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# Fish Species Assemblages and Diversity in Water Body Infested by Alien Species

(Himpunan Spesies Ikan dan Kepelbagaian dalam Jasad Air yang Diserang Spesies Asing)

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ABSTRACT

Human is one of the mediators for non-native species invasion, especially in the aquatic ecosystem. Aquaculture and sport fishing activities are the main reasons for non-native fish introduction, especially in man-made habitats. In the present study, we determined the fish community between the invaded as opposed to pristine ecosystems in north Terengganu, Malaysia. The primary data was collected using hook and line, hand-held push net, cast net and gills net while secondary data were also utilised from published and unpublished data. The fish general information including functional traits and prey-predator relationship were obtained from literature and reliable online resources. The data were used to construct hypothetical diagrams and analyzed using taxonomic distinctness index. The fish community between the two habitats differ significantly in which the non-native fish invaded habitat has much lesser fish species richness than that of the pristine habitat. Taxonomic diversity between the two habitats also was markedly different. The non-native *Cichla ocellaris* added predation pressure to fish community in the lacustrine habitat as the apex predator and were proven to feed on the native fish fauna in the lake. We discuss the community structure in both habitats and explore the further impact of invasion by this invasive alien species on the native fish species. We conclude that the presence of *Cichla ocellaris* amplify pressure to native fish community in the man-made lake.

Keywords: Conservation; introduced species; man-made habitat; natural habitat

ABSTRAK

Manusia ialah salah satu pengantara kepada pencerobohan spesies bukan asli terutamanya di dalam ekosistem akuatik. Aktiviti akuakultur dan sukan memancing adalah punca utama kepada pengenalan ikan bukan asli terutamanya di dalam habitat buatan manusia. Dalam kajian ini, kami telah menentukan komuniti ikan di dalam habitat yang diceroboh untuk dibandingkan dengan ekosistem semula jadi di utara Terengganu, Malaysia. Data primer dikumpul menggunakan kaedah pancing, pukat sodok, jala dan jaring sementara data sekunder diambil daripada penerbitan dan data yang tidak diterbitkan. Maklumat umum mengenai ikan termasuk trait fungsian and hubung kait mangsa-pemangsa diambil daripada kepustakaan dan sumber dalam talian yang dipercayai. Data kemudian digunakan untuk membina rajah hipotetik dan dianalisis menggunakan indeks keternyataan taksonomi. Komuniti ikan antara kedua-dua habitat berbeza dengan ketara kerana habitat yang mengandungi bukan asli mempunyai kekayaan spesies ikan yang jauh lebih rendah daripada habitat semula jadi. Kepelbagaian taksonomi antara kedua-dua habitat juga amat berbeza. Ikan bukan asli, *Cichla ocellaris* telah menambahkan tekanan pemangsaan kepada komuniti ikan di habitat lakustrin sebagai pemangsa apeks dan telah terbukti menjadikan ikan asli sebagai makanan di dalam tasik. Kami telah membincangkan struktur komuniti di kedua-dua habitat dan kesan pencerobohan selanjutnya oleh spesies asing invasif ke atas spesies ikan asli ini. Kami membuat kesimpulan bahawa kehadiran *Cichla ocellaris* meningkatkan tekanan kepada komuniti ikan asli di tasik buatan manusia.

Kata kunci: Habitat buatan manusia; habitat semula jadi; pemuliharaan; spesies asing

## INTRODUCTION

The introduction of alien fish species was recognized as one of the main causes for community homogenization (Cavalcante et al. 2023) and species extinction, worldwide (Pyšek et al. 2020). Such incident of alien species introduction, coupled with habitat alterations accelerate native species extirpation, are correlated strongly with the biotic homogenization of the ecosystem (Rahel 2002) and community structure trade-off (Catford, Bode & Tilman 2018). Malaysia has a long history of alien fish introduction mainly for aquaculture, biological control, and sport fishing especially in man-made lakes, reservoirs and dams. The presence of large water bodies promotes water-related ecotourism activities including sport fishing (Aqmal-Naser & Ahmad 2024a). This has subsequenlty led to the introduction of alien fish species such as peacock bass (*Cichla* spp.), due to its fighting prowess lacking in native fish species.

Regrettably, the introduction of peacock bass (*Cichla* spp.), a ferocious carnivorous species mainly feeding on fishes and other aquatic fauna (Sastraprawira et al. 2020) in Malaysia in the early 90s for sport fishing (Zakaria & Bahrin 2018) has many adverse impacts. The negative impact exerted by this species to native aquatic fauna community in Peninsular Malaysia was not immediately known although it has been found in various water bodies. The South America-originated fish was favorable for the fishing game in Europe and Asia and popular as an exotic pet (Franco et al. 2022a). This voracious predator feeds on multi-diverse prey and is able to alter the native community in which they were introduced (Sastraprawira et al. 2020). Post-introduction effects of this species become a concern due to their highly invasive characteristics (Espínola et al. 2023).

In this study, we determined if the presence of *Cichla ocellaris* modified the fish community in the reservoir as opposed to natural and pristine small stream nearby. We hypothesized that the fish community in the pristine habitat is diverse than that of habitat with alien fish species. We also discuss the possible consequences of the invasive species *Cichla ocellaris* toward the native fish species, which is capable of accelerating universal exchange that eventually can replace the corresponding native species, which occupy similar niches.

