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Diversity of Fish Fauna and Water Quality at Mid-Stretch of Batang Rajang at Ng. Benin and Peraran, Kapit, Sarawak

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The dissertation is submitted in partial fulfilment of requirement for the degree of Bachelor of Science with Honours in Aquatic Resource Science and Management

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DECLARATION OF AUTHORSHIP

I, Nadine Stanley Mopilin declare that the final year project entitles:

Diversity of Fish Fauna and Water Quality at Mid-Stretch of Batang Rajang at Ng. Benin and Peraran, Kapit, Sarawak

and the work presented in the report are both my own, and have been generated by me as the result of own original research. I confirm that:

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- I have acknowledged all main sources of help;
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Signed: _____

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List of Abbreviations

BOD	Biochemical Oxygen Demand
TSS	Total Suspended Solids
Chl-*a*	Chlorophyll-*a*
DO	Dissolved Oxygen
BW	Body Weight
SL	Standard Length
TL	Total Length
GSI	Gonadosomatic Index
HSI	Hepatosomatic Index
H'	Shannon-Wiener's Diversity Index
D	Margalef's Species Richness Index
J'	Pielou's Evenness Index

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ABSTRACT

This study was carried out to document the fish composition and to record the status of water quality at mid-stretch of Batang Rajang. This is due to lack of published report on the fish composition at this area after the construction and operation of Bakun Hydroelectric Dam in 2002 and 2012, respectively. Six stations from downstream area (Ng. Benin) and seven stations from upstream area (Peraran) were selected. The fishes were caught using mono-filament gill nets of different mesh sizes, three layered nets and cast net while YSI Multi-parameter was used to measure the water quality parameters *in-situ*. A total of 477 individuals were caught. Three dominant families are Cyprinidae family (70%), followed by Siluridae (8.6%) and Pangasiidae (6.3%).The three dominant species are *Barbonymus schwnenfeldii* (10.9%), followed by *Cyclocheilichthys apogon* (10.48%) and *Osteochilus vittatus* (5.45%). The Shannon-Weiner diversity index is higher at upstream (Peraran) while Margalef's richness index and Pielou's evnness index is higher at downstream (Ng. Benin). Two out of three species analyzed for length-weight relationship had negative allometric growth. As for water quality, pH ranged from 6.14 to 7.29, turbidity ranged from 6.85 NTU to 299.40 NTU, conductivity ranged from 0.02 µS/cm to 46.60 µS/cm, temperature ranged from 24.48 °C to 28.81 °C, BOD_5 ranged from 2.52 mg/L to 5.37 mg/L, chlorophyll-*a* ranged from 0.0445 µg/L – 1.231 µg/L and TSS ranged from 2.18 mg/L to 83.36 mg/L. The PCA indicates that fishes such as *Puntioplites waandersii* and *Pangasius macronema* can tolerate well with stated range of TSS. This study has found that the regulated release of water from Bakun Hydroelectric Dam may have affected the water quality and the diversity of fish in this study area.

