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PEATLAND FISH OF SABANGAU, BORNEO: ECOLOGY AND IMPLICATIONS FOR FUTURE MONITORING AND CONSERVATION

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SUMMARY

Fishing is one of the main sources of livelihood and dietary protein in villages in tropical peatland areas, yet peatland rivers remain at high risk from human disturbance, making assessments of fish biodiversity and monitoring of water quality a high priority. This project has completed some of the first in-depth assessments of local fish biodiversity of both tropical peat-swamp forest (TPSF) standing water and blackwater river habitats in the Sabangau catchment in Central Kalimantan, Borneo. Monthly environmental and fish data were collected over a 13-month period. These form the baseline for future monitoring projects and also allow an evaluation of locally initiated sustainable livelihood projects (such as the use of fish ponds) which have been piloted in this location. In the long-term this information will be vital to improved understanding of these wetland habitats, their importance for community livelihoods, and ultimately to finding ways of promoting ecosystem conservation alongside community development.

Keywords: *fish, peat, Borneo, monitoring, livelihoods*

INTRODUCTION

Due to the unique characteristics of the tropical peat swamp forest (TPSF) habitat, including their acidic waters, Indonesia's peatland rivers are important fish habitats that often have a higher degree of endemism than other rivers (Ng *et al*., 1994; Noor *et al*., 2005). Fishing is one of the main sources of livelihood for the communities living along the rivers and forests in Central Kalimantan (Lyons, 2003). However, with ever-increasing human populations, alarming deforestation rates throughout Indonesia, and ongoing pollution and habitat degradation, the prognosis for water habitats throughout Asia is a matter of growing concern (Dudgeon, 2000). There have been few studies of fish in this region, but one by Giam *et al.* (2012) found that if TPSF deforestation continues, 77% of fish species are likely to become extinct in Sundaland, with Central Kalimantan being most heavily impacted. This would have severe implications for the wetland ecosystems as well as the local communities depending on the forest and water habitats for their livelihoods. It is therefore vital to understand these wetland habitats, their importance for community livelihoods and cultures, and ultimately to find ways of promoting conservation alongside community development.

The results presented in this paper are part of a larger interdisciplinary project that is evaluating broader values related to fishing and the importance of fish for local communities. The ecological element of this project reported here was focused on sampling the local fish to add to our understanding of TPSF fish ecology and biodiversity in this region. Therefore, this project involved monthly fish and water quality surveys in the Sabangau Forest and River, including measurements of water pH, turbidity, oxygen saturation, nutrient levels and other environmental variables. The research methodology was also designed to identify appropriate approaches for fish population sampling to form the basis of future monitoring and sampling strategies.

The results of 13 months of fish and water surveys in the Sabangau river and 5 months of surveys in the forest are presented followed by discussion of the implications of the results for future fish and river water quality monitoring.

METHODS

The Sabangau River was sampled from September 2014 to September 2015, and the Sabangau Forest from January 2015 to August 2015. A shorter sample period was used in the forest due to insufficient water to set traps (a minimum of 10cm water depth is needed) during the other months. Traditional wire traps, *tampirai*, were used to sample fish, with a mesh size of 0.6 cm and dimensions of approximately 89 x 38 x 38 cm (length x width x height). The bait used was a mixture of *tempeh* and *terasi* (fermented soya bean with fermented shrimp paste). This bait is commonly used by local fishermen and was recommended for use in this project by them.

Every month, a total of 5 sampling days were completed. Traps were set up on alternating sides of the river over a 7km stretch. Kereng Bangkirai, the nearest village, is located in the middle of this sampling area. Twenty traps were used, with a distance of 400 m between each trap. In the forest, the traps were placed in standing water pools and small canals (max width 2.5m). Two canals were used where seven traps were placed in each canal, 50m away from each other. The further 6 traps were placed in standing water pools.