## MATERIALS AND METHODS

### STUDY SITES

Both Tasik Telabak and Sungai Chantek is located in Besut district, north Terengganu, on the east coast of Peninsular Malaysia (Figure 1). Tasik Telabak is a small reservoir, located near Jerteh and often used for recreational fishing, has small floating cages for aquaculture purposes. Sungai Tabal supplies the water to the lake, flows into a larger reservoir off Sungai Besut, irrigating the rice field before emptying in the South China Sea.

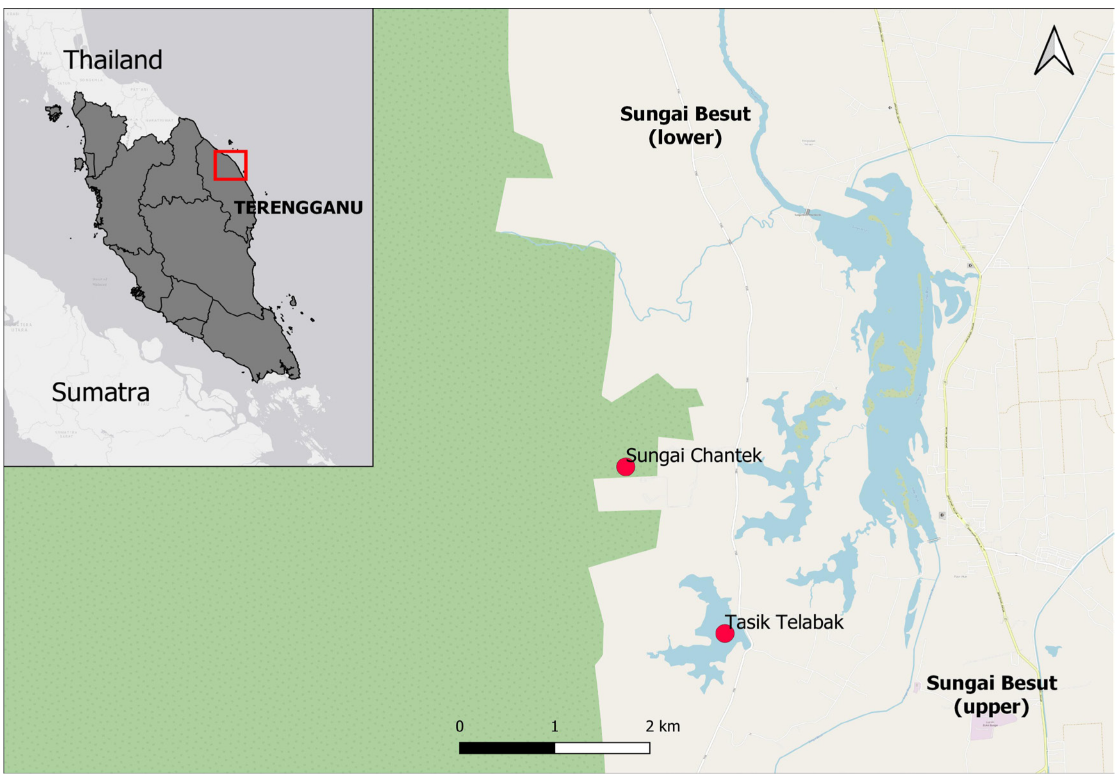


FIGURE 1. The inset shows the location of both study sites in Terengganu state while the enlarged map shows the river and stream drainages for both study sites which flows into Sungai Besut

## DATA COLLECTION AND ACQUISITION

First-hand data was collected in Tasik Telabak (referred to as 'stagnant water' hereafter) using multiple fishing gears including hook-and-line, hand-held push net (0.5 cm mesh size), cast net (1-inch mesh size), and gills net (1-inch mesh size) during the multiple visits to the site. To compare fish assemblages between two different types of water, the fish occurrence in Sungai Chantek (referred hereafter to as 'flowing water') were compiled based on the previous studies by Ahmad, Fahmi-Ahmad and Rizal (2018) and unpublished undergraduate theses. Data from both studies were pooled together to represent the flowing water habitat. Then, all the taxonomic identities of each fish species were revised and updated following Zakaria-Ismail, Fatimah and Khaironizam (2019). The general information on the fish's importance, their functional traits and the general species'prey-predator relationship were obtained from literature, various available and reliable online sources (Fishbase, Seriously Fish & IUCN Redlist).

## DATA ANALYSIS

A descriptive and simple comparative pie chart was constructed to determine the family composition between flowing and stagnant water habitats. Venn diagram was also used to dictate the shared and unique species present in both water systems. The taxonomic diversity of fishes between both types of habitats was assessed via average taxonomic distinctness (AvTD) and variation in taxonomic distinctness (VarTD) using PRIMER6 software. The higher value of AvTD indicated diverse fish assemblages while lower value indicated species are more closely related based on the taxonomic make up. The higher value of VarTD indicated higher variability (some species are closely or distantly related) while lower value indicated an even taxonomic spread). The analysis can be used mainly to compare the biodiversity across different habitat, assess the impact of environmental changes on the biodiversity or identify the area with high conservation values based on the taxonomic uniqueness. The point that lies outside the 95% confidence funnel showed departed taxonomic diversity from the master list (Clarke & Gorley 2005).