Keywords: Fish fauna, Diversity, water quality, Batang Rajang

ABSTRAK

Kajian ini dijalankan bagi mendokumentasikan komposisi ikan dan merekodkan status kualiti air di pertengahan Batang Rajang. Ini adalah kerana tiada rekod kajian komposisi ikan dijalankan selepas pembinaan loji hidroelektrik Bakun pada tahun 2002 dan beroperasi pada tahun 2012. Enam stesen dari hilir (Ng. Benin) dan tujuh stesen di hulu (Peraran) telah dipilih. Ikan ditangkap menggunakan pukat mono-filamen, pukat 3 lapis dan jala. YSI muti-parameter juga telah digunakan untuk mengukur kualiti air secara in-situ. Sebanyak 477 individu ikan telah ditangkap. Tiga keluarga yang dominan adalah Cyprinidae (70%), diikuti oleh Siluridae (8.6%) dan Pangasiidae (6.3%). Tiga spesis dominan yang didapati adalah Barbonymus schwnenfeldii (10.9%), diikuti dengan Cyclocheilichthys apogon (10.48%) dan Osteochilus vittatus (5.45%). Indeks kepelbagaian Shannon-Weiner adalah lebih tinggi di hulu (Peraran) dan indeks kekayaan Margalef serta indeks kesamarataan Pielou adalah lebih tinggi di hilir (Ng. Benin). Dua daripada tiga spesis yang dianalisis untuk hubungan panjang-berat mempunyai hubungan alometrik negatif. Bagi kualiti air, pH berjulat di antara 6.14 - 7.29, kekeruhan berjulat 6.85 NTU to 299.40 NTU, kekonduksian berjulat 0.02 µS/cm - 46.60 µS/cm, suhu berjulat 24.48°C - 28.81 °C, BOD5 berjulat 2.52 mg/L - 5.37 mg/L, klorofil-a berjulat 0.0445 µg/L – 1.1231 µg/L dan TSS berjulat 2.18 mg/L - 83.36 mg/L. PCA merumuskan bahawa spesies seperti Puntioplites waandersii dan Pangasius macronema menyesuaikan diri dengan nilai julat TSS pada masa kini. Kajian ini mendapati bahawa perlepasan air yang dikawal oleh Loji Hidroeletrik Bakun berkemungkinan menjejas kualiti air dan kepelbagaian ikan di kawasan ini.

Kata Kunci: Fauna ikan, Kepelbagaian, kualiti air, Batang Rajang

1.0 INTRODUCTION

There are about 100 river basins that flow from the highlands that are found in East Malaysia of which only 22 that are found in Sarawak (WWF, 2015). These rivers are important habitat for freshwater fish fauna. Batang Rajang is the longest river in Sarawak located in the northwest of Borneo which flows 563 km into Kapit. As mentioned by Salam and Gopinath (2006), Batang Rajang has a total length of 565 km and 51000 km^2 of total catchment area.

There are a total of 254 freshwater fish species that has been documented in Sarawak (Atack, 2006). Studies that have been carried out to document the freshwater fishes in Sarawak include Watson and Balon (1984) in which 57 species were documented in Baram and Parenti and Lim (2005) which documented 164 species in Batang Rajang basin. Apart from these two studies, there are also other studies conducted within Sarawak related to fish fauna namely by Nyanti *et al.* (1999) in which 24 fish species were documented in Bario, Khairul Adha *et al.* (2009) that recorded 36 fish species in Batang Kerang, and Nyanti *et al.* (2012) which documented 33 species of fish and crustacean in Lutong River.

There has been lack of published report on the composition of fish fauna at mid-stretch of Batang Rajang at Ng Benin and Peraran after the construction and operation of Bakun Hydroelectric Dam. Although a study was conducted by Goh at 2015, she focuses on Peraran and Punan Bah, whereby this study focus on Ng. Benin and Peraran. Therefore, the goal of this research is to study the diversity of fish fauna in Ng. Benin and Peraran, Batang Rajang, Kapit. The objectives of this study were:

i) To document the fish fauna at Ng. Benin and Peraran area of Batang Rajang,

ii) To determine the species richness, evenness and diversity indices at Ng. Benin and Peraran area of Batang Rajang,

iii) To determine the Gonadosomatic Index and Hepatosomatic Index of fish at Ng. Benin and Peraran area of Batang Rajang,

iv) To study the feeding habits of selected fish species at Ng. Benin and Peraran area of Batang Rajang, and

v) To record the status of water quality Ng. Benin and Peraran area of Batang Rajang.

