http://www.ejournalofsciences.org

Fish Species Composition and Diversity of Small Riverine Ecosystems in the Lake Victoria Basin, Kenya

Benson M. Mwangi[1], Mornica A. Ombogo[2], Jacinta Amadi[3], Ntambi Baker[4], Daniel Mugalu[5]

[1,2,3]Department of Zoological Sciences, Kenyatta University, Nairobi Kenya,
[4]National Fisheries Research Institute, Uganda and [5]Makele University, Kampala, Uganda

ABSTRACT

Riverine ecosystems in the Lake Victoria Basin (LVB) significantly contribute to the lake's water budget and aquatic biodiversity. Despite their significance to the lakes fisheries, only limited biodiversity studies have been carried out, particularly in the smaller riverine ecosystems. This study investigated the fish species composition, diversity and distribution in two small riverine ecosystems (Rivers Awach Seme and Kisian) draining the Kenyan Lake Victoria Basin. Sampling was carried out monthly from August 2009 to June 2010, at three sampling sites of 100-m stretch along each river, representing the upper, middle and lower reaches. Fish were caught using an electro-fisher, identified with the help of relevant taxonomic guides and staff from the Kenya Marine and Fisheries Research Institute, measured for total lengths and weighed to the nearest 0.1 cm and 0.1 gm, respectively. The results showed that the two rivers had a diverse fish community consisting of 11 species, namely, *Barbus altianalis* Boulenger, *Labeo victorianus* Boulenger, *Barbus cercops* Whitehead, *Clarias gariepinus* Burchell, *Barbus nyanzae* Whitehead, *Barbus kerstenii* Peters, *Barbus jacksonii* Günther, *Barbus appleurograma*, *Oreochromis leucostictus* Trewavas, *Gambusia affinis* Baird & Girard, and *Bagrus docmak* Forsskål, out of which 9 were present in River Kisian and 7 in River Awach. The fish community at River Kisian was dominated by *C. gariepinus*, constituting over 42.5% while at River Awach, *B. altianalis* and *B. nyanzae* dominated with over 46.3% and 30.7% of the total catch, respectively. Fish abundance and evenness were much higher in River Awach suggesting that this river would provide better fisheries if managed appropriately. Generally, the results show that the two rivers may be an important source of fish for both the lakes ecosystem as well as local fisheries if appropriate management interventions are instituted.

Keywords: *Lake Victoria Basin, riverine fisheries, Clarias, Kisian, Awach-Seme*

I. INTRODUCTION

Fresh water ecosystems support large numbers of species of plants and animals. Fish inhabiting freshwaters comprise 25% of living vertebrates (about 55,000 described species) and represent 13-15% of the 100,000 freshwater animal species currently known [1]. In Africa, a large proportion of the inland fisheries are located along the shores of lakes, but the continent's vast river systems are also rich in fisheries and may produce up to one-half the total catch from inland waters [2]. Because inland fisheries often supply only the domestic market and contribute little to the export economy of most developing nations, and because the quantity of fish harvested is often overshadowed by that of marine fisheries, riverine fisheries are often given low priority by national governments.

Riverine ecosystems in the Lake Victoria Basin (LVB) contribute immensely to the lakes' water budget and aquatic biodiversity. They also provide breeding grounds of many lacustrine fish species and act as sources of fish and other edible aquatic life to the local communities. Fish are a source of highly nutritive protein and also contain other essential nutrients required by the body [3]. Market surveys show strong consumer preference [4] and higher pricing [5] towards riverine fish species.

One important descriptor of a community is the number of species present and their relative abundances (species richness and diversity). The diversity of biological species in a river correlates strongly with the diversity of its habitat parameters [6]. It is often claimed that freshwater ecosystems are the most endangered ecosystems in the world [7] affecting both species diversity and abundance. Global estimates suggest that 75 to 95 percent of riverine habitats are degraded [8] [9] [10]. These have resulted in less fishing opportunity and a direct impact on the people that depend on riverine fisheries for their livelihood [11]. Since the early 1970s, riverine fish populations have been at their lowest levels and the decline is continuing [11]. The decline has been attributed to channelling, destruction of riparian vegetation, agricultural and industrial pollution, hydrologic alterations, illegal methods of fishing (e.g. use of herbs and nets of small mesh sizes) amongst others [12] [13] [14] [15].