Traps were set the day before the first sampling day. Each trap was then checked and emptied daily, with all fish caught identified and their standard length (SL) measured to the nearest mm. If a large number of fish was caught (over 100 individuals), a sample of 20 individuals of each species were measured with the rest counted. Mortality was noted. Environmental measurements were taken at each site, including: weather conditions, pH, surface water temperature, dissolved oxygen content of the surface water (% and mg/L) and Secchi depth (as a proxy for turbidity). On the final sampling day, samples were taken of the surface water and brought to the University of Palangka Raya laboratory to be tested for NH_3, NO_2 and NO_3.

The river and forest surveys had some variations in terms of the environmental data that were gathered. In the river, the water depths (from middle of the river as well as trap locations) were measured. In the forest, Secchi depth data were not obtained due to the pools and canals in the forest being too shallow. Lastly, flow measurements were not taken in the river, but were taken in the forest where surface water flow in the canals was measured using a stopwatch and a floating ping-pong ball.

Fish catch per unit effort (CPUE) was calculated using the following formula (Merilä, 2015):

$$CPUE = N_{catch}/(N_{traps}*N_{nights})$$

where N_{catch} = Number of fish trapped, N_{traps} = Number of traps set, N_{nights} = Number of nights set

RESULTS

In the river, a total of 55,147 fish were trapped and counted from September 2014 to September 2015 over 1,300 trap nights, with 22,917 fish measured. In the forest, a total of 3,938 fish were trapped and counted from February to July 2016 over 600 trap nights, with 3,905 fish measured. In the river 39 different species were trapped, and in the forest 27 species were trapped. *Rasbora kalbarensis* was added to the list following observations in the river. This species is too small to be trapped using the methods used. This addition leads to a final count of 47 different species from 15 different families (Table 1).

Table 1: Fish species found in the Sabangau River and Forest between September 2015 and September 2016

Family	Latin Name
Osphronemidae	*Betta anabatoides, Betta foerschi, Luciocephalus pulcher, Luciocephalus aura, Belontia hasselti, Sphaerichtys osphromenoides, Sphaerichtys acrostoma, Trichopodus pectoralis*
Cyprinidae	*Cyclocheilichthys janthochir, Osteochilus spilurus, Desmopuntius foerschi, D. hexazona, D. rhoboocellatus, D. johorensis, Eirmotus sp., Rasbora kalochroma, R. cephalotaenia, R. dorciocellata, R. kalbarensis, Osteochilus melanopleura, Trigonopoma gracile, Striuntius lineatus*
Channidae	*Channa pleurophthalmus, C. micropeltes, C. lucius, C. bankanensis, C. sp.*
Siluridae	*Silurichtys hasseltii, Kryptopterus macrocephalus, Ompok leiacanthus, Wallago leeri*
Helostomatidae	*Helostoma temminickii*
Hemiramphidae	*Hemirhamphodon chrysopunctatus*
Mastacembelidae	*Macrognathus maculatus, M. aculeatus*
Clariidae	*Clarias sp., Clarias sp., Enchelochlarias tapeinopterus*
Bagridae	*Mystus olyroides, Leiocassis micropogon, Leiocassis sp.*
Pristolepididae	*Pristolepsis grooti*

Anabantidae	*Anabas testudineus*
Nandidae	*Nandus nebulosus*
Horabagridae	*Pseudeutropius moolenburghae*
Chacidae	*Chaca bankanensis*
Synbranchidae	*Monopterus sp.*

Table 2 illustrates the species richness, total number of fish trapped, Catch Per Unit Effort (CPUE) and the inverse of Simpson's diversity index.

