WATER QUALITY, DIVERSITY AND DISTRIBUTION OF FRESHWATER FISHES IN , NEGERI SEMBILAN

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Abstract

The study of diversity and distribution of freshwater fishes at Sungai Sungai Muar in Kuala Pilah, Negeri Sembilan was done on 30-31 January 2011. Cast net and trawl were used in the sampling activities. Species of fishes found during sampling activities includes Cyclocheilichthys apogon, Osteochilus hesseltii, Hampala microlepidota, Puntius gonionotus, Oreochromis mossambicus, Hyposarcus pardalis and Prophagorus nieuhofi. In Sungai Sungai Muar, fishes from family Cyprinidae was dominant with total of 24 individuals from 4 species which include Cyclocheilichthys apogon, Osteochilus hesseltii, Hampala microlepidota and Puntius gonionotus. Diversity and distribution of species was analyzed using diversity index which is Shannon-Weiner and Simpson Index. Based on the analysis provided, the reading shows that Sungai Muar consist of high diversity of fish species with diversity indexes 2.14 (Shannon-Weiner) and 0.75 (Simpson). The most abundant species at the site was Osteochilus hesseltii with 13 individuals while the least abundant species was Prophagorus nieuhofi with one individual only. For water quality observation, the mean of the following data was recorded as the following; temperature was 24.9 °C, the percentage of Dissolved Oxygen (DO) was 58.97 %, the conductivity of water was 68.27 µs and pH was 6.94. Based on the data, we can conclude that the condition of Sungai Muar in Kuala Pilah is Sungai Muar was classiffied as Class I which indicates suitable for very sensitive aquatic species.

Keywords: Water Quality, Diversity, Distribution, Freshwater and Fish

1. Introduction

In general, the fish fauna in East, and South and Southeast Asia is dominated by cyprinids (about 1000 species), followed by loaches (about 400 species) of the families Balitoridae and Cobitiidae, gobids of the family Gobiidae (300 species), catfishes (about 100 species) of the family Bagridae and members of the Osphronemidae family (85 species). Tropical area contains most of the fish species diversity and in Asia the diversity at the family level (121 families) was considerably higher than in Africa. Only 50 and 55 families have been recorded in Latin America inland waters. For example, the number of finfish species which had recognized is estimated to be around 25,000 in the world. From these numbers of species, around 10,000 species are found in freshwater and another 160 species require freshwater, at one stage or the other, to complete their life cycle (Nguyen & Silva 2006).

Tropical area contains most of the fish species diversity and in Asia, the diversity at the family level (121 families) was considerably higher than in Africa. Only 50 and 55 families have been recorded in Latin American inland waters (Nguyen & Silva 2006). Studies on freshwater fish diversity and distribution have been conducted at many localities of Peninsular Malaysia and Borneo (Sabah and Sarawak). For example, in Peninsular Malaysia, a study was carried out by Mohsin and Ambak (1983), Bera Lake by Mizuno and Furtado (1982), Ulu Endau by Zakaria-Ismail (1987) and Temenggor River by Zakaria-Ismail (1993).

However, according to author, there is no study has been conducted in the Serting and Jempol River in Negeri Sembilan. Information on the status of freshwater fish diversity remains insufficient and still uncertain on how many species of fish available in Malaysia.

The diversity and distribution of freshwater fish also was affected by abiotic components which includes chemical and physical parameters. The chemical parameters include water pH, dissolve oxygen, turbidity, nitrate, phosphate, sulfate, level of suspended solids, and water conductivity while physical parameter includes width and length. According to Henderson and Crampton (1997), both white water and black water which consist of different concentration of turbidity, conductivity, pH and temperature held high diversity fish communities with many species in common. But, the number of Amazonian fish found at white water habitat more diverse yielding 108 species compared with only 68 species from black water habitat. The changes of stability of water system due to the crop activity also affect the diversity and density of fish. Evidence was found for migration of fish from varzea lakes during periods of low oxygen availability. According to Mohd Sham (2001), the acidic property of Ulu Menderang may have caused a reduction of the fish. *Rasbora sumatrana* and *Puntius binotatus* are the most common and abundance fish species in the stream with high concentration of dissolved oxygen.

Other than that, the stability of ecosystem also affects the species diversity of freshwater fish. According to Zaret (1982), the data presented on fish species diversity from the four major lake basins of Africa shows that the less stable environments consist of less number of species than the stable ones. Environmental stability can be measured using certain parameters. It can be measured by seasonal variance of physical, biological and chemical parameters. Species diversity will be measured by total species number (species richness), or "equitability", *H*', a quantitive measure of diversity based on total species and their frequency distribution (Pielou 1969). From this article, it studies on controversy of the stability or diversity of fish at lake or river habitat. As a result, the data shows that Chagres River-Gatun Lake basin have no significant difference in species diversity values (Zaret 1982).

