Journal of Sustainability Science and Management 2010 Volume 5 (1): 13-20

FRESHWATER FISH DIVERSITY IN SUNGAI KELANTAN

MOHD AZMI AMBAK* AND MOHAMMAD ZAIDI ZAKARIA

Department of Fisheries Science and Aquaculture, Faculty of Agrotechnology and Food Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia.

**Corresponding author: ambak@umt.edu.my*

Abstract: An extensive survey on ichthyofauna was carried out at five tributaries of Sungai Kelantan in 2009 to determine whether turbidity has influence on the diversity of fishes. Fishes were collected using various fishing gears and secchi disc was used to measure water transparency or light-penetration level. Species Richness and Simpson index of diversity were used in the analysis to compare the species diversity. A total of 779 fishes were collected comprising 36 species belonging to nine orders (Beloniformes, Channiformes, Cypriniformes, Mastacembelliformes, Osteoglossiformes, Perciformes, Sygnathiformes, Symbranchiformes, and Siluriformes) and twelve families. The ichthyofauna were dominated by the cyprinids (19 species) and detrivores. The result shows that Sungai Pergau, upper part of the Sungai Kelantan system, having the least turbid water, were identified as having the most diverse fish community compared to the lower part of the Sungai Kelantan system. This study can be regarded as a significant contribution to the understanding of ichthyofauna of the Kelantan river.

KEYWORDS: fish diversity, Sungai Kelantan, freshwater fishes, species richness

Introduction

Kelantan, the fourth biggest state in Peninsular Malaysia, is situated in the north east of Peninsular Malaysia and Kelantan River (named Sungai Kelantan in Malay language and so named in this article) is the major river in Kelantan. Sungai Kelantan is a unique river in South-east Asia since it is the only river known to flow northwards.The length of the river from the headwaters to the estuary is about 450 km and is fed by more than 180 streams with a catchment area of about 11,900 km^2. However, the description of the river is complicated by the local naming convention; instead of using the name Sungai Kelantan (Kelantan River) from estuary to source, the name is only used for the section from the estuary to confluence of its two main tributaries, Sungai Galas and Sungai Lebir, near the town of Kuala Krai. The same naming convention applies to these tributaries. Thus, the main river from source to river mouth involves four names; originating from Sungai Betis (first 30 km from the source), then Sungai Nenggiri, followed by Sungai Galas, before meeting Sungai Lebir (Lebir river) to form the Sungai Kelantan. The river flows past four important towns; Kuala Krai, Pasir Mas, Tumpat and Kota Bharu, the state capital, which lies near the mouth of the river.

The Sungai Kelantan system has supported rich and diverse groups of fish fauna. Mohsin and Ambak (1983) mentioned at least 38 species from the Kelantan river system, including the following: Osteoglossiformes (two species), cyprinids (27 species), cobitid (two species), silurids (five species) and channid (two species). However, the fishes were mainly caught by using gillnets, thus if other efficient methods such as rotenone or electro-shocking were used, more species would have been caught.

In the early and mid 90s, the Kelantan river system was still rich in freshwater fishes, supporting a total of 55 species (The Government of Malaysia, 1989). Yusoff (1995) in her study reported a presence of 50 species from 40 genera from Kelantan river, while Ambak (2003)

reported the presence of 32 fish species in Sungai Nenggiri, including high-value species such as *Tor tambroides, T. tambra, T. douronensis Neolissochilus* spp., *Puntius daruphani* and *Bagarius bagarius*. Fish diversity in Sungai Kelantan system was high and comparable to those other major rivers such as Sungai Pahang and Sungai Terengganu. This is comparable to studies by various workers who reported that there were 35 fish species in Sungai Terengganu and 30 to 40 fish species in Kenyir Lake (Mohammad Zaidi *et.al*., 2000; Zulkafli *et al.*, 1999). Only 30 fish species were reported from the upper Sungai Pahang (Asian Wetland Bureau, 1992).