Table 2: Species richness, number of fish trapped and calculated inverse Simpson's diversity for each habitat

Habitat	**Species richness**	**Number of fish trapped**	**Average CPUE**	**Simpsons 1-D**
River	39	55145	42.21	0.82
Forest	27	3938	1.22	0.70

Figure 1: Monthly CPUE in the river and forest

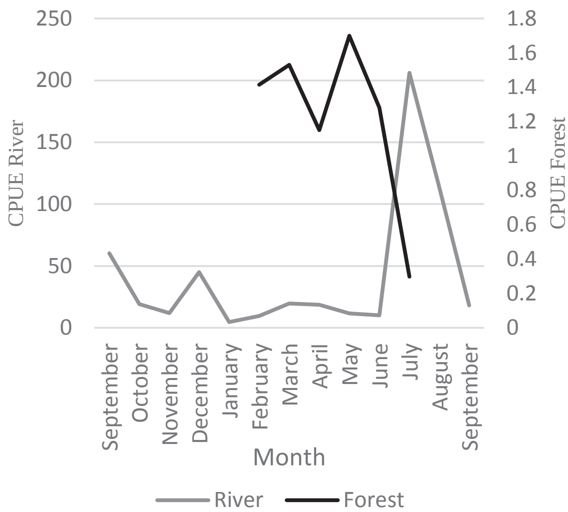


Figure 2: Average rainfall (mm) per month and river and forest water depth (m) from September 2014 to September 2015

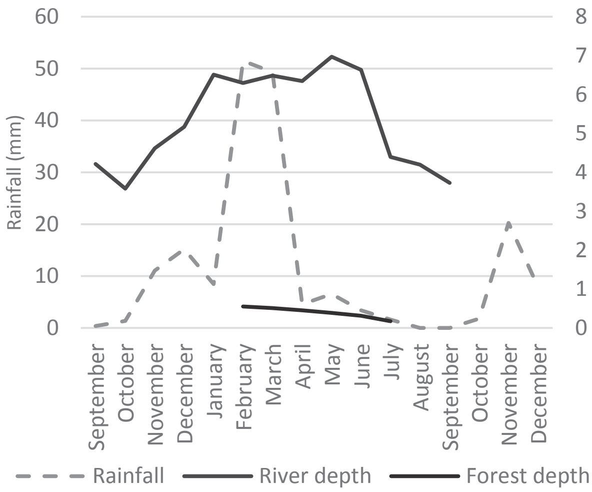
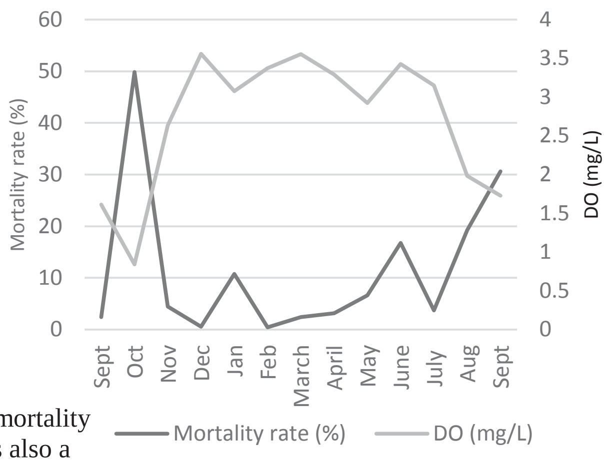


Figure 1 illustrates the calculated CPUE for each month from September 2014 to September 2015 in the Sabangau River and from February to July 2016 in the forest. In the river, the two increases in CPUE in December and July are related to the changing seasons from dry season to wet season (December) and wet season to dry season (July). During these months, large changes in environmental conditions occurred in, for example, rainfall and water depth (Figure 2). These months also coincide with the main fishing seasons in the area, when increased numbers of local villagers are seen fishing on the river.

Percent mortality was calculated for each month of trapping and Figure 3 illustrates the mortality rates of the river surveys. In October 2014 we had the maximum level of fish mortality in our traps, reaching 50%. This then dropped to less than 10% for the majority of the wet season when dissolved oxygen levels were also higher. We see an increasing trend of mortality rates after July (with the onset of the dry season) where there is also a corresponding decrease in dissolved oxygen levels.

