20. Fish species diversity and the role of Kyoga satellite lakes in conservation of fish species diversity.

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Abstract

Lakes Victoria and Kyoga had many fish species, which were important as food for local population and valuable in scientific studies. Over the past twenty years, the diversity of fish in these lakes had declined due to over-exploitation, introduction of new fish species including the piscivorous Nile perch and degradation of fish habitat. This study examined fish species diversity in the seven small lakes in the Kyoga lake basin and compaired this with the main lake Kyoga (Iyingo) and historical data from Lake Victoria which have had high anthropogenic impacts. A total of 68 fish species were recorded of which 41 were haplochromines. Almost all the native non-cichlids which occurred in the main lakes (Victoria and Kyoga) before the Nile perch upsurge were recorded. Lakes Nawampasa, Gigati, Kawi, Agu and Nyaguo had the highest fish species and trophic diversity. The trophic diversity of haplochromines (based on Shannon Weaver Index) was highest in Lake Nawampasa (1.28), followed by Gigati (1.25), Kawi (1.18), Agu (0.8), Lemwa (0.81), Nyaguo (0.35) and was lowest in the main Lake Kyoga. Potential threats to these lakes were from collectors of ornamental fish species, especially the haplochromines, the spread of the predatory Nile perch and the water hyacinth, which are already in Lake Kyoga, and the destruction of macrophytes through harvesting of papyrus and reclamation for agriculture. The human population around these lakes harvested the fishes for food but the levels of exploitation were still low because the lakes were adjacent to main Lake Kyoga, the major supply of fish. Ornamental fish dealers were encouraged to start captive breeding of the fish for export to reduce pressure on the lakes and demonstrations for breeding were set up at FIRI in Jinja. Results from this survey support the motion that these satellite lakes are important refugia for endemic diversity. Based on survey, we recommend that some of these lakes like Nawampasa, Gigati, Kawi, Agu and Nyaguo could be designated as conservation areas of species threatened in the main lakes. One of the factors that seem to have prevented the spread of Nile perch into Kyoga Minor lakes seems to have been the presence of extensive swamps around these lakes and the low oxygen levels that exist in these habitats. Clearing of swamps and vegetation that separate Kyoga Minor lakes from the main lake should be avoided to prevent Nile perch from spreading into these lakes. Meetings and seminars were held with some of the communities living around the lakes sampled and the importance of fish species found in these lakes and the dangers of destructive practices discussed

Background

The Victoria and Kyoga Lake basin (Fig. 1) had similar and diverse fish fauna with many species which were found only in these lakes and a few satellite lakes within their basins (Graham 1929, Worthington 1929). These fishes were locally important as food and internationally valuable in ecological and evolutionary studies. The lakes had a trophically diverse fish community dominated by haplochromine cichlids. These haplochromines occupied all trophic levels in the lakes and played an important role in maintaining the stability of the ecosystem.

Over-exploitation, introduction of predatory Nile perch, and environmental degradation was followed by drastic reduction in stocks of native fish species in the main water bodies of lakes Victoria and Kyoga (Ogutu-Ohwayo 1990, Ogutu-Ohwayo & Hecky 1991, Witte *et* a/1992).

The loss of species and trophic diversity, and associated alterations in food webs have been accompanied by more frequent algal blooms and deoxygenation of the hypolimnion, which sometimes have been associated with mass fish kills in Lake Victoria (Ochumba & Kibara 1989). The accumulation of excess organIc matter is an indication that much of the organic matter produced in the lake is not being channelled efficiently through the food web. The decline in stocks of the trophically diverse fish community seems to have reduced grazing pressure and the overall ecological efficiency of the lake systems.

Preliminary observations in the Victoria and Kyoga lake basins had shown that some of the fish species and trophic groups that were decimated from lakes Victoria and Kyoga survived in nearby satellite lakes (Ogutu-Ohwayo 1993, Chapman *et* a/1996). The Kyoga lake basin has many satellite lakes comprising of about 24 lakes of varying sizes most of which are within a swamp extending from the eastern shores of the main lakes (Figure 2). This study examined the fish stocks and trophic diversity that are present in the Kyoga satellite lakes and how these lakes can be used to conserve those fish species threatened in lakes Victoria and Kyoga.

