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A RECENT SURVEY OF FRESHWATER FISHES OF THE PAYA BERIAH PEAT SWAMP FOREST, NORTH PERAK, MALAYSIA

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Abstrak: Satu kajian intensif iktiofauna telah dijalankan di Hutan Paya Beriah, yang terganggu baru-baru ini, untuk mendapatkan maklumat tentang spesies ikan yang masih boleh didapati. Sejumlah 32 spesies ikan daripada 13 famili dan 23 genus telah direkodkan semasa kajian ini termasuk spesimen daripada famili Channidae dan Siluridae yang masih belum dapat dipastikan lagi. Keputusan kajian ini menunjukkan bahawa terdapat perbezaan yang nyata terhadap kualiti air dan komposisi ikan jika dibandingkan dengan beberapa kajian terdahulu. Dalam kajian pertama, *Rasbora einthoveni* merupakan spesies ikan yang dominan, tetapi dalam kajian kedua dan kajian ini *Trichogaster trichopterus* telah berubah menjadi spesies ikan dominan. Kehilangan beberapa spesies endemik dan jarang dijumpai seperti *Sphaerichthys osphromenoides* (biji durian) dan *Luciocephalus pulcher* (tembuk tebing) dari kawasan ini boleh dikaitkan dengan pertukaran guna tanah di kawasan kajian. Kebanyakan zon semula jadi di persisiran sungai telah musnah. Pertukaran guna tanah juga akan menyebabkan perubahan hidrologi sungai yang seterusnya akan menyebabkan kerosakan yang tidak boleh dipulihkan terhadap habitat tanah bencah. Oleh yang demikian tindakan susulan perlu diambil bagi memelihara kelestarian habitat tanah bencah bagi memelihara keunikan biodiversiti ikan spesies endemik.

Abstract: An intensive fish sampling study was carried out in the recently disturbed Paya Beriah Peat Swamp Forest to obtain as much information on the fish species still present there. A total of 32 species of fish from 13 families and 23 genera including unconfirmed species of Channidae and Siluridae were recorded during the study. The result from the study showed that there were significant changes to the water quality and fish composition when compared to previous studies. In the first study, *Rasbora einthoveni* was the dominant species; but in the second and the present study, *Trichogaster trichopterus* became the dominant species. The loss of endemic and rare species, such as *Sphaerichthys osphromenoides* (chocolate gourami) and *Luciocephalus pulcher* (pikehead), from this area may be related to the changes of land use in the study area as most of the natural riparian zone has been destroyed. The changes in land use also changed its water hydrology thus causing irreversible damage to the wetland habitat. Therefore, urgent action should be taken to preserve the survival of such wetland areas to conserve its unique endemic fish biodiversity.

Keywords: Diversity, Fish, Land Use, Malaysia, Swamp, Riverine

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INTRODUCTION

Wetlands are land transitional between terrestrial and aquatic systems where the water-table is usually at or near the surface of the land (Cowardin *et al.* 1979). Wetlands can, for example, protect downstream agricultural lands by limiting the extent flooding. It also functions as a sediment trap. A floodplain can prevent the silting up of downstream irrigation schemes, while allowing seasonal fertilization of the flooded land. One example of wetlands habitat is swamp forest.

Generally, peat swamp forest has a black watercolor, with a unique water quality usually with a low pH (less than 5.5). The low of pH was due to the oxidation of sulphate soils as well as the presence of humic acid, tannins and other organic acids (Johnson 1967a). The water was usually soft, poorly buffered and lacking in calcium. Just as peat swamp forest has unique water chemistry, it also has many interesting endemic and rare species of fauna and flora. One of the rare and threaten fish species that has been found in peat swamp forest drainage areas was the Golden Arowana (*Sceloropagus formasus*) especially around Bukit Merah areas (Ali 1999; Mohamad Zaini 2003). Besides that, swamp is an important water storage area.

