

Fish diversity of two major inlet rivers of Lake Malawi: Spatial and temporal change

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Abstract

A study to investigate spatial and temporal changes in fish species diversity of Bua and Linthipe rivers was conducted between March 2010 and August 2011. Fish was sampled using a 6.35mm (¼ inch) seine net or by electrofishing in five sites. Results showed that alpha diversity of the two rivers did not differ significantly ($p > 0.05$). However, beta diversities of Bua and Linthipe rivers were significantly different at 95% and 90%, confidence levels, respectively. Bua had higher beta diversity ($p < 0.1$). Similarly, species richness along the Bua was higher than along the Linthipe river. The differences were attributed to diverse habitat types in Bua compared to Linthipe river and differences in water quality parameters (e.g. total suspended solids, chlorophyll *a* and dissolved oxygen (DO)). A management strategy to arrest the disappearance of river species calls for an immediate action by authorities. The high diversity in Bua river system is attributed to the existing Game and Wildlife reserve allowing for diverse available habitat in the river system.

Key words: Alpha diversity, beta diversity, river, species richness

Résumé

Une étude visant à étudier les changements spatio-temporels dans la diversité des espèces de poisson des rivières Bua et Linthipe a été réalisée entre Mars 2010 et Août 2011. Les poissons ont été échantillonnés à l'aide d'une senne nette de 6,35 mm (¼ po) ou par pêche électrique dans cinq sites. Les résultats ont montré que la diversité alpha des deux rivières ne diffère pas significativement ($p > 0,05$). Cependant, les diversités bêta des rivières Bua et Linthipe étaient significativement différentes à des niveaux de confiance de 95% et 90%, respectivement. La rivière Bua avait une plus grande diversité bêta ($p < 0,1$). De même, la richesse en espèces le long de la rivière Bua était plus élevée que le long de la rivière Linthipe.

Les différences ont été attribuées à divers types d'habitats dans la rivière Bua par rapport à la Linthipe et les différences dans les paramètres de qualité de l'eau (par exemple, les solides totaux en suspension, la chlorophylle *a* et l'oxygène dissous (DO)). Une stratégie de gestion pour stopper la disparition des espèces dans les rivières appelle à une action immédiate des autorités. La grande diversité dans le système de la rivière Bua est attribuée à la réserve existante de chasse et celle qui est sauvage permettant l'habitat disponible diversifié dans le système fluvial.

Mots clés: Diversité alpha, diversité bêta, rivière, richesse en espèces

Background

In Malawi, the fisheries sector is an important source of food security, contributing about 43.6% of dietary protein (Macuine, 2006). The sector provides off-farm employment for about 35,000 fishers, 2,000,000 fish processors (Duponchelle and Ribbink, 2000) and mongers (Mkanda, 2000). Overall, fisheries contribute up to 4% of Malawi's Gross Domestic Product (GDP) (Mkanda, 2000).

Just like in other African lakes (Ohwayo and Balirwa, 2004), fish supplies from lake Malawi have declined (Weyl *et al.*, 2001). The Bua and Linthipe rivers are important to Malawi fisheries as they contribute to Lake Malawi's primary productivity through supply of nutrients. The rivers are important breeding grounds for potamodromous fish species like *Opsaridium microlepis* (Tweddle, 1982) which is currently an endangered fish species (Kazembe *et al.*, 2006). Additionally, rivers harbour a diverse and unique species, habitats and ecosystems (Allan and Flecker, 1993). For instance, in Bua river basin, thirty-three fish species belonging to 9 families have been recorded.

Biological sustainability of the fish resource can be achieved if biodiversity is conserved, endangered species protected and harvest levels are within pre-determined sustainable levels (Weyl, 2007). Unfortunately, present and past fish diversity status of the major riverine inlets still remain unknown. Hence, this study aims at assessing the current fish diversity and changes that may have occurred over the past two decades.

The catchments of Bua and Linthipe rivers are contrasting; Bua River passes through the Nkhotakota Wildlife Reserve with a forest coverage of 1,800 km² (WWF SARPO, 2005) whilst

the Linthipe catchment is mainly used for agricultural production (Gomani, 2007). Hence, this study was conducted to generate information on the temporal and spatial fish diversity changes of the two contrasting river systems.

Literature Summary

Rivers harbour a diverse and unique canopy of species, habitats and ecosystems (Allan and Flecker, 1993). Factors such as habitat loss and degradation, spread of exotic species, overexploitation, secondary extinctions, chemical and organic pollution and climate change lead to diversity loss in these riverine systems (Allan and Flecker, 1993). Differences in species composition between rivers were observed by Penczak *et al.* (1994) in tributaries of the Parana River; Caracu and Agau do Rancho. These were attributed to differences in conductivity, pH, fish hiding places, riparian vegetation and submerged macrophytes (Penczak *et al.*, 1994).