Specific objectives

a) develop an inventory of the fish species present in the Kyoga satellite lakes

b) rank the relative importance of the lakes in relation to their fish species diversity so as to recommend those that should be protected

c) examine how human activities such as fishing, collection of fish for ornamental trade and destruction of refugia affect fish species diversity in these lakes

d) examine the trophic diversity of haplochromines in these lakes

e) sensitise the people around these lakes on their value and on the dangers of unsustainable fisheries and land use practices.

Study Area, Materials and Methods

The study was based on seven lakes in the Kyoga Lake basin (Figure 2). These were Lakes Lemwa, Kawi, Agu, Nyaguo, Gigati, Nakuwa and Nawampasa. Some data was also collected from Lake Kyoga in the region bordering the minor lakes. The lakes are located between longitude 32° 051 E to 33° 351 E and latitude 1° 051 N to 1° 551 N, at an altitude of 1037m above sea level. They are located in an extensive swamp east of Lake Kyoga. The swamp consists of two main arms. The south eastern arm which is part of the Mpologoma swamp includes lakes Lemwa, Kawi, Nakuwa and Nawampasa The north eastern arm comprises lakes Agu, Nyaguo and Gigati. All the lakes were shallow with an average depth of 2.5 to 4.0m (Table 1).

Lake Kawi and Lake Lemwa were surrounded by papyrus, *Cyperus papyrus* right up to the open water edge. Lakes Nawampasa, Gigate, Nyaguo and Agu had a variety of habitats consisting of *Vossia cuspidata, Typha domingensis,* C. *papyrus,* and *Miscanthidium sp.* Between the shoreline vegetation and the open water of these lakes, there was a belt of dense aquatic macrophytes consisting of submerged plants *Ceratophyllum sp,* and, water lilies *Nymphaea spp.* Lake Nakuwa lacked the zone of dense aquatic macrophytes. The shoreline of Lake Kyoga was lined with *Eichomia crassipes,* C. *papyrus* and V. *cuspidata.*

Materials and Methods

Fish specimen were collected using monofilament gill nets (range 25.4 - 101.6 mm) and locally constructed basket traps. The nets were set at dusk, and retrieved the following morning. Fish were sorted into their taxonomic groups to species level whenever possible and the number and weight of each taxa recorded. Haplochromines were preserved in 10% formaldehyde solution. In the laboratory haplochromines were sorted into taxonomic groups to genus or species level where possible using morphometric and meristic procedure described in Greenwood (1981). If a fish could not exactly fit the described characters it was assigned an "chieronym". The different haplochromine taxa were then preserved separately for food analysis.

The preserved haplochromines were cut open, the stomach of each fish dissected out and its degree of fullness determined as empty (0), <1/4, 1/4, 1/2, 3/4 or full (1). The stomach contents were emptied on to a petri dish, flooded with water, examined under a binocular microscope and later under a compound microscope. The food items were sorted and identified as far as possible. The relative importance of food items were determined by the point method (Hynes, 1950). Each haplochromine taxa was assigned to one of the trophic groups previously described for Lake Victoria haplochromines as detritivores, phytoplanktivores, higher plant eaters, zooplanktivores, molluscivores, parasite eaters, insectivores, peadophages, prawn eaters, crab eaters and piscivores.

Fish species composition was estimated from percentage contribution by number of each species. Shannon-Weaver Index H' (Pielou, 1969), number of species and number of trophic groups were used to estimate species and trophic diversity. The biodiversity values of fish in the different lakes were assessed using the method given by (Fuller *et al.* 1998). Those lakes that were considered special because of having species that were absent from other lakes were also identified.