2.0 LITERATURE REVIEW

2.1 Freshwater Fish Fauna

Thirteen thousands species of freshwater fishes are estimated to exist around the world (Agostinho *et al.*, 2008). There are close to 1000 fish species in Southeast Asia that has been recorded (Kottelat & Whitten, 1993) and freshwater fish species has the highest number documented in the river drainage of South-Eastern Asia (Jobling, 1995). It is also reported that Southeast Asia region which includes West Malaysia and Borneo has one of the highest recorded diversity of freshwater fishes worldwide (Zakaria-Ismail, 1991).

Malaysia is known for being one of the twelve mega-biodiversity centers worldwide because of its richness in flora and fauna species and according to Kottellat & Whitten (1996), Malaysia is in the list of the top 10 countries which has the highest freshwater fish diversity with over 600 documented species. At least 164 species of freshwater fish are from Batang Rajang (Parenti & Lim, 2005).

The most dominant fish family is the Cyprinidae with a percentage of 63.8% in the brown water habitat at Batang Kerang in Balai Ringin, Sarawak according to a study by Khairul Adha *et al.* (2009). Another study also found that Cyprinidae dominates the total fishes caught with a total of 59.5% in Ng. Merit (Hassan *et al.,* 2010). The Cyprinid family consists of members that are economically valuable such as *Tor tambroides* known locally as '*Empurau*' and *Tor douronensis* known locally as '*semah*' (Atack, 2006).

2.2 Freshwater Habitat

The main geographical distribution of freshwater ecosystems includes lakes, rivers, streams and ponds, which are home for most of the freshwater fish species (Ng, 2011). Most of the rivers in East Malaysia are longer in length and wider in size compared to rivers in West Malaysia. In general, freshwater habitat can be divided into two categories,

lentic ecosystem and lotic ecosystem. Lentic ecosystem refers to still or stagnant water and examples of lentic ecosystem are lakes, swamps and paddy fields but in contrast, lotic ecosystem refers to flowing water, such as streams, irrigation canals and rivers (Mohsin & Ambak, 1983).

Freshwater fish are seasonal and are always moving. Under normal circumstances, they do not stay at the same area for a long period of time and migrations largely influences the changes in fish distribution in river ecosystems. There are many factors operating at multiple scales that can affect the distribution and abundance of stream fishes (Poff, 1977; Schlosser, 1987). Harris (1995) reported that there is a close relation between availability of food, breeding sites, water current, depth, topography and physicochemical properties of water and the composition and distribution of fish fauna in each habitat. Topography is one factor that influence distribution of fish fauna as supported by Nyanti (1995) in his study, that only specialized adapted fish can survive in higher altitude and therefore, higher altitude retain less fish compared to middle and lower altitude. Other than that, spawning season or the existence of new feeding ground due to flooding of the river which results from the changes in seasons could also be a factor (Wotton, 1992).

The freshwater habitats at Batang Rajang consists mostly main river channel, rocky hill streams and semi-shaded forest streams with muddy or sandy bottom, and with decomposing dead leaves and fallen branches (Parenti & Lim, 2005).

2.3 Threats to fish fauna and their habitats

Impoundment of dam can have many negative effects on the river habitat such as biological, chemical and physical properties of rivers and riparian environments. The water quality, quantity and breeding grounds can be affected by dams because it changes aquatic ecology and hydrology of river upstream and downstream (Helland-Hansen *et al.*, 1995).

Agostinho *et al.* (2008) reported that impoundments will results in shifting of fish species composition and abundance which includes rapid increase of number in some fish species and reduction or even loss of others. In addition, Hurford *et al.* (1988) stated that if the water is released in order to maintain the river flow, the ecosystem downstream would be greatly affected and fish populations will not be an exception.

There will also be influence on riverine fish that has adapted to fast current and organisms such as planktons which are natural fish foods, including species that are sensitive to habitat change which may have growth and health problems which leads to increase in mortality (FAO, 2002).

