DISTRIBUTION, RELATIVE ABUNDANCE, POPULATION STRUCTURE AND FOOD OF SURVIVING HAPLOCHROMINE CICHLIDS IN THE LITTORAL AREAS OF NAPOLEON GULF (LAKE VICTORIA)

BY

NAMULEMO GERTRUDE

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DEPARTMENT OF ZOOLOGY,
MAKERERE UNIVERSITY KAMPALA

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DECLARATION

I wish to certify that this dissertation is a result of my own investigation and has not been submitted for a degree in any other University.

Signature.....

NAMULEMO GERTRUDE

SUPERVISORS

Signed.....

Dr. Ogutu-Ohwayo, Richard
Fisheries Research Institute
P.O.Box 343, Jinja
UGANDA

Signed.....

Dr. Yusuf Kizito
Department of Zoology,
Makerere University,
P.O.Box 7062, Kampala
UGANDA

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SUMMARY

Prior to the introduction and establishment of Nile perch *Lates niloticus*, haplochromine cichlids were the most abundant and speciose group of fishes in lakes Victoria, Kyoga and Nabugabo. They occupied virtually all trophic levels and played an important role in the flow of organic matter in these ecosystems. Following the establishment of Nile perch, stocks of haplochromines declined rapidly, and some species completely disappeared. This was accompanied by drastic changes in biological and physico-chemical conditions in Lake Victoria. Recent studies on fish stocks of Lake Victoria have been confined to offshore waters. In this study, the distribution, relative abundance and food of surviving haplochromine cichlids in littoral areas of Lake Victoria were examined to find out the species diversity in the zone and specifically the food of the haplochromines. The data were compared with historical data to see whether the distribution, relative abundance, and diet of the haplochromines have changed and what role the surviving haplochromine species were playing in the trophic ecology of the lake. The study was based in the Napoleon Gulf of Lake Victoria.

Twelve fish taxa were recorded. Numerically, the Nile perch *Lates niloticus*, dominated the catch (42.3%) followed by haplochromines (30.7%), *Oreochromis niloticus* (12.2%), *Tilapia zillii* (8.9%), *Synodontis afrofischeri* (2.3%), *Brycinus sadleri* (1.9%), *Mormyrus kannume* (0.5%), *Oreochromis leucostictus* (0.4%), *Synodontis victoriae* (0.4%), *Clarias gariepinus*(0.2%), *Oreochromis variabilis* (0.1%), and *Protopterus aethiopicus* (0.1%). Fish diversity and abundance decreased with increasing distance from the shoreline and varied between stations. It was highest at Rwamafuta (1.12), followed by Kikondo (1.1), Kiryowa (1.07), Kirinya (0.74) and Cliff (0.61).

Twenty three haplochromine species were recorded. These were, in order of numerical abundance, *Astatoreochromis alluaudi* (17.9%), *Astatotilapia "unicuspid"* (14.8%), *Prognathochromis paraguiarti* (12.7%), *Paralabidochromis "yellowbody"* (10.6%), *Paralabidochromis "goldchest"* (9.8%), *Harpagochromis guiarti* (7.5%), *Astatotilapia nubila* (6.5%), *Astatotilapia "bicuspid"* (4.2%), *Neochromis "scraperteeth"* (3.2%), *Neochromis nigricans* (2.8%), *Paralabidochromis crassilabris* (1.6%), *Paralabidochromis "velvetblack"*

(1.6%), *Paralabidochromis "yellowbars"* (1.3%), *Neochromis pseudonigricans* (1.2%), *Paralabidochromis "rockcribensis"* (0.9%), *Astatotilapia sp.* (0.8%), *Paralabidochromis "shortsnout"* (0.7%), *Parabidochromis "blue deep-body"* (0.6%), *Ptyochromis xenognathus* (0.5%), *Paralabidochromis "sharpteeth"* (0.4%), *P. "bigeye"* (0.4%), *P. chilotes* (0.2%) and *P. "curved head"* (0.2%). Species diversity and abundance of haplochromines also decreased with increasing distance from the shoreline. It was highest at Kiryowa (1.52), followed by Kikondo (1.12), Rwamafuta (0.72), Kirinya (0.54), and Cliff (0.52).

Most of the haplochromine stomachs examined contained larval insect remains, namely chironomid larvae and pupae, chaoborid larvae and pupae, ephemeropteran nymphs, *Odonata* nymphs and some trichopteran nymphs. Some haplochromines had remains of molluscs in their stomachs and others had *Caridina nilotica*. A few stomachs also contained fish remains in addition to insect remains. Some plant remains (aquatic weeds) and filamentous green algae were also encountered in some haplochromine stomachs.

This study has shown that overall fish species diversity in the shallow near shore areas has, as in the case of offshore areas decreased. However, the diversity in the shallow inshore areas is higher than in the offshore ones especially the inshore areas with macrophyte cover and areas with rocky habitats. Among haplochromines very few trophic groups are still present. Most surviving haplochromines are insectivores with a few molluscivores and prawn-eaters with very little phytoplanktivory and detrivory. Primary production is no longer channeled via the haplochromine food chain.

CHAPTER I

1.0. Importance of haplochromines in the ecology and fishery of Lake Victoria.

1.1. Background

Prior to the introduction and establishment of Nile perch, *Lates niloticus* (Linnaeus, 1758), haplochromine cichlids were the most abundant group of fishes in lakes Victoria, Kyoga, and Nabugabo. They formed at least 83% of the fish biomass in Lake Victoria until the early 1980s (Kudhongania & Cordone, 1974; Okaronon *et al*., 1985). They were important as human food and in evolutionary studies. Lake Victoria alone had more than 300 haplochromine species more than 99% of them endemic (van Oijen *et al.,* 1984; Witte *et al.*, 1992). They occupied virtually all trophic levels and played an important role in the flow of organic matter in these ecosystems. Species had unique combinations of food and habitat preferances (van Oijen,1982; Goldschmidt *et al*., 1990). Up to eleven trophic groups comprising phytoplanktivores, detritivores, epilithic and epiphytic algal grazers, plant eaters, molluscivores, zooplanktivores, insectivores, piscivores, parasite eaters, paedophages, and scale eaters were identified in the Mwanza Gulf alone (Witte & van Oijen, 1990).

At the time that Graham (1929) made the first fishery survey of Lake Victoria, haplochromines were regarded as trash fish because they are small fishes with many bones, and consumers tended to avoid them. For this reason, it was suggested that a large piscivore like Nile perch, *Lates niloticus*, be introduced into Lake Victoria from Lake Albert to feed on the haplochromines, and convert their biomass into a larger fish of greater commercial and recreational value (Graham, 1929; Anderson, 1961). Nile perch were introduced into Lake Kyoga in 1955 and 1956 and to Lake Nabugabo in 1960 and 1963 to assess the effects they would have on fish fauna similar to that of Lake Victoria (Gee, 1964). Before these trials were evaluated, Nile perch were in 1960 found to have gained access to Lake Victoria, and additional fish were introduced into the lake in 1962 and 1963 (Gee, 1964; Ogutu-Ohwayo, 1990).

In Lake Victoria, catches of Nile perch increased rapidly in 1977 in Kenya waters, in 1981 in Ugandan waters, and in 1983 in Tanzania waters (Okemwa, 1984; Ogari, 1985; Okaronon *et al.*, 1985; Goudswaard & Witte, 1985; Ogutu-Ohwayo, 1990a). This was accompanied by a reduction and in some cases, total disappearance, of many of the native fish species (Ogutu-Ohwayo 1990a,b, 1994). Haplochromine cichlids, which had been the most abundant species both in number of species and in biomass got depleted and virtually disappeared from most parts of the lake by the late 1980s (Witte *et al* 1992). Although the decline was initiated by human exploitation, predation by the Nile perch is thought to have been responsible for the rapid decline in haplochromines and overall fish species diversity in the lakes following its establishment. This is supported by the fact that haplochromines were, at that time, the most important item in the diet of Nile perch (Hamblyn, 1966; Gee, 1969; Okedi, 1971; Ogutu-Ohwayo, 1985; 1990a, 1990b). There were differences in the rate of decline within, as well as between, trophic groups (Witte *et al.*, 1992). Molluscivores, insectivores, and epiphytic algal grazers survived in the shallow littoral zone where catches of Nile perch were relatively low, while non-surviving species occurred there during only part of their life cycle (Witte *et al*., 1992). Least affected were the rock frequenting haplochromines, particularly the permanent rock dwellers which live between boulders and in rock crevices where they hide from the Nile perch (Seehausen, 1996).

The decline in haplochromine species was accompanied by drastic changes in biological and physico-chemical conditions, especially in Lake Victoria. Algal biomass in Lake Victoria increased four to five times, phytoplankton production doubled, and water transparency decreased (Mugidde, 1992, 1993). Decay of the excess organic matter has depleted the water column of dissolved oxygen leading to development of hypoxic conditions in water deeper than 40 m during the period of stratification. This has reduced habitable space for many fish species and is thought to have driven deep water haplochromines to shallower waters where they fell easy prey to Nile perch (Hecky, 1993; Kaufman & Ochumba, 1993). The disruption and reduction of the diverse and trophically complex haplochromine community by the Nile perch seems to have initiated changes in food web structure of the lakes by reducing grazing pressure. This disruption contributed to accumulation of organic matter and to some of the changes discussed above (Ogutu-Ohwayo & Hecky, 1991). Algal composition has changed and is now dominated by blue greens. The blue-green algae were the major food of the

detrivorous/phytoplanktivorous haplochromines and the pelagic phytoplanktivores. Together these two trophic groups constituted about 50% of the total haplochromine biomass in the lake (Goldschmidt, 1986; Witte & van Oijen, 1990). Their depletion must have reduced grazing pressure and left much of the algae produced in the lake unconsumed.

The Nile perch seems to have been most effective in reducing those indigenous fish species in sub-littoral to the deep water the habitats which are frequented by the piscivorous phase of the predator (Balirwa 1995). Some haplochromines have been shown to survive in shallow littoral zones of some of the lakes to which Nile perch was introduced (Ogutu-Ohwayo 1993, 1994; Chapman et al. 1996a,b). Stocks of some haplochromines have also started to recover in Lake Kyoga following heavy fishing pressure on the predator and an increase in aquatic macrophytes which provide refugia and reduce predation losses (Ogutu-Ohwayo, 1994). The presence of haplochromines in refuge areas in the lakes to which Nile perch was introduced and the improvement of haplochromine stocks in Lake Kyoga shows that there are chances of some native species recovering and overall species diversity increasing in those lakes to which Nile perch was introduced.