However, Sungai Kelantan started to become very turbid due to high suspended solids content and siltation, starting in the early 1990's. Sungai Nenggiri was already very turbid in mid 1990's due to logging activities in the upstream areas. When Nenggiri joined Sungai Galas at Bertam, Sungai Galas subsequently became turbid too. Likewise, Sungai Pergau which was less turbid, increases its turbidity when it joined Sungai Galas at Dabong. Downstream of Sungai Kelantan, the river water remains turbid, not only due to turbid waters from the upstream, but also due to sand-mining activities. From Kuala Krai down to Kelantan estuary in Tumpat, there are about 128 sand-mining companies operating in the river which is one of the major causes of benthic habitat destruction and water turbidity.

It is a well-known fact that siltation can deplete fish populations and cause local species extinction (Rabeni and Smale, 1995). Siltation causes physiological stress to fishes due to clogged gills. Fishes that rely on vision to feed will be much affected. Spawning beds and egg hatchability are seriously impaired. Turbidity also limits the energy source from the sun thus subsequently limiting the primary production and secondary production and the food web.

Although a few studies, mentioned earlier, were conducted to examine the species assemblage of Sungai Kelantan, none have dealt with the response of fish and other biological attributes to turbidity and siltation. The impact of river siltation on the fish species (and their food) available in Kelantan River has to be evaluated without delay. Initial findings (interviews) indicate the likelihood of serious threats that may lead to local extinction of certain species. The primary aim of this study is to present an inventory of the fish species available and assess the fish diversity and their assemblage in Sungai Kelantan in relation to water turbidity.

Materials and Methods

Sampling and Study sites

Fish-sampling stations were established at five existing JPS stream-flow gauging stations in Sungai Kelantan basin, namely Sungai Nenggiri (Kg. Bertam Baru), Sungai Pergau (Kg. Kandek, Batu Lembu), Sungai Galas (Dabong), Sungai Lebir (Tualang and Kg. Lela Jasa), and Sungai Kelantan (Kusial). Samplings were done from April to August 2009 at five stations and the fishes were collected using cast nets, gill nets of various mesh sizes, hooks and lines, within 200 metres at each sampling station. Backpack and boat-mounted electro-shockers were used to maximise fish catch so as to obtain a realistic fish inventory. The fish samples were then separated by species and the identification of fish species was done based on their physical and morphological appearance. For each specimen, total length (TL), standard length (SL) and body-weight measurements were taken.

In this study, we used Simpson's Diversity Index to understand the fish community and diversity at five different sampling stations. Water temperature, pH, dissolved oxygen, turbidity, phosphate and alkalinity were recorded in situ using digital equipments, such as pH metres and Hach DR/2000 5 portable water-analysis kit. Secchi disk was also used to measure the light-compensation level.

Sampling technique and research methodology

Various sampling techniques were used, based on the physical characteristics of the sampling sites as shown in Table 1. All the specimens were preserved in 10% formalin with tag for further analysis. Each individual caught was identified to its highest taxonomic level base or species level while the samples that were difficult to identify in the field were further examined in the laboratory. Data were also gathered from interviews with locals and, together with earlier published and unpublished reports, they were used to assess the state of the fish resources and species vulnerability.

Table 1. Site characteristics and fish-sampling techniques used to collect the fish specimens

Site characteristics	Fish sampling technique
Substrate: sandy / muddy / silt. **Stream flow:** very slow, depth more than 2m	UMT boat equipped with 75HP outboard engine and electro-shocker were used to cover ~200m distance. Sampling using gill nets, cast nets and long line; gill net – left for at least 6 hours.
Substrate: gravel / sandy / muddy; **Stream flow:** moderate and depth less than 2m	Sampling using a cast net, gill net and backpack shocker; duration of sampling cast net- 15-30 throws per station, gill net – left for at least 6 hours. Most often, boat equipped with outboard engine was used.
Substrate: rocky, gravel and/or sandy **Stream flow:** relatively fast; depth less than 1 meter	Sampling using hand net, scoop net and castnet. In addition, backpack electro-shocker was employed; duration of sampling about 20 mins for stunting of about 20 – 50 m stretch of stream.