According to Wyatt-Smith (1954), 50 years ago, there are about 497,276 ha of swamp forest in Peninsular Malaysia. Currently only about 200,000 ha of the swamp forest still exist in Peninsular Malaysia and most of this swamp is located in Pahang. There are also significant areas of swamp forest located in Perak, Selangor and Johor but these are smaller in size. Johnson (1967b) indicated that the fish distribution in Peninsular Malaysia is not related to physical parameters but more towards its water chemistry. Johnson (1967b) showed that although black water habitat has low fish productivity, it had more fish species when compared to other habitats especially tree-country streams. This was confirmed by recent studies (Davies & Abdullah 1988; Ng *et al.* 1992; Lee 2003). The presence of rare ichthyofauna such as *Channa bankanensis, Boraras maculata, Betta livida, B. hipposideros* and others has indicated the importance of this habitat in maintaining and supporting a rich biodiversity of a very specialized fish assemblages (Ng & Lim 1991; Ng & Kottelat 1994). Most of these recent studies were concentrated at the North Selangor Peat Swamp Forest. The importance of swamp forest in the fish industry was that it provided a wide variety of beautiful fishes for the aquarium and ornamental fish industry.

As swamp forest was considered as low land productivity area or in other words as a wasteland area with not much economic value, most of these areas had been converted to residential, industrial and agricultural uses. One of these area is the Paya Beriah Peat Swamp Forest, which has a total area of 5,500 ha bordered by dykes, road system and railway tracks, and it is located near the Bukit Merah Reservoir (Ismail & Ali 2002). The transformation of this natural wetland habitat to a man-made ecosystem may lead to significant changes of the water quality. This will directly and indirectly lead to deterioration of flora and fauna associated with its. The fish population and its biodiversity in Paya Beriah Peat Swamp Forest is not well documented. So far there were two studies on fish population in this area. The first fish study was carried out in 1996 (Zakaria *et al.* 1999), which documented 20 fish species mainly from Sungai Beriah Kiri,

whereas 30 species were recorded during the second study in 2004. The second study covered all drainage systems of Sungai Beriah (Rezawaty 2004).

According to Ismail and Ali (2002), in 1998 almost 95% of Paya Beriah Peat Swamp Forest land use was as a swamp with Cyperaceae and other plants that thrive in the wet conditions with some encroachment by settlement and smaller portion of rubber and oil palms. However, the current land use at Paya Beriah Peat Swamp Forest has changed drastically in the past three years. Significant portions of the land have been converted to oil palm plantations and the other portion converted for residential purposes.

Biologists and ecologists often use diversity indices and species richness indices to measure the community structure as well as bio-indicators of the environmental stresses. Therefore, this present study was carried out to study the status of fish diversity in Paya Beriah Peat Swamp Forest. The present results were compared to the previous studies at Paya Beriah Peat Swamp Forest to study the impact of land use changes on fish biodiversity.

MATERIALS AND METHODS

The Study Sites

Three sampling stations were set up for the study, namely Sungai Beriah Kanan, Sungai Beriah Kiri and Sungai Beriah (Fig. 1). Sungai Beriah Kanan (N 05°05 E 100° 40.5) is located 5.95 km from Bukit Merah Town. Upstream of the bridge on the right of the river, the land was still swamp forest; whereas on the left was an old oil palm estate. The downstream of the bridge, the land adjacent to the river was recently converted to a palm oil plantation area. The upstream of the bridge, the river width was less than 2 m; whereas downstream of the bridge, the river width was about 3–4 m wide. The average depth was about 1 m.

Sungai Beriah Kiri (N 05° 07.3 E 100° 39.1) was located 4.1 km north of Sungai Beriah Kanan (Fig. 1). The width of the river ranges from 3 m to 5 m, while the depth ranges from 0.3 m to 2.0 m. Most of the surrounding area has been converted to an oil palm estate about two years ago.

Sungai Beriah (N 05° 06 E 100° 36') was formed by the merger of both rivers and was located 13.6 km to Bagan Serai Town (Fig. 1). On both sides of the river, upstream of the bridge, was an old oil palm estate whereas downstream of the river flowed through undisturbed peat swamp forest. The width of the river ranges from 8 m to 10 m and the depth was more than 1 m. This river flowed into Sungai Samagagah.

Sampling Strategies

Most of the samples were obtained along the river or drainage areas at the respective sampling stations, which were located near the roads (paved or dirt), logged forest and oil palm plantation. This was because, currently, there was no undisturbed peat swamp forest in the Paya Beriah Peat Swamp Forest.

To obtain as much species as possible, both active and passive sampling gears were applied. A pair of cast nets was operated by the same two individuals, as this was to minimize sampling bias. At each sampling station, the area was

sampled with cast nets for 1 hour that covered both upstream and downstream of the bridge. A scoop net was also used in isolated inundated patches along the sampling stations.