Conservation of biodiversity is recognised as very important for the stability of the ecosystem. The United Nations Convention on Biological Diversity recognised conservation of biological diversity as a basis for sustainable development. Declining fish species diversity and food web dynamics have been recognised by National Agricultural Research Organisation (NARO), as one of the major constraints that may affect increased and sustainable fish production in Uganda.

Recent studies on the fish stocks of Lake Victoria have mainly been carried out in more offshore waters (Okaronon, 1994) and there is overall lack of information on the fish stocks in the nearshore areas. This study will contribute to the knowledge on the fish stocks in the nearshore areas of the lake and that required in conservation of biodiversity by examining the distribution, relative abundance, and food of haplochromines which survive in the littoral area of Lake Victoria. Information from the study will be compared with historical data to see whether the distribution, relative abundance and diet of the different trophic groups has

changed since the Nile perch upsurge and what role the surviving species are playing in the trophic ecology of the lake.

1.2. Objectives

The major objective of the study is to quantify the distribution, relative abundance of the fish stocks, and food of surviving haplochromines in the littoral areas of Napoleon Gulf of Lake Victoria, and the role of these haplochromines in the trophic ecology of the lake. This will be achieved by examining:

i Relative abundance and distribution of the different fish taxa.
ii Relative abundance and distribution of haplochromine trophic groups.
iii Food of the major surviving haplochromine trophic groups.
iv Comparing the current with historical data

1.3. Hypotheses

i The native species especially haplochromines are more abundant nearshore and in specific habitats not accessible to Nile perch, e.g macrophytes, rocky outcrops, and areas with low disslved oxygen concentration.
ii The contribution of haplochromines to overall fish biomass has decreased.
iii The number of trophic groups and their relative abundance has changed.

CHAPTER II

2.0. Study Areas, Materials, and Methods

2.1. Study Areas

Specimens were collected from Napoleon Gulf in the northern region of Lake Victoria. The study covered four stations which were representative of four habitat types namely: Rocky substrate (Rwamafuta and Kikondo); macrophyte cover habitat (Kiryowa); gentle slope (Kirinya) and steep slope (Cliff) off Jinja Club (Figure 1).

The description of the sampling sites was as follows:

2.1.1. Kiryowa: This site is located at the mouth of the Bugungu stream. The shoreline was dominated by papyrus, *Cyperus papyrus*, with some hippo grass, *Vossia sp*., towards the western end of the site. The vegetation was fringed by a belt of Water hyacinth, *Eichhornia crassipes*, 2-3 m wide. The area had a maximum depth of 6 m with a bottom substrate of submerged rock.

2.1.2. Cliff: This site is opposite the Kiryowa site. It is characterised by a steep slope ending in an exposed clay shoreline with occassional stands of *Vossia* sp. From time to time, the area was invaded by the Water hyacinth which is later transported away to the nearby source of the River Nile. The area has a maximum depth of 6 m with a bottom substrate of soft mud.

2.1.3. Kikondo: This site has a shoreline characterised by laterite rocks which extend into littoral area giving it a bottom substrate of hard rock. The shoreline is for most part covered by remnants of forest, in form of thickets which extend few metres into the water. Stands of cattails

(*Typha* sp.) and Water hyacinth occur among the rock outcrops. Maximum depth is 10 m.

2.1.4. Kirinya: This site is characterised by a gentle slope with a papyrus shoreline fringed by Water hyacinth. Maximum depth was 4 m with a bottom of soft mud.

2.1.5. Rwamafuta: This site is located on a rocky island within the Buvuma Channel. It was characterised by rocky outcrops along the shoreline and was exposed to strong waves. Most of the time the area was covered with Water hyacinth. The bottom has a substrate of submerged rock. Maximum depth was 4 m. The shoreline was exposed and composed of hard gravel.

2.2. Material and Methods.

2.2.1. Sampling in the field

Fish specimens were collected using three fleets of gill nets. Each fleet consisted of one net of mesh sizes 25.4 mm to 76.2 mm stretched at an interval of 12.7 mm. The three fleets of nets were, at each station, set at three locations. The first location was along the shoreline and was regarded as having been 1 m from the shore. The second fleet was at 20m and the third fleet at 200 m from the shore. Each of these stations was sampled once a month for twelve months from October 1995 to September 1996. The nets were set at 18.00 hours in the evening and retrieved at 7.00 hours the following morning. Dissolved oxygen concentration was measured at the sites where each fleet was set during the setting of nets, using the Hydrolab Surveyor II.

The fish caught were sorted out into different taxonomic groups, and the number and weight of the different fish taxa recorded. Haplochromines were fixed in 5% formalin and labeled with time, date, mesh size, size of net and site, and examined later in the laboratory. Whenever possible, photographs of fresh haplochromine specimens were taken in the field to be used in later identification.

2.2.2. Laboratory Analysis

In the laboratory, the haplochromines were identified to genera using the key by Greenwood (1981a). The total length, standard length, and weight of individual haplochromine specimen were measured. The length were measured to the nearest centimeter using a measuring board while the weight was taken using spring balances to 1 decimal point in grams. Each haplochromine specimen was opened and its sex and the state of gonad maturity determined according to Bagenal & Braum (1978). The stomach was removed, and a subjective determination of its degree of fullness determined as 0, <1/4, 1/4, 1/2, 3/4, or 1, depending on how full the stomach appeared. The stomach was then slit open onto a microscope slide under a binocular dissecting microscope, and its contents sorted using fine mounted needles, and identified. The relative importance of different food items was determined using a point

method 0, 1, 2, 4, 8, and 16 following Hynes (1950) based on percentage contribution estimate by eye.

CHAPTER III

3.0. Relative abundance and distribution of the different fish taxa in the littoral areas of Napoleon Gulf (Lake Victoria)

3.1. Introduction

Before introduction and establishment of the Nile perch *Lates niloticus*, haplochromines were the most abundance group of fishes in Lake Victoria, Kyoga and Nabugabo. They formed at least 83%, by weight of the fish biomass in Lake Victoria up to early 1980s (Kudhongania & Cordone 1974, Okaronon *et al*, 1985). They occupied virtually all trophic levels and played an important role in the flow of organic matter in these ecosystems. Each species had its own unique combination of food and habitat preference (van Oijen 1982, Goldschmidt *et al* 1990). Up to eleven trophic groups were identified in the Mwanza Gulf van Oijen op. cit.). These included; phytoplanktivores, detritivores, algal grazers, plant eaters, molluscivores, parasite eaters, zooplanktivores, insectivores, piscivores, paedophages, and scale eaters. The detritivorous/ phytoplanktivores and the pelagic phytoplanktivores together constituted about 50% of the total haplochromine biomass in the lake (Goldschmidt 1986, Witte & van Oijen 1990).

By 1990, haplochromines comprised less than 2% of the biomass, (Ogutu-Ohwayo, 1990; Witte *et al.*, 1992). During trawl surveys of 1993/95 in the Ugandan offshore waters of Lake Victoria, haplochromines comprised 0.2% of the biomass (Okaronon, 1994). This mass extinction has been attributed to predation by an introduced predator *Lates niloticus* (Nile perch). First introduced into Lake Victoria in 1954, its numbers exploded in the early 1980s and this was accompanied by rapid disappearance of the haplochromine stocks (Witte *et al*, 1992). Although the Nile perch population boom and haplochromine crush correlate in time, it is evident that Nile perch is but one of many causes of the haplochromine decline (Kaufman, 1992).

Decline in haplochromine species was accompanied by drastic changes in biological and physico-chemical conditions especially in Lake Victoria. Algal biomass in Lake Victoria

increased four to five times, phytoplankton production doubled and water transparency decreased (Muggide 1992, 1993). Decay of the excess organic matter has depleted the water column of oxygen leading to development of anoxic conditions in water deeper than 40 m. This has reduced habitable space for many fish species and is thought to have driven deep water haplochromines to shallower areas where they fell easy prey to Nile perch (Hecky, 1993). The disruption and, reduction of the diverse and trophically complex haplochromine community by the Nile perch seems to have initiated changes in food web structure of the lakes e.g by reducing grazing pressure which may have led to accumulation of excess organic matter and some of the changes discussed above (Ogutu-Ohwayo & Hecky, 1991). Algal composition has changed and became now dominated by blue-greens. The blue-greens were the major food source of the detritivorous/planktivorous haplochromines and the pelagic phytoplanktivores. Together these two trophic groups constituted about 50% of the total haplochromine bionass in the lake (Goldscmidt, 1986; Witte and van Oijen, 1990). Their depletion could have reduced grazing pressure, leaving most of the algal biomass produced in the lake unconsumed.

There were differences in the rate of decline within as well as between, trophic groups (Witte *et al*., 1992). Molluscivores, insectivores and epiphytic algal grazers survived in the shallow littoral zone (Witte *et al* op. cit.) The Least affected were the rock frequenting haplochromines particularly the permanent rock dwellers which live between boulders and in rock crevices in which they hide from Nile perch.

Recent assessment of fish stocks of Lake Victoria have concentrated in deep waters of Lake Victoria (Okaranon, 1994) and these suggest that haplochromines and other native species are virtually absent from Lake Victoria. Some studies have, however, shown that some of the endangered species survive near shore areas especially with vegetated and rocky shores. The objective of this study was to examine the composition and relative abundance especially of haplochromine cichlids in the nearshore areas of Lake Victoria.

3.2. Material and methods

Preliminary analysis showed that haplochromines, which were the target group of this study were caught only in nets of 25.4 mm to 76.2 mm mesh. This analysis only involves those sizes of fish retained in the 25.4 mm to 76.2 mm mesh gill nets which are the only nets that retain haplochromines. The actual population structure of the different species retained in those nets was analysed. In the analysis of overall relative abundance and distribution for all fish, haplochromines were lumped together as one taxa. The relative abundance and spatial distribution of fish species at each sampling station was determined by comparing the number and weight of the different fish taxa caught in the three gill net fleets at different positions from the shore. To compare relative abundance and distribution of the different fish taxa between the sites, catch data from the three nets at the different sites were pooled and compared between stations. The current data of overall relative abundance was finally compared with the pre-perch data.

Haplochromine specimen were sorted according to mesh size of the net and the position of the fleet, fixed in 5% formalin. Each sample was labelled with time, date, mesh size, gill net fleet location and site, and taken to the laboratory for further analysis. In the laboratory, the haplochromines were identified to trophic level and where possible, to species level using the key provided by Greenwood (1981). Identification of haplochromines to species level was based on external morphological characters especially proportional measurements, live colours, body markings, and dentition. The above characters and measurements were compared with those of the species already described to determine the species name. Specimen not identified to species level were given acronym names. A descriptive basis of giving these acronyms is given in Appendix 1. The definitions of the proportional measurements were based on Greenwood (1981). Preserved specimen of the haplochromines encountered are deposited in the Fisheries Research Institute (FIRI) museum.