Fish abundance and species richness

Fish abundance was expressed as number of individuals per 100 m sampled while species richness were easily express as the total number of species.

Diversity Index

In this study, we used Simpson's index (D) of diversity to measure the species richness, i.e., the diversity has been measured by the number of species at each sampling station. This index was chosen since it is simple and easy to interpret. The value of Simpson's diversity index ranges from 0 (infinite diversity) to 1 (complete evenness), the higher the value the worse it is in terms of fish community. These are given by;

$$D = 1 - (\sum p_i^2)$$

where, pi is the proportional of the ith species in the sample. The sample was collected from a large fish community, in which the total number of species is known.

Our analysis on Species Richness, Diversity and Composition are indicated by :

i. Total number of fish species (S).
Simpson Diversity Index (D)
Number of high-value, clean-water fish
Number of suckers and loaches (members of Balitoridae, Cobitidae and Sisoridae families) i.e., benthic fishes common in fast waters that are intolerant to low water quality.
Trophic condition, i.e., proportion of top carnivores; proportion of insectivorous cyprinids; proportion of omnivores; proportion of detrivores.

Diversity and abundance of fish from each sampling station were compared among the stations and other areas in the same sub-geographical divisions.

Results

Fish species

A total of 779 fishes were collected comprising 36 species belonging to nine orders (Beloniformes, Channiformes, Cypriniformes, Mastacembelliformes, Osteoglossiformes, Perciformes, Sygnathiformes, Symbranchiformes, and Siluriformes) and twelve families. Most number of fishes (66%) were collected from Sungai Pergau, while the least number of fishes (1%) were collected from Sungai Galas. The most dominant family was Cyprinidae with 721 fishes from 19 species (Table 2). The most dominant species is *Mystacoleucus marginatus,* making up 45.5% of the cyprinid family, followed by *Lobocheilus cornutus, Rasbora sumatrana* and *Labiobarbus lineatus.*

Since there are more than 60 species of Cyprinids in Peninsular Malaysia, the cyprinids in Sungai Kelantan system represent barely a third of all cyprinid species in Peninsular Malaysia. Likewise, in an ideal situation, all resident species should have mature, maturing and juvenile specimens. However, in all sampling stations, all species assemblages are dominated by small size juveniles, thus, although more than 700 specimens were caught, they yielded less than 5 kg in terms of total biomass. Furthermore, all the dominant species are detrivores and allochthonous feeders.

Table 2. List of freshwater fish species from Kelantan River at various stations**.**

Family	Species	Sg Nenggiri	Sg Pergau	Sg. Galas	Sg Lebir	Sg. Kelantan	IUCN
Osphronemidae	*Osphronemus goramy*	0	1	0	0	0	Not Evaluated
Bagridae	*Hemibagrus baramensis*	0	0	0	0	1	Not Evaluated
	Hemibagrus planiceps	0	0	0	0	1	Not Evaluated
	Mystus nigriceps	0	2	0	0	1	Not Evaluated
	Mystus nemurus	0	1	0	0	0	Not Evaluated
Belonidae	*Xenentodon canciloides*	3	5	0	0	4	Not Evaluated
Cobitidae	*Acanthopsis choirhynchos*	0	2	0	0	5	Not Evaluated
	Lepidocephalus octochirrus	0	5	0	0	0	Not Evaluated
Channidae	*Channa striata*	0	0	0	0	4	Not Evaluated
Clariidae	*Clarias batrachus*	0	0	0	0	1	Not Evaluated
Cyprinidae	*Barbichthys laevis*	1	11	0	0	0	Not Evaluated
	Barbonymus schwanenfeldii	3	3	0	2	24	Not Evaluated
	Puntius daruphani	0	0	1	1	0	Not Evaluated
	Cyclocheilichthys apogon	10	3	1	0	0	Not Evaluated