## RESULTS

A total of 45 fish species from 20 families and eight orders were recorded, in which flowing water has more species (32 species) than the stagnant water habitats with 15 species, respectively. One invasive fish species, *Cichla ocellaris* was recorded, only in the stagnant water habitat (Table 1).

Family Cyprinidae is the most dominant in both types of habitat with 26% in flowing water and 27% in stagnant water. In the flowing water habitat, few families were recorded but were absent in the stagnant water namely Balitoridae, Bagridae, Cobitidae, and Mastacemblidae. Meanwhile, few families were only recorded in the stagnant water such as Notopteridae, Pristolepididae, Belonidae, Eleotridae, and Cichlidae. The family Osphronemidae was among the dominant family with higher species richness in the stagnant water, but lesser in the flowing water. About 29% represented ten fish families (from 10 species) occupied the flowing water, where the species is common in the flowing stream with diverse microhabitats rather than stagnant water. For example, these included *Nemacheilus selangoricus* (Nemacheilidae), *Amblyceps foratum* (Amblycipitidae), *Glyptothorax fuscus* (Sisoridae), and *Microphis martensii* (Sygnathidae) (Table 1; Figure 2). The invasive species, *Cichla ocellaris* is represented solely by the family Cichlidae (Figure 2). In Tasik Telabak, three species namely *Cichla ocellaris*, *Channa micropeltes* and *Channa striata* were considered as apex predators while other fish species were grouped into pelagic predator, epibenthic predator and benthic predator. However, at Sungai Chantek, only *Hampala macrolepidota* is regarded as the apex predator, meanwhile *Channa limbata* is the mesopredator (Figures 3 & 4). Both habitats only shared one single species (Figure 5). The taxonomic diversity for both funnel plots shows no departed values outside the 95% confidence interval. Stagnant water shows a higher value of Delta$^+$ and Lamba$^+$ but with lower fish species richness compared to flowing water (Figure 6).

Based on the Venn diagram (Figure 5), both types of habitat only shared one common species namely *Cyclocheilichthys apogon*. About 13 species are unique to the stagnant water namely *Notopterus notopterus*, *Barbonymus schwanefeldii*, *Puntigrus partipentazona*, *Thynnichthys tynnoides*, *Rasbora borapetensis*, *Rasbora trilineata*, *Oxyeleotris marmorata*, *Trichopodus trichopterus*, *Trichopsis vittata*, *Channa striata*, *Pristolepis grooti*, *Cichla ocellaris,* and *Xenentodon canciloides* (Table 1). *Oxyeleotris marmorata*, *Trichopodus trichopterus*, and *Rasbora borapetensis*. Meanwhile, 30 species are unique to the flowing water such as *Acantopsis dialuzona*, *Balitoropsis zollingeri*, and *Osteochilus vittatus* (Figure 5; Table 1).

## DISCUSSION

An apex predator is known as the top predator in the food chain. They can drive the changes in the ecosystem, including the aquatic food webs (Vejrik et al. 2019). This is because, apex predators consumed almost all types of prey (generalism) (Vejrik et al. 2017), and could either directly or indirectly affect the food web including the mesopredator (Welch et al. 2022). Mesopredator meanwhile, is a mid-ranking predator which preys on smaller size prey and has hunting limitation (Vejrik et al. 2017). Hence, the population of mesopredators will increase if the number of apex predators decreased.

TABLE 1. The species list of fishes from flowing and stagnant water

| Species & Family | Flowing water | Stagnant water | Importance | Functional traits | |
|---|---|---|---|---|---|
| Notopteridae | | | | Food | Predatory |
| *Notopterus notopterus* | 0 | 1 | F | C | AP |
| Cobitidae | | | | | |
| *Acantopsis dialuzona* | 1 | 0 | F, O | C | AP |
| *Pangio filinaris* | 1 | 0 | O | C | AP |
| Balitoridae | | | | | |
| *Balitoropsis zollingeri* | 1 | 0 | O | O | NAP |
| *Homaloptera parclitella* | 1 | 0 | O | O | NAP |
| *Homalopteroides nebulosus* | 1 | 0 | O | O | NAP |
| *Pseudohomaloptera leonardi* | 1 | 0 | O | O | NAP |
| Nemacheilidae | | | | | |
| *Nemacheilus selangoricus* | 1 | 0 | O | O | NAP |
| Cyprinidae | | | | | |
| *Barbodes* cf. *binotatus* | 1 | 0 | F, O | O | NAP |
| *Barbonymus schwanefeldii* | 0 | 1 | F | O | NAP |
| *Ceratogarra cambodgiensis* | 1 | 0 | F, O | O | NAP |
| *Cyclocheilichthys apogon* | 1 | 0 | O | O | NAP |
| *Hampala macrolepidota* | 1 | 0 | F, O | C | AP |
| *Labiobarbus leptocheilus* | 1 | 1 | F, O | O | NAP |
| *Mystacoleucus obtusirostris* | 1 | 0 | F, O | O | NAP |
| *Osteochilus vittatus* | 1 | 0 | F, O | O | NAP |
| *Poropuntius deauratus* | 1 | 0 | F, O | O | NAP |
| *Puntigrus partipentazona* | 0 | 1 | O | O | NAP |
| *Thynnichthys tynnoides* | 0 | 1 | F | O | NAP |
| Danionidae | | | | | |
| *Rasbora borapetensis* | 0 | 1 | O | C | NAP |
| *Rasbora paucisqualis* | 1 | 0 | O | C | NAP |
| *Rasbora paviana* | 1 | 0 | O | C | NAP |
| *Rasbora trilineata* | 0 | 1 | O | C | NAP |
| Bagridae | | | | | |
| *Batasio fluviatilis* | 1 | 0 | O | C | NAP |
| *Hemibagrus capitulum* | 1 | 0 | F | C | NAP |
| *Leiocassis poeciloptera* | 1 | 0 | O | C | NAP |
| Amblycipitidae | | | | | |
| *Amblyceps foratum* | 1 | 0 | O | C | NAP |
| Sisoridae | | | | | |
| *Glyptothorax fuscus* | 1 | 0 | O | C | NAP |
| *Ompok siluroides* | 1 | 0 | F, O | C | NAP |
| Clariidae | | | | | |
| *Clarias leiacanthus* | 1 | 0 | F | O | NAP |
| Syngnathidae | | | | | |
| *Microphis martensii* | 1 | 0 | O | C | NAP |