Fish species diversity was estimated using Shannon-Weaver Index of diversity H' (Pielou, 1969). The Diversity Index H' was calculated using the formula:

$$\mathbf{H'} = -\sum_{\mathbf{i=1}}^{\mathbf{s}} \mathbf{p_i} \log_{\mathbf{e}} \mathbf{P_i}$$

where s is the number of species and p_i is the proportion by number, of each taxon in the sample.

3.3. RESULTS

3.3.1. Overall relative abundance and distribution for all species

Overall, twelve fish taxa were recorded from all the five stations. The overall relative importance of the most abundant fish taxa both by number and weight is illustrated in Figure 3.1. Numerically, Nile perch was the most dominant (42.3%) followed by haplochromines (30.7%), *O. niloticus* (12.2%), *T. zillii* (8.9%), *S. afrofischeri* (2.3%), *B. sadleri* (1.9%). Other fish species recorded included *M. kannume*, *O. leucostictus*, *S. victoriae*, *C. gariepinus*, *O. variabilis* and *P. aethiopicus*. When weight is considered Nile perch contributed most (79.9%) followed by haplochromines (7.8%), *O. niloticus* (5.3%), *T. zillii* (3.7%), *S. afrofischeri* (0.9%), *S. victoriae* (0.5%), *B. sadleri* (0.5%), *M. kannume* (0.4%), *O. leucostictus* (0.2%), *P. aethiopicus* (0.2%), *C. gariepinus* (0.2%) and *O. variabilis* (0.1%).

The average number of *L. niloticus*, *Synodontis* spp. and *M. kannume* increased from the 0 m to the 200 m positions, while that of haplochromines, *O. niloticus* and *T. zillii*, *B. sadleri*, *O. leucostictus*, *C. gariepinus* and *P. aethiopicus* decreased from the 0 m to the 200 m positions (Figure 3.2). *O. variabilis* was recorded only from the 0m position. The highest total number of fish was recorded in the 0 m, followed by the 20 m and then the 200 m positions.

Fish species diversity at the different stations based on Shannon Weaver Index of Diversity is illustrated in Figure 3.3. Fish species diversity was lowest at Cliff (0.61), followed by Kirinya (0.74), Kiryowa (1.07), Kikondo (1.1), and Rwamafuta (1.12).

In addition to the various fish taxa recorded, crabs of the species *Potamonatus niloticus* were recorded from all the sampling sites except Kirinya. The highest number of crabs was from Rwamafuta, a site with a rocky shoreline. In general the crabs were most abundant in the inshore fleet. The mean number of crabs recorded from the various sampling sites is shown in Table 3.3.

Dissolved oxygen levels also varied with site as shown in Table 3.4, but were generally lowest at the shoreline increasing outwards into the open water.

3.3.2 Population structure of all the fish taxa

The length frequency distribution for all the fish caught in gill nets of 25.4 mm to 76.2 mm is illustrated in Figure 3.4. Virtually all the fish caught in these were between 6 cm and 30 cm total length with the exception of *P. aethiopicus* whose size ranged from 36 cm to 52 cm total length. The size range of the species was as follows: 7 cm to 32 cm for *L. niloticus*, 6 cm to 31 cm for *O. niloticus*, 7 cm to 18 cm for haplochromines, 7 cm to 22 cm for *T. zillii*, 11 cm to 24 cm for *O. leucostictus*, 11 cm to 21 cm for *O. variabilis*, 8 cm to 20 cm for *B. sadleri*, 9 cm to 19 cm for *S. afrofischeri*, 17 cm to 29 cm for *S. victoriae*, 15 cm to 29 cm for *M. kannume*, 12 cm to 32 cm for *C. gariepinus* and 36 cm to 52 cm for *P. aethiopicus*.

3.3.3. Relative abundance and distribution of all fish taxa within stations

3.3.3.1. Kiryowa

Eleven fish taxa were recorded from Kiryowa. The relative importance of the most abundant fish taxa at Kiryowa both by number and weight is illustrated in Figure 3.5. In terms of numbers, the most abundant species were, in order of importance, haplochromines (44.3%), Nile perch(24.6%), *Oreochromis niloticus* (21.2%), *Tilapia zillii* (6.6%), *Brycinus sadleri* (1.1), *Synodontis afrofischeri* (0.9%), *Oreochromis leucostictus* (0.7%), *Clarias gariepinus* (0.3%), *Mormyrus kannume* (0.2%), *Oreochromis variabilis* (0.1), *Protopterus aethiopicus* (0.04%). When weight is considered, Nile perch contributed most (34.9%) followed by haplochromines (31.7%), *O. niloticus (*19.0%), *T. zillii* (6.3%), *Clarias gariepinus* (3.2), *S. afrofischeri* (1.6%), *O. leucostictus* (1%), *B. sadleri*(0.5), *M. kannume*(0.5%), *P. aethiopicus*(0.5%), and *O. variabilis* (0.2%).

The distribution of the different fish taxa varied from the inshore to offshore (Fig. 3.6.). The average number of haplochromines, *O. niloticus*, *T. zillii* and *B. sadleri* decreased from the 0 m to the 200 m positions, while that of Nile perch and *S. afrofischeri* increased from the 0 m to the 200 m positions. Among the other species encountered, *O. variabilis*, *O. leucostictus* and *C. gariepinus* were most dominant in the 0m position and *M. kannume* occured only in this fleet while *P. aethiopicus* occured mainly in the 20 m position.

3.3.3.2. Cliff

Nine fish taxa were recorded from the Cliff station. The relative importance of the most abundant fish taxa at Cliff both by number and weight is illustrated in Figure 3.7. By number, the order of abundance was Nile perch (64.9%), haplochromines (15.5%), *S. afrofischeri* (12.2%), *T. zillii* (4%), Nile tilapia (1.2%), *M. kannume* (0.7%), *C. gariepinus* (0.4%), *B. sadleri* (0.2%), and *O. leucostictus* (0.1%). When weight is considered, Nile perch contributed most (72.9%) followed by *S. afrofischeri (10.4%),* haplochromines (8.3%), *T. zilli* (4.2%), Nile tilapia (2.1%), *M. kannume* (2.1%), *B. sadleri* (0.2%), *C. gariepinus* (0.2%) and *O. leucostictus*.

As for the Kiryowa station, the average number of Nile perch, haplochromines and *T. zillii* decreased from the 0 m to the 200 m position, while those of *S. afrofischeri* increased from 0 m to the 200 m position (Figure 3.8). The pattern of Nile perch distribution was different from Kiryowa and decreased from inshore to offshore probably due to steep shoreline at the Cliff station. Among the other species encountered *O. leucostictus*, *B. sadleri*, *C. gariepinus* and *O. niloticus* occurred only in 0 m position while *M. kannume* increased from the 0 m to the 200 m position.

3.3.3.3. Kikondo

Twelve fish taxa were recorded from Kikondo. The relative importance of the most abundant fish taxa at Kikondo is illustrated in Figure 3.9. Numerically, the most abundant species were Nile perch (44%) followed by haplochromines (37.9%), *T. zillii* (5.5%), *O. niloticus* (4.9%), *S. afrofischeri* (3.1%), *S. victoriae* (2.4%). Other species encountered in small numbers included *M. kannume* (0.9%), *B. sadleri* (0.6%), *O. variabilis* (0.2%), *O. leucostictus* (0.2%), *C. gariepinus* (0.2%), and *P. aethiopicus.* When weight is considered, Nile perch again contributed most (49.4%), followed by, haplochromines (20%), *O. niloticus* (8.2%), *T. zillii* (7.1%), *S. victoriae* (5.9%), *S. afrofischeri* (4.7%), *M. kannume* (1.2%), *P. aethiopicus* (1.2%), *B. sadleri* (0.6%), *O. leucostictus* (0.3%), *O. variabilis* (0.2%) and *C. gariepinus* (0.1%).

The average number of Nile perch, *S. afrofischeri, S. victoriae* and *M. kannume* were most dominant in the 200 m position decreasing towards the 0 m position, while those of haplochromines were highest in the 0 m position followed by that of 20 m (Figure 3.10). *T. zillii*, *O. niloticus*, *O. variabilis*, *O. leucostictus*, *C. gariepinus*, *P. aethiopicus* and *B. sadleri* occurred only in the 0 m position.

3.3.3.4. Kirinya

Ten fish taxa were recorded from Kirinya. The relative importance of the most abundant fish taxa at Kirinya both by number and weight is illustrated in Figure 3.11. When numbers are considered, the most abundant species were, in order of abundance, Nile

perch (77%), *B. sadleri* (10.5%), haplochromines (8.6%), and *T. zillii* (2.7%). Other species recorded in small numbers included *P. aethiopicus*, *O. niloticus*, *O. leucostictus, S. afrofischeri, M. kannume* and *C. gariepinus*. When weight is considered, Nile perch was the most dominant (82.8%) followed by *B. sadleri* (5.7%), haplochromines (4.3%), *T. zillii* (2.8%), *P. aethiopicus* (2.8%), *O. niloticus* (1.4%), *S. afrofischeri* (1.4%), *O. leucostictus* (0.3%), *C. gariepinus* (0.1%), and *M. kannume* (0.03%).

Distribution of the dominant fish taxa from Kirinya is illustrated in Figure 3.12. The average number of Nile perch increased from the 0 m to the 200 m positions while that of haplochromines, *T. zillii, B. sadleri*, *O. niloticus,* and *P. aethiopicus* decreased from the 0 m to the 200 m positions. *O. leucostictus* and *C. gariepinus* occurred only in the 0 m position while *S. afrofischeri*, and *M. kannume* occurred only in the 200 m position.

3.3.3.5. Rwamafuta

Twelve fish taxa were recorded from Rwamafuta. The relative importance of the most dominant fish taxa at Rwamafuta both by number and weight is illustrated in Figure 3.13. When numbers are considered, *L. niloticus* contributed most (45.9%), followed by *T. zillii* (21%), haplochromines (18.3%), *O. niloticus* (10.9%), *S. afrofischeri* (2.3%). The species recorded in minor quantities included *M. kannume*, *C. gariepinus, B. sadleri, O. leucostictus, S. victoriae, O. variabilis*, and *P. aethiopicus*. When weight is considered, *L. niloticus* dominated the catch (48.3%) followed by *T. zillii* (19.2%), *O. niloticus* (17.5), haplochromines (9.2%), *M. kannume* (1.7%), *S. afrofischeri* (1.7%), *O. leucostictus* (0.3%), *S. victoriae* (0.3%), *P. aethiopicus* (0.2%), *C. gariepinus* (0.1%), *O. variabilis* (0.1%), and *B. sadleri* (0.02%).