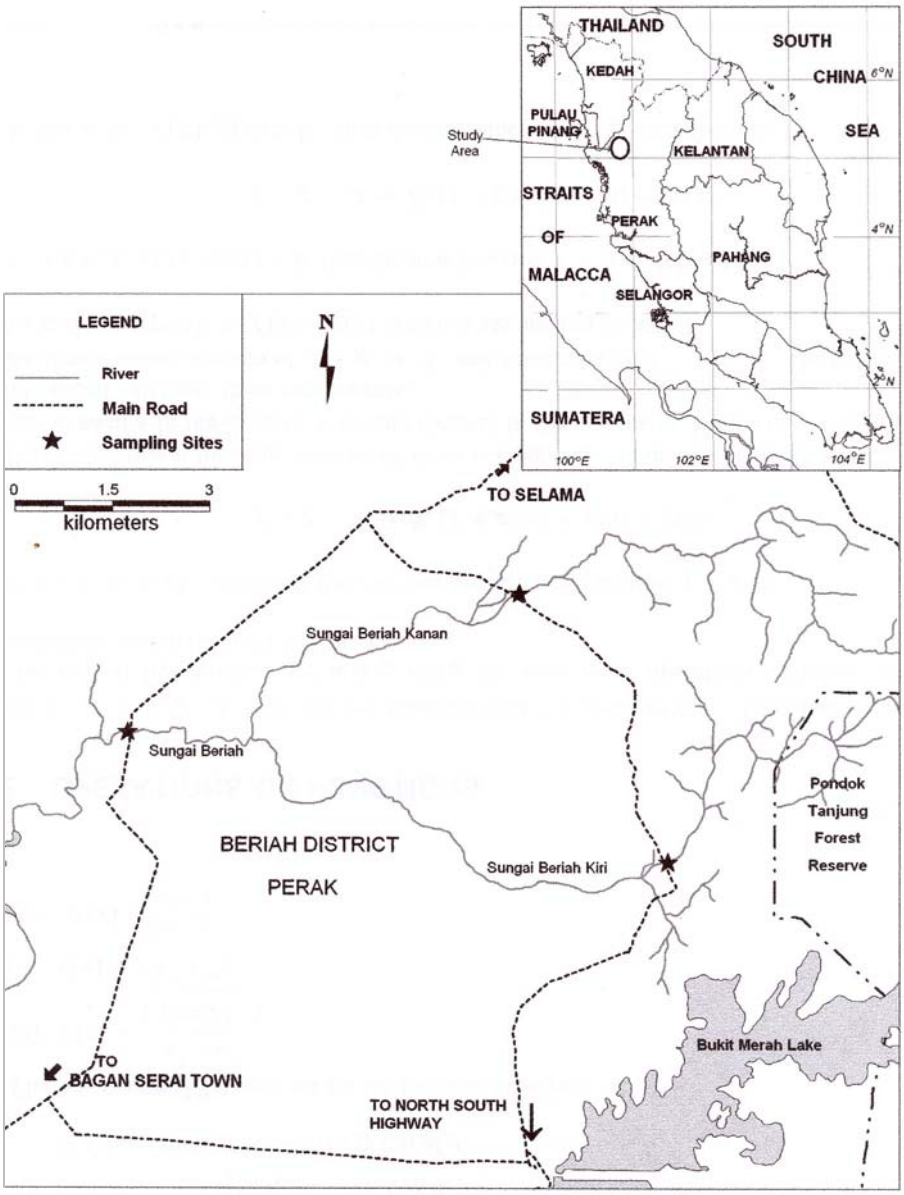

Figure 1: The location of main drainages system of the Paya Beriah Peat Swamp Forest which shows the flow of Sungai Beriah Kanan, Sungai Beriah Kiri and Sungai Beriah.

A gang of three different gill nets with mesh sizes (45, 75 and 85 mm) were set up at dusk along Sungai Beriah Kanan and Sungai Beriah Kiri; and left for 12 hours before being retrieved early the next morning. Interviews with local people found fishing at Sungai Beriah Kanan were also carried out.

A modified backpack electro-shocker with high safety precaution and awareness was used at all sampling stations. Usually the electro-shocking took about half an hour at each of the selected sites. The electro-shocked fished were then collected for the study.

