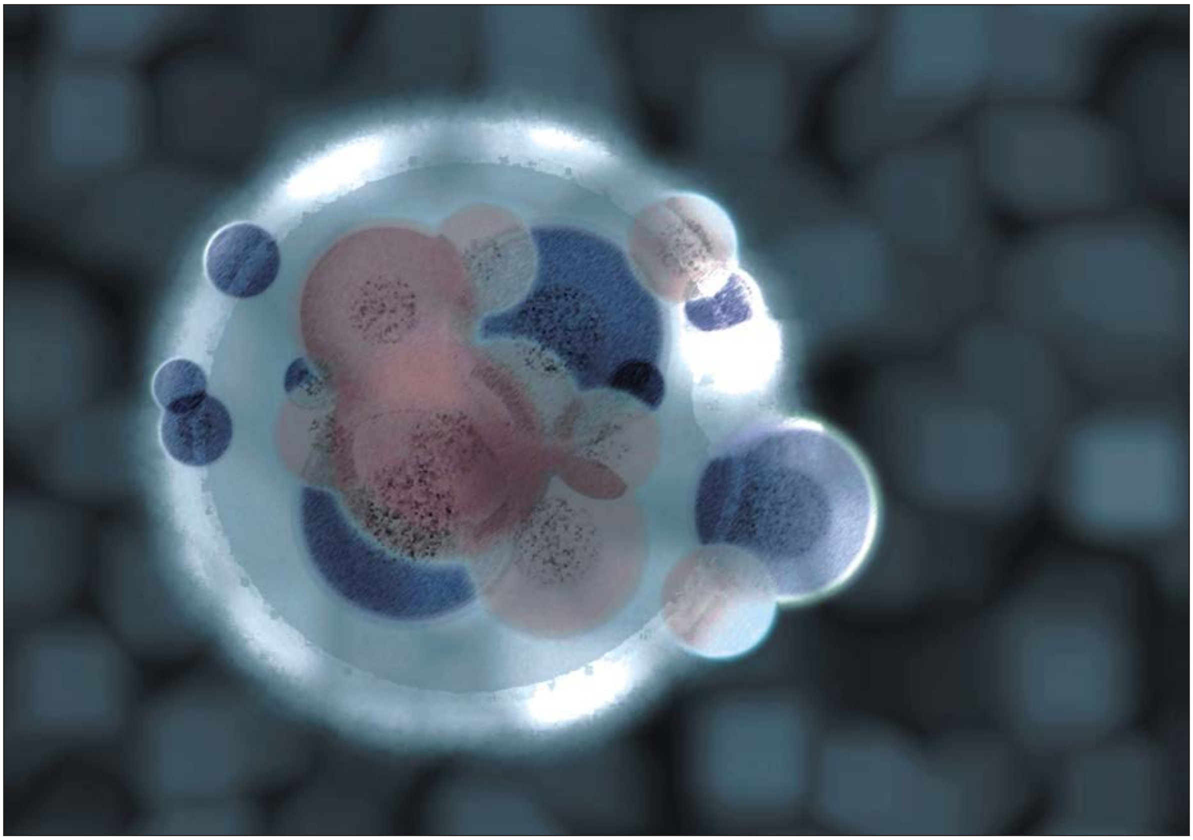

# Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 6 (2): 365-369, 2006
ISSN 1727-3048


# The Water Quality of Several Oxbow Lakes in Sabah, Malaysia and its Relation to Fish Fauna Distribution

[2]Lee Yook Heng, [1]Lee Nyanti Chukong, Robert B. Stuebing and Mani Omar
[1]The Faculty of Resource Science and Technology,
Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia
[2]School of Chemical Sciences and Food Technology, The Faculty of Science and Technology,
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

**Abstract:** A record of the water quality and fish fauna composition of the Luagan Rompong oxbow lake of the Padas River near Beaufort, the Kalandaun and Kalananap oxbow lakes of the Kinabatangan River at Sukau is presented in this study. The water quality of all three oxbow lakes exhibited wide daily variation in dissolved oxygen content (3.9-12.4 mg $L^{-1}$) and also large changes in daily water, especially for the Kinabatangan oxbow lakes. All three lakes demonstrated different composition of fish fauna with the Cyprinidae famili (45-80%) dominating in the lakes. The Shannon-Weiner diversity indices for fish from all the lakes were between 2.15 and 3.13 with the Kalandaun Lake at the Kinabatangan River showed highest fish fauna diversity.