Impoundment of dam on river is a very intense process which leads to formation of a new ecosystem (Baxter, 1977). The impacts of river damming includes habitat fragmentation, conversion of lotic to lentic habitat, variable flow and thermal regulations, degraded water quality, altered sediment transport process and changes in timing and duration of floodplain inundation (Cushman, 1985; Pringle, 2000). The long term effect of dam construction can be very unfavorable for the fish. For example in Arkansas, USA, the dam construction on the white river causes long term changes in fish assemblage including significant reduction in species richness (Quinn & Kwak, 2003).

Pollutants are also a threat to the fish fauna. Rhind (2009) mentioned that Pollutants such as synthetic organic materials and heavy metals can cause adverse effect to physiological systems in all animal species which includes freshwater fish. He also stated that and the effect of the pollutants are different for each species.

2.4 Length-weight Relationship (LWR)

The analysis of length-weight relationship (LWR) is basically describing length and weight in mathematical form so they could be converted into one another and to measure the variation of the actual length and expected length of fish taking into consideration, factors such as gonad development and fatness (Le Cren, 1951). Therefore, LWR can be used to monitor the health or 'well being' of the fish specifically the fatness, feeding states and spawning states. As mentioned by Zakeyudin *et al.* (2012), by determining the LWR, biology and management of different fish species can be studied.

Factors such as sex, foods, stress and water quality can affect the condition factor of fish (Khallaf *et al.*, 2003). The condition factor value of fish, which is expressed by length-weight factor indicates its condition, where higher condition factor value indicates better condition and vice versa.

2.5 Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI)

Gonadosomatic index (GSI) is a formula expressed in percentage that measures the weight of gonad and its relation to body weight (Munro *et al.*, 1990). Hepatosomatic Index (HSI) can be used to predict the total glycogen levels of fish, however the relationship between HSI and energy reserves are highly variable on a seasonal basis (Chellapa *et al.*, 1995).

2.6 Feeding Habits

Food plays an important role in determining the rate of growth and condition of the fish because it is the main source of energy. It is reported that the feeding activities of fishes have strong impact on their prey (Northcote, 1988). It is also reported that there are variation in feeding habits of fishes according to the food availability (Alam *et al.*, 2011).

There are 4 categories that fishes can be classified into based on their diet, which are invertivores, herbivores, omnivores and piscivores (Schrader, 1989). Analysis of stomach content are vital in understanding the pattern of fish feeding and tropic interaction of aquatic predators and prey in the food web.

2.7 Water Quality Parameters

Water quality parameters are studied for many purposes and mostly are related to pollution due to industrial wastes, domestic wastes and sedimentation due to land clearing. These notorious pollutions can deteriorate the water quality and affect the limited water resources available in Malaysia.

In Sarawak, the industrial activities and impoundment of dam have directly and indirectly affected the natural environment in regard to water quality. Moreover, water quality also affects the conditions of fish. As reported by Reash and Pigg (1990), the diversity and abundance of freshwater fish can be indicated by water quality parameters. Therefore, it is important to study and relate between these two factors.

Water quality parameters such as temperature, pH, salinity, turbidity, conductivity and dissolved oxygen (DO) can affect the distribution of fish fauna in the river basin. As mentioned by Coutant (1977), different fish species prefer to live in different water conditions. There is a relationship indicated from the comparison of selected water-quality constituents and fish communities (Deacon & Mize, 1997).

2.7.1 Total Suspended Solids (TSS)

Total Suspended Solids (TSS) is related to turbidity and transparency, as suspended solids are particles that take longer duration to settle to the bottom due to its small size. Hassan (2010) reported that suspended matter includes materials that are eroded from river

banks and settle in the water column. Excess suspended solids in the water column are not favorable to aquatic organisms especially to the freshwater fishes. Twenty five mg/L or more of total suspended solids in water column can results in lower fish productivity (Arrignon, 1999).

2.7.2 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is the amount of oxygen dissolved in water and is essential in limnology (Yap *et al.*, 2011). DO is required by aquatic organisms for respiration and it controls the metabolic activity of the organism which is also dependent on the amount of stress or pressure applied and also the surrounding temperature.