Human activities are the major factors that cause the changes on the diversity and distribution of freshwater fish. The development of freshwater ecosystem by human being has lead to drastic changes in freshwater fish faunal including the gain of non-natives species and loss of many natives. According to Marchetti *et al.* (2006), increased urbanization tends to favor the extinction of unique native, the persistence of relatively few native species and also the introduction and establishment of already widespread non-native. Based on the result, it shows that in the area of Sacramento-San Joaquin watershed has a high number of species at risk (12) as well as a high diversity of native species (29) and the largest watersheds area (>140,000 km^2) in the state.

In addition, deforestation also can cause reduction in number of freshwater fish species. It is due to the reduction of woody debris input to tropical streams or directly removed wood from stream based in logging practices are affecting both the diverse fish communities and local economies dependent on stream fisheries. Through a survey conducted by Wright and Flecker (2004) on the pools area with and without wood, where they share the similar physical characteristics, pools with woods consist of more individuals and species of fish than pools without wood. Human activities that potentially compromise fish welfare include anthropogenic changes to the environment, commercial fisheries, recreational angling, aquaculture and ornamental fish keeping and scientific research. So, there are a lot of activities can be held to increase animal welfare and minimize the harmful (Huntingford *et al.*. 2006).

Since the publication of the Brundtland Report, 'Our Common Future' in 1987 (UNEP 1987), biodiversity and conservation became an integral part of development (Nguyen & Silva 2006). Biodiversity is a measure of the variety life. Conservation or protection of fish

measures in freshwater ecosystem increasingly aim for some blend of sustainable watershed management, flow maintenance, protection of water quality, exclusion of exotic species, and more localised conservation designation focused on specific water bodies (Ormerod 2003). Beside that, the Clean Water Act has set forth the objective of restoring and maintaining the "…chemical, physical, and biological integrity of the Nation's waters…". In the 1970's, the major fundings and efforts of the programs of water pollution control focused on point sources of pollution. It is because the conduction process of controlling and regulating is much easier (Karr and Dudley 1981).

2. Materials and Method

Negeri Sembilan is located at 50 km south of Kuala Lumpur. The study of abundance and distribution of freshwater fish was conducted at Sungai Muar, one of the streams located in Kuala Pilah, Negeri Sembilan. The net were used as a tool to catch the fish samples. The data were analysed using Ecological-Methodology software to find the diversity and distribution of fishes. Hence, the analysis of water quality also was conducted using Yellow Spring Instrument (YSI) Thermometer Meter. Sungai Muar is 2.0 m in depth, whereas the width of the river is about 10-20 m. Soil types is muddy and the soil was covered by grasses. These sampling activities were conducted during rainy season. Based on the observation, the area of . Sungai Muar was disturbed by anthropogenic activities such as house development and road.

Net. A cast net is a simple device which was used for fishing activity. The samples of fishes were stored in plastic containers fill with stream water to prolong their live. The sampling was done within 30 m stream segment at each sampling site. Hence, the physical characteristics of Sungai Muar was observed and discussed.

Samples Preservation. Sample preservation is one of the important methods where a captured fish which cannot be identified *in-situ* was preserved to maintain the body of specimens. In this process, diluted formalin containing 5-10% of formaldehyde was used for preservation.

Fish Identification. The process of fish identification was conducted using the preserved samples and pictures. This analysis was conducted to separate different type of fish into genus, species and family. Fish identification requires information such as fin, color, mouth, eye, lateral line, gill cover and pelvic fin. This is the scientific method in describing, naming, and classifying organisms which called Taxonomy. Hence, the picture of fish was taken immediately using digital camera since formalin decolorizes fish's color (Vijaylaxmi, 2010). Some reference such as books and website were used in the process of identification and classification. The website of "The IUCN Red List of Threatened Species", a book entitled Freshwater Fish in Western Indonesia and Sulawesi and Fishes in Malaysia was used in the process of identification. Length, weight and width of fish were also measured.