Most studies on riverine fisheries in the Lake Victoria Basin region have focused on large rivers such as Sondu-Miriu, Kuja, Nzoia, Yala and Nyando e.g. [16]. However, studies focusing on small riverine fisheries are rare probably due to the perception that fisheries of small rivers are not economically viable although fish from such rivers may grow to large sizes (Fig. 1). Despite these fisheries production opportunities, these ecosystems are currently faced with serious anthropogenic degradation, including poor agricultural activities, clearance of riparian vegetation, nutrient enrichment and climate change. The need for biodiversity studies of such ecosystems cannot therefore be overemphasized. This study focused on the fish species composition, their distribution, diversity and abundance of two small rivers, Rivers Awach Seme and Kisian, both of which drains into Lake Victoria.

Figure 1: A specimen of a large catfish, *Clarius gariepinus*, caught from River Awach Seme, Lake Victoria Basin, Kenya. The fish weighed 4 kg.

II.   MATERIALS AND METHODS

Rivers Kisian and Awach-Seme arises from the Maragoli forest and Maseno highlands, respectively, in the Western Province of Kenya (Fig. 2). River Kisian then flows through Kisumu East District at latitude of 0°04′16″S and longitude 034°40′03″E while River Awach Seme flows through Kisumu West District at latitude 0°09658″S and longitude 034°47434″E, in Nyanza Province. The area receives a bimodal rainfall with one short season from October to December and a long rainy season from March to July. Rainfall varies from 258.0 to 816.0mm annually. During periods of heavy rainfall, the upper catchments of the 2 rivers experience exceedingly high rainfall causing the rivers to flood excessively, breaking off their banks and inundating low-lying farmlands. Annual temperatures average around 23°C with a small annual range of about 2°C. The two rivers were selected due to their proximity to one another and similarity in hydrological characteristics.

At each of the rivers, 3 sampling sites were selected representing the upper (KS1 and AS1), middle (KS2 and AS2) and lower reaches (KS3 and AS3) for Kisian (KS) and Awach Rivers (AS), respectively. Substratum at Kisian sites varied from mud in the upper and lower reaches to a continuous rocky bottom interspaced by huge boulders at the mid reaches. The river banks were bare with farming activities extending up to the river banks. The diversity of the riparian vegetation was variable consisting mainly of napier grass *(Pennisetum* spp)., *Eucalyptus spp*., *Mimosa spp*, *Albezia caraira*, *Lantana camara, Phragmites australis, Musa domestica* and *Tithornia diversiflora.* At Awach Seme, the substratum was composed mainly of sand and a few boulders. Several sections of its banks were well protected compared to River Kisian. The riparian vegetation was composed of *P. australis*, *Psidium guajava*, *Mimosa spp.* and *Tithornia diversiflora*, *Psidium guajava*, *Ficus spp.*, *Acacia spp.* and *Mimosa spp.* The two rivers were prone to human activities including sand harvesting, car washing, fishing, and livestock watering and bathing. Small scale gold mining was also practiced at Awach upper site.
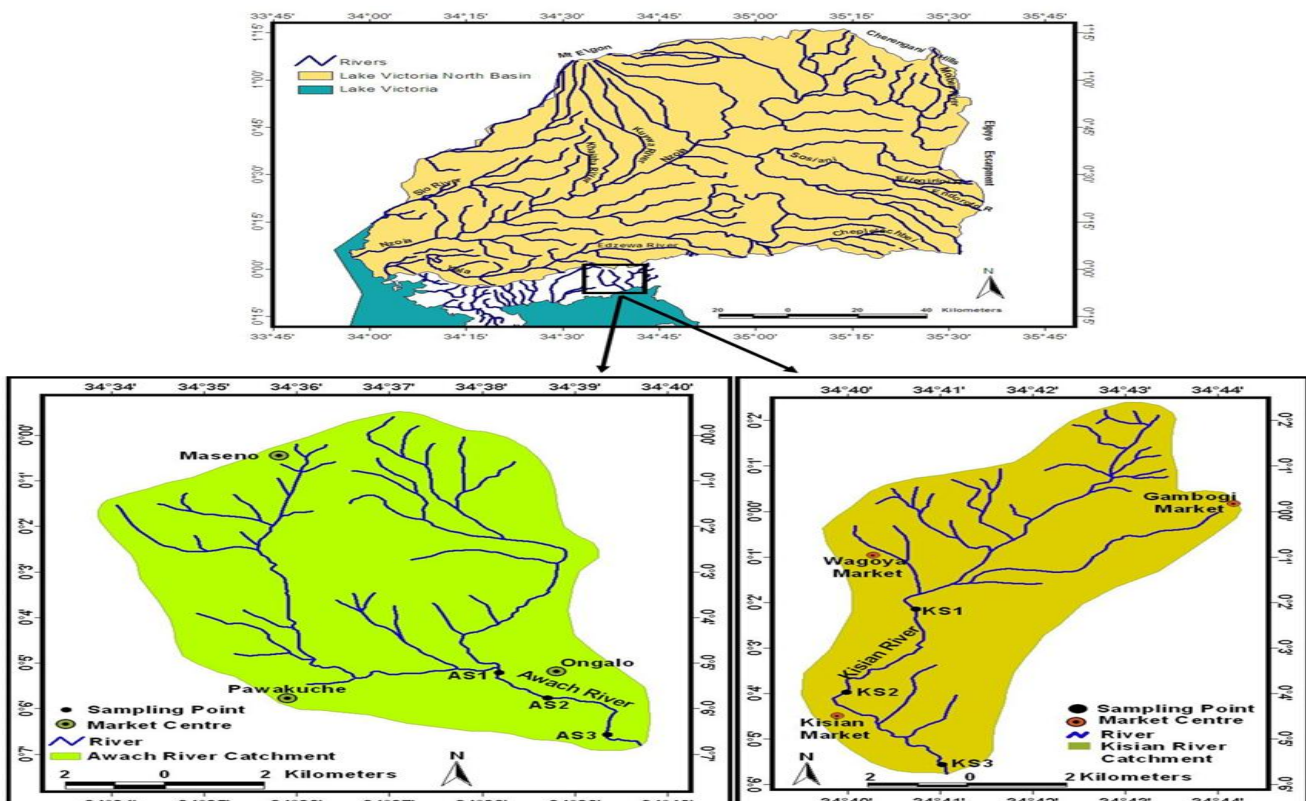

