study.

#### 1. Introduction

Malaysia is home to a variety of aquatic ecosystems, including streams, rivers, lakes, estuaries, and oceans. In aquatic ecosystems, there are two broad categories of ecosystems: the lotic and lentic ecosystems. Lotic ecosystems are those that have moving water, such as rivers and streams. Lakes and ponds, on the other hand, are examples of lentic ecosystems with static water. Rivers are the most common form of inland aquatic habitat found in Malaysia. Peninsular Malaysia has more than 9000 km<sup>2</sup> of river, while East Malaysia has more than 8000 km<sup>2</sup> of river [1]. There are about 150 major river systems in Malaysia, with around 100 in Peninsular Malaysia and the rest in East Malaysia [2].

Fishes in Malaysia, as keystone species in the river, have been threatened by human activities such as deforestation and the introduction of non-native species [3]. Changes in land use can affect the composition of freshwater fish in waterbodies [4-6]. Deforestation has been proven to alter the species composition of fish [7-9]. When compared to rivers without riparian, rivers with riparian exhibit a richer species composition of freshwater fish [4,10,11]. Changes in land use alter river water chemistry, causing endemic fish populations to decline or vanish in a short period of time [5]. Aside from that, since the 19th century, Malaysia has been introducing non-native freshwater fish for aquaculture. Saba et al [12] concluded that non-native ornamental and recreational fish have been found in several states

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over the last few decades, implying that non-native fish had been released from these industries. Chow et al [6] also demonstrated the presence of introduced ornamental suckermouth fish (*Hypostomus* plecostomus) in an urban river in Johor.

Documentation and study of freshwater fish have been undertaken for several decades in Malaysia. Hundreds of freshwater fish species have been identified in previous research, many of which are native to Malaysia [3]. Primary research is frequently focused on a single area, making it impossible to provide an overview of the fish assemblages in Malaysia. Furthermore, due to a lack of interest in the study, as well as difficulties in sampling in rural areas, there is a scarcity of data on freshwater fishes in certain regions, particularly East Malaysia [13,14]. Thus, the goal of this study was to provide an overview of freshwater fish assemblages in Malaysian lotic habitats via a desktop study, which entails gathering, analysing, and summarising other people's published work. A desktop study of Malaysian fish assemblages could also reveal the country's freshwater fish research gap.

## 2. Methodology

A desktop study on freshwater fish in Malaysian lotic habitats was conducted between July and November of 2020. The search for literature with publication years ranging from 1990 to 2020 was done using the major scientific databases, including Google Scholar, ScienceDirect, and SpringerLink. Keywords such as freshwater fish, stream and river, and Malaysia were used during the literature search. Fish occurrence data were extracted from the literature and compiled according to Malaysian states. Fish data was organized in Microsoft Excel spreadsheets by family, genus, and species. The data were crosschecked with Fishbase [15] and California Academy of Science's Catalogue of Fishes [16] to ensure that the family and species found from literature are standardized to avoid spelling errors and synonyms. Fish that were identified as confer (cf.) or up to genus level were excluded from further analysis. The fact that the primary data was collected by other researchers using different sampling strategies and level of identification, along with possible errors in fish species identification, the use of synonyms, and typos, could have an impact on the quality of the secondary data and introduce potential biases while using it for data analysis. Non-metric multidimensional scaling (NMDS) based on the Bray-Curtis similarity matrix was used to illustrate the fish assemblages in each state of Malaysia based on the frequency of fish occurrence in each state. Stress value in NMDS was used to measure the goodness of fit in NMDS where stress value less than 0.2 was considered as a good fit. Cluster analysis was run in this study to show the similarities in the fish assemblages of each state. The cluster was considered statistically significant at a linkage distance of < 60% and the number of clusters was decided by the practicality of the outputs [17]. All analysis was conducted using the PAleontological STatistics software package (PAST, Palaeontological Association, 2001).

#### 3. Results & Discussion

The present study demonstrated that a large portion of fish fauna studies in Malaysian lotic habitats were conducted in Perak, which is also the state with the highest richness of freshwater fish species (Table 1). On the other hand, no study was found in Perlis and Malacca, and limited research was found in Penang. The findings showed that ichthyofaunal research is unevenly conducted throughout Malaysian states and is insufficient in some of them. More research should be conducted in those states to fill the information gap and provide the most current data on freshwater fish in Malaysia.

A total of 385 freshwater fish species representing 49 families have been documented across the country (Figure 1). With 88 species recorded, the Cyprinidae family dominated Malaysia's streams and rivers. Danionidae has the second-highest number of species (44), followed by Bagridae (27) and Osphronemidae (21). There are 15 families with only one species documented in the literature, including Adrianichthyidae, Ailiidae, Amblycipitidae, Anabantidae, Anguillidae, Aplocheilidae, Botiidae, Chacidae, Clupeidae, Helostomatidae, Lobotidae, Nandidae, Phallostethidae, Serrasalmidae, and Vaillantellidae.

State	Number of species	Sources
Johor	100	[6, 18-20]
Kedah	55	[21-25]
Kelantan	65	[26-30]
Negeri Sembilan	17	[31,32]
Pahang	139	[20, 33-40]
Penang	7	[41]
Perak	230	[5, 19, 22, 30, 42-56]
Sabah	74	[4, 7, 57-64]
Sarawak	97	[65-69]
Selangor	68	[70-74]
Terengganu	56	[75-77]

Table 1. Number of freshwater fish species recorded in each state of Malaysia.



Figure 1. The fish family and the number of species documented in previous literature.