Data Analysis. Shannon-Weiner Index and Simpson Index was used to measure and compare the fish diversity at Sungai Muar. Ecological-Methodology software was used to analyse the data of fish.

a. Shannon-Weiner Index ($H^{'}$)

Shannon-Weiner Index ($H^{'}$) was used to determine the diversity of fish species based on number of species and the number of individual in each species (Muchlisin and Siti Azizah, 2009).

$$H^{'} = -\sum p_i \ln(p_i)$$

where H' = Shannon-Weiner Index, $p_i = \frac{n_i}{N}$

p_i = Proportional abundance of the species i

n_i = Total number of individual of species i

N= Total number of individuals of all species

According to Samad *et al.* (2003), the data has been used to compare the diversity of fish between sampling stations. Usually, the value of this index is around 1.5 until 3.5. It is also assumed that the sampling activities have been done randomly from bigger population (infinite). This index also consider as all species in the community are includes in the sample.

b. Simpson's Index (*D*)

Simpson's index was used to determine and analyse the probability that two individuals randomly selected from a sample which belongs to different species. This index is often used to quantify the biodiversity of a habitat. The value of D ranges between 0 and 1. With this index, 0 represents infinite diversity and 1, no diversity. Hence, the bigger the value of D, the lower the diversity of species (Muchlisin and Siti Azizah, 2009).

$$D = \sum p_i^2$$

where D= Simpson's Index, $p_i = \frac{n_i}{N}$

p_i = Proportional abundance of the species i

n_i = Total number of individual of species i

N= Total number of individuals of all species

D is often subtracted from 1 to give Simpson's Index of Diversity (D')

$$D' = 1 - D$$

Where D' = Simpson's Index of Diversity.

By the increasing number of fish diversity, the data shows the increasing value of this index. If the number of species collected is larger, the diversity of species will be higher or more diverse. The index value must be greater than or equal to one and less than or equal to the total number of species (Gregorius & Gillet 2008). From the data, one can conclude that certain streams consist of highly diversity of fish rather than others. This kind of measurement not only can be used to determine the diversity of fish, but it is also can be used to measure genetic variation and population genetic diversity (Chen *et al.* 2007).

Chemical Parameter Measurement. Chemical parameters concentration also can influence the diversity and distribution of fish. Some species will colonize the stream which is more acidic or basic depending on their ability to adapt to the water conditions. Chemical parameters which include temperature, pH (range 0 to 14), dissolved oxygen, turbidity and conductivity were measured using Yellow Spring Instrument (YSI) Thermometer Meter.

3. Results and Discussions

3.1 Fish Diversity and Abundance.

Table 1 shows the data of diversity and distribution of fish caught in Sungai Muar. Total numbers of fish caught were 37 individuals from 4 families. From these 7 species of fishes, the most abundant species was *Osteochilus hesseltii* from family Cyprinidae with 13 individuals (36%). This was followed by *Hyposarcus pardalis* with 10 individuals (28%) and *Cyclocheilichthys apogon* with 5 individuals (11%). *Hampala microlepidota* and *Puntius gonionotus* was also caught with 3 individuals each. Two introduced species was caught during the sampling activities. They were *Oreochromis mossambicus* with 2 individuals (5.5%) and *Hampala microlepidota* with 3 individuals only (8.3%). The least abundant species is *Prophagorus nieuhofi* from family Clariidae with 1 individual (2.7%) only.

Table 1. The diversity and abundance of fish at Sungai Muar, Negeri Sembilan

Family	**Common Name**	**Scientific Name**	**No of Individual**
Cyprinidae	Cemperas	*Cyclocheilichthys apogon*	5
	Terbul	*Osteochilus hesseltii*	13
	Sebarau	*Hampala microlepidota*	3
	Lampam Jawa	*Puntius gonionotus*	3
Cichlidae	Tilapia Hitam	*Oreochromis mossambicus*	2
Ospronemidae	Bandaraya	*Hyposarcus pardalis*	10
Clariidae	Keli Limbat	*Prophagorus nieuhofi*	1
4	**7**	**7**	**37**

From this data, fishes from family Cyprinidae that presented by (24 individuals from 4 species) was dominant in Sungai Muar, Negeri Sembilan followed by fish species from family Ospronemidae (10 individuals from 1 species), family Cichlidae (2 individuals from 1 species) and family Clariidae (1 individual from 1 species). According to Jeffrine *et al.* (2005), 895 individuals belonging to 41 species and 16 families were collected from Jempol and Serting. Dominant species found was also from family Cyprinidae including *Hampala microlepidota*, *Osteochilus* sp. and *Cyclocheilichthys apogon*. So, the data showed that similar or same species was caught from both sampling activities. This may be influenced by the location. All Sungai Muar, Sungai Serting and Sungai Jempoll are located at the same state. Other than that, the distribution of fishes at Sungai Muar may also be influenced by water quality of the stream.