The average number of haplochromines, *T. zillii*, and *O. niloticus* decreased from the 0 m to the 200 m positions while those of *L. niloticus* were highest in the 20 m position followed by the 0 m position (Figure 3.14). The average number of *M. kannume*, *S. afrofischeri* and *S. victoriae* increased from 0 m to the 200 m positions. *O. variabilis, O. leucostictus, C. gariepinus*, and *P. aethiopicus* occurred only in the 0 m position.

3.4. Comparison between stations

Comparison of the most abundant fish taxa between stations is illustrated in Figure 3.15. *L. niloticus*, haplochromines, *O. niloticus*, and *T. zillii* were recorded from all the five stations. The mean number of *L. niloticus* was highest in Rwamafuta followed by Kiryowa, Kirinya, Kikondo, and lastly, Cliff**.** Haplochromines were most abundant in Kiryowa followed by Kikondo, Rwamafuta, Kirinya and Cliff. *O. niloticus* was most abundant in Kiryowa followed by Rwamafuta, Kikondo, Cliff and Kirinya. The highest number of *T. zillii* was recorded from Rwamafuta followed by Kiryowa, Kikondo, Kirinya and Cliff.
S. afrofischeri was most abundant in Cliff followed by Rwamafuta, Kikondo, Kiryowa and Kirinya. *B. sadleri* occurred mostly in Kirinya followed by Kiryowa, Kikondo, Rwamafuta and Cliff.

3.5. Overall relative abundance and distribution of haplochromines

Overall, twenty two haplochromine species were recorded from all the five stations (Table 3.15) and these included *Astatoreochromis alluaudi*, *Paralabidochromis "goldchest"*, *Astotilapia sp.*, *Astatotilapia "bicuspid"*, *Astotilapia nubila*, *Astatotilapia "unicuspid"*, *Neochromis nigricans*, *Neochromis pseudonigricans*, *Neochromis "scraperteeth"*, *Paralabidochromis "big eye"*, *Paralabidochromis "blue deep-body"*, *Paralabidochromis chilotes*, *Paralabidochromis crassilabris*, *Paralabidochromis "curved head"*, *Parabidochromis "rockcribensis"*, *Paralabidochromis "sharpteeth"*, *Paralabidochromis "shortsnout"*, *Paralabidochromis "velvetblack"*, *Paralabidochromis "yellowbars"*, *Paralabidochromis "yellowbody"*, *Ptyochromis xenognathus*, *Harpagochromis guiarti* and *Prognathochromis paraguiarti*.

The overall relative abundance of the most abundant haplochromine species both by number and weight is illustrated in Figure 3.16. When numbers are considered, *A. alluaudi* was the most dominant (17.9%) followed by *A. "unicuspid"* (14.8%), *P. paraguiarti* (12.7%), *P. "yellowbody"* (10.6%), *P. "goldchest"* (9.8%), *H. guiarti* (7.5%), *A. nubila* (6.5%), *A. "bicuspid"* (4.2%), *N. "scraperteeth"* (3.2%), *N. nigricans* (2.8%), *P. crassilabris* (1.6%), *P. "velvetblack"* (1.6%), *P. "yellowbar"* (1.3%), *N. pseudonigricans*(1.2%), *P. rockcribensis* (0.9%), *Astatotilapia sp*. (0.8%), *P. "shortsnout"* (0.7%), *P. "blue deep-body"* (0.6%), *P. xenognathus* (0.5%), *P. "sharpteeth"* (0.4%), *P. "bigeye"* (0.4%), *P. chilotes* (0.2%), and *P. "curved head"* (0.2%), By weight, the most dominant species was *A. alluaudi* (20.9%) followed by *P. paraguiarti* (16.5%), *P. "goldchest"* (12.7%), *H. guiarti* (11.8%), *P. "yellowbody"* (9.6%), *A. nubila* (6.4%), *A. "unicuspid"* (5.4%), *A. "bicuspid"* (3.0%), *N.nigricans* (1.9%), *N. "scraperteeth"* (1.8%), *P. crassilabris* (1.8%), *P. "velvetblack"* (1.4%), *P. "yellowbars"* (1.3%), *N. pseudonigricans* (0.9%), *P. rockcribensis* (0.9%), *Astatotilapia sp*. (0.6%), *P. "bigeye"* (0.5%), *P. xenognathus* (0.4%), *P. chilotes* (0.3%), *P. "curved head"* (0.3%), *P. "sharpteeth"* (0.3%), and *P. "shortsnout"* (0.3%).

Distribution of the different haplochromine species varied with distance from the shoreline (Figure 3.17). *P. chilotes*, *P. "bigeye"*, and *P. "curved head"* occurred only at the 0 m

position while *Astatotilapia sp*. occurred only in the 200 m position. The average number of *A. "unicuspid"* increased from the 0 m tothe 200 m positions, while that of the remaining species decreased from the 0 m to the 200 m position. Haplochromine species diversity at the different stations based on Shannon Weaver Index of Diversity is illustrated in Figure 3.18. Haplochromine species diversity was lowest at Cliff (0.52),followed by Kirinya (0.54), Rwamafuta (0.72), Kikondo (1.12), and Kiryowa (1.52).

3.6. Population structure of haplochromines

The length frequency distribution of the most dominant haplochromine species is illustrated in Figure 3.19. Virtually all the haplochromine cichlids caught were between 6 cm and 19 cm total length. The size range of the different species was as follows: 8 cm to 15 cm for *A. alluaudi*, 8 cm to 19 cm for *P. paraguiarti*, 6 cm to 12 cm for *A. "unicuspid"*,7 cm to 15 cm for *P. "yellowbody"*, 8 cm to 16 cm for *P. "goldchest"*, 9 cm to 18 cm for *H. guiarti*, 8 cm to 16 cm for *A. nubila*, 7 cm to 12 cm for *A. "bicuspid"*, 8 cm to 16 cm for *N. nigricans*, 7 cm to 15 cm for *N. "scraperteeth"*, 8 cm to 15 cm for *P. "velvetblack"* and 8 cm to 17 cm for *P. crassilabris*.

3.7. Relative abundance and distribution of haplochromines within stations.

3.7.1. Kiryowa

Twenty haplochromine species were recorded from Kiryowa. The relative importance of the most abundant haplochromine species from Kiryowa both by number and weight is illustrated in Figure 3.20. When numbers are considered, the most abundant species were, in order of importance, *A. alluaudi* (37%), *P. "goldchest"* (13.8%), *H. guiarti* (10.3%), *A. nubila* (9.2%), *P. paraguiarti* (9.2%), *A. "unicuspid*" (4.5%), *A. "bicuspid* "(4.4%), *P. "velvetblack"* (1.8%), *Astatotilapia sp.* (1.7%), *P. crassilabris* (1.6%), *N. "scraperteeth"* (1.6%), *P. "blue deep-body"* (1%), *P. "yellowbars*" (1%), *P. "sharpteeth"* (1%), *P. "bigeye"* (0.8%), *P. chilotes* (0.3%), *P. "rockcribensis"* (0.3%), *P. "shortsnout"* (0.2%), *N. nigricans* (0.1%) and *P. xenognathus (0.1%).* When weight is considered *A. alluaudi*

contributed most (37.2%) followed by *P. "goldchest"* (16.2%), *H. guiarti* (14.6%), *P. paraguiarti* (9.1%), *A. nubila* (8.3%), *A. "bicuspid"* (3.4%), *P. crassilabris* (1.7%), *P. "blue deep-body"* (1.5%), *A. "unicuspid"* (1.4%), *Astatotilapia sp*. (1.1%), *P. "bigeye"* (0.9%), *N. "scraperteeth"* (0.9%), *P. "velvetblack"* (0.8%), *P. "sharpteeth"* (0.6%), *P. chilotes* (0.4%), *P. "shortsnout"* (0.3%), *P. rockcribensis* (0.2%), *P." yellowbars"* (0.2%), *P. xenognathus* (0.1%), and *N. nigricans* (0.03%).

The distribution of the different haplochromine species varied from inshore to offshore (Figure 3.21). The average number of *A. alluaudi, P. "goldchest", H. guiarti, P. paraguiarti,* and *A. nubila* decreased from the 0 m to the 200 m positions while that of *A. "unicuspid"* increased from the 0 m to the 200 m positions. *P. xenognathus* and *N. nigricans* occurred only in the 20 m position, while *P. "velvetblack"* and *P. chilotes* occured only in the 0 m position.

3.7.2. Cliff

Eight haplochromine species were recorded from Cliff. The relative importance of the most abundant haplochromine species at Cliff both by number and weight is illustrated in Figure 3.22. By number, the order of abundance was *P. paraguiarti* (38.2%), *A. "unicuspid"* (21.5%), *P. "goldchest"* (15.3%), *N. "scraperteeth"* (8.3%), *P. "yellowbars"* (5.5%), *H. guiarti* (4.9%), *A. "bicuspid"* (2.1%), *P. rockcribensis* (1.4%), *N. nigricans* (1.4%), *A. nubila* (0.7%) and *P. xenognathus (0.7%).* When weight is considered *P. prognathochromis (51.4%)* was the most dominant followed by *P. "goldchest"* (19.9%), *P. "yellowbars"* (7.9%), *A. "unicuspid"* (6.9%), *H. guiarti* (5.2%), *N. "scraperteeth"* (4.3%), *A. nubila* (1.1%), *P. xenognathus* (1.0%), *N. nigricans* (0.8%), *A. "bicuspid"* (0.7%) and *P. "rockcribensis"* (0.6%).

Distribution of the different haplochromine species varied from inshore to offshore (Figure 3.23). The average number of *P. "goldchest"* decreased from the 0 m to the 200 m positions, while that of *A. "unicuspid"* was equal at all the three positions. *P. "rockcribensis"* occurred at the 0 m and 20 m positions. The remaining haplochromine species occurred only in the 0 m position.