Figure 2: Location of study sites along Rivers Awach Seme and Kisian, Lake Victoria Basin, Kenya

Fish were captured using a 400 V (10 A) electro-fisher operated with a Honda GX 240 8 HP generator. Fishing was carried out for between 15 and 20 min per 100 m length at each site, depending on water depth, terrain and catches. As soon as the fish were landed, they were identified to the species level with assistance of experts from Kenya Marine and Fisheries Research Institute (KMFRI) and relevant manuals such as [17]. The standard length (SL) and wet weight of each fish specimen were then immediately measured to the nearest 0.1 mm and 0.1g, respectively.

Fish species diversity was determined using Shannon-Weiner's Diversity index, $\overline{H}$ as follows:

$$H = -\sum_{i=1}^{s} p_i \ln(p_i)$$

where **pi** is the relative abundance of each species calculated as the proportion of individuals of a given species to the total number of individuals in the community.

Shannon's equitability (E_H) was used to determine whether the population is evenly distributed among the species present. It was calculated using;

$$E_H = H \Big/ \ln S$$

where **H** is Shannon's diversity index; **S** is total number of species in the habitat (**Species Richness**).

III.   RESULTS

The fish species community structure of Rivers Kisian and Awach-Seme constituted 11 species: *Barbus altianalis* Boulenger, *Labeo victorianus* Boulenger, *Barbus cercops* Whitehead, *Clarias gariepinus* Burchell, *Barbus nyanzae* Whitehead, *Barbus kerstenii* Peters, *Barbus jacksonii* Günther, *Barbus apleurograma* Blgr., *Oreochromis leucostictus* Trewavas, *Gambusia affinis* Baird & Girard, and *Bagrus docmak* Forsskål. From River Kisian, 9 species were obtained while in River Awach, 7 species were found (Table 1). Most species caught at R. Kisian were very rare and occurred only at the lower site (KS3), with only *C. gariepinus* occurring at all the three sites. *Clarius gariepinus* was the only fish species occurring in all the sites and also grew to very large sizes (Fig. 1). Despite the fewer fish species caught at River Awach Seme, most were quite abundant and more uniformly distributed (Table 2).

