THE BIOLOGY AND ECOLOGY OF LAKE VICTORIA FISHES:

THEIR DEVELOPMENT AND MANAGEMENT

(UGANDAN VERSION)

***Edited By**:* Ogutu-Ohwayo, R. , and. Wandera S.B.,
National Agricultural Research Organisation,
Fisheries Research Institute,
P. O. Box 343, Jinja, Uganda

December 2000

Table of contents

Title of Chapter and Authors	
1	Fishes and fisheries of the Victoria and Kyoga lake basins. *[Ogutu-Ohwayo, R. & Wandera, S.B.]*
2	The biology, ecology and fishery of (Mukene) *Rastrineobola argentea [Wandera S.B.]*
3	The biology, ecology and impact of Nile perch, *Lates niloticus* in lakes Victoria, Kyoga and Nabugabo and the future of the fisheries *[Ogutu-Ohwayo, R.]*
4	The biology, ecology and impact of introduced tilapiines especially the Nile tilapia, *Oreochromis niloticus* in lakes Victoria and Kyoga *[Nagayi, J.]*
5	The biology and ecology of native-non-cichlids in the Victoria and Kyoga Lake basins. *[Mbabazi, D. and Taabu-Munyaho, A.]*
6	Population characteristics of *Oreochromis esculentus* in the Victoria and Kyoga lake basins in -relation to conservation and restoration of the species. *[Nagayi, J.]*
7	The Food of haplochromine species surviving in the nearshore stations of Lake Victoria with specific reference to the Napoleon Gulf. *[Namulemo, G.]*
8	Trophic structure and diversity of haplochromines among Kyoga minor lakes *[Mbabazi, D.]*
9	Trophic interrelationships and food-webs among fishes in the Victoria and Kyoga lake basins *[Mbabazi, D.]*
10	The role of *Yssichromis* species in the trophic ecology and food-webs of Lake Victoria *[Ebong, I., Wandera, S.B. and Ogutu-Ohwayo, R.]*
11	Impact of fishing gears and methods and the consequences of using different mesh sizes of gillnets on the fisheries and on biodiversity of lakes Victoria and Kyoga *[Ogutu-Ohwayo, R., Wandera, S.B.]*
12	Management of the fishes and fisheries of the Victoria and Kyoga lake *basins [Ogutu-Ohwayo, R., Wandera S.B., Namulemo, G., Mbabazi, D.]*

CHAPTER 7

Food of the haplochromine species surviving in the nearshore areas of Lake Victoria with specific reference to Napoleon Gulf.

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 and Cordone, 1974; Okaronon *et al,1985).* Lake Victoria had more than 300 haplochromine species, more than 99% of them endemic (van Oijen *et aI,* 1984; Witte *et aI1992).* 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 and 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 paper, the food and feeding habits of the surviving haplochromine cichlids 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.

Objectives

The major objective of the study was to quantify 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 was achieved by examining the food of the major surviving haplochromine species

Material and Methods

Fish specimens were collected from various stations in the Napoleon Gulf 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 12.7mm. The nets were set at 18.00 hours in the evening and retrieved at 7.00 hours the following morning.

Haplochrornines were fixed in 5% formalin and labeled with time, date, mesh size, size of net and site, and taken to the laboratory for further analysis. Whenever possible, photographs of fresh haplochromine specimens were taken in the field to be used in later identification.
In the laboratory, the haplochromines were identified to genus level and where possible, to species level using the key provided by Greenwood (1981 a). Biometric data on individual specimens was 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 & Braum (1978). The stomach of each fish was dissected out and its degree of fullness determined, whether empty (0), ¼, ½, ¾ or full (I).
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 point method based on Hynes (1950). The trophic group of a species was determined by the most dominant food item in its diet.