Study Description

The study was conducted in Bua and Linthipe rivers which are found in the central region of Malawi between 1247.28°S, 3411.68°E and 1347.06°S, 3426.07°E, respectively (Kingdon *et al.*, 1999). Bua River is 255 km long with 10,700 km² catchment whilst Linthipe River is 190 km long with a 8,560 km² catchment. Bua River originates from Mchinji highlands and runs through Nkhotakota, Kasungu, Ntchisi, Dowa, Mchinji and Lilongwe districts. Linthipe River originates from Dzalanyama Ranges (Dedza) and runs through Dedza, Lilongwe and Salima districts.

In Linthipe River fish sampling was done at the river mouth (Nkama area) and Kamuzu Bridge, 1.13 km and 25.88 km from Lake Malawi, respectively. For the Bua River fish was sampled from the river mouth, Nkhotakota Bridge and Nkhotakota Game Reserve, 23.53km, 17.30km and 1.67km from Lake Malawi, respectively. Fish was sampled monthly using a fine ¼ inch net from July to November 2010. Specimens were collected in containers, induced to instant death and fixed using 10% formalin. Fish families were identified and photographed on site. Specific species were later identified using fish identification Key for Malawi riverine fishes (Tweddle, 1996).

Data collected in 1976, 1992, 1995 and 2010 were used to study temporal fish diversity changes of Bua River. No secondary fish data was available for Linthipe. Data were analysed using Species Diversity and Richness Software (Seaby and Henderson, 2006). Total species counts per sampling site,

species richness, alpha diversity and beta diversity were determined. Analysis of Variance (ANOVA) was used to test differences between means of specimen and species count, species richness, alpha and beta diversity using GENSTAT statistical package. Means were separated using the Least Significance Difference (LSD) test. Two sample t-test was used to test the differences in alpha and beta diversity of the two rivers.

Research Application

A total of 4769 and 4370 fish specimens were caught from Bua and Linthipe rivers, respectively. Tilapia was the most dominant group in both river systems. The number of specimen and species at both the mouth of Bua and Linthipe Rivers, were significantly higher ($p < 0.05$ and $p < 0.1$, respectively) than other sites in the upper reach of each river (Table 1).

Table 1. Mean (\pm SE) Number of specimen and species per river and sampling site.

River	Statistic	River site	No. of specimen	No. of species
Bua		Mouth	653 ^a \pm 136.3	11 ^a \pm 1.897
		Bridge	157 ^b \pm 62.99	5.4 ^b \pm 0.678
		Wildlife	144 ^b \pm 27.05	5.2 ^b \pm 0.374
	LSD		271.5	3.646
	P		0.02	0.007
Linthipe		Mouth	757 \pm 292.7	9.00 \pm 1.304
		Bridge	117 \pm 25.65	5.00 \pm 1.304
	LSD		677.6	4.252
	P		0.061	0.062

NB: Means with the same superscripts in the same column are not significantly different at 95% confidence level.

Bua River mouth had had the highest record of number of species (up to 17) in September while Linthipe river mouth had the second highest with 11 different species caught in the month of October. In general, river mouths had higher species richness than sites in upper reaches. Within each river system, alpha diversity was not significantly different. However, beta (between habitats) diversity of the two rivers was significantly different ($p < 0.1$) with the Beta diversity of Bua river higher than Linthipe River (Table 2).

For Bua River, fish data of 1976, 1992, 1995 and 2010, showed that specimen counts, species richness and beta diversity has decreased by 97%, 52.5% and 22%, respectively between 1976 and 2010. The decline in species diversity is linked to the decline in number of fish species where a total of 13 fish species

Table 2. Mean (\pm SE) Alpha (α) and Beta (β) Diversity for each river system.

River	Statistic	α Diversity	β Diversity
Bua		1.664 \pm 0.141	6.30 \pm 0.682
Linthipe		1.522 \pm 0.0778	4.20 \pm 0.624
	LSD	0.3710	2.132
	P	0.403	0.053

(1976-1995) did not reappear. Contradictingly new fish species - *Zaireichthys maranjesis* and *Pseudocrenilabus philander* were recorded.

Linthipe river on the other hand did not have past fish data for assessment of temporal change in fish diversity. However, communities have reported that three potamodromous species of *Labeo mesops* (Ntchila), *Barbus euryostomus* (kadyakolo) and *Opsaridium microlepis* (Mpassa) have either completely disappeared or become scarce (Kaunda 2004). These claims were substantiated in this study whereby no specimen of *Labeo mesops* and *Barbus euryostomus* were caught using either an electrofisher or seine net.

The disappearance of the species from the two river systems is worrisome and cause for concern. A management strategy to arrest the disappearance of river species should be put in place. The high diversity in Bua river system is attributed to the existing Game and Wildlife reserve allowing for diverse habitat available in the river system. The un-availability of data for Linthipe river amplifies the importance of carrying out long term research in diversity studies.

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