Photosynthesis produces oxygen (with the presence of enough light and nutrients) by photosynthetic organisms. In contrast, respiration and nitrification are processes that require oxygen except in hypoxic or anoxic conditions, in which denitrification produces oxygen (Yap *et al.*, 2011).

2.7.3 Temperature

Temperature is the measurement of intensity of heat instead of amount of heat and has a close connection to DO. Higher temperature of water will result in lower DO which would have a negative impact on most freshwater fishes. However, higher temperature also increases metabolic activities that could increases development rates (Munro *et al.*, 1990).

2.7.4 pH Value

The pH of a solution is the concentration of hydrogen ions that indicates the alkalinity or acidity of the substance on a logarithm scale. pH value of 7 indicates neutrality, pH value lower than 7 is classified as acidic and pH value higher than 7 classified as alkaline or basic.

According to Viessman and Hammer (2005), the safe range for freshwater fish is pH 6.5 to 9.0, while Randall (1991) reported that pH less than 5 and pH more than 9 will be too extreme for the fish. Fish eggs and fry are extremely sensitive to changes in pH and a little change could result in mass mortality.

3.0 MATERIALS AND METHODS

3.1 Study Site

The study site for this research is at the middle stretch of Batang Rajang specifically at Ng. Benin and Peraran area, Kapit. Kapit is situated approximately 151 km downstream of the Bakun Hydroelectric Dam. Therefore, the stretch of Batang Rajang at Ng. Benin and Peraran is considered as regulated river as the water flow is regulated by discharge from Bakun Hydroelectric Dam.

To study the distribution of fish fauna, collection of samples were carried out at selected stations at Ng. Benin and Peraran of Batang Rajang and its tributaries. Two sampling trips were carried out at the selected areas at two different times. Six stations were selected at Ng. Benin (downstream) and seven stations at Pereran (upstream). The sampling stations were selected based on the accessibility of the sampling sites. Sampling at downstream (Ng. Benin) and upstream (Peraran) were carried out from 7 July 2015 until 9 July 2015 and 8 December 2015 until 11 December 2015, respectively. The map of the study area is presented in Figure 1.