Results

The relative importance of the haplochrornines encountered were in order of importance by number *A. alluaudi, A. "unicuspid", P. "paraguiarli", P. "yellowbody", P. "goldchesl", H guiarli, A. nubila, A. "bicuspid", N "scraperleelh", N nigricans, P. crassilabris, P. "velvelblack", P. "yellowbar", N pseudonigricans, P. "rockcribensis", Aslalolilapia sp., P. "shorlsnoul", P. "blue deepbody", P. xenognalhus, P. "sharpleelh", P. "bigeye", P. chiloles*, and *P. "curved head"* (Figure I). Of the 24 species, there were adequate samples to examine food for only 17 species. These included, *A. alluaudi, A. "unicuspid", P. paraguiarli, P. "yellowbody", P. "goldchesl", H guiarli, A. nubila, A. "bicuspid", N "scraperleelh", N nigricans, P. crassilabris, P. "velvelblack", P. "yellowbars", N psuedonigricans, P. rockcribensis", P. xenognalhus,* and *P. chiloles*.

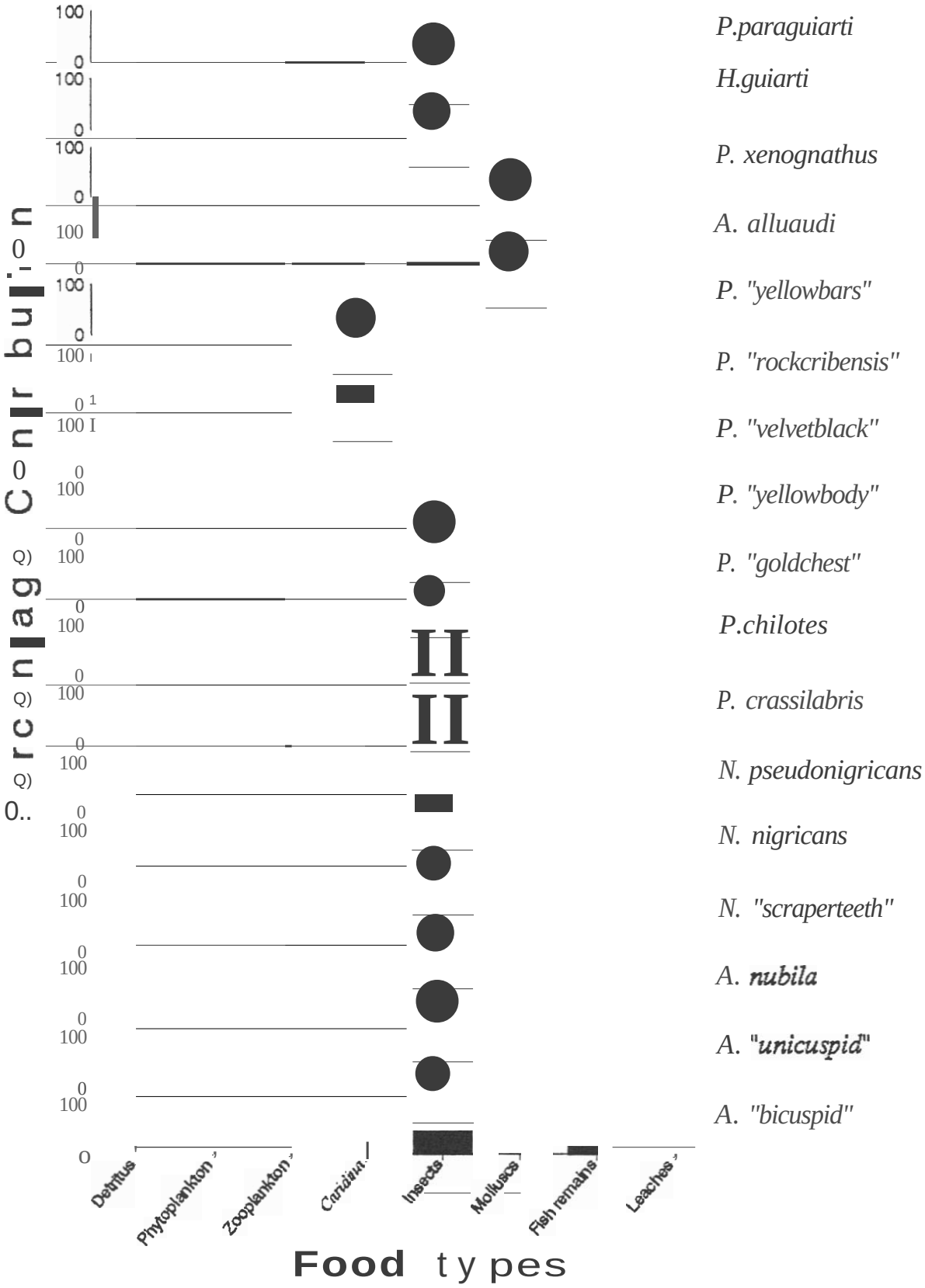
Seventeen haplochromine species were examined for food analysis as detailed below and in Table I and Figure I. The names that appear in quotes are cheironyms. Table 2 shows the relative proportions of eight food catagories as percentages of the total points scored by all the food catagories in each species. 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 guiarli, A. nubila, N nigricans, P. xenognalhus,* and *P. chiloles.*