	Cyclocheilichthys heteronema	4	13	0	1	0	Not Evaluated
	Hampala macrolepidota	0	2	0	0	1	Not Evaluated
	Labiobarbus sumatranus	0	1	0	0	0	Not Evaluated
	Labiobarbus lineatus	8	5	0	0	54	Not Evaluated
	Lobocheilus cornutus	0	105	0	0	0	Not Evaluated
	Mystacoleucus marginatus	10	322	0	0	24	Not Evaluated
	Neolissochilus stracheyi	0	1	0	0	0	Not Evaluated
	Neolissochilus hexagonolepis	0	1	0	0	0	Not Evaluated
	Puntioplites bulu	0	1	0	2	0	Not Evaluated
	Rasbora sumatrana	14	6	2	0	62	Not Evaluated
	Rasbora trilineata	0	0	0	0	3	Not Evaluated
	Raiamas guttatus	0	11	0	0	0	Not Evaluated
	Osteochilus hasselti	1	0	0	0	2	Not Evaluated
	Osteochilus vittatus	0	0	0	0	2	Not Evaluated
	Chela anamolura	0	0	1	0	0	Not Evaluated
Notopteridae	*Notopterus notopterus*	0	0	0	1	2	Not Evaluated
Mastacembalidae	*Mastacembalus armatus*	1	0	0	0	1	Not Evaluated
	Mastacembalus maculatus	1	3	0	0	0	Not Evaluated
	Mastacembelus sp.	0	3	0	0	0	
Siluridae	*Ompok bimaculatus*	1	0	0	0	0	Not Evaluated
Sisoridae	*Bagarius bagarius*	0	3	0	0	0	Not Evaluated
Schilbidae	*Laides hexanema*	0	3	1	4	0	Not Evaluated
TOTAL	36	57	513	6	11	192	779

Fish Abundance, Species Richness and Diversity

The greatest fish abundance was observed at Sungai Pergau with 513 individuals followed by Sungai Kelantan (192 fishes), Sungai Nenggiri (57 fishes), Sungai Lebir (11 fish) and the least, Sungai Galas with only 6 individuals. In terms of species richness, Sungai Pergau was the richest (S = 20), followed by Sungai Kelantan (S=15), Sungai Nenggiri (S=11), Sungai Lebir (S=5) and Sungai Galas (S=5). Similarly, Sungai Pergau had the most diverse fish community, followed by Sungai Kelantan, Sungai Lebir, Sungai Nenggiri and Sungai Galas as shown in Table 3.

Table 3. Measure of Water Turbidity and Diversity of Fishes in Kelantan River System.

Station	Secchi depth(mm)	Turbidity (FTU)	Total Fish Catch	Species Richness	Simpson's Diversity Index
Sungai Nenggiri	80	366	57	11	0.8776
Sungai Pergau	150	46.5	510	20	0.502
Sungai Galas	60	476	6	5	0.9333
Sungai Lebir	80	155	11	5	0.8545
Sungai Kelantan (Kusial)	90	146.5	192	15	0.8368

Although Sungai Pergau has the highest number of fishes, and possesses the richest and most diverse fish species, it is showing signs of degradation. The water is quite turbid with an average of 46.5 FTU. The fish community is dominated by omnivorous and detrivorous species (*Mystacoleucus marginatus, Lobocheilus cornutus*, *Barbichthys laevis, Cyclocheilichthys* spp and *Labiobarbus* spp). Top carnivores are absent and insectivorous species (*Raiamas guttatus, Chela anamolura* and *Rasbora* spp.) are limited in number. All other stations have turbid waters (>100 FTU) with a very low presence or complete absence of high-value river carps (Cyprinidae), suckers and loaches. Sungai Kelantan recorded the presence of a number of low water-quality tolerant fishes such as the walking catfish (*Clarias batrachus*) and haruan snakehead (*Channa striata*).