3.7.3. Kikondo

Seventeen haplochromine species were recorded from Kikondo. The relative importance of the most abundant species at Kikondo both by number and weight is illustrated in Figure 3.24. When numbers are considered, the most abundant species were *A."unicuspid"* (47.3%), *P. paraguiarti* (25.4%), *N. "scraperteeth"* (8.4%), *H. guiarti* (6.2%), *A. bicuspid"* (2.6%), *P. xenognathus* (1.9%) *P. "goldchest"* (1.5%), *P. crassilabris* (1.1%), *P. "yellowbars"* (1.1%), *A. alluaudi* (0.9%), *N. pseudonigricans* (0.7%), *P. "curved head"* (0.7%), *A. nubila* (0.6%), *P. "blue deep-body"* (0.4%), *N. nigricans* (0.4%) and *P. "velvetblack"* (0.2%). When weight is considered, *P. paraguiarti* contributed most (42.8%) followed by *A. "unicuspid"* (21.7%), *H. guiarti* (12.4%), *N. "scraperteeth"* (5.0%), *P."goldchest"* (2.5%), *P. crassilabris* (2.5%), *A. "bicuspid"* (2.2%), *P. "yellowbars"*, *P. xenognathus* (1.7%), *P. "curved head"* (1.4%), *N. nigricans* (1.2%), *A. alluaudi* (1.2%), *P. "blue deep-body"* (1.0%), *A. nubila* (1.0%), *N. pseudonigricans* (0.8%) and *P. "velvetblack"* (0.4%).

The distribution of the different haplochromine species varied from inshore to offshore (Figure 3.25). The average number of *P. paraguiarti* and *N. "scraperteeth"* decreased from the 0 m to the 200 m positions while that of *A. "unicuspid"* increased from the 0 m to the 200 m positions. The remaining species occurred only in the 0 m position

3.7.4. Kirinya

Seven haplochromine species were recorded from Kirinya. The relative importance of the most abundant haplochromine species at Kirinya both by number and weight is illustrated in Figure 3.26. When numbers are considered the most abundant species were, in order of abundance, *A. nubila* (35.2%), *P. "goldchest"* (21.1%), *H. guiarti* (17.2%), *A. "bucuspid"* (7.0%), *A. "unicuspid"* (6.2%), *P. "yellowbars"* (4.7%), *A. alluaudi* (4.7%), *P. paraguiarti* (2.3%), *P. chilotes* (0.8%), *P. rockcribensis* (0.8%). When weight is considered, *A. nubila* contributed most (30.1%) followed by *H. guiarti* (22.1%), *P. "goldchest"* (18.9%), *A. alluaudi* (8.1%), *P. "yellowbars"* (6.7%), *A. "bicuspid"* (4.8%), *P. paraguiarti* (4.3%), *A. "unicuspid"* (2.6%), *P. "rockcribensis"* (1.6%) and *P. chilotes* (0.7%).

Distribution of the different haplochromine species varied from inshore to offshore (Figure 3.27). The average number of *A. nubila*, *P. "goldchest"*, *H. guiarti*, and *A. "unicuspid"* decreased from the 0 m to the 200 m positions. *A. "bicuspid"*, *A. alluaudi*, and *P. chilotes* occurred only in the 0 m position. *P. "yellowbars"* and *P. paraguiarti* occurred in the 0 m and 200 m positions while *P. "rockcribensis"* occrred only in the 20 m position.

3.7.5. Rwamafuta

Fifteen haplochromine species were recorded from Rwamafuta. The relative importance of the most dominant haplochromine species at Rwamafuta both by number and weight is illustrated in Figure 3.28. Numerically, *P. "yellowbody"* (57.6%) contributed most followed by *N. nigricans* (13.9%), *N. pseudonigricans* (5.8%), *A. "bicuspid"* (5.8%), *P. "goldchest"* (4.7%), *P. "velvetblack"* (3.7%), *P. crassilabris* (3.0%), *P. rockcribensis* (2.6%), *A. "unicuspid"* (0.7%), *P. "shortsnout"* (0.7%), *A. alluaudi* (0.2%), *P. paraguiarti* (0.5%), *A. nubila* (0.2%), *N. "scraperteeth"* (0.2%), and *P. guiarti* (0.2%). When weight is considered *P. "yellowbody"* was the most dominant (61.7%) followed by *N. nigricans* (10.3%), *P. "goldchest"* (5.6%), *N. pseudonigricans* (4.7%), *P. rockcribensis* (3.8%), *P. crassilabris* (2.8%), *A."bicuspid"* (2.7%), *P. "velvetblack"* (0.7%), *P. paraguiarti* (0.7%), *A. alluaudi* (0.4%), *H. guiarti* (0.3%), *A. "unicuspid"* (0.3%), *N. "scraperteeth"* (0.2%), and *A. nubila* (0.2%).

Distribution of the different species varied from inshore to offshore (Figure 3.29). The average number of *P."yellowbody"*, *N. nigricans*, *P. "velvetblack"* and *P. crassilabris* decreased from the 0 m to the 200 m position while that of *P. rockcribensis* increased from the 0 m to the 200 m positions. *N. pseudonigricans*, *A. "bicuspid"*, *N. "scraperteeth"*, and *A. nubila* occurred only at the 0 m position.

3.8. DISCUSSION

Comparison of current relative abundance with historical data is illustrated in Figure 3.30. In the present study, twelve fish taxa were recorded. When numbers are considered, *L. niloticus* contributed most followed by haplochromines, *O. niloticus, T. zillii, S. afrofischeri, B. sadleri, M. kannume, O. leucostictus, S. victoriae, C. gariepinus, O. variabilis,* and *P. aethiopicus*. When only native fish taxa are considered, the most abundant was haplochromines followed by *S. afrofischeri, B. sadleri, M. kannume, S. victoriae, C. gariepinus, O. variabilis* and *P. aethiopicus*. *O. variabilis* was the only native tilapine recorded.

In gill net surveys carried out in the Napoleon Gulf by EAFFRO in 1956/57, before introduction of exotic species, twelve fish taxa were recorded (Figure 3.30). The most dominant taxa, numerically, by then was haplochromine cichlids (48%) followed by *M. kannume* (22.5%), *B. docmac (8.7%), Tilapia spp*. (7.4%), *Labeo victorianus (5.2%), C. mossambicus* (1.9%), *Gnathonemus spp*.(1.8%), *Alestes spp.* (1.4%), *P. aethiopicus* (1.2%), *B. altianalis* (1%), *Mormyrus macrocephalus* (0.6%) and *Marcusenius spp.* (0.3%). The tilapiines included *O. variabilis* and *O. esculentus.* Haplochromines and *M.kannume* were caught at every station while *L. victorianus* and *C. mossambicus* occured at a few stations. In the present study, numbers of haplochromines, *O. niloticus, O. variabilis, O. leucosticus, O. esculentus, T. zillii, B. jacksoni, C. gariepinus,* and *P. aethiopicus* were most abundant in the inshore fleet decreasing outwards towards the open water whereas that of *L. niloticus*, and *Synodontis spp,* were highest in the 200m offshore fleet decreasing towards the shoreline. Fish species diversity decreased with increasing distance from the shoreline, which at all the sites sampled, was fringed with aquatic macrophytes. Rwamafuta and Kikondo sites, both of which are characterised by rocky shorelines, had a high species diversity also in the middle fleets. Among the haplochromine cichlids, most species were most abundant in the 0 m position decreasing outwards into the 200 m position except A. "unicuspids" which increased from 0 m position to the 200 m position. Some species showed preference for particular habitats. Among such species were *N. nigricans,* and *N. pseudonigricans* which occured mostly at Rwamafuta and Kikondo both stations of which have rocky habitats. *P. "yellowbody"* was recorded only from

Rwamafuta. *Astatotilapia* sp. *P. "sharp teeth"* and *P. "curved head"* occured only at Kiryowa. The rest of the species were recorded from several stations but in varying quantities.

Studies carried out before the introduction of Nile perch, showed that the majority of Lake Victoria fishes lived in shallow inshore waters and that species had definite habitat prefernces so that their relative abundance differed according to the habitat type (Beauchamp, 1956). Greenwood (1974) noted that representatives of all trophic catagories could occur in several habitats although the algal grazers and the species feeding on higher plants were restricted to habitats or parts of habitats where there are rooted plants or, in the case of the grazers (e.g *N. nigricans*), suitable substrata for algal growth. It was also noted that some species may move between habitats, or from one type of substrate to another. In Lake Victoria it seems probable that some species will at times utilise this ability to shift habitats at least as a measure to avoid adverse conditions (Fryer & Iles, 1972). In the 1989-1992 survey it was also found that marginal swamps and rocky reefs were important refugia for indigenous species in Lake Victoria (Kaufman & Ochumba, 1993). It was noted in the Mwanza Gulf of Lake Victoria (Witte *et al*., 1992) that in a few habitats within the lake the original communities of fish species seem less affected, e.g the rock-dwelling haplochromines. Ogutu-Ohwayo (1993) noted that many surviving species, especially haplochromines, in Lake Nabugabo were confined to macrophytes along the lake margin.

Inshore areas with aquatic macrophytes may serve as both structural and in some cases low-oxygen refugia for prey species from Nile perch. Nile perch is very sensitive to low-oxygen conditions which may limit their interaction with prey species in hypoxic habitats (Fish 1956). Schofield and Chapman (unpublished data) found several lines of evidence that Nile perch are relatively intolerant of low-oxygen conditions including high threshlolds for aquatic surface respiration relative to other indigenous fishes of the Lake Victoria basin, a faster time to loss of equilibrium in hypoxic conditions than other species from the region, and a high critical oxygen tension. In addition, during fish kills on Lake Victoria, Nile perch exhibit higher mortality than many indigenous species. It was also observed during fish kills on Lake Victoria that Nile perch are more sensitive to low levels of dissolved oxygen, more so than many cichlids, thus prey species could exploit hypoxic habitats as refugia from Nile perch.

Chapman et al (1995) demonstrated that some of the cichlids from Lake Victoria can tolerate extremely low levels of oxygen which may permit these fishes to use structural inshore habitats as refugia. In the present study dissolved oxygen levels, at all the sites, were lowest along the shoreline increasing outwards into the open water.

Recent studies had indicated that haplochromine cichlids and other native species had been depleted from Lake Victoria. This study has shown that some native species have survived in the nearshore areas of the lake especialy areas with macrophytes. Ogutu-Ohwayo (1994) has reported resurgence of native species, especially haplochromines in Lake Kyoga following reduction of Nile perch stocks due to overfishing and enhancement of macrophyte refugia due to the spread of Water hyacinth. Similar changes may take place in Lake Victoria especially as Nile perch is subjected to heavy fishing pressure due to the ready market provided by the fish processing plants.

3.10. CONCLUSION AND RECOMMENDATIONS

Comparison of the fish catches recorded before introduction of Nile perch with those after its introduction and establishment indicates that relative abundance of the various fish taxa in Lake Victoria has changed. A fishery once dominated by cichlids (tilapiines and haplochromines) is now dominated by the introduced predator, *Lates niloticus*, and some native species have either disappeared or are extinct.