3.1.1 Analysis of fish diversity by Shannon-Weiner Index and Simpson Index

The data was analysed using Ecological-Methodology software. Shannon-Weiner Index and Simpson index shows that Sungai Muar consists of high number of fish diversity. Based on analysis of fish at Sungai Muar, Simpson's = 0.75; Shannon-Weiner = 2.14.

Table 2. The data analysis of fish at Sungai Muar, Negeri Sembilan

Sampling Site	Shannon-Weiner	Simpson's Index (1-D)
Sungai Muar	2.14	0.75

From the analysis, the diversity of freshwater fish in Sungai Muar can be considered as highly diversed. Hence, the ecosystem of Sungai Muar is suitable as habitat of freshwater fish species.

Figure 1. *Osteochilus hesseltii*

Figure 2. *Oreochromis mossambicus*

Figure 3. *Hyposarcus pardalis*

Figure 4. *Cyclocheilichthys apogon*

3.1.2 Data of length, weight and width of fish caught at Sungai Muar, Negeri Sembilan

As shown in Table 3, the length of samples successfully collected ranged from 8 cm to 26 cm while the weight ranged between 11.17 g to 360.11 g. The width of samples ranged from 2.5 cm to 8 cm. There were five individuals of *Cyclocheilichthys apogon*(Figure 4) caught during the period of study with maximum length, 15.5 cm and minimum length about 13.1 cm. The median length of this species was 13.4 cm. The highest weight for *Cyclocheilichthys apogon* was 105.98 g and the lowest weight was 57.83 g whereas the median weight was 59.2 g. The maximum width for this species was 6 cm and the minimum width was 5.6 cm. The median width of this species was 5.8 cm.

Next, there were 13 individuals of *Osteochilus haseltii* (Figure 1) successfully caught. The maximum length of sample was 19 cm and minimum length was 13 cm respectively whereas the median length of this species was 15 cm. The highest weight of *Osteochilus haseltii* caught was 157.13 g and the lowest weight was 64.01 g. The median weight of this species was 85.46 cm. The maximum width for this species was 6.5 cm. Both minimum width and median width of these species was 5 cm.

Table 3. The data of length, weight and width of fish samples caught at Sungai Muar

Common name	Scientific Name	Length (cm)	Weight (g)	Width (cm)
Cemperas	*Cyclocheilichthys apogon*	13.1	57.83	5.6
Cemperas	*Cyclocheilichthys apogon*	15.5	105.98	6
Cemperas	*Cyclocheilichthys apogon*	15	99.57	6
Cemperas	*Cyclocheilichthys apogon*	13.4	59.2	5.8
Cemperas	*Cyclocheilichthys apogon*	13.2	58.9	5.6
Terbul	*Osteochilus haseltii*	13.3	73.48	5.5
Terbul	*Osteochilus haseltii*	19	157.13	6.5
Terbul	*Osteochilus haseltii*	17.5	121.49	6
Terbul	*Osteochilus haseltii*	13.5	64.83	5
Terbul	*Osteochilus haseltii*	16	107.72	6
Terbul	*Osteochilus haseltii*	14.5	73	5
Terbul	*Osteochilus haseltii*	17.5	133.3	6
Terbul	*Osteochilus haseltii*	15	85.46	5
Terbul	*Osteochilus haseltii*	14	74.66	5
Terbul	*Osteochilus haseltii*	16	95.68	5.5
Terbul	*Osteochilus haseltii*	13	64.01	5
Terbul	*Osteochilus haseltii*	14	70.13	5
Terbul	*Osteochilus haseltii*	14	67.2	5
Tilapia Hitam	*Oreochromis mossambicus*	15.5	116.19	5.5
Tilapia Hitam	*Oreochromis mossambicus*	24	360.11	8
Keli Limbat	*Prophagorus nieuhofi*	26	50	3.5
Sebarau	*Hampala microlepidota*	21.5	176.76	6.5
Sebarau	*Hampala microlepidota*	15	83	5
Sebarau	*Hampala microlepidota*	14	59.03	4.5
Lampam Jawa	*Puntius gonionotus*	13	82.3	6
Lampam Jawa	*Puntius gonionotus*	12	52.36	5
Lampam Jawa	*Puntius gonionotus*	8	11.17	2.5
Bandaraya	*Hyposarcus pardalis*	20	123	4
Bandaraya	*Hyposarcus pardalis*	19	122.53	4
Bandaraya	*Hyposarcus pardalis*	21	167.83	4
Bandaraya	*Hyposarcus pardalis*	19	133.12	3.5
Bandaraya	*Hyposarcus pardalis*	19.5	121.2	3.5
Bandaraya	*Hyposarcus pardalis*	17	115.19	3
Bandaraya	*Hyposarcus pardalis*	18	102.32	3.5
Bandaraya	*Hyposarcus pardalis*	12.5	45.42	2.5
Bandaraya	*Hyposarcus pardalis*	13.5	61.51	3
Bandaraya	*Hyposarcus pardalis*	12	38.78	2.5