**Key words:** Oxbow lake, Sabah, fish fauna, water quality, river, Cyprinidae

## INTRODUCTION

In general, lakes are rather rare in Malaysia as they only made up 6% of all fresh water resource. Well known but major natural lakes found in west Malaysia are the Chini and the Bera lakes in Pahang. However, more commonly found are smaller natural lakes formed from cut off river meanders and these lakes are usually called oxbow lakes. Oxbow lakes are frequently a source of fish for people live in the vicinity of the lake.

Oxbow lakes or cut-off meanders are always associated with rivers flowing through physiographally old alluvial plains. These lakes are formed at either sides of a meandering river. Unequal erosion of the river banks at the meander results in the eventual isolation of the meander from the main river as a U-shaped oxbow lake. This kind of lake is not a common feature of Sabah's landscape (*ca* 6°N 117°E) but some of them can be found at the lower stretches of the Kinabatangan River and the Padas River. These lakes apart from as a source of fish protein for the rural population, some of them are also used for fish aquaculture purposes.

In west Malaysia, fish fauna found in major natural and man-made lakes (reservoirs) are well documented (Mohsin and Ambak, 1991; Abdul Rashid *et al.,* 1989). In Sabah, most fish fauna on record were from large rivers such as Kinabatangan, Labuk, Segama and Kalabakan in the east coast (Inger and Chin, 1990). In this study, the water quality and fish fauna distribution of several oxbow lakes related to the Padas and the Kinabatangan rivers were reported.

## MATERIALS AND METHODS

**Study sites:** The oxbow lake for fish fauna and water quality survey near the Padas River at the West Coast of Sabah was the Luangan Rompong lake situated approximately 8.5 km from Beaufort. The lake is about 0.5 km in length and the width range from 30-40 m. The depth of the lake varies with an average of 7 m. The oxbow lake is still connected to the Padas river, thus exchange of water still occurs between the lake and the parent river through a small stream of about 100 m long. The area adjacent to the lake is mostly oil palm and rubber plantations.

Two oxbow lakes were selected near the Kinabatangan River at Sukau at the East Coast of Sabah (*ca* 5° 30'N; 118° 15'E). These oxbow lakes are situated side by side and adjacent to the Kinabatangan river. The two oxbow lakes are the Lake Kalandaun, a completely isolated oxbow lake and the Lake Kalananap, which is still connected to the main river by a small stream of about 100 m in length and 3 m wide, with a depth of approximately 1 m during the dry season. Lake Kalandaun has approximately the same surface area (*ca.* 0.5 square km) as Lake Kalananap. Both lakes are fresh

**Corresponding Author:** Dr. Lee Yook Heng, School of Chemical Sciences and Food Technology, The Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia Fax: 6-03-8421540

water and have uneven depth of up to 8 m maximum. The surrounding environment of the lakes is mainly undisturbed fresh-water swamp forest and lowland rain forest which was logged about ten years ago.

**Water quality study:** Surveys on the water quality and fish fauna were performed several times over a period of eight months. In each water quality survey, surface water samples were taken at three locations of each lake and the water quality was examined both in the morning and afternoon. The measurements at all the three locations in each lake were then used to calculate the mean value and standard deviation for all samplings.

Water quality parameters such as dissolved oxygen, pH, conductivity and temperature were measured on site. Dissolved oxygen was measured by a YSI Oxygen meter, pH by a Corning pH meter, conductivity by a YSI Salinometer whilst water temperature by a thermometer. Other water quality parameters such as nitrate-nitrogen, total dissolved phosphates and major cations (calcium, magnesium, potassium and sodium) were analysed in the laboratory according to standard procedures (APHA, 1992).