The results also indicate that the distribution of the surviving native species in Lake Victoria has not changed from what it was before the introduction of exotic species into the lake. The surviving native species occur mostly in inshore areas with macrophyte cover and in areas with rocky habitats. Their persistance with Nile perch may relate to their use of structural inshore areas which may serve as refugia for prey species from Nile perch.

In view of the above observations, protection of macrophyte refugia and rocky outcrops would be valuable in conservation of endangered fish species in Lake Victoria.

CHAPTER IV

4.0. Food of the dominant surviving haplochromine cichlids from the nearshore areas of Napoleon Gulf (Lake Victoria).

4.1. Introduction

The establishment of the introduced species in Lakes Victoria and Kyoga was accompanied by a decline of most, and perhaps total disappearance of some, of the native fish species (Ogutu-Ohwayo, 1994). Though the initial decline was due to overfishing (Jackson, 1971), predation by Nile perch and competition with introduced tilapias contributed to the depletion of the native fish stocks. Haplochromines were originally the most abundant fishes in both lakes and formed at least 80% by weight of the demersal stocks of Lake Victoria (Kudhongania & Cordone,1974; Okaronon *et al.*,1985). Lake Victoria had more than 300 haplochromine species, more than 99% of them endemic (van Oijen *et al*, 1984; Witte *et al*., 1992). Each species had its own unique combination of food and habitat preference (van Oijen, 1982; Goldschmidt *et al*., 1990). Up to eleven trophic groups were identified in the Mwanza Gulf. These included phytoplanktivores, detritivores, algal grazers, plant eaters, molluscivores, zooplanktivores, insectivores, piscivores, parasite eaters, paedophages and scale eaters. Greenwood (1974) had earlier identified up to five trophic groups of haplochromines in the Napoleon Gulf. These included insectivores, piscivores, molluscivores, plant material eaters and scale eaters.

Haplochromines disappeared rapidly following establishment of Nile perch, in Lake Victoria. There were differences in the rate of decline, within as well as between, trophic groups (Witte *et al*., 1992). Molluscivores, insectivores and epiphytic algal grazers survived in the shallow littoral zone. (Witte *et al*., 1992).

The reduction in stocks of the diverse and trophically complex haplochromine community was concurrent with changes in the physical, chemical and biological processes in Lake Victoria. Algal biomass increased four to five times, phytoplankton production doubled and water transparency decreased (Mugidde, 1992; 1993). Algal composition changed and

became dominated by blue-greens. The blue-green algae were the major food source of the detritivorous\phytoplanktivorous haplochromines and the pelagic phytoplanktivores. Together these two trophic groups constituted about 50% of the total haplochromine biomass in the lake (Goldschmidt, 1986; Witte & van Oijen, 1990). Their depletion must have contributed to a reduction in grazing pressure which left much of the primary production in the lake unconsumed. Decay of this organic matter has depleted the water column of oxygen leading to anoxia in waters of more than 40 m depth during periods of stratification.

In this chapter, the food and feeding habits of the surviving haplochromines was examined to assess whether the diet of the different trophic groups had changed and what role the haplochromine species still surviving in the lake are playing in the overall trophic ecology of the lake.

4.2. Material and Methods

Samples of haplochromine specimen were obtained from the study as detailed in Chapter II. In the laboratory, the haplochromines were identified to genus level and where possible, to species level using the key provided by Greenwood (1981). The morphometric measurements used in identifying the haplochromines to species level were defined in Chapter III. Biometric data on individual specimens were then recorded. In each case, the total length, standard length and weight of individual specimen were measured. Each fish was cut open and the sex and gonad maturity state determined according to Bagenal and Braum (1978). The stomach of each fish was dissected out and its degree of fullness determined, whether empty (0), <$\frac{1}{4}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ or full (1). The stomach was slit open on to a microscope slide under a low-power binocular microscope, flooded with water and examined. A high-powered compound microscope was also used when necessary. Each food item was identified as far as possible. By using fine mounted needles, different prey items identified were sorted out and assigned percentage contribution by eye estimate. The percentages were then converted into points; 0,1,2,4,8,and 16

depending upon the relative importance of the food item in the stomach, using a method based from Hynes (1950). The trophic group of a species was determined by the most dominant food item in its diet.

4.3. Results

4.3.1. General composition of diet

The relative importance of the haplochromines encountered were in order of importance by number *A. alluaudi*, *A. "unicuspid"*, *P. "paraguiarti"*, *P. "yellowbody"*, *P. "goldchest"*, *H. guiarti*, *A. nubila*, *A. "bicuspid"*, *N. "scraperteeth"*, *N. nigricans*, *P. crassilabris*, *P. "velvetblack"*, *P. "yellowbar"*, *N. pseudonigricans*, *P. "rockcribensis"*, *Astatotilapia sp.*, *P. "shortsnout"*, *P. "blue deepbody"*, *P. xenognathus*, *P. "sharpteeth"*, *P. "bigeye"*, *P. chilotes*, and *P. "curved head"*. Of the 24 species, there were adequate samples to examine food for only 17 species. These included, *A. alluaudi*, *A. "unicuspid"*, *P. paraguiarti*, *P. "yellowbody"*, *P. "goldchest"*, *H. guiarti*, *A. nubila*, *A. "bicuspid"*, *N. "scraperteeth"*, *N. nigricans*, *P. crassilabris*, *P. "velvetblack"*, *P. "yellowbars"*, *N. psuedonigricans*, *P. rockcribensis"*, *P. xenognathus*, and *P. chilotes*.

Seventeen haplochromine species were examined for food analysis as detailed below and Figure 4.1. The names that appear in quotes are acronym names. This analysis included haplochromines of 6 cm to 19 cm. The food of small fishes less than 5 cm standard length were not included in this because it was very difficult to identify fishes of this size. No historic data is available on the food of many of the haplochromines examined in this study except for *A. alluaudi*, *P. paraguiarti*, *H. guiarti*, *A. nubila*, *N. nigricans*, *P. xenognathus*, and *P. chilotes.*

Eight food catagories were recorded from the haplochromine stomachs examined in the present study (Figure 4.2). These included in order of importance, insects (69.2%), molluscs (8.9%), plant material (6.9%), *C. nilotica* (6%), fish (5.2%), leaches (2.2%), detritus (1.4%) and zooplankton (0.4%). Insects, especially larval and pupal chironomids, Ephemeroptera and Odonata were the most important food category. Besides species feeding principally on insects, many others included some insect material in their diet. Two species, *A. alluaudi* and

P. xenognathus had mollusc remains as the dominant food item. *A. alluaudi* had both the crushed shells and the mollusc flesh together in the

stomach while *P. xenognathus* had only the mollusc flesh in its guts. *A. alluaudi* crushes the prey in the pharyngeal mill while the later wrenches the snail from its shell. Two species, *P. "rockcribensis"* and *P. "yellowbar"* fed predominantly on the prawn *C. nilotica*.

Ostracods, *C. nilotica*, phytoplankton and to a lesser extent, detritus contributed to the diet of several haplochromines which belonged to the insectivore and molluscivore trophic groups. Fish remains occured in seven species which otherwise had insect remains as the most dominant food item in their guts. Four species included leaches in their predominantly insectivorous diet. The food of individual haplochromines is discussed in the sections that follow.

4.3.2. Specific feeding habits

4.3.2.1. Astatoreochromis alluaudi

One hundred forty three specimen of *A. alluaudi* of 68-147 mm standard length (SL) were examined and sixty one of them contained ingested material. The food items found included gastrospods (82%), Odonata nymphs (9.1%), high plant material (3.4%), *C. nilotica* (1.7%), detritus (1.5%), filamentous green algae (0.9%), chironomid larvae (0.8%), chironomid pupae (0.2%), ephemeropteran nymphs (0.2%), ostracods (0.2%) and bivalve molluscs (0.1%). One specimen (105mm SL) contained high plant material, detritus and filamentous green algae. Fifteen specimen contained only gastropod molluscs while the rest had a mixture of gastropod molluscs, ostracods and insect remains but in all cases gastropod molluscs dominated in quantity.

4.3.2.2. Astatotilapia "unicuspid"

One hundred seventy eight specimen of *A. "unicuspids"* of 53-102 mm SL, were examined. Of these forty six had food in their stomachs. The food items included, in order of abundance, chaoborid larvae (32.1%), ephemeropteran nymphs (14.6%), *C. nilotica* (12.7%), leaches (12.2%), chironomid larvae (11.6%), Odonata nymph (7.6%), chironomid pupae (4.6%), filamentous green algae (1.7%), ostracods (0.9%), detritus (0.8%), chaoborid pupae (0.5%) and high plant material (0.4%). One stomach contained two leaches. Three specimen

contained *C. nilotica*, chironomid larvae and Odonata nymph, one contained only chironomid larvae and another three had only ephemeropteran nymphs. The remaining specimen contained a mixture of chironomid larvae and ephemeropteran nymph.

4.3.2.3. Prognathochromis paraguiarti

Three hundred fifteen specimen of *P. paraguiarti* of 64-139 mm SL were examined out of which seventy one contained ingested material. The materials found in the stomachs included, in order of importance chironomid larvae (49.2%), chironomid pupae (15.7%), Odonata nymphs (15.6%), ephemeropteran nymphs (6.9%), fish embryo remains (3.3%), *C. nilotica* (3.1%), bivalves (1.8%), trichopteran nymphs (1.5%), high plant material (1.1%), filamentous green algae (1.1%), ostracods (0.5%) and chaoborid pupae (0.1%). Four stomachs contained fish embryo, two contained a mixture of bivalves and chironomid larve, three contained high plant material in addition to various larval insect remains. One stomach contained filamentous green algae and two contained *C. nilotica*. The rest contained a mixture of larval insect remains and ostracods.

4.3.2.4. Paralabidochromis "yellowbody"

This species was only recorded from Rwamafuta.Two hundred forty five specimen of *P. "yellowbody"* of 60-124 mm SL were examined out of which eighteen contained ingested material. The food items found in the stomach included, in order of abundance, chironomid larvae (39.5%), Odonata nymphs (21.6%), ephemeropteran nymphs (18.2%), leaches (8.3%), trichopteran nymphs (6.1%), chironomid pupae (2%), high plant material (1.5%), *C. nilotica* (1%), ostracods (0.9%), and detritus (0.7%). Seven specimen contained only chironomid larvae, one contained *C. nilotica*, one contained detritus and the rest contained a mixture of chironomid larvae, high plant material and ostracods.