All specimens collected were placed in different containers by sampling gears and sampling location. The specimens were count and identified up to the species level by using a standard key taxonomic by Mohsin and Ambak (1983), Kottelat *et al*. (1993) and Roberts (1996). After identification and recording of data, specimens still alive were released back to the natural habitat. Dead specimens and a few specimen of uncertain and representative of each species were taken back to the laboratory for further taxonomic study and deposited as sample collection in 5% formalin fixative. Wherever possible, *in situ* observation and identification of fish species were done.

Selected water parameters such as dissolved oxygen (DO) pH, conductivity and temperature were also determined *in situ* by using a Hydrolab Multiprobe Data Sonde at the respective sampling stations.

RESULTS

The water parameters at all sampling stations were presented in Table 1. Sungai Beriah Kanan recorded the highest DO reading at 3.22 mg/L followed by Sungai Beriah Kiri with 2.71 mg/L and the main Sungai Beriah with 0.68 mg/L. On the other hand, Sungai Beriah recorded the highest water temperature at 27.38°C followed by Sungai Beriah Kanan at 26.99°C and Sungai Beriah Kiri at 26.33°C. Sungai Beriah was more acidic with mean pH 4.24 when compared to Sungai Beriah Kanan with pH 5.85 and Sungai Beriah Kiri with pH 5.97. Both Sungai Beriah Kanan and Sungai Beriah Kiri showed a low conductivity of 0.02 mS/cm whereas at Sungai Beriah the conductivity was much higher with a reading of 0.09 mS/cm. Sungai Beriah recorded the highest reading of alkalinity (12 mg/L), hardness (11.20 mg/L), ammonia (0.12 mg/L) and total dissolved sediment (TDS) (48.30 mg/L) compared to Sungai Beriah Kanan and Sungai Beriah Kiri.

Table 1: Some physio-chemical properties of water at each sampling station during the study.

Parameters	Sungai Beriah Kanan	Sungai Beriah Kiri	Sungai Beriah
DO (mg/L)	3.22	2.71	0.68
Temperature (^{o}C)	26.99	26.33	27.38
pH	5.85	5.97	4.24
Conductivity (S/cm)	0.02	0.02	0.09
Alkalinity (mg$CaCO_3$/L)	10	10	12
Hardness (mg/L)	7.34	9.18	11.2
Phosphate (mg/L)	ND*	0.01	0.01
Nitrate (mg/L)	0.01	0.01	0.01
Ammonia (mg/L)	0.04	0.04	0.12
TDS (mg/L)	14.55	10.40	48.30

*ND: not detected

A total of 32 species of fishes from 13 families and 23 genera were recording during this study including one unconfirmed species of Channidae and Siluridae, respectively (Table 2). Sixteen fish species were obtained at Sungai Beriah Kanan, whereas 15 species were caught at Sungai Beriah Kiri and 18 species at Sungai Beriah (Table 2). Sungai Beriah recorded the highest species number compared to other sampling stations as many specimens were sampled from isolated inundated patches and drainages located along the river bank. Only one specimen each of *Channa lucius, Channa striata*, an unidentified Channa, *Osteochilus vittatus, Mastacembelus* armatus, *Puntius hexazona* and *Mystus micracanthus* were caught during the study.

The family Cyprinidae was the dominant family (34.4%) followed by Belontidae (12.5%), Channidae (9.4%) and Bragidae (9.4%) (Table 2). Many studies have shown that the recorded cyprinids were the most common species in Malaysian freshwater habitat (Ng *et al.* 1992; Zakaria *et al*. 1999; Lee 2003).

Table 2: The fish species checklist and its distribution in Paya Beriah Drainage System during the study.