**Fish collection:** Various techniques including hook-and-line, traps, gill nets, an eight foot wide "otter trawl" net and cast nets were used to collect fish specimens from the lake. All fish samples were fixed in a 10% formalin solution and later preserved in 70% ethanol before fish identification was carried out. Systematics followed that of Inger and Chin (1990), Roberts (1989) and Mohsin and Ambak (1991). A radar Fish Finder (Humminbird Platinum ID Portable) was used to locate schools of fish in the lakes as well as to measure the lake bottom profile.

## RESULTS AND DISCUSSION

**Water quality of oxbow lakes:** In general all lakes demonstrated similar values of pH, dissolved oxygen, temperature and major cations such as calcium, magnesium and potassium. But the Luangan Rompong lake showed lower values of conductivity when compared to the Kinabatangan oxbow lakes (Table 1). The lower values of conductivity of the Luangan Rompong lake can not be explained by the effect of major cations as they are similar in concentrations in all three lakes. The higher value of conductivity of the Kinabatangan oxbow lakes is likely to be attributed to the presence of ionic humic substances from the fresh water swamp forest in the surrounding of the lakes. For nutrients such as total phosphates and nitrate, however, the Luangan Rompong lake demonstrated levels that were several times higher than the Kinabatangan oxbow lakes. This is not surprising as the Luangan Rompong lake is surrounded by cultivated land where nitrogen and phosphorus fertilizers would be used to improve crop yield. These nutrients may find their way into the surrounding lake water.

In all three lakes, both the pH and dissolved oxygen varied in a wide range. For example, dissolved oxygen concentrations changed by several times whilst pH varied from slightly acidic to highly alkaline. These water quality changes may be caused by the presence of green algae, especially at the Kalandaun lake of the Kinabatangan River. Obviously, such behaviour also occurred in the Luangan Rompong lake near the Padas River.

The water quality changes in the mornings and afternoons of the Kalandaun Lake, a completely isolated oxbow lake may be compared with that of the Kalananap Lake, which is still connected to the Kinabatangan River. The most obvious changes in water quality were that of the dissolved oxygen and pH (Table 2). For these two variables, marked differences were observed when the measurements of morning and afternoon were compared using Mann-Whitney non-parametric statistical tests (Table 2). For Lake Kalandaun, the dissolved oxygen content and pH of the water were significantly higher in the afternoon ( $p<0.01$ ) when compared to morning. These values were also significantly higher than that of Lake Kalananap and Kinabatangan River ($p<0.01$). In contrast, the dissolved oxygen of Lake Kalananap and Kinabatangan River did not differ significantly whether they were measured in the morning or afternoon. In fact the pH and dissolved oxygen recorded for all three water bodies during the mornings were similar (Table 2).

The daily variations of dissolved oxygen and pH of the Kalandaun oxbow lake are large. On a hot and sunny day, the dissolved oxygen content of the lake sometimes reached super-saturation (typically 150%) and under such condition, the water became alkaline. For water temperatures above 25°C, the dissolved oxygen was observed to increase linearly with water temperature. The increase was strongly correlated ($r = 0.89$; $p< 0.0001$, $n = 15$). This may be indirectly related to the amount of sunshine that was not measured. Water pH also appeared to increase linearly with the increase in dissolved oxygen content but the correlation was weaker ($r = 0.68$, $p<0.005$, $n = 15$), though still highly significant.

Such behavior of dissolved oxygen (Miranda *et al.*, 2001) and pH had been observed in lake where eutrophication process occurred. Coupled with the presence of high amount of chlorophyll, large fluctuations in the dissolved oxygen and pH of a water body are characteristics of eutrophication (Chapman, 1992). Although the chlorophyll content of the lake was not