Results and Discussion

Species Composition and Diversity

A total of 68 fish species were recorded (Table 2 and 3). Of these, 41 species were haplochromines. The highest number of species was recorded in Lake Nawampasa (40), followed by lakes Nyaguo (34), Gigati (31), Kyoga (31), Agu (28), Kawi (26), Lemwa (22) and Nakuwa (17). The highest number of haplochromine species were recorded in Lake Nawampasa (27) followed by Gigati (25), Kawi (20), Agu (17), Nyaguo (16), Kyoga (15), Lemwa (12), and Nakuwa (3). Among non-haplochromines, the highest number of species was recorded in Lake Nyaguo (18), followed by Kyoga (16), Nakuwa (14), Nawampasa (13), Agu (11), Lemwa (10), Gigati and Kawi (6). Out of the 41 haplochromines recorded in the Kyoga Lake basin, 26 species were present in the minor lakes but absent in the main lake. Out of 27 non-haplochromines species recorded, 11 were present in the satellite lakes but absent in the main Lake Kyoga. On this basis, Lakes Nawampasa, Gigati, Kawi, Agu and Nyaguo were identified as having potential for conservation of endangered species.
Species diversity of haplochromines was higher in the satellite lakes than in Lake Kyoga. Species diversity of haplochromines based on Shannon Weaver Index, was highest in Lake Agu (1.68), followed by lakes Nawampasa (1.6), Kawi (1.27), Nyaguo (1.22), Gigati (1.17), Kyoga (1.08), Lemwa (1.07) and was lowest in Lake Nakuwa (0.22) (Figure 3b). The diversity of non-haplochromines was highest in Lake Nakuwa (1.62), followed by lakes Nyaguo (1.59), Kyoga (1.51), Agu (1.16), Nawampasa (0.90), Gigati (0.57), Lemwa (0.40) and Kawi (0.34) (Figure 3a).

When the habitats were considered (Fig. 4), it was observed that lakes with submerged macrophytes had higher fish species diversity than those without submerged macrophytes. Fish species diversity decreased from the vegetated habitat inshore to open waters offshore. Protection of aquatic vegetation around the lakes would therefore, contribute towards conservation of fish species diversity in the lakes.

Food and Trophic Diversity of haplochromines

Trophic diversity was examined only for haplochromines and compared with the main lakes Kyoga and Victoria. 41 haplochromine species from the Kyoga lake basin were examined for food and only 24 species contained food material. The food was composed of cyanobacteria, fish eggs, green algae, yellow- green algae, detritus, fish, higher plant material, insects (mainly odonates, mayflies, dipterans) and molluscs. Overall, seven trophic groups comprising paedophages (31 %), piscivores (21 %), algal eaters (21 %), insectivores (15%), higher plant eaters (5%), molluscivores (5%) and detrivores (5%) were recorded. All trophic groups were encountered in the minor lakes but only two trophic groups comprising insectivores (87%) and mOlluscivores (12%) occurred in the main lake. Trophic diversity varied considerably (Fig. 5). The Shannon Weaver diversity based on trophic groups was highest in Lake Nawampasa (1.28), followed by lakes Gigati (1.25), Kawi (1 ,18), Agu (0.89), Lemwa (0.81), Nyaguo (0.35) and lowest in Lake Kyoga.

Impact of Human Activities

The potential threats to fish species diversity in Kyoga Minor lakes include: human exploitation, collection of ornamental fish for export, degradation of the fish habitat, spread of the Nile perch and water hyacinth. The human population around the lakes harvested the fishes for food but the levels of exploitation were generally low. The lakes were also near Lake Kyoga which was a major supply of fish. Human exploitation was therefore not yet a major threat to the fisheries of these lakes. Ornamental fish exporters collected, mainly *Astatotilapia latifasciata* and *Haplochromis lividus,* principally from Lake Nawampasa. During the process other haplochromine species were discarded. Because of this wasteful practice, collecting of ornamental fish for export from Lake Nawampasa was suspended by the Fisheries Department. The other main threat to these lakes is due to harvesting of papyrus and the reclamation of land for agriculture. For instance, agricultural activities are currently encroaching the land around Lake Kawi. This not only destroys potential refugia but also exposes these shallow lakes to siltation. The spread of the Nile perch can also be dangerous to these lakes especially if the habitats of these lakes becomes suitable for its survival. The Nile perch has been prevented from spreading to many of the satellite lakes due the extensive swamps that separated the lakes from Lake Kyoga. The extensive vegetation cover also provided low oxygen conditions under which Nile perch may not survive. Destruction of these barriers may allow Nile perch to colonize and survive in these lakes and cause damage to the fish species diversity. Another potential problem may arise out of spread of water hyacinth into these lakes. The spread of the water hyacinth especially in the Lake Kyoga basin is currently under control using weavils.