Species	Local name	Family	SBKn	SBKr	BS
Anabas testudinues	Puyu	Anabantidae	+*	-	-
Aplocheilus panchax	Tahi lalat	Aplocheilidae	+	-	-
Mystus micracanthus	Baung	Bagridae	-	-	+
Mystus negriceps	Baung	Bagridae	+	-	-
Mystus nemurus	Baung	Bagridae	+	+	+
Betta splenden	Sepilai	Belontiidae	-	-	+
Belontia hasselti	Tebakang	Belontiidae	+	-	-
Trichogaster pectoralis	Sepat siam	Belontiidae	-	-	+
Trichogaster trichopterus	Sepat kedah	Belontiidae	-	-	+

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Table 2 *(continued)*

Species	Local name	Family	SBKn	SBKr	BS
Channa lucius	Bujuk	Channidae	+	-	+
Channa sp.?	Unidentifeid channa	Channidae?	-	+	-
Channa striata	Haruan	Channidae	-	+	-
Dermogenys pussilla	Julung-julung	Hemiramphidae	-	+	-
Helostoma temmincki	Temakang	Helostomatidae	+	-	+
Chela anomalura	Lalang	Cyprinidae	-	+	+
Cyclocheilichthys apogon	Temperas	Cyprinidae	+	+	+
Labiobarbus lineatus	Kawan	Cyprinidae	-	+	-
Osteochilus hasselti	Terbui	Cyprinidae	+	-	+
Osteochilus vitattus	Rong	Cyprinidae	+	+	-
Puntius binonotus	Sisik tebal	Cyprinidae	+	+	
Puntius hexazona	Pelampong jaring	Cyprinidae	-	-	+
Puntius lineatus		Cyprinidae	+	+	-
Rasbora cephalotaenia	Seluang	Cyprinidae	-	+	-
Rasbora sumatrana	Seluang	Cyprinidae	-	+	+
Rasbora trilineata	Seluang	Cyprinidae	-	+	+
Mastacembelus armatus	Tilan	Mastacembelidae	-	+	-
Chitala lopis	Belida	Notopteridae?	-	-	+
Notopterus-notopterus	Selat	Notopteridae	+	-	+
Pristolepis fasciata	Patung	Pristolepidae	+*	+	+
Ompok bimaculatus	Laih	Siluridae	+	-	+
Ompok?	Unidentified specimen	Siluridae?			
Monopterus albus	Belut	Synbranchidae	+	-	-
		13	16	15	18

Notes: + = present; - = absent; * = observation from local fishing man
SBKn = Sungai Beriah Kanan; SBKr = Sungai Beriah Kiri; SB = Sungai Beriah

DISCUSSIONS

Compared to the previous study at Paya Beriah Peat Swamp Forest by Ismail and Ali (2002), there were slight changes of water quality. DO readings at Sungai Beriah Kanan and Sungai Beriah Kiri has increased from 2.14 mg/L and 2.11 mg/L, respectively (Ismail & Ali 2002) to 3.22 mg/L and 2.71 mg/L during this study. However, DO readings at Sungai Beriah decreased from 1.21 mg/L to 0.68 mg/L. There was also increase of pH compared to the previous study at Sungai Beriah Kanan and Sungai Beriah Kiri from pH 4.77 and 4.87, to pH 5.85 and 5.97, respectively. However, at Sungai Beriah the pH decreased slightly from pH

4.29 to 4.24. There were not much differences in water temperature which were 27.0°C, 26.3°C and 27.4°C at Sungai Beriah Kanan, Sungai Beriah Kiri and Sungai Beriah, respectively when compared to previous studies.

Alkalinity levels were low throughout the whole wetland ecosystem at Paya Beriah Peat Swamp Forest, and this was characteristic of most black water systems in Malaysia as Johnson (1967a) has shown. All sampling stations were classified as "soft water" due to its low hardness. Orthophosphate, nitrate-nitrogen and ammonia-nitrogen levels were also very low at all sampling stations.

The unique condition of this blackish water environment with limited aquatic flora and fauna diversity living in the river but had a high value of conservation due to its uniqueness. Many of the fish species are endemic and are extremely popular as an ornamental fish (Johnson 1967b).

This study adds to the existing fish checklist that been recorded in Paya Beriah Peat Swamp Forest since 1996 (Table 3). Twenty species were recorded in 1996 (Zakaria *et al.* 1999) while a total of 30 species were reported by Rezawaty (2004). However, the lower number of fish species in Zakaria *et al.* (1999) study maybe due to it being restricted to Sungai Beriah Kiri (mistakenly identified as Sungai Beriah Kanan) only, whereas Rezawaty (2004) and the present study were based on the entire Sungai Beriah drainage system.

Table 3: A comparative fish species checklist that been identified and recorded by species and family at Paya Beriah Peat Swamp Forest drainage system.