There were two individuals of *Oreochromis mossambicus* (Figure 2) caught during the period of research. The highest length of these species was 24 cm while the lowest length was 15.5 cm. The maximum weight measured for these species was 360.11 g and minimum weight was 116.19 g. The highest and lowest width of *Oreochromis mossambicus* collected was 8 cm and 5.5 cm respectively.

Unfortunately, only single individual of *Prophagorus nieuhofi* was caught with 26 cm length. The weight of this species was 50 g, whereas the width was 3.5 cm. Due to lack of data, the range of length, weight and width could not be analyzed for these species.

On top of that, there were three individuals of introduced species, *Hampala microlepodota* successfully caught. The maximum and minimum length of this species was 21.5 cm and 14 cm respectively, whereas the median length was 15 cm. The highest width of the samples collected was 6.5 cm and lowest width with 4.5 cm, while the median width was 5 cm. The maximum weight measured for *Hampala microlepidota* caught was 176.76 g and the lowest weight is 59.03 g. The median weight of these species was 83 g.

There were also three individuals of *Puntius gonionotus* caught during sampling. The highest and lowest width of the samples collected was 6 cm and 2.5 cm respectively. The median width measured was 5 cm. The maximum weight of this species was 82.3 g and 11.17 g was the lowest weight, while the median weight was 52.36 cm. The maximum, minimum and median length of *Puntius gonionotus* was 13 cm, 8 cm and 12 cm respectively.

Last but not least was *Hyposarcus pardalis* (Figure 3) with 10 individuals caught. The length of these species ranged between 12 cm and 21 cm while 18.75 cm for the median length. Next, the maximum weight is 167.83 g and the minimum weight was 38.78 g. The median weight was 111.76 g. Furthermore, the highest and lowest width of *Hyposarcus pardalis* was 4 cm and 2.5 cm respectively, whereas the median width was 3.5 cm.

3.2 Water Quality.

Table 4. Water Quality of Sungai Muar, Negeri Sembilan.

Water Quality	Mean	Standard Deviation (SD)
Temperature (°C)	24.90	4.35×10^{-15}
Dissolved Oxygen (DO) %	58.97	1.72×10^{1}
Conductivity (µs)	68.27	2.08×10^{-1}
pH	6.94	2.89×10^{-2}

Table 4 represents data of Water Quality of Sungai Muar. The temperature of water in Sungai Muar averaged at 24.9°C, dissolved oxygen was at 58.97%, conductivity was 68.27 µs and pH of the water was 6.94. According to the National Water Quality Standards (NWQS) for Malaysian rivers (Department of Environment Malaysia, 2005), temperature, electrical conductivity and pH were classified as class I which means the water is good for very sensitive aquatic species. This explains why the diversity and distribution of fish were still high. On the other hand, dissolved oxygen

(DO) does not fall within normal range which is between 1 to 7 mg/l. Due to unavailability of a few other important parameters such biological oxygen demand and chemical oxygen demand no solid conclusions can be made about the depth of the pollution of the river.

Based on the observation, the surrounding area of . Sungai Muar is undergoing rapid development and pollution of the river is anticipated in the near future. Fish diversity and distribution may be threatened because of the pollutions. Regular monitoring and management should be imposed to prevent drop in numbers of fish at the river. Bataybal (1998) in his study has confirmed one of the primary causes of species extinction is habitat destruction.

4. Conclusion and Recommendation

The total fish caught in Sungai Muar of Negeri Sembilan is 36 individuals from 4 families. 7 species was found during these sampling activities. It was considered as highly diversed and with abundant species. Sungai Muar was dominanted by *Osteochilus hesseltii* from family Cyprinidae, followed by *Hyposarcus pardalis* and *Cyclocheilichthys apogon*. The results showed that Sungai Muar can be considered as not threatened by development pressure due to anthropogenic activities.

Conservation programme should be conducted in order to protect the ecosystem of Sungai Muar. Although, the condition of Sungai Muar were not yet affected by the development, most of species in Sungai Muar are considered as non-threatened and they also were not listed in IUCN Redlist, their existance however still have to be monitored. The environmental administration such as Enviromental Impact Assessment (EIA) should be done in this area to conserve the stability of this ecosystem.

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