Discussion

The overall fish species and trophic diversity of haplochromines in the Kyoga Minor lakes was very high as compared Lake Nakuwa and the main lake Kyoga. The most obvious explanation is the absence of Nile perch from the minor lakes examined. Nile perch has been prevented from entering the main lakes by swamps separating the lakes. The fish species and trophic diversity of haplochromines varied within the minor lakes. Generally the lakes in the north eastern arm namely Lake Nawampasa, Lake Gigati, and Lake Agu had higher species and trophic diversity as compared to those in the south eastern arm mainly Lake Lemwa. This is probably due to high habitat diversity, comprising submerged plants and floating water lilies that are found in these lakes, which provide a wide ecological niche as compared to Lake Lemwa and Kawi which are dominated by papyrus swamps along the shoreline with only open waters. However Lake Kawi had higher trophic diversity than Lake Nyaguo in the north eastern arm because Lake Kawi is very close to the north eastern arm and probably shares some of the characteristics of both arms. Lake Agu had low number of species despite the high shannon Weaver index of diversity because it exhibited high evenness of relative abundances. The biodiversity value of this lake was also rated low, however this lake had one species *Paralabidochromis victoriae* which was absent in those lakes with high species diversity and was therefore considered as a special lake. Lake Agu has little human exploitation and is very close to Lake Nyaguo which would provide alternative source of fish protein if Lake Agu was gazette for conservation purposes. Lake Nawampasa had both high number of species and evenness of relative abundances. The biodiversity value was rated as high thus making this suitable for conservation purposes. The lake has very little human exploitation because it is adjacent to the main Lake Kyoga which provides an alternative source of fish protein. Lake Gigati had a high number of species with low evenness of relative abundaces. The biodiversity value was rated as high. This lake has a very high human exploitation to the extent that at anyone time of the day nets cover three quarters of the lake (Personal observation). This is very close to lakes Kawi and Nyasala which would provide alternative sources of fish protein if this lake was gazetted for conservation purposes. Lake Kawi has a high fishing pressure, but the lake has suds that naturally help in reducing this pressure through carrying away nets of fishermen. Lake Nyasala and Nakuwa have Nile perch and may not be suitable for conservation of haplochromines but may rather be suitable for human exploitation.

Before the Nile perch upsurge, there were eleven trophic groups of haplochromines in Lake Victoria (Goldschmidt, 1996). These included insectivores, piscivores, higher plant eaters, zooplantivores, crab eaters, prawn eaters, peadophages, algae eaters, molluscivores, parasite eaters and detritivores. After the Nile perch upsurge and the decline in haplochromines only three trophic groups consisting of insectivores, prawn eaters, zooplanktivores and molluscivores are commonly recorded in Lake Victoria (Namulemo, 1997 and Ebong,1998).

In Lake Kyoga, where Nile perch has been established the longest only two trophic groups of haplochromines are frequently encountered the insectivores and molluscioores. The current state in Kyoga satellite lakes is closer to that of Lakes Victoria and Kyoga before the Nile perch upsurge (Fig. 6). The Kyoga Minor lakes are therefore important in conservation of some of the trophic groups depleted from Lake Victoria. This observation indicates that haplochromines from the minor lakes play an important role in energy flow and overall ecological efficiency of these lake systems.