Eight food catagories were recorded from the haplochromine stomachs in the present study (Figure 2). These included in order of importance, insects (69.2%), molluscs (8.9%), plant material (6.9%), C. *nilolica* (6%), fish (5.2%), leaches (2.2%), detritus (1.4%) and zooplankton

Table I. Percentage composition of the food of some of the common surviving haplochromines in Napoleon Gulf

Species	DTR	FG	HPM	OST	CRL	CRP	CHL	CHP	EPM	TRI	ODON	BI	GAS	CA	FR	LE
Astatotilapia "bicuspid"	0	0	7.3	0	12.3	1.2	0	0	15.3	0	17.7	0	0	27.	18.5	0
Astatoti/apia "unicuspid"	0.8	1.7	0.4	0.9	11.6	4.6	32.1	0.5	14.6	0	7.6	0	0	5.5	0	12.2
Astatotilapia nubila	0.9	0.9	0.6	0	3.9	4.1	1.4	0	15.2	0	64.4	0	0	0	0	2.8
Neochromis "scraperteeth"	0	5.7	6.6	0.1	10.1	2.5	I.I	0	15.4	0	46.3	4.2	0	4.2	0	0
Neochromis nigricans	0.8	9.3	3.2	2.7	31.4	12.3	0	0	6.5	0	16.9	0	0	2.2	0	10.9
Neochrolllis pseudonigricans	2.6	I	14.9	6.1	35.6	2.6	0	0	7.7	1.3	7.7	0	0	0	20.5	0
Paralabidochromis	0	0	I	0	28	0	0	10	I	0	0	0	0	60	0	0
Paralabidochrolllis	0	0	0	0.9	55.1	1.5	0	0	38.0	0	4.4	0	0	0	0	0
Paralabidochrolllis chilotes	1.9	0	0	0	58.1	1.9	0	0	22.4	1.4	9.5	0	0	0	4.8	0
Paralabidochrolllis	9.3	0	0.5	0	5.2	1.2	0	0	0.2	39.4	0	0	2.3	30.	11.6	0
Paralabidochrolllis	1.8	9.9	17.8	0.2	3.2	5.3	0	0	5.2	0	50.1	0	0.6	0.8	4.9	0
Paralabidochromis "yellow	0.7	0	1.5	0.9	39.5	2	0	0	18.2	6.1	21.6	0	0	I	0	8.3
Paralabidochrolllis "yellow	0	0	0	0	6.1	0	0	0	9.2	0	3.1	0	0	80.	0	0
Astatoreochromis alluaudi	1.5	0.9	3.4	0.2	0.8	0.2	0	0	0.2	0	9.1	0.1	82.0	1.7	0	0
Ptyochrolllis xenognathus	0	0	0	0	0	0	5	0	5	0	0	0	90.0	0	0	0
Harpagochromis guiarti	0	0.2	0.6	0.2	5.2	0.3	0	0	1.5	0	69.3	0.2	0	0	20.2	0
Prognathochrolllis paraguiali	0	0.5	1.2	0.6	49.2	15.7	0	0	6.9	0	15.6	1.8	0	3.1	3.3	0