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| | | | | | |
|---|---|---|---|---|---|
| Eleotridae | | | | | |
| *Oxyeleotris marmorata* | 0 | 1 | F | C | NAP |
| Gobiidae | | | | | |
| *Glossogobius giuris* | 1 | 0 | O | C | NAP |
| Mastacemblidae | | | | | |
| *Macrognathus circumcinctus* | 1 | 0 | F, O | O | NAP |
| *Mastacembelus favus* | 1 | 0 | F, O | O | NAP |
| Synbranchidae | | | | | |
| *Monopterus javanensis* | 1 | 0 | F | C | NAP |
| Osphronemidae | | | | | |
| *Betta pugnax* | 1 | 0 | O | C | NAP |
| *Trichopodus trichopterus* | 0 | 1 | O | O | NAP |
| *Trichopsis vittata* | 0 | 1 | O | O | NAP |
| Channidae | | | | | |
| *Channa limbata* | 1 | 0 | O | C | AP |
| *Channa micropeltes* | 0 | 1 | F, O, S | C | AP |
| *Channa striata* | 0 | 1 | F, S | C | AP |
| Pristolepididae | | | | | |
| *Pristolepis grooti* | 0 | 1 | F | O | NAP |
| Cichlidae | | | | | |
| *Cichla ocellaris** | 0 | 1 | S, O | C | AP |
| Belonidae | | | | | |
| *Xenentodon canciloides* | 0 | 1 | O | C | AP |
| Total species | 31 | 15 | | | |

*indicated alien fish species
F: food, O: ornamental, S: sport fishing, C: carnivorous, O: omnivorous, AP: active predator, NAP: non-active predator