Conclusion

The present study has shown that many fish species and haplochromine trophic groups which existed in lakes Victoria and Kyoga prior to the Nile perch introductions and are present in the Kyoga Minor lakes. The study may also provide a picture of the trophic structure of haplochromines that existed in Lake Kyoga before Nile perch upsurge. The presence of Nile perch in Lake Kyoga has simplified the trophic structure of haplochromines in the lake from seven trophic groups to two. The Kyoga Minor lakes therefore provide a great opportunity for conservation of fish species diversity threatened by introduction of exotics and other anthropogenic impacts in the Victoria and Kyoga lake basins.
It is therefore recommended that;

a) Some of the Kyoga minor lakes like Nawampasa, Gigati, and Agu be designated as conservation areas of haplochromines and other species threatened by introduction of exotics in lakes Victoria and main lake Kyoga.

b) Clearing of swamps and vegetation that separate Kyoga Minor lakes from the main lake be avoided to prevent the spread of Nile perch into these lakes. This is because presence of extensive swamps around these lakes is one of the factors that has prevented Nile perch from colonising minor lakes.

c) There is need for a more detailed study on the trophic ecology to include the other fishes in these lakes in order to answer the question of how energy is channelled through the different systems.

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Table 1. Area and average depth of the Kyoga Lake basin lakes sampled

Name of lake	Area (km^2)	Average depth (m)
Lemwa	10	3.1
Kawi	5	3.2
Agu	4	2.2
Nyaquo	13	2.4
Giqati	1.7	2.4
Nakuwa	18	2.6
Nawampasa	8	2.6
Kyoga	204.7	3.5

Table 2. **The overall percentage composition of fish from different lakes in the Kyoga Lake Basin**

	LAKES									
SPECIES	Agu	Nyaguo	Kawi	Lemwa	Gigate	Nawampasa	Nakuwa	Kyoga	Minor lakes	Overall
Lates niloticus	0.00	0.00	0.00	0.00	0.00	0.00	26.55	11.27	0.50	1.36
Oreochromis niloticus	0.00	0.27	0.00	0.15	0.22	0.08	3.39	2.33	0.24	0.40
Haplochromines	40.28	20.83	97.03	93.67	60.91	65.57	10.17	51.63	60.63	59.91
Ctenopoma murei	0.00	0.00	0.14	0.45	0.00	0.00	000	0.02	0.04	0.04
Tilapia zillii	0.47	0.00	0.00	0.00	0.00	0.62	0.56	1.22	0.10	0.19
Oreochromis variabilis	0.00	0.00	0.00	000	0.00	0.08	000	000	0.01	0.01
Oreochromis leucostictus	0.00	1.20	1.13	2.26	0.45	0.00	1.13	0.98	0.66	0.68
Oreochromis esculentus	0.95	0.80	0.57	0.90	0.03	1.03	0.56	0.00	0.38	0.35
Synodontis afrofischeri	0.95	0.93	0.85	0.45	0.00	3.26	20.34	0.07	102	0.94
Synodontis victoriae	0.00	4.14	0.00	0.30	0.00	1.28	10.73	1.33	0.84	0.88
Barbus spp	0.95	4.14	0.00	0.15	0.00	0.04	0.00	0.00	0.50	0.46
Barbus trispidopleura	0.00	0.00	0.00	0.15	0.00	0.00	0.00	000	001	0.01
Barbus altianalis	0.00	0.00	0.00	0.00	0.00	0.00	7.91	0.13	0.15	0.15
Labeo victorianus	0.00	0.00	0.00	000	0.00	0.00	0.00	0.65	000	0.05
Brycinus sadleri	1.90	47.26	000	000	38.27	27.22	0.00	18.79	30 36	29.43
C/arias gariepinnus	0.00	0.13	0.28	1.51	0.12	0.41	1.13	0.09	0.28	0.27
C/arias liocephalus	0.00	0.00	0.00	000	0.00	0.12	2.82	0.00	0.07	0.06
Mormyrus kannume	0.00	0.13	000	000	0.00	0.00	0.00	0.00	0.01	0.01
Mormyrus macrocephalus	0.47	2.94	0.00	0.00	0.00	0.00	0.00	000	0.34	0.31
Marcusenius grahami	6.16	0.13	000	0.00	0.00	0.00	0.00	0.00	0 20	0.19
Marcusenius nigricans	0.00	0.53	0.00	000	0.00	0.00	0.00	0.00	0.06	0.05
Gnathonemus longibarbis	41 .71	3.47	0.00	0.00	0.00	000	0.00	0.07	1.67	1.54
Gnathonemus victoriae	4.74	10.41	0.00	000	0.00	0.04	1.13	10.90	1.31	2.08
Petrocephalus catastoma	1.42	2.40	0.00	000	0.00	0.00	0.00	0.09	0.31	0.29
Protopterus aethopicus	000	0.13	0.00	0.00	0.00	0.25	1.69	0.46	0.08	0.11
Afromastacembelus frenatus	0.00	0.13	000	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Schilbe intermedius	0.00	0.00	0.00	0.00	0.00	000	11.86	0.00	0.22	0.21
	100	100	100	100	100	100	100	100	100	100