In the Sungai Kelantan system, 7 species (*Ompok bimaculatus, Chela anamolura, Neolissochilus hexagonolepis, Acrossocheilus deuratus, Labiobarbus sumatranus, Mystus nemurus Osphronemus goramy*) which were once abundant are now considered rare, since they were collected once (excluding *Clarias batrachus*).

Discussion and Conclusion

In the early and mid 90s, the Sungai Kelantan system was still rich in freshwater fishes, supporting a total of 55 species (The Government of Malaysia, 1989). In a survey carried out in 1995, there were about 40 genera with about 50 species, 15 of which were commercially important (Yusoff, 1995). Quality fish species such as Baung (*Mystus* spp), Kelah (*Tor tambroides*), Kejor (*Neolissochilus hexagonolepis)*, Krai (*Puntius daruphani*), Lampam sungai (*P. schwanenfeldii*), Tenggalan (*Puntioplites bulu*), Patin (*Pangasius* spp.), Kelabau (*Osteochilus melanoptera*), Sebarau (*Hampala macrolepidota*), Terbul (*O. hasselti*) and the freshwater giant prawn (*Macrobrachium rosenbergii*) contributed more than 80% of the total catch, especially in the upstream reaches in Gua Musang (upstream of Sungai Galas) and Kuala Krai (a few kilometres downstream to the confluence of Sungai Galas and Sungai Lebir to form Sungai Kelantan).

The present study failed to capture any kelah, *Tor tambroides* and kelabau, *Osteochilus melanopleura* in the Kelantan river system despite very intensive sampling techniques being applied. Sungai Galas and Sungai Lebir suffered the worse fate. The fishes caught were comparatively small, probably due to more intensive fishing activity by the villagers and low water quality.

Simpson's diversity was relatively similar in all sampling station, $D_{Nenggiri}$=0.8776, D_{Galas}= 0.9333, D_{Lebir}= 0.8545, D_{Kusial}= 0.8368 except for Sungai Pergau, D_{Pergau}=0.502, which indicates a more diverse fish community compared to the other 4 stations. All sites had turbid waters with high sediment content. Increased siltation reduces fish production and diversity and was considered the most vital factors limiting fish-usable habitat. In the past, only the downstream section of the Sungai Kelantan was turbid and that was limited to only during the wet season. During the dry season, the river water was less turbid as less sediment from logging and other activities entered the river waters. In the period prior to the late 1990s, aquatic life in Kelantan river system was abundant with high diversity (most probably having a Simpson's Diversity Index <0.3).

In 1995, Sungai Lebir was relatively pristine, with undisturbed forest and clear water in the upstream at Kuala Koh that indicated that the river was in its natural state. The most abundant fish found there then were the inhabitants of clear-running water with sandy and rocky beds such as large-sized Kelah, Sebarau, Kelisa, Lampam sungai and Tenggalan (2 – 9 kg/piece). Aquatic insects such as mayflies, stoneflies and the trichopterans were abundant during that time with high densities of more than 100 organisms/m^2 (Yusoff, 1995). Both the fish and benthic aquatic insects are indicators of the clean-stream environment with high oxygen. Downstream of Sungai Lebir at

Sungai Aring and Sungai Lebir confluence, and at Olak Jeram, the water was also clean and clear. The rivers had clear water and a healthy fish food (e.g. aquatic insects) community.

According to IUCN Red List Category and Criteria, a population decline rate of at least 80% in 10 years is categorised as Critically Endangered; a population decline rate of at least 50% in 10 years is categorised as Endangered; and a population decline rate of at least 20% in 10 years is categorised as vulnerable. As defined in the IUCN Red Categories Handbook, "A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future".