DETR - Detritus FGA - Filamentous green algae HPM - High plant material CAR - Caridina BIY -Bivalves
OST - Ostracods CRL - Chironomid larvae CRP - Chironomid pupae FR - Fish remains GAST -Gastropods
CHL - Chaoborus larvae CHP - Chaoboms pupae EPMN - Ephemeroptera nymph ODON - Odonata nymphs



Fig, 1, Percentage contribution of items ingested by different haplochromines in Napoleon Gulf

Table 2. Percentage conlJibution of the food catagories to the diet of some common haplochromines from Napoleon Gulf

Species	DTR	PHYT	ZOOPL	CAR	INS	MOLL	FISH	LEACH
Aslaloli/apia "bicuspid"	0	7.3	0	27.7	46.5	0	18.5	0
ASlaloli/apia "lInicuspid"	0.8	2.1	0.9	12.7	71	0	0	12.2
Aslaloli/apia nllhila	0.9	\.5	0	5.6	89.0	0	0	2.8
Neochromis "scraperleelh"	0	12.3	0.1	4.2	79.2	4.2	0	0
Neochromis nigricans	0.8	12.5	2.7	2.2	70.8	0	0	10.9
Neochromis pseudonigricans	2.6	15.9	6.1	0	54.9	0	20.5	0
Paralabidochromis "rockcribensis"	0	I	0	60.0	39.0	0	0	0
Paralabidochromis crassilabris	0	0	0.9	0	99.1	0	0	0
Paralabidochromis chiloles	\.9	0	0	0	93.3	0	4.8	0
Paralabidochromis "velvelblack"	9.3	0.5	0	30.2	46.0	2.3	I\.6	0
Paralabidochromis "goldchesl"	\.8	27.7	0.2	0.8	63.8	0.6	4.9	0
Paralabidochromis "yellow-body"	0.7	1.5	0.9	I	87.4	0	0	8.3
Paralabidochromis "yellow-bars"	0	0	0	80.8	18.4	0	0	0
ASlaloreochromis allllalldi	1.5	4.3	0.2	\.7	10.3	82.1	0	0
Ptyochromis xenognalhlls	0	0	0	0	10	90	0	0
Harpagochromis guiarti	0	0.8	0.2	1.7	76.7	0.2	20.2	0
Prognalhochromis paraguiarli	0	2.2	0.5	3.1	89.0	0	3.3	0

DTR -Detritus ZOOP -Zooplankton INS -Insects FISH -Fish remains
PHYT -Phytoplankton CAR -Caridina nilotica MOLL -Molluscs LEACH-Leaches