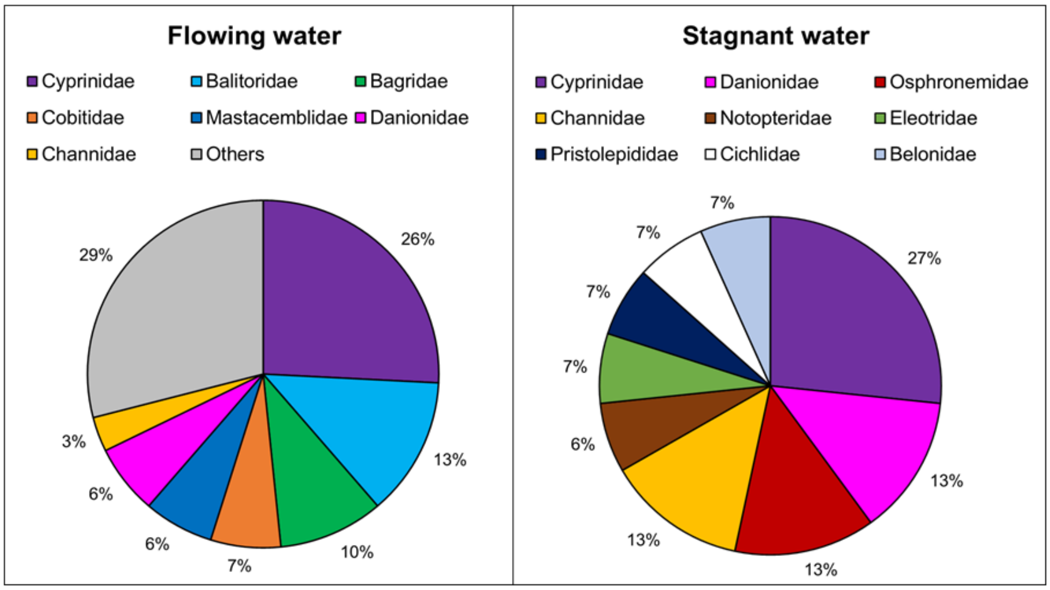


FIGURE 2. Family composition of fishes in flowing and stagnant water habitats

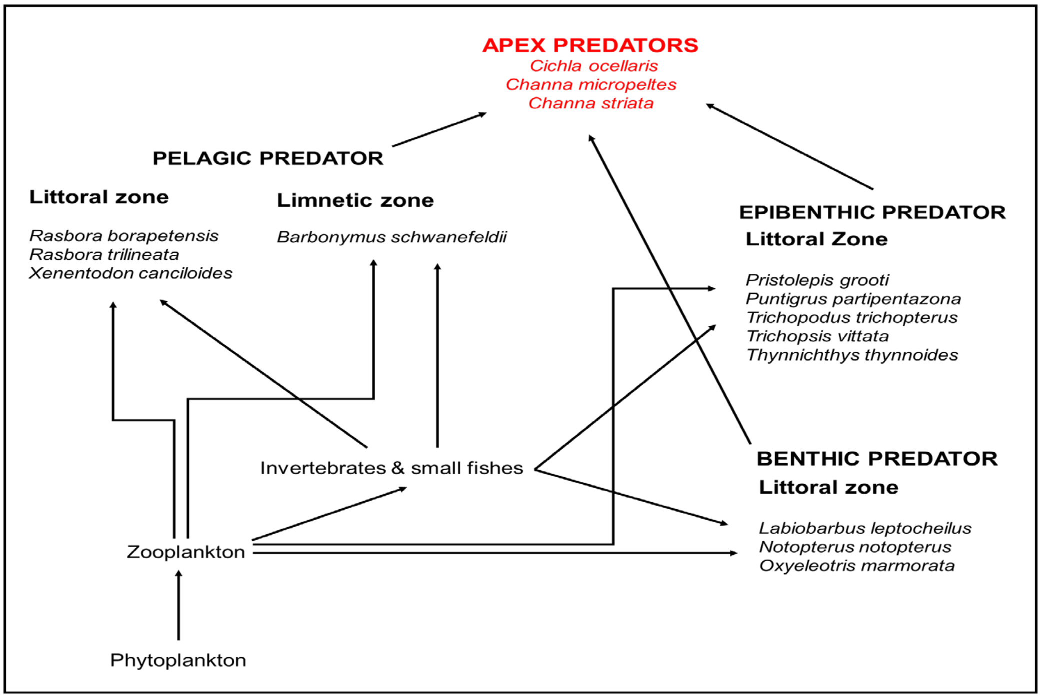


FIGURE 3. A hypothesized and simplified diagram of trophic relationship among fish species in Tasik Telabak based on the data collected

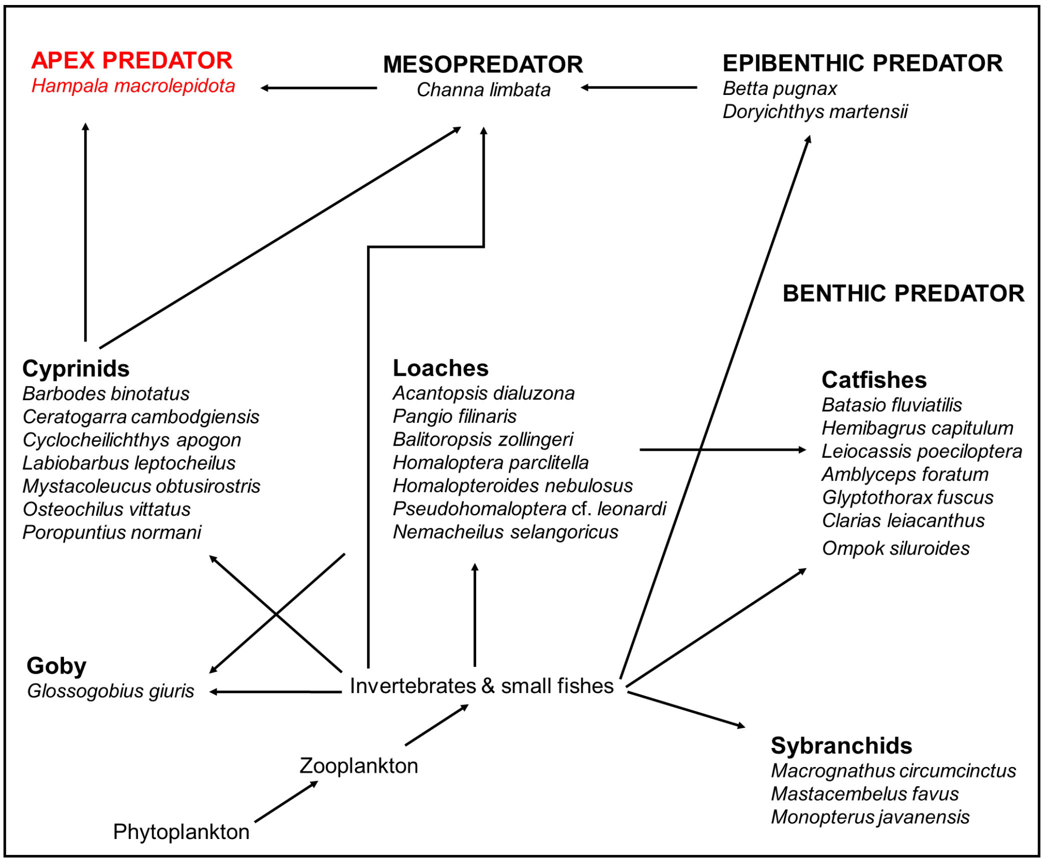


FIGURE 4. A hypothesized and simplified diagram of trophic relationship among fish species in Sungai Chantek based on the data collected