Figure 3: Monthly mortality rate (%) and dissolved oxygen levels (mg/L) in the Sabangau river



DISCUSSION

The sampling programme produced a species list comprising 47 fish species across both the Sabangau river and forest habitats. Giam *et al.* (2012) found 45 different species in Central Kalimantan TPSF habitats which our results support and add to. As with any fauna trapping methods, our fish traps have limitations including being selective against certain fish sizes, being dependent on fish behaviour and potentially being selective against certain species. With the use of a wider range of sampling methods this species list could be added to in the future. On the other hand, sampling was carried out over a much longer period than in most other surveys in this region. The species total is comparable to and at times higher than those from other surveys in peat-swamp environments. In Batang Kerang in Balai Ringin, Sarawak, 12 species were found in the black water habitat (Rahim *et al.*, 2009). In the North Selangor PSF 48 different species were recorded (Ng *et al*., 1992, 1994) and in Raja Musa PSF 22 species were recorded (Norhisyam *et al*., 2012). Sabangau is therefore a notable area for peat-swamp forest fish diversity.

A greater total number and diversity of fish were caught in the river than in the forest, thus the river has a higher diversity index than the forest. While the forest was sampled for fewer months and further sampling might encounter more species, this difference in diversity is also likely due to the river providing a greater range of habitats than the forest in terms of, for example, greater range of water depths and vegetation densities and types.

In order to continue to build a complete fish species list for the area, the use of additional fishing methods, including nets and rod fishing, would be necessary. When designing future sampling programmes, it is also recommended to take into consideration the perspectives of the local community members and fishers: fishing methods with high mortality rates should not only be avoided to limit fish deaths while sampling, but also to avoid fishers perceiving the researcher as fishing for consumption and taking fish from the river. This could potentially have negative implications for local perceptions of fish research and, thus, for conservation efforts.

Due to the limitations of the trapping method and its selectivity in terms of fish capture, it is not possible to produce absolute population estimates for the various species that were identified during the study. However, the same traps used in this research could be used in the future to monitor catch trends and population dynamics e.g. decreasing catch trends are a likely sign of decreasing fish populations in the area.

In addition to dissolved oxygen, this project is also investigating the other environmental variables that may contribute to fish mortality. A drop in dissolved oxygen levels in the river during October could have played a significant role in the increase in mortality seen in that month, but other factors may also have an influence. Based on correlations between environmental data and fish mortality, the project aims to provide guidelines for future monitoring of the river, by recommending time periods and environmental conditions that minimise mortality and are therefore most appropriate for fish surveys to be undertaken.

CONCLUSION

This project identified 47 fish species in the Sabangau peatland, with 39 species found in the Sabangau river and 27 in the peat swamp forest. Local trapping methods (*tampirai*) were used, with trapping in the river undertaken on a monthly basis over the period of 13 months, while the forest habitat was sampled over a 5-month period. Environmental variables including dissolved oxygen, water temperature, pH, turbidity and nutrient levels were also measured in both locations monthly. Fish mortality data were obtained which along with the environmental data will be used to inform appropriate sampling strategies for future monitoring in order to minimise fish mortality. The traps employed in this study were shown to be an effective sampling tool since they trapped fish according to a consistent and reasonably well understood bias, were available locally and required little expertise in deployment. These were important considerations for a baseline study that is anticipated to be continued by local staff in future years. In addition, the data from sampling in both the forest and river will be compared to data from traditional fish ponds that have been built as a sustainable livelihood initiative at the forest edge in order to better understand the potential of these artificial fish habitats for local livelihood support.

Continued monitoring in the sample locations is highly recommended in order to collect longer-term data on fish catch, and hence population, trends and water quality to facilitate on-going evaluation of river health. Fishing is an important source of protein and income locally and therefore surveys of fish populations and river health are vital not only to understand the TPSF environment but also the implications of environmental changes on local human communities. These data also provide essential information by which to evaluate local sustainable livelihood projects such as the use of fish ponds. While fish may not be the most charismatic of peat swamp forest species, like great-apes or felids, they provide one of the clearest faunal links between people, livelihoods and their natural environment. In areas with high dependence on fish for livelihoods, fish research and conservation projects could be a great opportunity to increase the relevance of environmental research to local communities and to potentially increase local support for conservation projects, as well as providing improved knowledge and understanding of livelihood strategies.

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