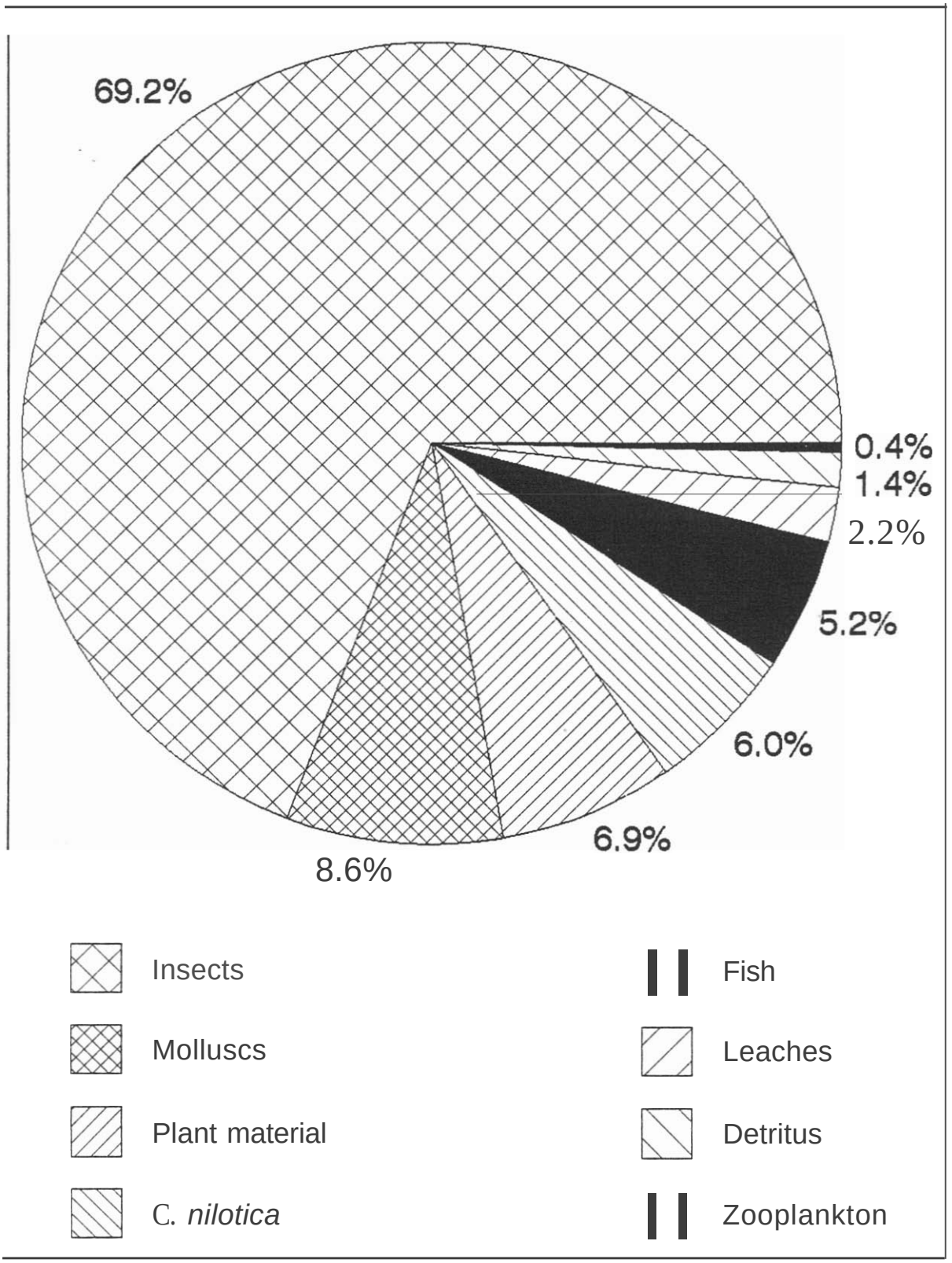


Fig. 2. Relative abundance of the various food items ingested by the haplochromines in the Napoleon Gulf

(0.4%). Insects especially larval and pupal chironomids, Ephemeroptera and Odonata were the most important food catagory. Besides species feeding principally on insects, many others included some insect material in their diet. Two species, *A. alluaudi* and *P. xenogmithus* 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.

Astatoreocllromis alluaudi

One hundred forty three specimen of *A. alluaudi* of 68-147 mm 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 molluscs (0.1%). One specimen (l05mm 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.

Astatotilapia "unicuspid"

One hundred seventy eight specimen of *A. "unicuspids"* examined 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 chironornid larvae and another three had only ephemeropteran nymphs. The remaining specimen contained a mixture of chironomid larvae and ephemeropteran nymph.

Prognathocllromis paraguiarti

Three hundred fifteen specimen of *P. paraguiarri* 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.