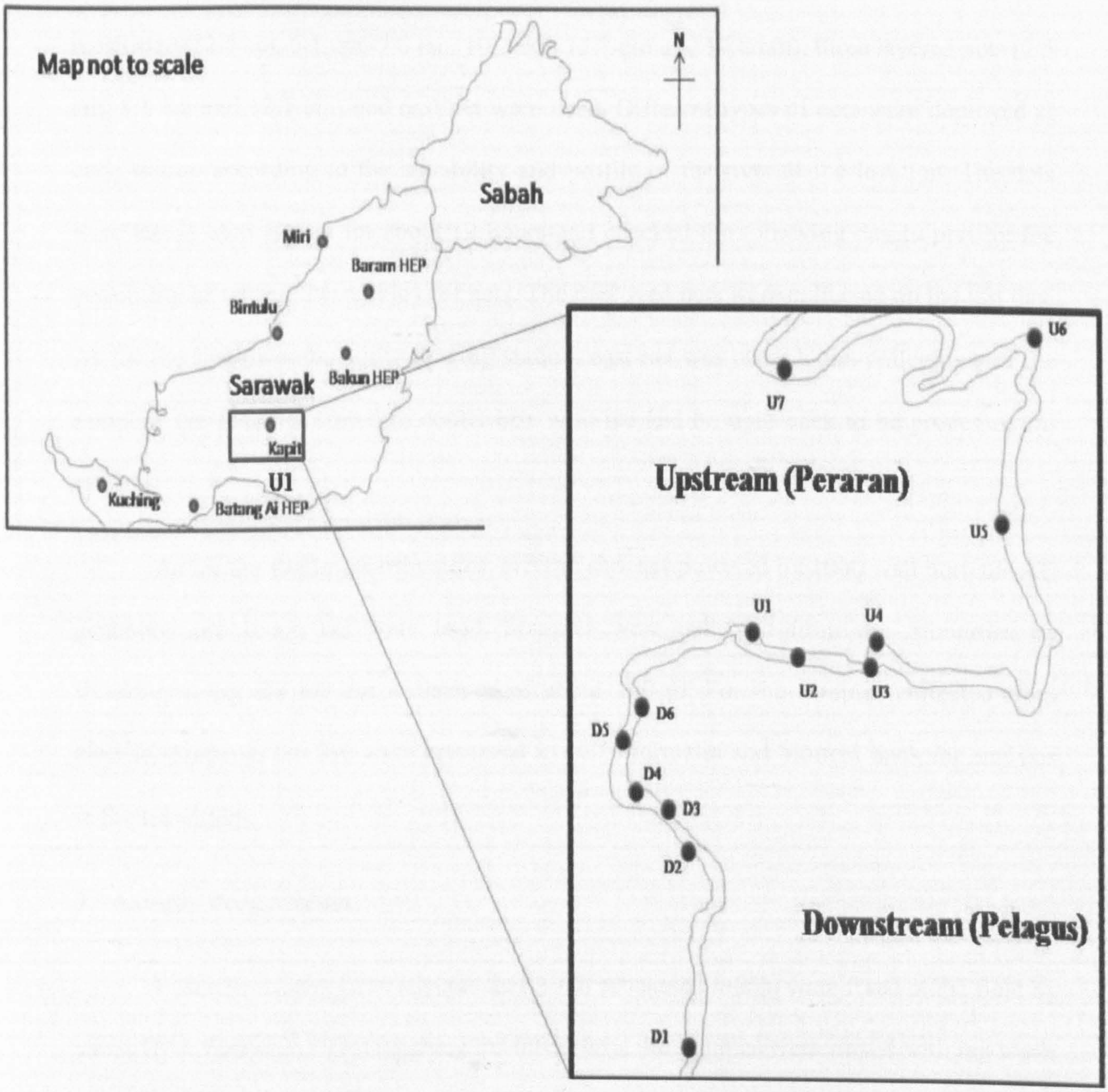

Figure 1: Map of sampling stations at Ng. Benin and Peraran, Batang Rajang, Kapit.

3.2 Fish sample Collection

Fish samples were collected from both main river and its tributaries at Peraran and Ng. Benin. For sample collection at the main river, mono-filament gill nets of different mesh sizes (2.5 cm, 5.1 cm, 7.6 cm, 10.2 cm, 12.7 cm and 17.8 cm), three layered nets (2.5 cm, 5.1 cm and 12.7 cm) and cast net were used. Different types of nets were deployed at each station according to the suitability and profile of the river at the location. The nets were left at each station for about 12 hours and checked the following day to prevent the possibility of rotting fish and loss of nets. The deployed nets were collected on the last day. As for the shallower and slow flowing station, cast net was used. Upon collections of the samples, the fish was stored in cooler box with ice and brought back to be processed *in-situ*.

As for the shallower tributaries, electric shocker powered by 1000 watt portable AC generator and scoop net were used. Samples were collected from the tributaries by shocking along the site for a distance of about 100 m. For the samples collected from electric shocking, the fish were preserved in 10 % formalin and brought back for analysis in the laboratory.

3.3 Sample Preservation

Fish collected at the study site that is not processed *in-situ* were fixed at the field by using 10 % formalin. Upon reaching the laboratory, the samples were rinsed with tap water and transferred to 70 % ethanol solution for further analysis and long term preservation. The stomachs of the dissected fish were preserved in 5 % formalin for further analysis.

3.4 Fish Measurement and Identification

The fish samples were identified using the taxonomy keys according to Kottelat *et*