Table 1: The water quality of some oxbow lakes and Kinabatangan River in Sabah during a water quality and fish fauna survey

| Water quality parameter | Luangan Rompong | Kalandaun | Kalananap | Kinabatangan River |
|---|---|---|---|---|
| Temperature (°C) | 29-36 | 25-35 | 25-35 | 24-33 |
| Dissolved oxygen (mg $L^{-1}$) | 3.9-11.4 | 4.6-9.0 | 4.0-12.4 | 4.4-7.0 |
| pH | 6.0-8.5 | 6.1-7.6 | 6.5-9.5 | 5.7-6.8 |
| Conductivity (μs $cm^{-1}$) | 71.8-86.2 | 75-150 | 65-130 | 63-180 |
| Total phosphates (μg $L^{-1}$) | 80-450 | 10-70 | 10-100 | na |
| Nitrate (mg $L^{-1}$) | 1.4-6.4 | 1.6-3.7 | 1.1-2.4 | 2.1-3.8 |
| Calcium (mg $L^{-1}$) | 8.5-10.9 | 6.9-10.5 | 4.9-13.2 | 7.6-11.6 |
| Magnesium (mg $L^{-1}$) | 1.4-3.4 | 3.0-4.8 | 2.3-4.9 | 4.0-5.0 |
| Potassium (mg $L^{-1}$) | 2.8-4.9 | 2.3-4.0 | 1.8-4.8 | 1.9-3.9 |
| Sodium (mg $L^{-1}$) | 7.0-13.3 | 4.4-8.8 | 4.3-8.9 | 5.8-7.7 |

Table 2: The fluctuation of several water quality parameters of the Kinabatangan River, Kalananap and Kalandaun Lakes in the mornings and afternoons

| Parameter | Kinabatangan River | Kalananap Lake | Kalandaun Lake |
|---|---|---|---|
| Temperature (°C ) | | | |
| * Morning | 29±5[a] | 30±4 | 27±3 |
| ( n = 4 -9) | (24-32)[b] | (25-34) | (25-29) |
| **Afternoon | 31±2 | 31± 4 | 32± 4 |
| n = 4-16 | (25-33) | (25-35) | (25-35) |
| Dissolved Oxygen(mg $L^{-1}$) | | | |
| Morning | 6.4±0.7 | 6.6±1.3 | 6.3±1.3 |
| (n = 4 - 10) | (5.3-7.0) | (4.6-8.6) | (4.0-7.7) |
| Afternoon | 5.6±1.1 | 7.0±1.3 | 10.3±1.8 |
| N = 4-17 | (4.6-6.7) | (5.4-9.09) | (8.4-12.4) |
| pH | | | |
| Morning | 6.2±0.5 | 6.7±0.4 | 7.1±0.4 |
| (n = 4-11) | (5.7-6.8) | (6.1-7.5) | (6.5-7.6) |
| Afternoon | 6.6±0.4 | 7.0±0.5 | 8.7±0.5 |
| (n = 5-15) | (6.2-6.8) | (6.2-7.6) | (7.8-9.5) |

[a]Mean value± standard deviation, [b]Range of values, n = Number of measurements, * Period of 6:00 -12:00 r, ** Period of 12:00 - 18:00 h

measured, the water was a deep, rich green color (chlorophyll) during most of the surveys may indicate the presence of phytoplankton and algal as this has been reported before for oxbow lakes of the Czech Republic and Argentina (Pithart, 1999; Izaguirre *et al.*, 2004). It is not possible to confirm whether the Lake Kalandaun in a state of eutrophication as water quality measurements were not detail enough to merit any conclusion on eutrophication. However, it is certain that differences in water quality did exist between the two oxbow lakes. Such differences may be caused by influence from the parent river.

**Fish fauna distribution:** Most of the fish species caught in the Luangan Rompong lake were from the Cyprinidae family (11 species) with other major species from the Siluridae (2 species), Anabantidae (2 species) and Channidae (2 species) families (Table 3). In terms of the number of individual fish collected from each family, the Cyprinidae made up of almost 73% of all the catch from the lake follows by Anabantidae (18%) and Cichlidae (~ 3%) (Fig. 1).