Paralabidochromis "yellowbody"

Two hundred forty five specimen of *P. "yellowbody"* of 60-124 mm SL from Rwamafuta 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. This species was only recorded from Rwamafuta.

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.

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 specimens 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.

ASlalolilapia 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.

Aslalolilapia "bicuspid"

Eighty seven specimen of *A. "bicuspid"* of 61-99mm 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%).

Neocltromis "scraperteetlt"

Seventy six specimen of *N "scraperteeth"* of 60-127mm 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%).

Neocltromis 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.

Paralabidocltromis 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.

Paralabidocltromis "velvetblack"

Thirty-eight specimen of "velvetblack" of70-123mm 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%).

Paralabidocltromis "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 ofEphemeropteran nymphs, Odonata nymphs and chironomid larvae.

Neocltromis pseudonigricans

Thirty-three specimens of *N pseudonigrieans* of 62-99 rom 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 (I%). 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.

Paralabidoehromis "roekeribensis"

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

Ptyoehromis xenognathus

Twelve specimen of *P. xenognathus* of 72-110 rom 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.

Paralabidoehromis clzilotes

Sixteen specimen of 65-120 rom 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%), and detritus (1.9%) and trichoptera nymphs (1.4%).

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 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 (I), and 53 species of unknown trophic groups.

Comparison of the present data with information obtained before the upsurge of *L. nilotieus* 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