Species	Family	Local name	Present study	Rezawaty (2004)	Zakaria *et al.* (1999)
Anabas testudinues	Anabantidae	Puyu	+	+	-
Aplocheilus panchax	Aplocheilidae	Tahi lalat	+	+	+
Mystus micracanthus	Bagridae	Baung	+	-	-
Mystus negriceps	Bagridae	Baung	+	-	-
Mystus nemurus	Bagridae	Baung	+	-	-
Nemacheilus selangoricus/fasciatus	Balitoridae		-	-	+
Belontia hasselti	Belontiidae	Tebakang	+	+	-
Betta pugnax	Belontiidae	Sepilai	-	-	+
Betta splenden	Belontiidae	Sepilai	+	+	-
Betta taeniata?	Belontiidae	Sepilai	-	+	-
Parosphronemus filamentosus	Belontiidae	Karim	-	-	+
Sphaerichthys osphromenoides	Belontiidae	Biji durian	-	+	+
Trichogaster pectoralis	Belontiidae	Sepat siam	+	+	-
Trichogaster trichopterus	Belontiidae	Sepat kedah	+	+	-
Channa?	Channidae	+?	+?	-	-
Channa lucius	Channidae	Bujuk	+	-	+
Channa striata	Channidae	Haruan	+	+	-
Clarias macrocephalus	Clariidae	Keli	-	+	-

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Table 3 *(continued)*

Species	Family	Local name	Present study	Rezawaty (2004)	Zakaria *et al.* (1999)
Acanthopsis choirorhynchos	Cobitiidae	Pasir	-	+	-
Chela anomalura	Cyprinidae	Lalang	+	-	
Cyclocheilichthys apogon	Cyprinidae	Temperas	+	+	+
Hypophthalmicthys molitrix	Cyprinidae	Kap perak	-	+	-
Labiobarbus lineatus	Cyprinidae	Kawan	+	+	
Osteochilus hasselti	Cyprinidae	Terbui	+	+	+
Osteochilus vitattus	Cyprinidae	Rong	+	-	-
Puntius binonotus	Cyprinidae	Sisik tebal	+	+	-
Puntius gonionotus	Cyprinidae	Lampam Jawa	-	+	-
Puntius hexazona	Cyprinidae	Pelampong jaring	+	+	+
Puntius lineatus	Cyprinidae		+	+	+
Puntius schwanenfeldii	Cyprinidae	Lampam sungai	-	+	-
Rasbora borapetensis	Cyprinidae	Seluang	-	+	-
Rasbora brittani	Cyprinidae	Seluang	-	+	+
Rasbora cephalotaenia	Cyprinidae	Seluang	+	+	+
Rasbora heteromorpha	Cyprinidae	Seluang	-	-	+
Rasbora pauciperforata	Cyprinidae	Seluang	-	-	+
Rasbora sumatrana	Cyprinidae	Seluang	+	+	+
Rasbora trilineata	Cyprinidae	Seluang	+	+	+
Oxyeleotris mamroratus	Eleotridae	Ketutu	-	+	-
Helostoma temmincki	Helostomatidae	Temakang	+	+	-
Dermogenys pussilla	Hemirhamphidae	Julung-julung	+	-	-
Hemirhampodon pogonognathus	Hemirhamphidae	Julung-julung	-	+	+
Luciocephalus pulcher	Luciocephalidae	Tembok tebing	-	-	+
Mastacembelus armatus	Mastacembelidae	Tilan	+	-	-
Nandus nebulosus	Nandidae	Daun kering	-	-	+
Chitala lopis	Notopteridae	Belida	+	-	-
Notopterus-notopterus	Notopteridae	Selat	+	+	-
Osphronemus goramy	Osphronemidae	Kaloi	-	+	-
Pristolepis fasciata	Pristolepididae	Patung	+	+	-
Ompok bimaculatus	Siluridae	Lais	+	-	-
Ompok?	Siluridae		+?	-	+
Monopterus albus	Synbranchidae	Belut	+	-	-

Note: + = present; - = absent

The differences of species number recorded in the recent study may also be related to the different sampling design and also the changes to the riparian habitat surrounding the sampling locations which are summarized in Figure 2. In the present study, a combination of active (cast nets), passive (gill nets) and electro-shocker sampling gears were used in the study when compared to the first and second studies, which only used scoop nets and push nets.