The effect of the introduction of the predatory alien fish species especially the apex predator has been known to reduce native fish species, worldwide. The predation is visible, which can lead to the extinction of the native species (Britton 2023). For example, the introduction of topmouth gudgeon, *Pseudorasbora parva* in Netherland has reduced the abundance of the native species in the river (Spikmans et al. 2020). Meanwhile in Lake Victoria, the introduction of apex *Lates niloticus* has a detrimental effect by reducing more than 200 on endemic cichlid of the lake (Balirwa et al. 2003). In a contrasting study, the introduction of alien prey has led to the shift in the diet of a native apex predator, the common pike which consumes more native trout and perch, thus alleviating the predation pressure on native fish species (McLoone et al. 2019).

Post-introduction of *Cichla* spp. in natural or man-made habitat is always detrimental. The species from this genus are known to be top predators with higher habitat plasticity. For example, in Brazil *Cichla* spp. had affected fish assemblages through predation on smaller fish (Franco et al. 2022b). Meanwhile, in neotropical reservoirs, *Cichla ocellaris* had successfully reduced the density of 95% native fish species and 18% species richness within two years after its introduction (Pelicice & Agostinho 2009). The comparison between invaded and non-invaded lakes by *Cichla monoculus* also showed the decline of native fish species, while the peacock bass becomes the most dominant species (Sharpe et al. 2017). The predatory attack of the peacock bass (*Cichla kelberi*) towards native fish and shrimp is also far more aggressive compared to the native predator (Carvalho et al. 2021).

The larvae of *Cichla* spp. feed mainly on slow growing and less competitive organisms (Sastraprawira et al. 2020), while the adult preys on all types of fishes (Santos et al. 2019). Hence, the competition between this invasive predator and native fish species will later be intensified. A study by Bacheler, Neal and Noble (2004), had shown the diet overlapped between introduced *Cichla ocellaris* and native *Gobiomorus dormitory* (bigmouth sleeper), and *C. ocellaris* consumed more fish. The impact of this predatory behavior also is apparent especially when the predator is taxonomically and/or functionally novel (Ricciardi & Atkinson 2004). For example, in Tasik Telabak, *Cichla* ocellaris is an active and pursuit predator while *Oxyeleotris marmorata* is a benthic and passive predator (sit and ambush). This advantage will be beneficial for *C. ocellaris*, but increase the competition with native *Channa striata* and *C. micropeltes* which were also apex predators.

There were only 15 fish species recorded in Tasik Telabak (stagnant water) compared to Sungai Chantek (flowing water). This study, without a doubt, needs more intense and continuous sample collection in the lake habitat to fully document the true fish species richness. The sampling efforts need to be increased by utilizing multiple fishing gears, as suggested by Fischer and Quist (2014) when conducting fish inventories in the lentic water systems. The area of the sampling points must be increased (Simon & Morries 2014) and additional habitat and repetitive sample collection (Aqmal-Naser et al. 2023) must be surveyed to record more additional species in the lake. The flowing water harbor more species as more efficient sampling techniques were used mainly the