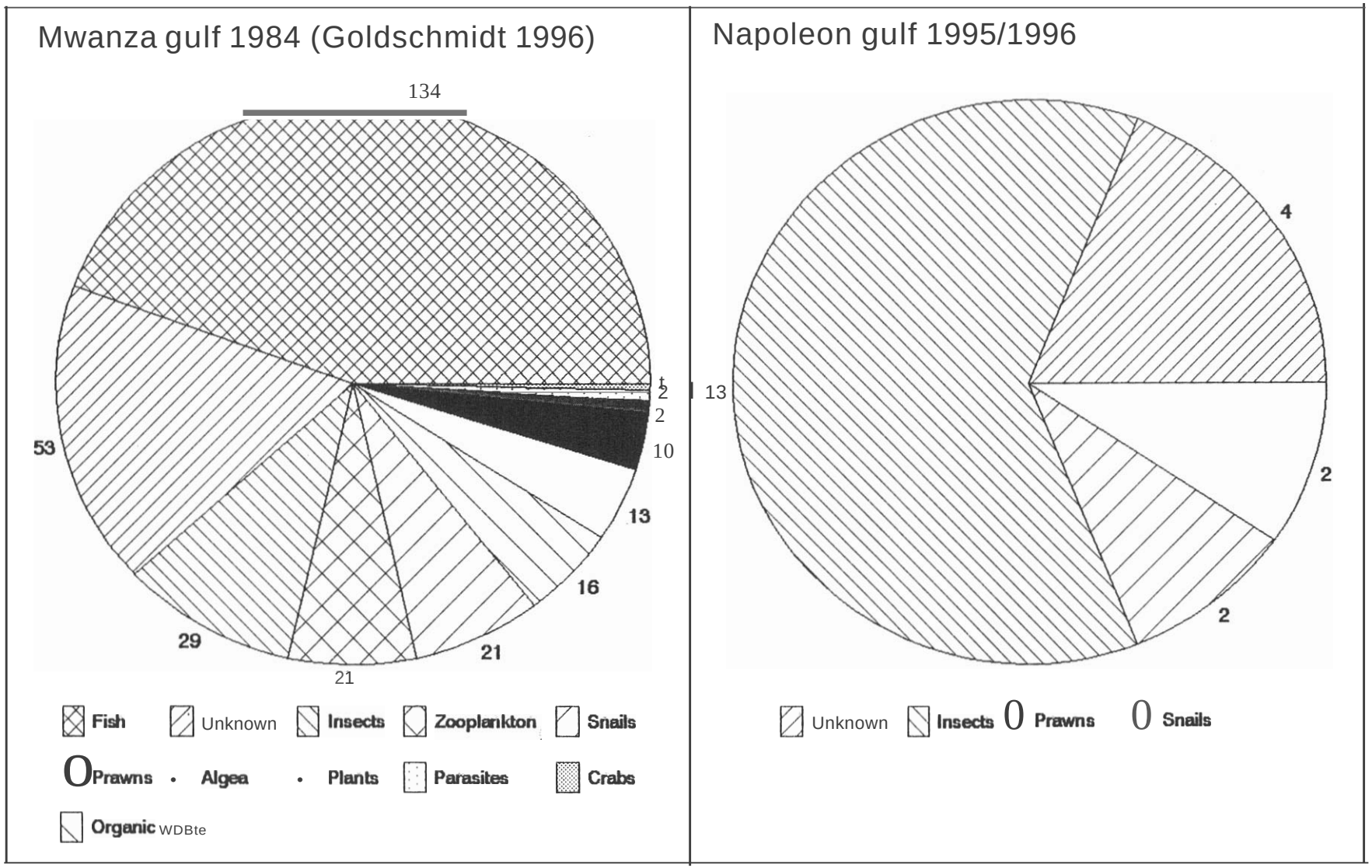


Fig. 3. Comparison of number of haplochromine trophic groups from Mwanza gulf and Napoleon gulf based on data from the Mwanza gulf 1996 and that collected during this study

Victoria, *A. alluaudi* was reported to feed almost exclusively on Mollusca and particularly on the thick-shelled *Melanoides luberculala* (Greenwood 1981). This fish therefore still depends on a molluscivorous diet. In the eleven specimen of *P. paraguiarli* 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. guiarli* 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. *nilolica*. 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. xenognalhus* 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 23 specimen of *P. chiloles* 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 adusla,* Trichoptera and Diptera larvae. Plant debris and sand grains also occurred in the stomachs. *P. chiloles* 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 specimens 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. *nilolica*, followed by larval insects and rarely phytoplankton. Thus *P. rockcribensis* could have shifted its diet to take advantage of the increasing biomass of C. *nilolica* 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.

CONCLUSION

The diet of the different trophic groups of the surviving haplochromines in the littoral areas of Lake Victoria has not 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 anyone 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 have disappeared. This implies that primary production is no longer channeled through via a haplochromine chain, as was the case before the establishment of exotic species in Lake Victoria.

REFERENCES

Anderson, AM. 1961. Further observations concerning the proposed introduction of Nile perch into Lake Victoria. *E.Afr. Agric. J.* 26: 195-201.

Bagenal, T.E & E. Braum 1978. Eggs and early life history, 165-201. *In T Bagenal (ed.)* Methods of assessment of fish production in fresh water. IBP Handook No. 3. Blackwell Scientific Publications. Oxford London.

Goldschmidt, T. 1986. Niche differentiation in planktivorous haplochromines in the Mwanza Gulf of Lake Victoria and a hypothesis on the speciation of haplochrornines iri genera!. Ann. Mus. Roy. Afr. Centro Sc. Zoo!. 251: 42-52

Goldschmidt, T., F. Witte and J. de Visser, 1990. Ecological segregation of zooplanktivorous haplochromines (Pisces, Cichlidae) from Lake Victoria. Oikos 58: 343-355.

Goudswaard, P. and F. Witte, 1985. Observations on Nile perch *Lates niloticus* (L) In Tanzania waters of Lake Victoria. FAO Fish. Rep. No. 335: 62-67.

Greenwood, P.H. 1974. The cichlid fishes of Lake Victoria, East Africa: the biology and evolution of a wpecies flock. *Bull. nat. Hist.* (Zoo!.). Suppl. 6: 1-134

Greenwood, P.H. 1981a. The haplochromine fishes of the East African lakes. Collected papers on their taxonomy,biology and evolution with an introduction and species index. New York: Cornell University Press, 839pp.