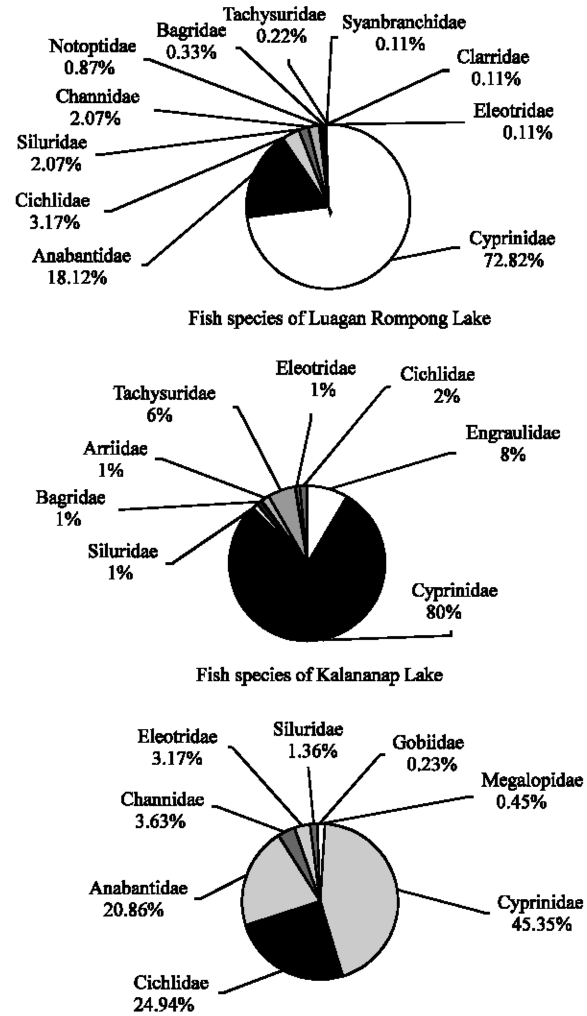


Fig. 1: The distribution of fish fauna families for the Luangan Rompong lake as compared to the Kinabatangan oxbow lakes

Cyprinidae is also the major family found in the Kinabatangan oxbow lakes (Fig. 1). However, the number of species found in the Luangan Rompong lake are more than that of the Kalananap lake. This can be seen from the Shannon Weiner diversity index for Luangan Rompong and Kalananap lakes which are 2.93 and 2.15, respectively. The fish fauna diversity of the Luangan Rompong lake is close to that of the Kalandaun lake. Among the three lakes, the Kalananap lake is more open to the influence of the parent river compared with Kalandaun, which is completely isolated or the Luangan Rompong that is only partially isolated. Thus, the water of the Luangan Rompong lake will tend to be richer in nutrients as these are not lost through water exchange processes that causes dilution. The higher level of various nutrients will encourage higher lake productivity and food for more species of fish. This explanation is consistent with the nutrient status of the Luangan Rompong lake that is much higher than the Kalananap lake. The main cause of loss of aquatic habitat for fish from agriculture runoff comes from contamination by suspended sediments (Knight and Welch, 2001) and this did not occur for the Luangan Rompong lake although it is surrounded by agriculture areas.

In both the Kalandaun and Kalananap Lakes near the Kinabatangan River, Cyprinidae dominated the fish fauna composition (Table 3). Most of the fishes caught were herbivores and low order predators. *Dangila sabana* which feeds on algae, diatoms and detritus (Inger and Chin, 1990 ) is particularly abundant in both lakes. Other species of fish such as *Osteochilus microcephalus, Oreochromis mossambicus* and *Anabas testudineus* with similar feeding behavior were abundant only in Lake Kalandaun. In contrast, the high order predators like *Setipinna melanochir, Channa striatus* and *Oxyeleotris marmorata* which are picivorous contributed to less than 10% of the total catch in each lake (Table 3)

Fish fauna diversity in Lake Kalandaun is higher than that of Lake Kalananap as evaluated by the Shannon Weiner Diversity Index (H' = 3.13 vs. H' = 2.15). Six species of fish from Lake Kalandaun were not found in Lake Kalananap or the Kinabatangan River. Only two species of fish from Lake Kalananap were not found in Lake Kalandaun and Kinabatangan River (Table 3). The overlap between the fish species of the two lakes was about 35%, surprisingly low considering the proximity of the two lakes.

The fish fauna composition of Lake Kalandaun differs considerably from that reported for the Kinabatangan River (Inger and Chin, 1991). Of the 16 species of fish found in Kalandaun, six of them have not been reported for Kinabatangan River. Among them, are *O. mossambicus* and *O. niloticus*, not native to Sabah and only introduced for the aquaculture industry some thirty years ago. Most of the fishes from the Cyprinidae family collected from both lakes have also been found in other oxbow lakes of the Kinabatangan River further upstream (Inger and Chin, 1991). Unlike Lake Kalandaun, Lake Kalananap has a fish fauna composition which represents a small subset of the Kinabatangan River fish fauna (Table 3).