4.3.2.5. Paralabidochromis "goldchest"

Two hundred thirty three specimen of *P. "goldchest"* of 62-128 mm SL examined were examined eighty four had ingested material in the stomachs. The items ingested included

Odonata nymphs (50.1%), high plant material (17.8%), filamentous green algae (9.9%), chironomid pupae (5.3%), ephemeropteran nymphs (5.2%), fish (embryo) remains (4.9%), chironomid larvae (3.2%), detritus (1.8%), *C. nilotica* (0.8%), gastropods (0.6%) and ostracods (0.2%). The three stomachs containing fish remains were of breeding females and could have been their own young. Seventeen stomachs contained only Odonata nymphs, one contained only *C. nilotica*, one contained a mixture of Odonata nymphs and chironomid larvae, two contained a mixture of filamentous green algae, high plant material and Ephemeroptera nymphs occurred in one of them.

4.3.2.6. Harpagochromis guiarti

One hundred seventy six specimen of *H. guiarti* of SL 70-152 mm were examined, sixty six had food in the stomachs. The material found in the stomachs included Odonata nymphs (69.3%), fish remains (20.2%), chironomid larvae(5.2%), *C. nilotica* (1.7%), Ephemeroptera nymphs (1.5%), high plant material (0.6%), trichopteran nymphs (0.4%), chironomid pupae (0.3%), bivalves (0.2%), ostracods (0.2%) and filamentous green algae (0.2%). Six specimen contained fish remains and some larval insect remains. Twenty one specimens contained only Odonata nymphs while the rest contained a mixture of Odonata nymphs, chironomid larvae, high plant material, bivalves and a few ostracods.

4.3.2.7. Astatotilapia nubila

One hundred sixty specimen of *A. nubila* of 65-129 mm SL were examined out of which sixty one contained ingested material. The food items found included, in order of abundance, Odonata nymphs (64.4%), ephemeropteran nymphs (15.2%), *C. niloticus* (5.6%), chironomid pupae (4.1%), chironomid larvae (3.9%), leach (2.8%), chaoborid larvae(1.4%), filamentous green algae (0.9%), detritus (0.9%) and high plant material (0.6%). One stomach contained a leach.

4.3.2.8. Astatotilapia "bicuspid"

Eighty seven specimen of *A. "bicuspid"* of 61-99 mm SL were examined out of which 18 contained food in the stomach. The food items encountered included *C. nilotica* (27.7%), fish remains (18.5%), Odonata nymphs (17.7%), ephemeropteran nymphs (15.3%),chironomid larvae (12.3%), high plant material (aquatic weeds) (7.3%) and chironomid pupae (1.2%).

4.3.2.9. Neochromis "scraperteeth"

Seventy six specimen of *N. "scraperteeth"* of 60-127 mm SL were examined and twenty one of them contained food. Two contained a mixture of filamentous green algae and high plant material, while one contained a mixture of insect (Odonata) remains and filamentous algae. In general, in order of their abundance, the food material encountered in the stomachs included Odonata nymphs (46.3%), ephemeropteran nymphs (15.4%), chironomid larvae (10.1%), high plant material (6.6%), filamentous green algae (5.7%), trichopteran nymphs (3.8%), *C. niloticus* (4.2%), bivalve (4.2%), chironomid pupae (2.5%), chaoborid larvae (1.1%), and ostracods (0.1%).

4.3.2.10.Neochromis nigricans

Seventy nine specimen of *N. nigricans* examined of 61-133 mm SL were examined and twenty five contained ingested material in their stomachs. The dominant food items were chironomid larvae (31.4%), Odonata nymphs (16.9%), chironomid pupae (12.3%), leach (10.9%), filamentous green algae (9.3%), ephemeropteran nymphs (6.5%), trichopteran nymphs (3.7%), high plant material (3.2%), ostracods (2.7%), *C. nilotica* (2.2%) and detritus (0.8%). Most stomachs contained a combination of high plant material, chironomid larvae and chironomid pupae. One specimen contained ostracods in addition to high plant material. Ephemeropteran nymphs occurred in only one specimen.

4.3.2.11. Paralabidochromis crassilabris

Thirty eighty specimen of *P. crassilabris* of 63-138 mm SL were examined and ten of them contained food. The food items included chironomid larvae (55.1%), ephemeropteran

nymphs (38%), Odonata nymphs (4.4%), chironomid pupae (1.5%) and ostracods (0.9%). Five stomachs contained only chironomid larvae and ephemeropteran nymphs. Two had odonata nymphs, one had chironomid pupae and one contained ostracods in addition to chironomid larvae and ephemeropteram nymphs.

4.3.2.12. Paralabidochromis "velvetblack"

Thirty eight specimen of P. "velvetblack" of 70-123 mm SL were examined out of which 21 had food. The food items encountered included Odonata nymphs (39.4%), *C. nilotica* (30.2%), fish remains (11.6%), detritus (9.3%), chironomid larvae (5.2%), gastropods (2.3%), chironomid pupae (1.2%), high plant material (0.5%) and ephemeropteran nymph (0.2%).

4.3.2.13. Paralabidochromis "yellowbars"

Fourteen specimen of *P. "yellowbar"* with SL 64-126 mm site were examined out of which eight contained food material. The food items included *C. nilotica* (80.8%), Ephemeroptera nymph (9.2%), chironomid larvae (6.1%) and Odonata nymphs (3.1%). Four stomachs contained only *C. nilotica*, one contained *C. nilotica* and chironomid larvae while one contained a mixture of Ephemeropteran nymphs, Odonata nymphs and chironomid larvae.

4.3.2.14. Neochromis pseudonigricans

Thirty three specimen of *N. pseudonigricans* of 62-99 mm SL were examined out of which fourteen contained food. The dominant food items were chironomid larvae (35.6%), fish remains (20.5%), high plant material (14.9%), Odonata nymphs (7.7%), ephemeropteran nymphs (7.7%), ostracods (6.1%), detritus (2.6%), chironomid pupae (2.6%), trichopteran nymphs (1.3%) and filamentous green algae (1%). Three stomachs contained ostracods, one contained ephemeropteran nymphs and one contained filamentous green algae, in addition to high plant material and chironomid larvae. Two stomachs contained odonata nymphs in addition to chironomid larvae. One stomach contained chironomid pupae only.

4.3.2.15. Paralabidochromis "rockcribensis"

Fifteen stomachs of *P. "rockcribensis"* of 67-112 mm SL were examined and six of them contained food. The food items included *C. nilotica* (60%), chironomid larvae (28%), chaoborid pupae (10%), ephemeropteran nymphs (1%) and high plant material (1%). Four stomachs had *C. nilotica* only, two contained ephemeropteran nymphs in addition to *C. nilotica* chironomid larvae, and high plant material.

4.3.2.16. Ptyochromis xenognathus

Twelve specimen of *P. xenognathus* of 72-110 mm SL were examined out of which three contained food. The food items included gastropods (90%), ephemeropteran nymphs (5%) and chironomid pupae (5%). Only the soft parts of gastropods were found in the stomachs.

4.3.2.17. Paralabidochromis chilotes

Sixteen specimen of 65-120 mm SL were examined out of which seven contained food. The food items found included chironomid larvae (58.1%), ephemeropteran nymphs (22.4%), Odonata nymphs (9.5%), fish remains (4.8%), chironomid pupae (1.9%), detritus (1.9%) and trichoptera nymphs (1.4%).

4.4. DISCUSSION

Insects are the most important food organisms eaten by haplochromines in the littoral areas of Lake Victoria. Besides the 13 species that had fed predominantly on insects, many others included some insect material in the their diet. The haplochromines studied can, therefore, be divided into three trophic groups (Figure 4.3) namely insectivores (13), molluscivores (2), and prawn-eaters (2). Species whose trophic groups were unknown were four. Greenwood (1974) working on species in the Napoleon Gulf of Lake Victoria recorded five trophic groups and these were in order of abundance, insectivores, piscivores, molluscivores, plant material (algae and macrophytes) and scale-eaters. In the sublittoral areas of the Mwanza Gulf (Goldschmidt, 1996), eleven trophic groups were

recorded (Figure 4.3) and these included fish-eaters (134), insectivores (29), zooplanktivores (21), molluscivores (21), detritivores (16), prawn-eaters (13), algae-eaters (10), and plant-eaters (2), and parasite-eaters (2) and crab-eaters (1), and 53 species of unknown trophic groups.

Comparison of the present data with information obtained before the upsurge of *L. niloticus* indicate that haplochromines which were still surviving had not changed their diet although most of them tend to feed on a variety of larval insects in addition to their original diet. In Lake Victoria, *A. alluaudi* was reported to feed almost exclusively on Molluscs and particularly on the thick-shelled *Melanoides tuberculata* (Greenwood, 1981). This fish therefore still depends on a molluscivorous diet. In the eleven specimen of *P. paraguiarti* examined by Greenwood (1981), one specimen contained fish remains together with a little phanerogam tissue, five contained fragments of larval ephemeroptera while the remaining eleven yielded a mixture of plant tissue and insect fragments (larval ephemeroptera). This fish therefore still depends on its original diet. In the specimens of *H. guiarti* examined by Greenwood (1974) the material found in the guts included fishes, insects, chironomid larvae and less frequently larval ephemeroptera and fragments of phanerogam tissue. H. guiarti therefore still depends on its original diet although it is now including *C. nilotica*. In Lake Victoria, *A. nubila* were found to have a rather omnivorous diet in which larval insects and small crustacea predominate (Greenwood, 1981), but they now seem to be more restricted to invertebrates especially insects. Out of the seventeen specimen of *P. xenognathus* examined by Greenwood (1981), ten contained only the soft parts of Gastropoda, three contained chironomid and ephemeroptera larvae, two contained detritus and three contained unidentified sludge. Eight of the twenty three specimen of *P. chilotes* examined by Greenwood (1981) contained food in the stomach and intestines. One fish had fed mainly on *C. nilotica* and the others insect larvae namely *Povilla adusta*, Trichoptera and Diptera larvae. Plant debris and sand grains also occurred in the stomachs. *P. chilotes* therefore still depends on an invertebrate diet.

Laboratory experiments of food preferences have indicated that food segregation takes place only during periods of low food abundance (Liem & Kaufman, 1984). Further, species apparently specialised for certain food sources may switch food preferences when other foods

become superabundant (Witte, 1987). Recent studies on Lake Victoria indicate increase in densities of lakeflies and dipteran larvae (Kaufman, 1992; Mbahinzireki, 1993).