Table 3. **The overall percentage composition of haplochromines from different lakes in the Kyoga Lake Basin**

HAPLOCHROMINE SPECIES	LAKES								Mean of Minor lakes	Mean of all lakes
	Lemwa	Kawi	Agu	Nyaguo	Gigate	Nawampasa	Nakuwa	Kyoga		
Astatoreochromis alluaudi	0.72	1.19	3.19	0.50	0.87	0.15	0.00	0.27	0.77	0.74
Astatotilapia latifasciata	0.00	0.00	0.64	000	0.69	1A1	0.00	000	0.70	0.65
Astatotilapia martini	0.10	0.00	0.00	0.74	0.04	0.00	0.00	0.00	0.05	0.05
Astatotilapia nubila	22.98	8.71	3.19	25.81	OA3	0.30	22.22	25.97	4.35	5.66
Astatotilapia "miniblack"	0.10	000	7.99	000	0.74	5.90	0.00	0.00	2.00	1.88
Astatotilapia "fattooth"	54.66	64.37	17.57	49.13	26.22	3903	44A4	0.00	36.61	34AO
Astatotilapia "macrops"	0.00	0.16	0.00	1A9	0.28	0.07	0.00	000	0.23	0.22
Astatotilapia "thicklipped"	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.00	0.04	0.04
Astastotilapia "kyogaastato"	0.00	000	0.00	000	000	0.15	33.33	6.97	0.25	0.65
Gaurochromis sp	0.00	000	0.00	0.00	0.00	0.15	000	0.05	0.04	0.04
Haplochromis lividus	13.04	0.63	43.13	0.50	43.74	32.27	0.00	0.14	31.78	29.86
Lipochromis "blackcryptodon"	0.21	3A8	0.64	0.74	0.39	0.82	0.00	0.14	0.84	0.79
Lipochromis cryptodon	0.00	OAO	0.00	0.50	0.05	000	0.00	0.00	0.09	0.08
Lipochromis microdon	0.00	0.24	0.64	0.00	OA4	OA1	0.00	000	0.36	0.34
Lipochromis obesus	000	2.69	4.79	0.50	0.97	0.67	0.00	0.00	1.09	1.02
Lipochromis parvidens	0.00	016	1.92	0.00	1.22	0.97	0.00	0.14	0.91	0.86
Lipochromis "white"	0.00	0.16	0.00	0.00	000	0.00	0.00	0.00	0.02	0.02
Lipochromis maxillaris	0.00	0.32	0.64	0.00	0.05	0.52	0.00	0.00	0.20	0.19
Paralabidochromis "blackpara"	6.83	1A3	0.00	0.00	0.02	0.00	0.00	40.73	0.75	3.17
Paralabidochromis"redfin"	0.10	0.63	0.00	0.00	0.25	0.59	000	0.00	0.34	0.32
Paralabidochromis "deep body"	0.00	000	0.00	0.00	0.04	000	0.00	0.00	0.02	0.02
Prognathochromis argentus	0.62	2.38	5.11	0.00	0.60	4.79	0.00	0.00	1.89	1.78
Prognathochromis "long lowerjaw piscivore"	0.00	000	0.00	0.50	0.04	0.00	0.00	0.00	0.04	0.03
Prognathochromis pellegrini	0.00	000	2.56	0.00	0.00	3.79	0.00	0.00	0.97	0.91

