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THE FOOD OF *HAPLOCHROMIS BURTONI* (PISCES : CICHLIDAE) OF LAKE MUGESERA (RWANDA)

by

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SUMMARY

In view of a better comprehension of the trophic relationships of Lake Mugesera (a lake of the Akagera system, Rwanda), a stomach and gut content analysis has been carried out on 38 adult specimens of *Haplochromis burtoni* (GÜNTHER, 1893), a cichlid which was up to now only known from the Lake Tanganyika system. *H. burtoni* is a benthic insectivore and detritivore and shows a wide range of prey species. The main animal prey are Chironominae larvae. Rotifera are numerically abundant in the food contents, but volumetrically insignificant.

INTRODUCTION

Lake Mugesera is a shallow dentritic lake, one of the water bodies located in the valleys adjacent to the Nyabarongo river, which is part of the Akagera watershed (Rwanda) (Fig. 1). The hydrobiological aspects of Lake Mugesera are discussed by DAMAS (1953, 1954) and NTAKIMAZI (1985).

In order to arrive at a better understanding of the trophic relationships that occur in Lake Mugesera, a study has been carried out on the food of *Haplochromis burtoni* (GÜNTHER, 1893), a small cichlid species, one of the 16 fish species actually recorded in this lake.

Two questions were investigated : (1) on which food items feeds this population (qualitative aspect) and (2) in which proportions are the various food items ingested (semi-quantitative aspect).

MATERIALS

The fishes ($n = 38$) were caught between the 27th of July and the 12th of August 1985 on the Western shore of Lake Mugesera at a location called « Bac » (02°08′S 30°19′E, Fig. 1). They were collected with a beach seine of fine mesh size or with gill nets at different periods of the day : 6h-7h (5 females (f), 4 males (m), 9h-10h (2f, 5m), 14h-15h (2f, 3m), 15h-16h (4m) and 17h-18h (5f, 8m).

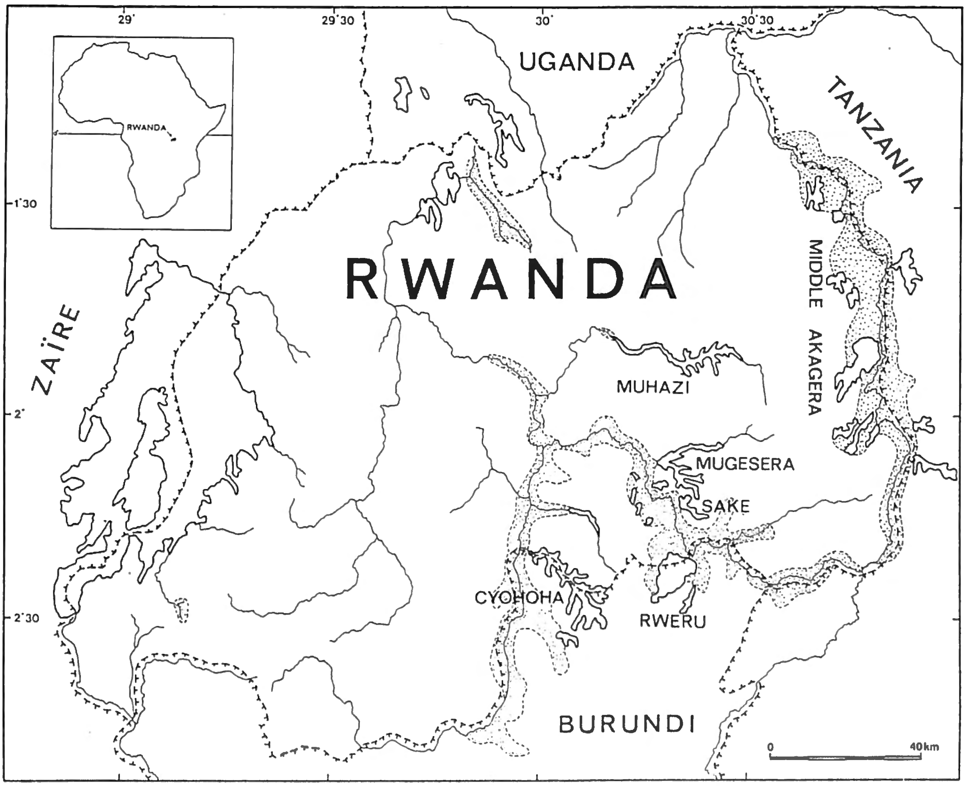

Fig. 1. — Map of Rwanda : the lakes of the Bugesera-depression. Dotted areas indicate swampy depressions.