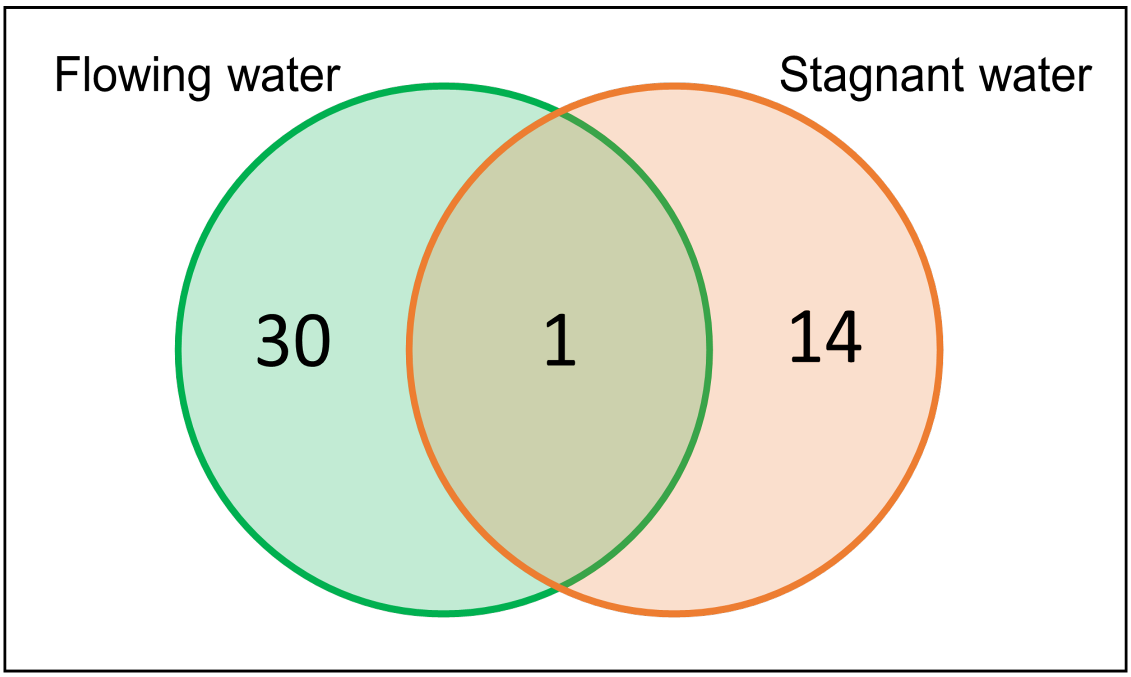


FIGURE 5. Shared and unique species from two types of habitats studied

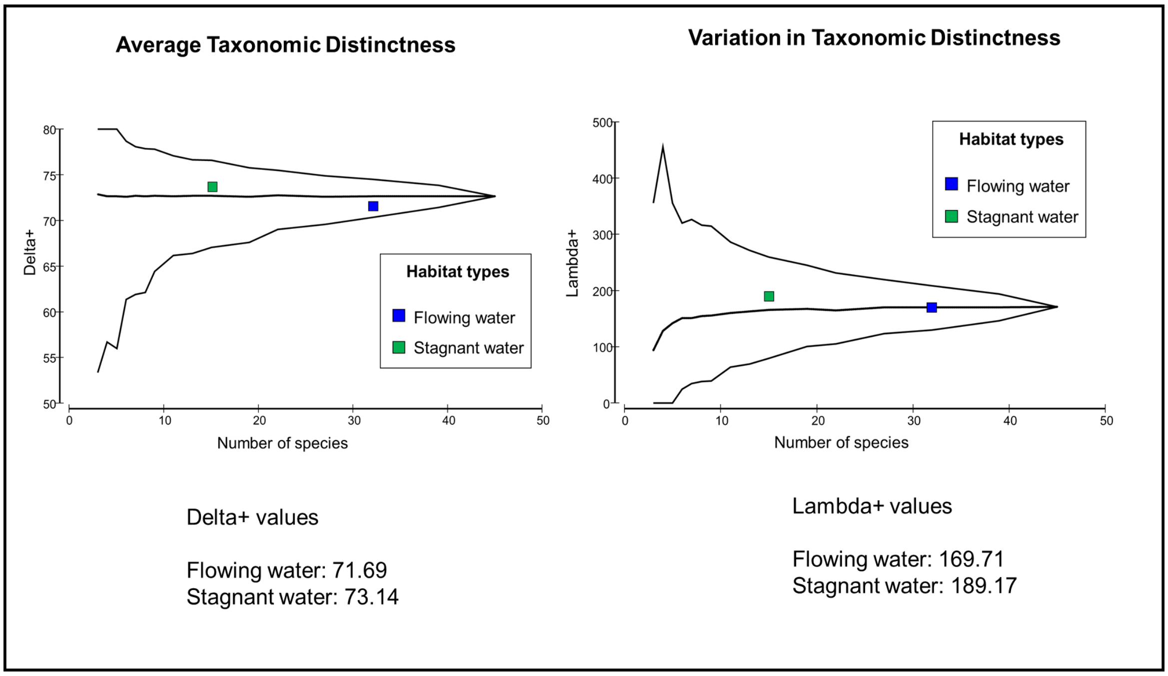


FIGURE 6. The average taxonomic distinctness and variations in taxonomic distinctness of fishes in two types of habitat

electrofishing method (Aqmal-Naser et al. 2024; Porreca et al. 2013).

The use of the secondary data also offer several advantages including time and cost effectiveness, resource optimization, as well as because of the data availability and accessibility. The secondary data offer opportunities for additional analysis and research, enriching understanding of the ecosystem (Pernat et al. 2024). For example, the need to fulfil certain information on the taxonomic information of the animals (i.e., rare and common) or occurrence of certain animal species (Steven et al. 2021). The secondary data is also important to determine spatial-temporal variations of the studied subject (Putman et al. 2021). Although the effort to explore the use of secondary data is still in the early stage, the important of the data in informing biodiversity research is critical (Aqmal-Naser et al. 2023; Pernat et al. 2024).

The existence of the *Cichla ocellaris* requires continual assessment to determine the community changes in this stagnant water system after the introduction of peacock bass. In Tasik Telabak, only *Channa micropeltes*, *Channa striata,* and *Cichla ocellaris* were considered as top and apex piscivores predators, rather than *Notopterus notopterus*; the latter was known to consume more invertebrates rather than small fishes (McMeans et al. 2019). Being one of the most active and voracious predators, *Cichla* spp. mostly attack bigger size fish species but weaker (Aguiar-Santos et al. 2018; Neal et al. 2017). The presence of *Cichla* spp. also had outcompeted the other invasive species (*Micropterus* sp. and *Oreochromis* sp.) in the natural river system in Brazil (Valverde et al. 2019). Nearly half of fish species (eight species) from the lake were regarded as food fish, while the other seven species were suitable as ornamental fishes. The introduction of peacock bass is often associated with the reduction of the native fish species, especially in the lake system (Agostinho et al. 2021). The previous findings also found that *Cichla ocellaris* in Tasik Telabak has a hyperphagia appetite, which consumed various fish species from several fish families and freshwater prawns (Khaleel et al. 2020), thus, indicating that the species is an apex predator with general prey species.