Greenwood (1974) also noted that L.Victoria haplochromines retain a measure of flexibility in their feeding habits. Such evolution could have played a part in the evolution of the haplochromine species flock. *N. nigricans* was supposed to be predominantly a grazer on epilithic algae. In Lake Victoria, ingested material from thirty two stomachs of *N. nigricans* showed a preponderance of diatoms over all other material (Greenwood, 1981). The current observations suggest that this fish has shifted from a more plant to invertebrate diet. Most of the specimen of *N. nigricans* examined were caught from Rwamafuta site which is exposed to very strong wave action that makes it difficult for epilithic algae to grow on the rocks. This could have led the species to shift its diet from the epilithic algae to other readily available food items, especially larval insects. The Haplochromine Ecology Survey Team noted that *"H". rockcribensis* was a scraper-toothed insectivore, the gut contents of specimen caught in Kenya contained insect larvae mixed with bivalve and gastropod shell hash (Kaufman & Ochumba, 1993), while in the present study *P. "rockcribensis"* fed predominantly on *C. nilotica* followed by larval insects and rarely phytoplankton. Thus *P. rockcribensis* could have shifted its diet to take advantage of the increasing biomass of *C. nilotica* in Lake Victoria.

However, some of the species encountered have not yet been described and this makes it difficult to compare their present diet with what it was before the upsurge of Nile perch. In addition, the population of haplochromines in Napoleon Gulf has changed. Most of the known described species that used to dominate the catch are no longer encountered. The majority of the haplochromines being recorded in the present study are the undescribed ones.

4.5. CONCLUSION

The diet of the different trophic groups of the surviving haplochromines in the littoral areas of Lake Victoria does not appear to have changed. Insects are still the most dominant food organisms eaten by the haplochromines. Although zooplankton, plant material and detritus were never recorded as being dominant food items in any one species, they were frequently

found in guts of species whose food was otherwise of different origins. Fish remains were also recorded from stomachs of several species although they were never a dominant food item in any of the species. Some of the trophic groups not found in the present study could could have dissappeared. This implies that primary production is no longer channeled through a haplochromine chain as was the case before the establishment of exotic species in Lake Victoria.

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APPENDIX 1

Definition of Proportional Measurements

Standard Length: Distance from the rostral tip of the upper jaw to the origin of the caudal fin.

Body Depth: The greatest vertical depth of the body, mostly found between points near the rostral origins of the dorsal fin and of the pelvic fin. It is expressed as a percentage of the standard length.

Caudal Peduncle Length: Distance between the vertical line through the caudal point of the anal fin insertion and that through the caudal border of the hypurals. It is expressed as a percentage of the standard length.

Caudal Peduncle Depth: The least vertical depth of the caudal peduncle. It is expressed as the ratio length/depth of the caudal peduncle and indicates the slenderness of the caudal peduncle.

Head Length: The length from the rostral tip of the premaxilla to the caudal convex end of the gill cover. It is expressed as a percentage of the standard length.

Snout Length: The distance from the rostral tip of the premaxillae to the rostral point of the bony border of the orbit. It is the junction of the orbit margin of the preorbital process and that side of the lachrymal which borders the eye. It is expressed as a percentage of the head length.

Snout Width: It is the greatest width of the head area rostral to the preorbital process of the neurocranium in dorsal aspect. It is found between a point on the left and right lachrymal abduction. It is expressed as the ratio length/width of the snout.

Preorbital Depth: Distance from the rostral corner of the bony orbit to the rostral corner of the lachrymal. It is expressed as a percentage of the head length.

Eye Diameter: Distance from the rostral point of the orbit to the ventral of the post orbital process. It is expressed as a percentage of the head length.

Cheek Depth: Distance from the ventral point of the bony margin of the orbit to the most ventral point along the ventral border line of the adducter muscle. It is expressed as a percentage of the head length.

Length of the Lower Jaw: Distance from the rostral to the caudal tip of the lower jaw. It is expressed as percentage of the head length.

Width of the Lower Jaw: Distance between a point on the left and on the right lower jaw just rostral to the rim marking its articulation with the suspensorium. It is expressed as a percentage of the head length.

Relative abundance and distribution of different haplochromine trophic groups

4.1. Material and Methods

The haplochromines identified were grouped into genera and the relative abundance and distribution of the various genera determined as in the previous chapter.

This site, which is located at the mouth of the Bugungu Stream and having a shoreline dominated by swamp vegetation, had the highest number of haplochromines. The mean number and mean weight of haplochromine genera from Kiryowa is shown in Tables 4.1. Seven haplochromine genera were recorded. By number (Table 4.1a and Figures 4.1a,1b), the order of abundance was *Astatoreochromis, Paralabidochromis, Astatotilapia, Harpagochromis, Prognathochromis, Neochromis* and *Ptyochromis*. By weight (Table 4.1b), the order of dominance was *Astatoreochromis, Paralabidochromis, Harpagochromis, Astatotilapia, Prognathochromis, Neochromis*, and *Ptyochromis*. Among the Paralabidochromis, 8 species were identified and these included *"P.velvet black", P.chilotes, P.crassilabris, P.rockcribensis, "P.yellow body", "P.goldchest", "P.yellow bars"*, and *P.deep-bodied blue*. The Astatotilapia included *A.unicuspid, A.bicuspid*, and *A.nubila*. *Neochromis* included two species namely *N.scraperteeth, N.nigricans*, and *N.pseudonigricans*.

Most of the genera were most abundant in the inshorefleet except *Ptyochromis* which was recorded only in the middlefleet. The highest number of haplochromines was reorded in the inshore fleet, followed by the offshore fleet.

Cliff

The mean number and mean weight of haplochromine genera recorded from Cliff is shown in Tables 4.2. All the haplochromine genera, except *Astatoreochromis sp*., recorded from Kiryowa site were also recorded from Cliff. The order of abundance by numbers (Table 4.2a and Figures 4.2a,2b), was *Prognathochromis, Paralabidochromis, Astatotilapia, Harpagochromis, Neochromis*, and *Ptyochromis*. By weight (Table 4.2b), the order of dominance was the same as by numbers.

All the genera, except *Astatotilapia*, were recorded only in the inshore fleet. *Astatotilapia* occurred also in the middlefleet and offshore fleet, but were most abundant in the inshore fleet followed by the offshore fleet.

Kikondo

This site has a shoreline characterised by laterite rocks which extend into littoral area giving it a bottom suvstrate of hard rock. Its shoreline is for most part covered by remnants of forest, in form of thickets which extend right into the first few metres of water. Stands of *Typha sp*. and Water hyacinth occur among the rock outcrops. The number and type of haplochromine genera recorded in Kikondo were similar to those recorded in Kiryowa, although the mean number of haplochromines was less. The order of abundance by numbers (Table 4.3a and Figures 4.3a,b), was *Prognathochromis*, *Astatotilapia*, *Neochromis*, *Harpagochromis*, *Paralabidochromis*, and *Ptyochromis*. By weight (Table 4.3b), the order of dominance was *Prognathochromis*, *Astatotilapia*, *Harpagochromis*, *Paralabidochromis*, *Neochromis*, *Ptyochromis* and *Astatoreochromis*.

Harpagochromis, *Ptyochromis* and *Astatoreochromis* were recorded only from the inshore fleet. *Astatotilapia* were most abundant in the offshore fleet, whereas the remaining genera were most abundant in the inshore fleet. The highest number of haplochromines was recorded in the fleet set along the shoreline, decreasing with increasing distance from the shoreline.

Kirinya

This site , which characterised by a papyrus shoreline fringed by Water hyacinth , had the list number of haplochromines both in number and diversity. Five haplochromine genera were recorded from Kirinya. The order of abundance by numbers (Table 4.4a and Figures 4.4a, and 4.4b), was *Astatotilapia*, *Paralabidochromis*, *Harpagochromis*, *Astatoreochromis* and *Prognathochromis*. By weight (Table 4.4b), the order of abundance was *Astatotilapia*, *Paralabidochromis*, *Harpagochromis*, *Astatoreochromis* and *Prognathochromis*.

All the genera were most abundant in the inshore fleet. The highest number of haplochromines was recorded in the inshorefleet.

Rwamafuta

The site is located on an isolated rocky island within the Buvuma Channel and is characterised with a rocky outcrops along the shoreline. The area is exposed to very strong waves and is occasionally covered with water hyacinth. Six genera of haplochromines were recorded in Rwamafuta. The order of abundance by number (Table 4.5a and Figures 4.5a, b), was *Paralabidochromis, Neochromis,* and *Astatotilapia*. *Astatoreochromis, Prognathochromis* and *Harpagochromis* were present in insignificant numbers. The order of dominance by weight (Table 4.5b) was *Paralabidochromis, Neochromis, Astatotilapia, Prognathochromis, Astatoreochromis,* and *Harpagochromis*.

All the genera were most abundant in the shoreline. *Paralabidochromis* and *Neochromis* were recorded in all the three fleetss although they weremost abundant in the inshore fleet. A few *Astatotilapia* were also recorded in the offshore fleet. The highest number of haplochromines was recorded in the inshore fleet.

Overall, seven genera were recorded for the whole sampling period and these included in order of abundance, by numbers (Table 4a and Figures 4a and 4b), *Paralabidochromis, Astatotilapia, Prognathochromis, Astatoreochromis, Harpagochromis, Neochromis* and *Ptyochromis*. By weight (Table 4b), the order of dominance was *Paralabidochromis, Astatoreochromis, Prognathochromis, Astatotilapia, Harpagochromis, Neochromis* and *Ptyochromis*. Most genera were recorded at all sites except *Neochromis spp*. which was mainly recorded in Kikondo and Rwamafuta, both of which have a rocky habitat.

The highest number of haplochromines was recorded in the inshore fleet decreasing towards the offshore. Relative abundance and distribution of the different haplochromine genera varied with site as shown in tables 4.1 to 4.5. Most genera were more abundant in the inshore areas deacreasing outwards into the open water,except for *Astatotilapia* which were recored

in big numbers in the 200m fleets in some sites especially Kikondo. General distribution and relative abundance of the different haplochromine genera in Napoleon Gulf is shown in Table 4. However, relative abundance and distribution of the different haplochromine genera varied with site as shown in Tables 4.1 to 4.5, for the months of October 1995 to May 1996.

Discussion

Greenwood(1974) observed that representatives of all trophic groups were found in each of the major habitats he studied although the algal grazers and the species feeding on higher plants were restricted to habitats where there were rooted plants or, in the case of algal grazers, suitable substrata for algal growth. In the present study, *Neochromis nigricans* which is known to be an algal grazer, was recorded mostly from sites with rocky habitats, that is, Kikondo and Rwamafuta. A few *N. nigricans* were recorded from Cliff and Kiryowa sites which have submerged rocks in some areas.