There seems to have been a shift in species composition towards those fish able to breathe air. More than half (55%) of the fauna biomass of Lake Kalandaun can be attributed to air breathing species such as *Anabas*

Table 3: A comparison of the type and number and biomass of fish found among oxbow lakes in Sabah

| Family | Species | Luagan Rompong | Kalandaun (No.) | Biomass (gm) | Kalananap (No.) | Biomass (gm) |
|---|---|---|---|---|---|---|
| Synbranchidae | *Monopterus albus* | 1 | 0 | 962 | 0 | |
| Engraulidae | *Setipinna melanochir* | 0 | 0 | | 21 | 734 |
| Megalopidae | *Megalops cyprinoids* | 0 | 2 | | 0 | |
| Notopteridae | *Notopterus chitala* | 8 | 0 | | 0 | |
| Cyprinidae | *Chela oxygastroides* | 6 | 0 | | 0 | |
| | *Nematabramis steindachneri* | 1 | 0 | | 0 | |
| | *Rasbora sumatrana* | 304 | 16 | 16 | 0 | |
| | *Puntioplites bulu* | 5 | 59 | 12301 | 99 | 3205 |
| | *Puntius binotatus* | 169 | 0 | | 0 | |
| | *Putius bramoides* | 1 | 34 | 1464 | 7 | 208 |
| | *Puntius collingwoodii* | 9 | 4 | 54 | 0 | |
| | *Lobocheilus bo* | 91 | 0 | | 0 | |
| | *Cyclocheilichthys apogon* | 59 | 0 | | 0 | |
| | *Cyclocheilichthys repasson* | 0 | 10 | 368 | 4 | 85 |
| | *Danglia sabana* | 5 | 65 | 3620 | 90 | 3463 |
| | *Osteochilus microcephalus* | 17 | 12 | 482 | 0 | |
| Siluridae | *Kryptopterus parvanalis* | 0 | 1 | 72 | 3 | 187 |
| | *Kryptoterus macrocephalus* | 17 | 0 | | 0 | |
| | *Kryptopterus limpok* | 2 | 0 | | 0 | |
| | *Ompok sabanus* | 0 | 5 | 126 | 0 | |
| Bagridae | *Mystus nemurus* | 3 | 0 | | 0 | |
| | *Mystus barameusis* | 0 | 0 | | 3 | 102 |
| Ariidae | *Batrachocephalus mino* | 0 | 0 | | 3 | 94 |
| Tachysuridae | *Tachysurus maculates* | 1 | 0 | | 16 | 806 |
| Clariidae | *Prophagorus cataractus* | 1 | 0 | | 0 | |
| Anabantidae | *Trichogaster trichopterus* | 158 | 0 | | 0 | |
| | *Trichogaster perctoralis* | 8 | 0 | | 0 | |
| | *Anabas testudineus* | 0 | 92 | 4880 | 0 | |
| Channidae | *Channa striatus* | 19 | 16 | 9688 | 0 | |
| | *Channa melanosoma* | 1 | 0 | | 0 | |
| Eleotridae | *Oxyeleotris marmorata* | 1 | 14 | 2141 | 2 | 289 |
| Gobiidae | *Glossogobius giurus* | 0 | 1 | 68 | 0 | |
| Cichlidae | *Oreochromis mossambicus* | 29 | 101 | 9747 | 4 | 143 |
| | *Oreochromis niloticus* | 0 | 9 | 2910 | 0 | |

*testidineus, Channa striatus* and *Oreochromis* spp. (Table 3). These are hardy colonisers likely to withstand the plunge in oxygen if occurs at night in the Lake Kalandaun. It is also interesting to note that this same group attained much larger sizes than any of the other species present and apparently are best suited to take advantage of the peculiarities of the Lake Kaladaun's aquatic environment, including its extremely high productivity. These same species are either completely absent or occur at low densities in dynamic systems such as Lake Kalananap, where a combination of lower productivity and possible competition under what for them are suboptimal conditions.