Table 1: Fish species community structure of Rivers Kisian and Awach-Seme in the Lake Victoria Basin, Kenya

| Species | Sampling sites | | | | | |
| | Awach-Seme River | | | River Kisian | | |
	Upper site	Mid site	Low	Upper site	Mid sit	Lower site
Oreochromis leucostictus	-	-	-	-	-	+
Barbus nyanzae	-	+	+	-	-	+
Barbus kerstenii	+	+	-	-	+	+
Labeo	-	+	+	-	-	+
Gambusia affinis	-	-	-	-	-	+
Barbus jacksonii	-	+	+	-	+	-
Clarius	+	+	+	+	+	+
Barbus cercops	+	+	+	-	-	+
Barbus altianalis	+	+	+	-	+	+
Bagrus docmak	-	-	-	-	+	-
Barbus apleurogramma	-	-	-	-	-	+

Table 2: Total count and relative abundance of different fish species from Rivers Kisian and Awach-Seme, Kisumu District, Kenya

	Species	River Kisian (total	%	River Awach (total	%
1	Oreochromis	1	1.4	-	-
2	Barbus nyanzae	1	1.4	183	30.7
3	Barbus kerstenii	1	1.4	4	0.7
4	Labeo victorianus	-	-	15	2.5
5	Gambusia affinis	19	26.0	-	-
6	Barbus jacksonii	-	-	14	2.4
7	Clarius gariepinus	31	42.5	55	9.2
8	Barbus cercops	1	1.5	49	8.2
9	Barbus altianalis	13	17.8	276	46.3
10	Bagrus docmak	1	1.4	-	-
11	Barbus apleurogramma	2	2.7	-	-

The fish community of River Awach-Seme was dominated by *B. altianalis* and *B. nyanzae,* constituting 46.3% and 30.7% of the total catch, respectively (Table 2). Most species occurred in the sampling sites near the lake indicating a close interaction between the river and the lake ecosystem. At River Kisian, the fish community was dominated by the catfish, *C. gariepinus,* constituting over 42.5% of the total catch and was common at all sampling sites (Table 1). The catfish occurred in all the sampling sites and grew to large sizes, reaching a weight of 4kg. Other species including *G. affinis* and *B. altianalis* were also frequent. *O. leucostictus, G. affinis, B. docmak* and *B.*

apleurogramma occurred in very low numbers and were only caught at Kisian mid and lower sites (Table 2).

Overall, fish species diversity, species richness and evenness were higher at Kisian River, although occurring in significantly lower abundance than Awach (Table 3). All measures of community structure (species diversity, richness and evenness) were generally higher in the middle and lower reaches for both rivers. Kisian and Awach lower sites had the highest species diversity, probably due to their proximity to the lake. Very few species occurred at the upper sites, with *C. gariepinus* being the only species that extended its range throughout the river system. Kisian River had significantly lower fish catches than Awach despite the higher species evenness, probably because of its high turbulence resulting in greater disturbance (Table 4).

Unlike River Awach, whose fish community structure was dominated by *B. altianalis*, the fish community of River Kisian was dominated by C. *gariepinus* with over 42% (Table 5

Table). Despite the higher number of species occurring in River Kisian, their abundance was almost 9 times lower than that of River Awach. Species evenness was similarly higher at River Awach, suggesting that this river provides better fisheries than River Kisian.

Table 3: Computed fish community indices of Rivers Awach and Kisian in Kisumu District, Kenya

Community index	River Awach-Seme	River Kisian
Total catch	596	73
Species richness	7	10
Species diversity (*H'*)	1.359	1.545
Species evenness (E$_H$)	0.698	0.671

Table 4: Total number of fish caught at each of the three sampling sites along River Awach Seme during the sampling period with their overall relative abundances (%).