Based on the present observation, at least 9 species can be categorised as Critically Endangered : *Tor tambroides, T. douronensis, T. tambra, Osteochilus melanopleura, Puntius daruphani, Ompok bimaculatue, Wallago attu, Acrossocheilus deuratus* and *Neolissochilus hexagonolepis* ; while at least 3 species can be categorized as Endangered : *Bagarius bagarius, Raimas guttatus* and *Labiobarbus sumatranus*.

Water is the key to all life and aquatic biota requires high-quality water for survival and well being. Certainly, the turbid condition of waters in the Sungai Kelantan system has seriously affected the fish populations. According to Rabeni and Smale (1995), benthic insectivores and herbivores, as well as lithophilous spawners, diminish with increased siltation.

In this study, it was crystal clear that rampant logging activities up the Kelantan River basin and Lojing Highland has led to serious erosion, subsequently causing heavy siltation in Sungai Kelantan ecosystem. The habitat was adversely destroyed, possibly causing serious depletion in the resource. Among several consequences of streamside vegetation removal, siltation is the one that most directly affects warm-water fish assemblages (Rabeni & Smale, 1995). A variety of mechanism by which siltation affects fishes have been clarified, including physiological stress from clogged gills, egg and larvae smothering, changes in normal feeding, and other activities that depend on vision (Rabeni & Smale, 1995). At broader temporal and spatial scales, siltation can cause local extinction of species that depend on coarse substrate for reproduction and feeding, also nektonic species that require a minimum water volume for foraging.

All freshwater fish species are important sources of protein to the indigenous people of the area. Although there are some species that can adapt to the ever-changing estuarine environment, constant clearing of the ecosystem they depend on for life sustenance will bring about inherent physical, chemical and biological stresses that, in the long term, will affect fish assemblages and diversity. Thus sustainable development of the area should be emphasised so that ecological balance can be maintained. In the final analysis, local extinction of some species is likely to happen if something is not done immediately.

Acknowledgements

We would like to express our thanks to the Faculty of Agrotechnology and Food Sciences, Universiti Malaysia Terengganu and Jabatan Perairan dan Saliran for supporting the grant for this research.

References

Ambak, M.A. (2003). *An inventory of the fishes of Sungai Nenggiri*. A report to GEC, Kuala Lumpur. (unpublished).

Asian Wetland Bureau. (1992). *Study of fish fauna of the Pahang river basin*, *Peninsular Malaysia* Kuala Lumpur. AWB.

Mohammad Zaidi, Z., K.Y. Ku Kassim and M.N. Johari. (2000). Fishes of Lake Kenyir, Terengganu, collected in 1992. *Fisheries and the Environment Beyond* 2000. UPM. Pg. 137-141.

Mohsin A.K.M. and M.A. Ambak. (1983). *Freshwater fishes of peninsular Malaysia*. Universiti Pertanian Malaysia. 284 pp.

Rabeni, C. F. and M. A. Smale. (1995). Effects of siltation on stream fishes and the potential mitigating role of the buffering riparian zone. *Hydrobiologia* 303 (1-3): 211-219.

The Government of Malaysia. (1989). Study of Kelantan River Basin Wide Flood Mitigation. Final Report. Part 1. Master Plan Study. JICA.

Yusoff. F.M. (1995). Kelantan river basin flood mitigation project: Environmental Impact Assessment – Aquatic living resources. A report for SMHB. Sdn Bhd. Kuala Lumpur.

Zulkafli, A.R., W.L.T van Densen and M.A.M Machiels. (1999). A comparison of the fish communities and trophic relationships in Kenyir and Semenyih reservoirs, Peninsular Malaysia. In: W.L.T van Densen and M.J. Morris (eds.). Fish and Fisheries of Lakes and Reservoirs in Southeast Asia and Africa. Pg. 77-94. Westbury Academic & Scientific Publishing. 432 pp.