The connectivity of this lake with the floodplain (rice field) and the main river, Sungai Besut become a great concern on the future spreading of the peacock bass. It has been observed that the species was able to colonize adjacent river tributaries, as far as 20 km from the initial point of introduction (Escobar-Camacho et al. 2019). The seasonally flooded rice field, a type of man-made habitat with various disturbance and hydrological changes (Aqmal-Naser, Iguchi & Ahmad 2023) has proven to be able to sustain and aiding the colonization of diverse alien fish species, which were considered as invasive, including *Clarias gariepinus, Oreochromis niloticus* (Aqmal-Naser & Ahmad 2018), and *Amphilophus citrinellus* which feed on the native fish and native frog species (Aqmal-Naser & Ahmad 2024b), and could be applicable for the colonization of the peacock bass. Not to mention, the water system with sufficient food sources has enabled *Cichla* spp. to thrive and burst their population (Golani et al. 2019). Hence, any escapees from the lake into the adjacent water systems in this area can further spread this species, especially into the main river basins and tributaries.

Among all families, the Cyprinidae and Danionidae are dominant in both flowing and stagnant water. The family is the most dominant in Malaysia (Zakaria-Ismail, Fatimah & Khaironizam 2019), exhibit various adaptation involving their mouth and body structures (Ward-Campbell, Beamish & Kongchaiya 2005), contributing to their wider distribution in most types of habitats. The presence of family Balitoridae only in flowing water strongly indicated the higher oxygen level in the flowing water (Randall & Riggs 2015). Plus, other labyrinths (air-breathing) families were only present in the stagnant water of the lake namely Notopteridae, Opshronemidae (only one species in flowing water), and Pristolepidae showing different family composition between the two types of water bodies. These families were abundant especially in the lake systems of Peninsular Malaysia (Fadzil et al. 2016; Hashim et al. 2012). The species which possess the labyrinth organ can survive in lower levels of dissolved oxygen by utilizing atmospheric air, aiding in their survival in such harsh condition (Hill & Yanong 2002).

The fish community in flowing water has higher species richness than the stagnant water but exhibits lower values of both AvTD and VarTD. The community in the flowing water tends to have species that are closely related to each other: 1) species belonging to the family Cobitidae, Cyprinidae, and Balitoridae; and 2) species belong to the order Cypriniformes and Siluriformes. The stagnant water was considered an altered habitat, exhibiting a higher value of both AvTD and VarTD, even with lower species richness but higher taxonomic diversity. This is similar to the study in the different habitat types, where the impacted site has lower species richness but higher taxonomic distinctness value due to the presence of distantly related species (Mattos et al. 2023). The species assemblages tend to vary as the species present might be closely or distantly related to each other (De et al. 2023). The use of the taxonomic distinctness analysis is crucial to determine the influence of the habitats changes on the fish community (Bhat & Magurran 2007).

Total eradication of alien fish species in Peninsular Malaysia is not a straightforward process. The future impact on the socio-economic and ecology must be taken into consideration first before any actions are implemented. The eradication program involves long-term monitoring, funding, and the process could affect the native species (Patoka et al. 2018). Furthermore, improper management could lead to the Lazarus Effect, where the alien species 'returning' to the habitat after the control pressures (monitoring and regulations) were neglected (Lockwood, Hoopes & Marchetti 2013). The introduction and invasion of alien fish species can be controlled via two-way strategies: 1) preventing introduction at the border; and 2) preventing secondary spread (Britton 2023). The prioritization of task is vital to manage the alien species invasion through pre-invasion and post-invasion approaches (McGeoch et al. 2016). During the pre-invasion period (preventing introduction at the borders), species that pose a high risk and the sites that are prone to invasion and most sensitive must be identified and monitored. The introduction of alien fish species can be controlled at the country/state borders for the inspection of banned genus or alien fish species (pre-border). The targeted parties including the importer and shipper, which might keep some of the banned species.

Since most of the alien fish species are now having a stable feral population, preventing the second spread has become a major concern. The post-invasion steps aim to identify and eradicate the alien species with the greatest impact of invasiveness and sites with the highest risk of invasions (post-border) (McGeoch et al. 2016). Education and awareness, targeted on the public community should be organized to educate on the importance of ecosystem conservation. Engagement with primary and secondary students in the schools is one of the best approaches to increase awareness regarding the alien fish species issues. The practices of catching and eating alien fish species during recreational fishing by anglers can help to reduce alien species invasion especially the larger or predatory species. The anglers, fisherman, and houseboat operators should be provided with information regarding the alien species, their threats towards fisheries resources, and how to handle alien fish species. Apart from that, any reservoirs connected to natural streams or rivers must be frequently monitored to stop the spreading of alien species into natural water systems.

## CONCLUSION

The results from this study had shown the fish community between invaded and non-invaded habitats was relatively different. While we cannot completely rule out the impact of the introduction of *Cichla ocellaris* in the habitat, it is worth to establish a first study on the fish community assemblages in Tasik Telabak for upcoming monitoring. The previous study has shown the prey preferences of this invasive species, which indeed needs continuous monitoring. It is suggested that further examination and study on how fish diversity changes and responds towards the novel both alien and native apex predators in this man-made habitat. Data collection along the river basin of Sungai Besut are also needed to detect the occurrence of *Cichla ocellaris* which is known to change the aquatic ecosystem by disturbing the natural food webs.

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