Fish species	Number of fish caught per study sites				
	AS	AS2	AS3	Total	%
Barbus altianalis	13	145	130	414	47
Barbus cercops	41	33	12	86	10
Barbus jacksonii	1	5	9	15	2
Barbus nyanzae	22	23	176	221	25
Barbus kerstenii	1	3	-	4	.01
Clarius gariepinus	51	51	15	117	13
Labeo victorianus	3	11	15	29	3

Table 5: Total number of each fish species obtained from each of the three sampling sites along River Kisian, Lake Victoria Basin, Kenya

Fish species	Number of fish caught per study sites				
	KS1	KS2	KS3	Total	%
Barbus altianalis	_	20	2	22	23
Barbus cercops	_	-	1	1	1
Barbus jacksonii	_	3	1	4	4
Barbus nyanzae	_	1	1	2	2
Barbus kerstenii	_	1	1	2	2
Clarius gariepinus	21	17	3	41	42
Labeo victorianus	-	2	-	2	2
Bagrus docmak	-	1	-	1	1
Barbus	-	-	2	2	2
Oreochromis	-	-	1	1	1
Gambusia affinis	-	-	19	19	20

IV.   DISCUSSION

The catfish*, C. gariepinus* was the dominant fish species in the 2 rivers and was also the most widely distributed, as it is highly toleratable to a wide range of environmental conditions (e.g. [18]. [17] also observed that *C. gariepinus* is able to survive in foul stagnant water because they possess an elaborate accessory breathing organ which enables it to utilize atmospheric oxygen. The accessory organs are in the form of much branched bodies developed from two of the gill arches on each side. They are also generalist feeders [19] and hence food is not a limiting factor in their distribution.

The higher species diversity and richness at River Kisian may be linked to the rivers morphology and hydrology. The river is characterized by a rocky substratum interspaced by large boulders, rapid riffles and shallow short pools, which increase its habitat heterogeneity resulting in greater habitat niches. [6] noted that increased riverine habitat heterogeneity was associated with higher fish assemblages in African river basin. River Kisian generally flows much faster than Awach (personal observation), resulting in higher disturbance effects on the stream communities. The higher disturbance may explain the increased diversity but low fish abundance. This observation is supported by the Intermediate Disturbance Hypothesis (IDH) of [20], which states that local species diversity is maximized when ecological disturbance is neither too rare nor too frequent. The lower total catch in Kisian could also be attributed to the higher level of human disturbance in and around River Kisian with activities like washing, bathing, sand harvesting, carwash and watering of livestock being common. Most of the river

http://www.ejournalofsciences.org

banks were also bare with farms and homesteads found close to the river edges.

The high diversity of fish species found in the two rivers is in agreement to results obtained in most other African riverine ecosystems. [21], for example, carried out a preliminary study on biodiversity of riverine fishes in Malawi and found 13 families, most of which also occurred in the lake systems to which the rivers flowed. Similarly, most of the fish species caught in Kisian and Awach Seme Rivers, also constitute the ichthyofauna community of Lake Victoria e.g. [22], suggesting a close link between the rivers and the lake. This close linkage between the rivers and the Lake ecosystem suggests that the rivers can act as refuges for the Lake Victoria fisheries. In fact, *B. altianalis* and *L. victorianus*, which were once the most abundant fish species in Lake Victoria have virtually disappeared from its commercial catches ([16] [23] [24] and their abundance in the river ecosystems may form a source of recolonization. These findings indicate that a riverine fishery has potential in improving provision of fish in the area if well managed, thereby reducing poverty in the area.

ACKNOWLEDGEMENT

REFERENCES

[1] Le´veˆque, C. B. 2005. An assessment of animal species diversity in continental waters. . Hydrobiologia 39-67.

[2] Welcomme, R. L. 1979. The inland fisheries of Africa, FAO. Rome: Committee for Inland Fisheries of Africa Occurance Paper 7, 69. FAO.

[3] Sikoki, F. D., & A. J. Otobotekere, 1999. Chapter 24: Fisheries. In E. Alagoa (Ed), The land people of Bayelsa State: Central Niger Delta((pp. 301-319). Port Harcourt, Nigeria: Onyoma Research Publications.

[4] Ogutu, G. 1988. Artisanal fisheries of Lake Victoria, Kenya. Social and economic aspects of production and marketing. . Nairobi: Institute of Development Studies (IDS) .

[5] Reynolds, J. E., & D. F. Greboval, 1988. Socio-economic effects of evolution of Nile perch fisheries in Lake Victoria: a review. Committee for inland Fisheries of Africa (CIFA) Technical Paper No. 17, 148.

[6] Kadye, W. T. & B. E. Marshal, 2006. Habitat diversity and fish assemblages in an African river basin (Nyagui River, Zimbabwe). African Journal of Ecology, 45, , 374-381.