After capture, they were immediately fixed in 4 % formaldehyde to stop digestion and transferred later into 70 % ethanol for preservation.

In this study no distinction is made between sexes nor catch periods : male as well female fishes of the five periods are pooled in one analysis in order to provide a general idea of the food of the species.

The chosen sample is homogeneous for total fish length (mean total length = 70 ± 0.3 mm), weight (mean weigth = 4.8 ± 0.1 g) and gut length (mean gut length = 157 ± 2.8 mm). Therefore there is no need to standardize the quantitative data generated by the numerical and the point methods in function of the gut lengths.

The captured fishes proved to be conspecific with *H. burtoni*. This is rather surprising as, up to now, this species was supposed to be endemic to the Lake Tanganyika area. In this area it inhabits shallow coastal waters, swamps and rivers. Nevertheless, after comparison with the reference material from this area, housed in the Koninklijk Museum voor Midden-Afrika in Tervuren, the Mugesera species showed to be identical with *H. burtoni* in all morphological aspects. It also exhibited two colour types, a blue and a yellow one in adult males, as is reported for the Tanganyika populations (see *e.g.* LOISELLE, 1975 ; FERNALD and HIRATA, 1979 ; CRAPON DE CAPRONA and FRITZSCH, 1985).

MATERIAL AND METHODS

We preferred to study both stomach and gut contents, because the data thus obtained are to a large extent complementary : (1) some food items are found only in the stomach because of their high digestibility (WINDELL and BOWEN, 1978) ; (2) the analysis of both zones offers the advantage of avoiding a possible bias of the results due to mechanical selective accumulation processes that may occur during the digestion (JANSSENS DE BISTHOVEN, 1987).

After their removal, the stomach and gut contents were transferred to microtubes in 70 % ethanol and stained with Rose of Bengal to provide an easy recognition of animal tissues. The samples were counted and identified under a light microscope in wet preparations.

The stomach and the gut of each specimen were kept apart and examined separately. For the quantification of each food item, data of all fishes were taken into account.

In order to quantify the food items, the numerical method (HYNES, 1950 ; BERG, 1979 ; HYSLOP, 1980), the method of percentage of occurrence (*e.g.*, used by BISHAI, 1977) and the method of points, proposed by OLATUNDE (1978) were used. The first method was applied to whole animal preys and hard fish structures : the items were counted and the summation over the entire sample was then divided by the total number of fishes. Thus for each food item a mean value per fish is obtained. The method of occurrences was applied to all the food items encountered, including uncounted items such as Protozoa, sand particles, minute setae of Oligochaeta, and Phytoplankton ; the occurrence values represent percentages of fishes containing these food items. The point method of OLATUNDE (1978) was modified to our purposes. We awarded each food item a defined number of points, depending on its estimated volume. These point values are therefore not a function of the degree of fullness of the stomach or the gut. Although the use of point methods in the analysis of stomach and gut contents was qualified by WINDELL (1968) as « a subjective allotment of points », we applied such method because no other valuable, easy, and fast alternative was available to quantify the food items in a volumetrical way. The method is applied to all food items, including those items, such as soft animal detritus, hard invertebrate remnants and plant material, that could not be numerically quantified. The results generated by the point method are afterwards condensed in seven food categories, in order to provide a general view of the food bulk. The (modified) point method of OLATUNDE (1978) allows to express the volumetrical significance of the food items in the total food bulk and is complementary to the numerical method.

FRYER and ILES (1972) found a relation between the relative gut length of cichlid species of Lake Tanganyika and their trophic niche : species with a relatively long intestinal tube showed a pronounced herbivorous or microphageous feeding habit, while species with a relatively short intestinal tube were rather carnivorous. ZIHLER (1982) qualified the so-called relative gut length (intestinal length/standard or total fish length) as a quite inappropriate value for comparison of the relative gut length between cichlid species, because of the occurrence of different body forms and thus of different allometric relations in the cichlid family. Therefore, this author suggested to use the « intestinal weight length » (IWL = intestinal length/$\sqrt[3]{\text{body volume or weigth}}$) because the volume or the weigth of fishes is less dependent on the body form. We nevertheless used the value generated by the mean gut length/mean total fish length, called « the Relative Gut Index » (RGI) by FRYER and ILES (1972), because the obtained value can be compared with RGI values of other cichlids, mentioned in FYER and ILES (1972). By using the RGI, a rough estimation of the trophic niche of *H. burtoni* can be made.