Family Cyprinidae is expected to have dominated Malaysian lotic habitats because it is the largest family of freshwater fishes [78]. Rivers in Brunei, Cambodia, and Thailand were also dominated by the Cyprinidae family [79,80]. The Cyprinidae family contributed nearly 80% of the total abundance of freshwater fishes in the Cambodian river [78]. The Cyprinidae family has the top five fish species that are found most frequently in Malaysian lotic habitats (Table 2). Except for Penang, their presence has been documented in almost every state. Fish species in the Danionidae family were previously classified as Subfamily Danioninae of the Family Cyprinidae [15]. However, phylogenetic studies of the Subfamily Danioninae suggested separating Danioninae from Cyprinidae and forming a new family due to genetic dissimilarities between Danioninae and other Cyprinidae members [16,81]. Despite being split off from the Cyprinidae family as a new family, the Danionidae family was the second largest in Malaysian lotic habitats. Devario regina is the most common Danionidae species which was found mainly in Kedah and Perak (Table 2). Bagridae is a catfish family that can be found from Japan to Borneo, according to Nelson et al [78]. There are endemic bagrid species in Malaysia, such as Nanobagrus nebulosus in Johor [18]. Osphronemidae is a family of fish that can be found in a variety of water bodies throughout Southeast Asia [77,81]. Some genera of Osphronemids have high tolerance to extreme conditions of environments, including the acidic water in the blackwater river [82]. Betta *pugnax* is the most common Osphronemidae species in Malaysia's lotic habitats (Table 2), with occurrences from the states of Johor, Kedah, Pahang, Perak, Selangor, and Terengganu. Betta pugnax from Penang was one of the first fighting fishes described [83]; however, the fish's occurrence was not captured in the present study since limited fish studies were undertaken in Penang.

**Table 2.** The top ten fish species recorded most frequently in Malaysian lotic habitats, and their presence (+) and absence (-) in each state.

Family	Species	Number of occurrences	Johor	Kedah	Kelantan	Negeri Sembilan	Pahang	Penang	Perak	Selangor	Terengganu	Sabah	Sarawak
Cyprinidae	Barbodes binotatus	63	+	+	-	+	+	-	+	+	+	+	+
Cyprinidae	Mystacoleucus obtusirostris	55	+	+	+	+	+	-	+	+	+	-	-
Cyprinidae	Osteochilus vittatus	55	+	+	+	+	+	-	+	+	+	-	+
Cyprinidae	Hampala macrolepidota	50	+	+	+	+	+	-	+	-	+	-	+
Cyprinidae	Cyclocheilichthys apogon	47	+	+	+	+	+	-	+	-	+	+	+
Danionidae	Devario regina	42	-	+	-	-	-	-	+	-	-	-	-
Channidae	Channa striata	40	+	+	+	-	+	+	+	+	-	+	+
Osphronemidae	Betta pugnax	39	+	+	-	-	+	-	+	+	+	-	-
Cyprinidae	Neolissochilus soroides	34	+	-	+	-	+	-	+	+	+	-	-
Mastacembelidae	Macrognathus maculatus	33	+	+	+	-	+	-	+	+	-	+	+

The similarities of each state's fish assemblages were shown in both a dendrogram (Figure 3a) and an NMDS plot with a stress value of 0.1119 (Figure 3b). The cluster analysis of 11 states revealed that fish communities were divided into six clusters. Kedah, Kelantan, Johor, Pahang, Perak, and Terengganu were found to have similar fish assemblages, which could be attributed to the connectivity of their rivers. For example, there were few rivers in Pahang that connected to other rivers in Johor's Endau-Rompin Forest Reserve [20]. Fish assemblages in five states, including Negeri Sembilan, Penang, Sabah, Sarawak, and Selangor, were found to be highly distinct to those in other states. Since Sabah and Sarawak are located on the island of Borneo, its distinct fish assemblage could be owing to endemic species [84]. Figure 4 illustrates that a total of 181 fish species recorded in Malaysian lotic habitats are found only in one state whereas less than 20 fish species are found in at least seven states in Malaysia. In other words, nearly half of the fish species (approximately 47%) in Malaysia are restricted to one state of Malaysia indicating endemism of freshwater fish is high in Malaysian lotic habitats. Fish assemblages in Negeri Sembilan, Selangor, and Penang may differ from those in other states due to differences in land use. Selangor is one of Malaysia's most developed states, with densely populated cities, whereas sampling sites in Negeri Sembilan and Penang were close to factories and farmland. Also, the presence of invasive fish species found in the Klang river as a result of the dumping of exotic pet fish [12] could possibly be a factor in Selangor's distinctive fish assemblage.



Figure 1. Fish assemblages in Malaysia. a) Dendrogram of cluster analysis for the Bray-Curtis fish similarity in each Malaysian state; b) NMDS plotting of fish occurrence frequency data in each Malaysian state.



Figure 4. Distribution range of freshwater fish species in Malaysian lotic habitats.

#### 4. Conclusion

A total of 385 species of freshwater fishes were recorded in the streams and rivers of Malaysia. The Cyprinidae family dominated Malaysian streams and rivers, with 88 species documented in previous research, followed by the Danionidae, Bagridae, and Osphronemidae. Kedah, Kelantan, Pahang, Perak, Terengganu, and Johor had the most similar fish assemblages based on frequency of occurrence, whereas Sabah, Sarawak, Negeri Sembilan, Penang, and Selangor had the most dissimilar fish assemblages. More research on the distribution and species composition of freshwater fishes in each Malaysian state, particularly Perlis, Malacca, and Penang, is needed to provide the most up-to-date information of Malaysian fish assemblages.

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