[7] Sala, O. E., F. S. Chapin III, J. J. Armesto, R. Berlow, J. Bloomfield, R. Dirzo, D. H. Wall, 2000. Global biodiversity scenarios for the year 2100. Science 10: 1770-1774.

[8] Behnke, A. C., 1990. A perspective on America's vanishing streams. Journal of the North American Benthological Society 9: 77-88.

[9] Dynesius, M., & C. Nilsson, 1994. Fragmentation and flow regulation of the river systems in the northern third of the world. . Science, 266 , 753-762.

[10] Muhar, S., M. Schwarz, S. Schmutz & M. Jungwirth, (2000). Identification of rivers with high and good habitat quality: methodological approach and applications in Austria. Hydrobiologia 422: 343-358.

[11] Manyala, J. O., & P. B. Ochumba, 1990. Small scale fishery of the lower Sondu-Mirui River. In: IFIP, Proceedings of the Symposium on Socio-economic aspects of the Lake Victoria fisheries.Vol. L RAF/87/099 - WP/05/89 (En.), pp 114. (pp. 101-110). UNDP/FAO.

[12] Whitehead, P. J. 1958. Indigenous river fishing methods in Kenya. East Africa Agriculture Journal 24 , 274-278.

[13] Van Someran, V. D. 1959. A study of a small basket trap river fishery in Kenya. East African Journal for Agriculture 24: 257-267.

[14] Balirwa, J. S., & F. W. Bugenyi, 1980. Notes on fisheries of the River Nzoia, Kenya. Biolological Conservation 18: 53-58.

[15] Ochumba, P. B., M. Goshen, & U. Pollingher 1984. Ecological changes in Lake Victoria after the invasion of Nile Perch (Lates Niloticus): The catchment, water quality and fisheries management. In: Proceedings of the Aquiculture/Schistosomiasis Network Meeting, Manila, the Philippines August 6-10, 1991. Washington, D.C: National Academy Press.

[16] Ochumba, P. B. O. and J. O. Manyala (1982). Distribution of fishes along the Sondu-Miriu River of Lake Victoria, Kenya with special reference to upstream migration, biology and yield. Aquacult. Fish. Manage 23: 701-719.

[17] Das, A. B. and Ratha, B. K. (1996). Physiological adaptive mechanisms of catfish (Siluroidei) to environmental changes. *In*: The Biology and Culture of Catfishes (eds.). M. Legendre and J. P. Proteau. Aquatic Living Resources 9: 135-143.

[18] Greenwood, P. H. 1966. The fishes of Uganda, 2nd ed. Kampala : The Uganda Society

[19] Willoughby and Tweddle, 1978. Willoughby, N. G. and Tweddle, D. 1978. The ecology of the catfish, Clarias gariepinus and Clarias ngamensis in the Shire Valley, Malawi. J. of Zoology 186 (4): 507-534.

[20] Connell, J. H., 1978. Diversity in tropical rain forests and coral reefs. Science 199 , 1302-1310.

[21] Likongwe, J. S. 2005. A preliminary study on biodiversity of riverine fishes in Malawi and their aquaculture potential. African Crop Science Conference Proceedings, Vol. 7, (pp. 1293-1296).

[22] Awange, J. L., & O. On'gan'ga, 2006. Lake Victoria: Ecology, Resources and Environment. Netherlands: Springer- VerlagBerlin Heidelberg.

[23] Manyala, J. O., & P. B. Ochumba, 1992. Distribution of fishes along the Sondu-Miriu River of Lake Victoria, Kenya with special reference to upstream migration, biology and yield. Aquaculture and Fisheries Management 23: 701-719.

[24] Abila, R. & E. G. Jansen, 1997. From Local to global markets. The fish exporting and fishmeal industries of Lake Victoria: structure, strategies and socio-economic impacts in Kenya. IUCN Eastern Africa Programme: Socio-economics of the Lake Victoria Fish.

[25] Balirwa, J. S., C. A. Chapman, L. J. Chapman, I. G. Cowx, K. Geheb, L. Kaufman & F. Witte, 2003. Biodiversity and fishery sustainability in the Lake Victoria Basin: An unexpected marriage? Bioscience 53: 703-715.