Hecky, R.E. and F.W.Bugenyi 1992. Hydrology and chemistry of the African Great Lakes and water quality issues: Problems and solutions. Mitt. Verein. rnt. Limnol. 23: 45-54.

Hecky, R.E. 1993. Peter Kilham Memorial Lecture. The eutrophication of Lake Victoria. Verh. Int. Verein. Limnol. 25: 39-48.

Hynes, H.B.N. 1950. The food of freshwater sticklebacks *(Gasterosteus aculeatus* and *Pygosteus pungitius),* with a review of methods used iri studies of food of fishes. J.Anirn.EcoI.19,36-58.

Jackson, P.B.N. 1971. The African Great Lakes Fisheries: past, present and future. *Afr. J Trap. Hydrobio. Fish.* I: 35-49

Kaufman, L. & P. Ochumba. 1993. Evolutionary and conservation biology of cichlid fishes as revealed by faunal remnants in northern Lake Victoria. *Cons. Bioi.* 7: 719-730

Kudhongania, AW. and EJ. Cordone. 1974. Batho-spatial distribution patterns and biomass estimates of the major demersal fishes in Lake Victoria. *Afr. J Trap. Hydrobiol. Fish.* 3(1), 15-31.

Liem, K.F., Kaufman, L.S. (1984). Intraspecific macroevolution: Functional biology of the polymorphic cichlid species *Cichlasoma minckleyi.* In: Echele, AA, Komfield, I (eds.): Evolution of Fish Species Flocks, University of Maine at Orono Press, Orono, Maine, pp. 203-215

Mbahinzireki, G. B., 1993. Observation on the benthic communities of northern Lake Victoria, Uganda. P.42. In: Kaufinan, L. *et al.* (Eds). People, Fisheries, Biodiversity and the Future of Lake Victoria. Proceedings of the Lake Victoria Ecosystem Workshop 7-21 August 1992, Jinja, Uganda. Egerton Research Laboratory of the New England Aquarium. Report 93-3

Mugidde, R., 1992. Changes in phytoplankton primary productivity and biomass in Lake Victoria (Uganda). MSc. Thesis, University of Manitoba. 84 pp.

Mugidde, R., 1993. The increase in phytoplankton production and biomass in Lake Victoria (Uganda). Verh. Int!. Verein. Limnol. 25: 846-849.

Ogutu-Ohwayo, R. 1994. Adjustments in fish stocks and in life history characteristics of the Nile perch, *Lates nilolicus* in lakes Victoria, Kyoga and Nabugabo. Ph.D Thesis.

Oijen, MJ.P. van. 1982. Ecological differentiation among the haplochrornine piscivorous species of Lake Victoria. *Nelh.* J *Zool.* 32: 336-363

Oijen, M.P. van; F. Witte and E.L.M. Witte-Maas. 1984. An introduction to ecological and taxonomic investigations of the haplochromine cichlids from Mwanza Gulf of Lake Victoria. *Nelh.* J *Zool.* 31: 149-174.

Okaronon, J. 0., 1994. Current Composition and Relative Abundance of the Fish stocks of Lake Victoria, Uganda. *Afr.* J *Trop. Hydrobiol. Fish.,* Vo1.5, No.2: 89-100

Witte, F. and E.L.M. Witte-Mass 1987. Implications for taxonomy and functional morphology of intraspecific variation in haplochromine cichlids of Lake Victoria. In: Witte, F. From Form to Fishery. Ph.D. thesis, Leiden University, chapter 11.

Witte, F. and MJ.P. van Oijen. 1990. Taxonomy, ecology and fisheries of haplochromine trophic groups. *Zool. Verh. Leiden* 262: 1-47.

Witte, F.; T.Goldschmidt; P.C. Gourdswaard; W.Ligvoet; MJ.P. van Oijen and J.H.Wanink 1992b. Species extinction and concomitant ecological changes in Lake Victoria. *Nelh.* J *Zool.* 42: 214-232.