The effects of the high productivity of Kalandaun can be seen in its total biomass (Table 3), which is about five times that of Lake Kalananap, though approximately equivalent capture effort was expended for both lakes. Mean fish size from Kalandaun is more than three times that for Kalananap, while the mean size for predatory fish is more than seven times larger for Kalandaun. Thus, the changes in water chemistry may be linked to high productivity, which then influences the fauna composition and biomass. Unfortunately, the dominant component of the Kalandaun fauna consists of introduced and in the case of *Oreochromis* spp., exotic species. Therefore, this has no doubt altered the original biotic composition of the lakes.

The overlapping of fish species of the Luangan Rompong lakes with the Kinabatangan oxbow lakes is very low, e.g., the percentage overlapping of fish species between Luangan Rompong and Kalandaun is 12.9% whilst between Kalananap is only 2.9%. This shows that the fish species distributions in these lakes are different from each other. Even for the two Kinabatangan oxbow lakes that are situated adjacent to each other, the percentage of overlapping in fish species is only 35.1%. Obviously, fish fauna distribution in oxbow lakes exhibits individual pattern, similar characteristics between two locations such as that of the Kinabatangan oxbow lakes do not ensure similar distribution pattern.

## CONCLUSIONS

Major family of fish found in the oxbow lakes of Sabah is the Cyprinidae. The Kinabatangan River exerts influence towards the Lake Kalananap in terms of the water chemistry and fish species distribution. In contrast, the Kalandaun oxbow lake, which is isolated, has evolved into an environment which bears little resemblance to the parent river. Variations in the chemical environment of the Kalandaun may be a major cause of stress to some fish communities and hence resulted in the observed differences in fish fauna composition. In short, these oxbow lakes demonstrated different fish diversity and individual distribution pattern with little species overlapping. The nutrient level of the lake water may have some influence on this pattern of fish distribution and diversity.

## ACKNOWLEDGMENT

We are grateful to the John D. and Catherine T. MacArthur Foundation of the USA for kindly providing us with a research grant to conduct this work. We also would like to thank Datuk Chin Phui Kong for his assistance in identification of many of the fish species.

## REFERENCES

Abdul Rashid Z., E. Arthur, E. Awang, J. Ibrahim and P.C. Liong. 1989, Report on the limnological study of reservoirs in Malaysia for inland fisheries development. Centre of Freshewater Fish Research. Fishery Department, Malaysia.

APHA (American Public Health Association), 1992. Standard Methods for the Examination of Water and Wastewater, Washington DC.

Chapman, D. 1992. Water Quality Assessments. Chapman and Hall, London, pp: 585.

Inger, R.F. and P.K. Chin, 1990. The Fresh-Water Fishes of North Borneo. Fieldiana. Zoology, 45: 267.

Izaguirre, I., I. O'Farrell, F. Unrein, R. Sinistro, M.S. Afonso and G. Tell, 2004. Algal assemblages across a wetland, from a shallow lake to relictual oxbow lakes (Lower Parana River, South America). Hydrobiologia, 511: 25-36.

Knight, S.S. and T.D. Welch, 2001. Mississippi Delta Management Systems Evaluation Area on oxbow lakes: Effects on ecology and water quality. Abstract of 222nd ACS National Meeting, Chicago, United States, AGRO-127.

Mohsin, A.K.M. and M.A. Ambak, 1991. The Fresh-Water Fishes of Penisular Malaysia. DBP, Kuala Lumpur.

Miranda, L.E., J. A.Hargreaves, S.W. Raborn, 2001. Predicting and managing risk of unsuitable dissolved oxygen in a eutrophic lake. Hydrobiologia, 457: 177-185.

Pithart, D., 1999. Phytoplankton and water chemistry of several alluvial pools and oxbows after the flood event – a process of diversification. Archiv Fuer Hydrobiologie, Supplement, 13: 93-113.

Roberts, T.R., 1989. The Fresh-Water Fishes of Western Borneo. California Academy of Science, San Francisco.