HAPLOCHROMINE SPECIES	LAKES								Mean of Minor lakes	Mean of all lakes
	Lemwa	Kawi	Agu	Nyaguo	Gigate	Nawampasa	Nakuwa	Kyoga		
Prognathochromis "silvermale"	0.00	0.00	0.00	1.99	0.00	000	0.00	0.00	0.07	0.07
Prognathochromis "black red tail piscivore"	0.00	0.00	0.00	0.74	0.00	0.07	0.00	0.00	0.04	0.04
Prognathochromis "stilleto"	0.00	0.08	0.32	0.00	0.00	1.89	0.00	0.00	0.47	0.44
Prognathochromis "shovelmouth"	000	8.31	2.24	13.90	1.60	2.90	000	19.27	2.96	3.95
Ptyochromis "gigatisheller"	0.00	0.00	0.00	0.25	0.04	0.04	0.00	0.00	0.04	0.03
Pyxichromis orthostoma	0.41	4.35	0.00	1.99	0.34	0.41	0.00	0.27	0.85	0.82
Paralabidochromis "victoriae"	0.00	0.00	0.32	0.74	0.00	0.00	0.00	0.00	0.04	0.03
Xystichromis phytophangus	0.00	0.16	5.11	0.00	20.81	2.34	000	0.27	1106	10.40
Yssichromis "lemwa zooplanktivore"	0.21	0.16	000	0.00	0.00	000	0.00	0.00	0.04	0.03
Yssichromis "kyoga zooplanktivore"	0.00	0.00	0.00	0.00	000	0.00	0.00	0.36	0.00	0.02
Paralabidochromis "earthquake"	0.00	0.00	0.00	0.00	000	0.00	0.00	2.32	000	0.14
Prognathochromis guiarti	0.00	000	0.00	0.00	000	0.00	0.00	0.68	0.00	0.04
Paralabidochromis "flame back"	0.00	000	000	0.00	000	0.00	000	2.41	0.00	0.15
Paralabidochromis "silverpara"	0.00	0.00	0.00	000	0.07	0.00	0.00	000	0.04	0.03
Haplochromis "unicuspid"	0.00	0.00	0.00	000	0.00	0.07	0.00	000	0.02	0.02
Astatotilapia "redtailfattooth"	0.00	000	0.00	0.00	0.00	0.04	0.00	000	0.01	0.01
Astatotilapia "pseudomartini"	0.00	000	000	0.00	000	0.22	0.00	0.00	0.05	0.05
Grand total	100	100	100	100	100	100	100	100	100	100

21. The Role of Nearshore Areas in Conservation of Fish Species Diversity of Lake Kyoga

Background

Lake Kyoga lies in the centre of Uganda north of the equator. It receives the outflow from Lake Victoria and drains into Lake Albert via the River Nile. The open area is about 2300 km^2 between 3.5 and 4.5m deep with a maximum of 5m. The indigenous fish fauna of L. Kyoga comprised a diverse fauna, most of which was represented in Lake Victoria as there was no effective barrier separating the faunas of the two lakes before construction of the Owen Falls Hydroelectric station in 1953 (Twongo, 1988). Until the early 1960s the fishery of L. Kyoga was based on at least five taxa of major economic importance.

The introduction of non-indigenous fishes especially *Lates niloticus* and *Oreochromis niloticus* into L. Kyoga in the mid 1950s appear to have upset the original ecological balance of the lake and caused changes in species diversity. The original fish fauna of the lake had evolved a trophic diversity that promoted efficient utilisation of most of the available energy resources (Twongo op. cit.). Tilapiines and phytoplanktivorous haplochromines were the major primary converters. *Rastrineobola argentea* preyed mainly on zooplankton, while the major invertebrate/benthos feeders were *Clarias* sp., *Schilbe intermedius*, *Synodontis* spp., *Protopterus aethiopicus*, *Labeo victorianus* and several mormyrids. The major predator was *Bagrus docmac*.