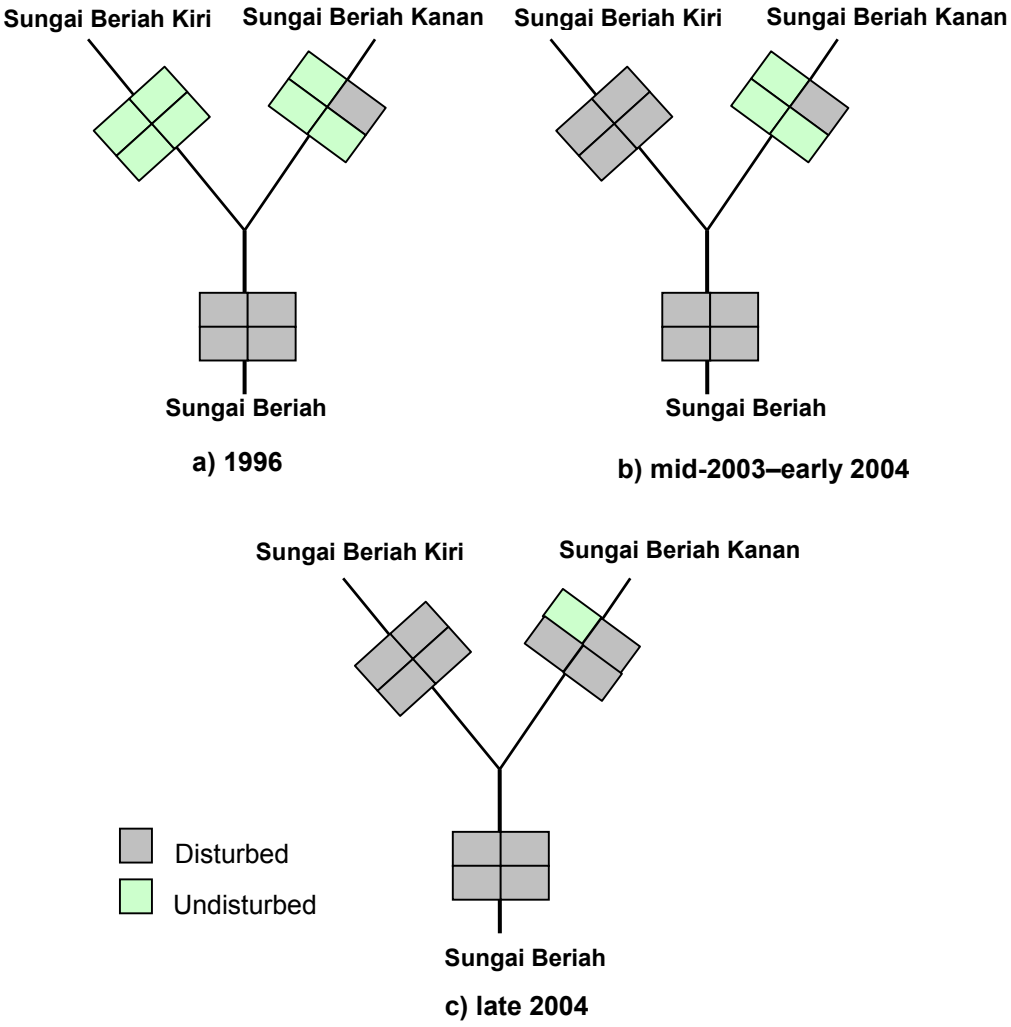

Figure 2: Land use changes at each sampling stations by year of the study.

There were changes in fish composition at the Paya Beriah Peat Swamp Forest when compared to previous studies. *Rasbora einthoveni* was the dominant species (37.8%) followed by *Puntius hexazona* (8.8%), *Hemirhamphodon pogonathus* (8.5%) and *Parosphronemus filamentosus* (7.1%) in the study by Zakaria *et al.* (1999). On the other hand, Rezawaty (2004) reported that *Trichogaster trichopterus* was the dominant species (25.2%) followed *by Puntius lineatus* (13.1%), *Helostoma temmincki* (11.3%) and *T. pectoralis* (6.4%). In this study the dominant species was *T. trichopterus* (24.1%) followed by *Puntius lineatus* (21.6%), *Rasbora sumatrana* (9.5%) and *Cyclocheilicthys apogon* (7.1%). The family Cyprinidae was still the dominant family (34.4%) followed by Belontidae (12.5%), Channidae (9.4%) and Bagridae (9.4%) (Table 2). Many studies have shown that cyprinids are the common species in Malaysians freshwater habitat (Ng *et al*. 1992; Zakaria *et al*. 1999; Lee 2003).