The establishment of the Nile perch in L. Kyoga was followed by decline of the population of indigenous fishes (Ogutu-Ohwayo, 1994). All the indigenous fishes of L. Kyoga with the exception of *R. argentea* continued to decline in abundance and by 1978, the indigenous tilapiine cichlids, *Barbus* spp., *L. victorianus*, *Synodontis* species., S. *intermedius*, B. *docman*, and several mormyrids were very rare and confined to the inshore weedy zone. *Clarias* spp. and P. *aethiopicus* occurred only close to the papyrus swamps. The fishery is now dominated by the introduced *L. niloticus* and O. *nilotiicus* and the indigenous *R. argentea*. Although the decline in species diversity has been accompanied by a steady increase in the yield to the fisherman, the great reduction in species diversity may affect long term sustained fish production of the lake. The probable reduction in niche utilisation is likely to interfere with fuller mobilisation of available energy in the ecosystem.

Experimental fishing carried out on L. Kyoga between 1988 and 1991 showed that Nile perch and Nile tilapia were the dominant species (Ogutu-Ohwayo 1994). Other species which included *T. zillii*, 0. *leucstictus*, S. *intermedius*, P. *aethiopicus*. C. *gariepinus*, *Barbus* species, S. *afrofischeri*, *L. victorianus*, mormyrids and *Afromastacembelus frenatus* were caught in very small numbers. *Oreochromis variabilis* and *Oreochromis esculentus* were never caught.

From 1991, haplochromine stocks started to increase both in catches and as prey of Nile perch. The increase in haplochromines coincided with the invasion and spread of Water hyacinth *Eichhornia crassipes* (Martius) 801m which invaded the lake in 1988 and became established between 1991 and 1992 (Twongo 1992). Floating beds of water hyacinth provide cover and as they move disperse haplochromines which survived under cover among macrophytes along the margins of the lake and among other refugia and allows them to re-colonise the lake and multiply. The recovery in haplochromines may also have been enhanced by possible reduction in Nile perch stocks due to the very high fishing pressure and the indiscriminate use of seine nets.

At present stocks of haplochromines have reduced. Control of the water hyacinth in L. Kyoga could have re-exposed the haplochromines to predation and resulted in their decline.

Study area

Thirteen stations of L.Kyoga were studied and these included Iyingo, Kakoge, Kigingi, Miseru, Nagulu, Muswakire, Bukungu (openwaer), Kiwantama, Kapiokolo, Kyankole, Kasatu, Gaba and Kalungi. Iyingo, Kakoge, Kigingi, Miseru Nagulu and Kiwantama are along the shoreline, Muswakire and Bukungu are openwater stations, Kapiokolo and Kyankole are near the mouth of R. Nile while Kasatu, Gaba and Kalungi are stations within R. Nile.

Material and methods

Experimental fishing was carried out using graded gillnets of mesh size 1 to 8 inches at an interval of 0.5 inches. The nets were always set in the evening and retrieved in the morning the following day. Fish specimen were identified to species level according to Greenwood 1974. For each species, the total number and total weight of the fish to the nearest gram were recorded. For each individual fish specimen, total length to the nearest centimetre was measured.

Results

In 1996 eight stations were sampled namely Kiwantama, Kapiokolo, Kyankole, Muswakire, Naluboyo, Muntu, Bukungu and Kampala. From Kiwantama 15 fish taxa were recorded and included *L. niloticus* (38.7%), Haplochromines (19.3 %), *G.victoriae* (14.4%), S. *afrofischeri* (9.9%), S. *victoriae* (3.0%), B. *sadleri* (3.0%), *T. zillii* (2.5%), O. *niloticus* (2.5%), *L. victorianus* (1.9%), O. *leucostictus* (1.9%), M. *macrocephalus* (1.4%), B. *altianalis* (0.6%), A. *frenatus* (0.3%), C. *gariepinus* (0.3%) and P. *aethiopicus* (0.3%). From Kyankole ten fish taxa were recorded and they included Haplochromines (41.2%), *L. niloticus* (23.5%), *T. zillii* (22.7%), *L. victorianus* (5.9%), B. *altianalis* (1.7%), M. *macrocephalus* (1.7%), *O.leucostictus* (0.8%), O. *niloticus* (0.8%), P. *aethiopicus* (0.8%) and S.