Both of the first two studies carried out in 1996 and mid-2003 till early 2004, the main sampling gears were scoop nets. However, the conditions of the surrounding riparian areas of sampling station were different. The condition of Sungai Beriah Kiri in 1996, which was misidentified as Sungai Beriah Kanan, was an undisturbed natural peat swamp forest at both locations, upstream and downstream of the bridge. In the second study in mid-2003 till early 2004, the upstream and downstream locations of Sungai Beriah Kiri were just being cleared for planting oil palm. During the present study, the downstream location of Sungai Beriah Kanan has now been converted to an oil palm plantation, with regular spraying of herbicides to control weeds.

Deforestation of natural habitat especially at or in close proximity to the rivers and stream has a significant impact on fish diversity, fish population and fisheries (Wright & Flecker 2004). Unique and rare fish species in peat swamp area, *Sphaerichthys osphromenoides*, which was well known as chocolate goramy and *Luciocephalus pulcher* (pikehead) have now vanished from this environment. The same fate was also faced by the endemic riverine plant, *Cyrptocoryne minima,* that was previously reported to be widespread at Sungai Beriah Kiri (Zakaria *et al.* 1999).

This land transformation has change the water quality directly and indirectly to flora and fauna composition. This was shown by Zakaria *et al.* (1999) which noted that the low species number at Ulu Sedili swamp forest may be related to it being converted into housing estate and agricultural land. Pesticides spraying especially herbicides to control weeds in agricultural areas close to aquatic habitat have also affected the fish population as the pesticides may flow into the nearby river by surface flow (Prowse 1970). Study also revealed that paraquat was the main herbicide that being sprayed frequently (at least 3 times per year) at this new environment at Sungai Beriah Kiri and Sungai Beriah. A mass fish kill, with *Chela anomulara* as dominant species killed, was observed and recorded in the ditches of an oil palm estate near to Sungai Beriah during the study. This Class II herbicide with moderate toxicity to fish was banned in Malaysia in 2002 and all use of it should to be phased out by 2005 (PAN 2003).

These rivers were being dredged occasionally to deepen and widen the rivers together with regular cleaning of debris, fallen trees, snags and aquatic

macrophytes as part of flood control mitigation. As a consequence, the dredging activities change the water quality and hydrology. Water quality became worse as the disturbances of river bottom and increase water flow resulted in high TSS. As mentioned by Zakaria *et al*. (1999), most fishes were recorded in channel stream of a wide river where the water is deeper and slower. Horwitz (1978) has indicated that more species could be found in a site where water current is slow.

The river clearing has also lead to the lost of unique habitats of selected fish species. This new environment condition has resulted in species replacement depending on how fast and how well they adapt. This was clearly shown as *T. pectoralis* and *T. trichopterus* that were not recorded in the first study have been recorded in the second and the present study. On the other hand, rare and endemic fishes such as *Sphaerichthys osphromenoides* (chocolate goramy) and *Luciocephalus pulcher* (pikehead) which were previously reported by Zakaria *et al.* (1999) were no longer present in the Paya Beriah Peat Swamp Forest.

Generally, the fish biodiversity at Paya Beriah Peat Swamp Forest was low in comparison to that of the North Selangor Peat Swamp Forest. This difference was related to their comparative size, while the area of the North Selangor Peat Swamp Forest was 30,000 ha whereas the Paya Beriah peat swamp forest was only 5,500 ha in size. Similar observation was made by Johnson (1967b), who noted that, more fish species were recorded at the south Peninsular Malaysia especially in Johor as this area had a larger area of blackwater habitat.

In conclusion, fish biodiversity and composition at Paya Beriah Peat Swamp Forest have changed drastically with the new development. Some of the endemic and rare fish species have already vanished or may even be extinct locally compared to previous studies. With no protective riparian zone at all the rivers in the study area, the changes of water quality and fish biodiversity become more serious. Therefore proper protection and management must be taken immediately to ensure the survival of the wetland areas at Paya Beriah Peat Swamp Forest.

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