RESULTS

A. Data presentation :

The stomach and gut contents of *H. burtoni* quantified by the numerical method and the method of occurrence are condensed in Table 1. Only those food items scoring an occurrence percentage > 10 % in either stomach or gut, were taken into consideration. The other food items and the encountered Nematoda are mentioned in the text.

The following list discusses the food items found in *H. burtoni* and displayed in Table 1.

— Organisms : counted on the basis of entire animals or heads.

1. Copepoda : both nauplii and adults.
2. Rotifera : Brachionidae and other families.
3. Undetermined worms : wormlike structures.
4. Trichoptera : Leptoceridae. The cases are also ingested.
5. Hydracarina : only juvenile Hydrachnellae (A. FAIN, pers. comm.).
6. Chironomidae pupae : whole pupae or (paired) respiratory organs.

7. cf. *Tanypus* spp. larvae.
8. cf. *Pentaneura* spp. larvae.
9. cf. *Procladius* spp. larvae.
10. cf. *Glyptotendipes* spp. 4th instar. Only the fourth instar larvae of cf. *Glyptotendipes* are mentioned in Table 1 at the generic level. The other Chironominae growth stages are mentioned under the heading « undetermined Chironominae ».
11. Chironominae 4th instar : includes cf. *Glyptotendipes* larvae, *Chironomus* group *plumosus* larvae as well as 4th instar undetermined Chironominae larvae.
12. Undetermined Chironominae of 3rd instar.
13. Undetermined Chironominae of 2nd instar.
14. Undetermined Chironominae of 1st instar.

(15.) Total Chironominae : items 11-12-13-14.

— « Subunits » : parts of fish skeleton and other organic structures, individually counted.

16. Fish scales.
17. Plant seeds : Cyperaceae.
18. Invertebrate eggs.

— Uncounted items due to their microscopical size. Only the frequency of occurrence (%) is given.

19. Oligochaeta minute setae.
20. Phytoplankton : *Trachelomonas* sp., *Oscillatoria* sp., *Melosira* sp., *Microcystis* sp., *Merismopodia* sp., *Spirulina* sp., *Phacus* sp., *Pediastrum* sp., *Tetraëdon* sp., *Kirchneriella* sp., *Navicula* sp., *Cymbella* sp., *Pinnularia* sp. and *Nitzchia* sp. (N. PODOOR, pers. comm.).
21. Protozoa.
22. Mineral particles.

— Organic remnants expressed as occurrence percentages.

23. Soft animal remnants : weak structureless animal material having a fish or an invertebrate origin, half-digested remnants.
24. Hard insect remnants : hard chitinous invertebrate structures such as wings, mandibulae, maxillae, legs, antennae, etc.
25. Plant material.

Fig. 2 gives the relative importance of 7 food categories, representing the total food bulk, according to the point method. Both stomach and gut data are represented.

1. Zooplankton : Cladocera and Copepoda.
2. Ostracoda, Rotifera, Oligochaeta, undetermined larvae.
3. Diptera (pupae as well as larvae).
4. Ephemeroptera, Trichoptera, Hydracarina.
5. Animal remnants : soft animal remnants and hard chitinous structures. The soft animal remnants were quantified by counting light microscopical fields, which were then converted into point values. The chitinous structures, such as legs, mouth parts and antennae, were counted before converting them in point values. The remnants of insect carapaces were counted per encountered aggregation, before conversion into points.
6. Plant material : Macrophyta remnants and seeds were individually counted and computed in point values, according to their estimated volume.
7. Parts of fish skeleton : scales.

B. Results :

In 95 % of the guts, Chironominae larvae were found with a mean value of 44.5 larvae per fish. In the gut a high occurrence is reached by cf. *Glyptotendipes* spp. larvae (occ. % of 4th instar larvae = 21 %), chironomid pupae (occ. % = 55 %), and 1st, 2nd, 3rd and 4th instar undetermined Chironominae.

TABLE 1

Stomach and gut contents of H. burtoni (n = 38) : N = data according to the numerical method in absolute values. OCC % = data according to the method of percentages of occurrence

FOOD ITEM	STOMACH		GUT	
	N	OCC %	N	OCC %
01 Copepoda	0.1	13	0.4	18
02 Rotifera	3.0	21	21.0	55
03 Undeterm. worms	0.1	3	0.4	13
04 Trichoptera	0.1	3	0.4	18
05 Hydracarina	1.5	3	1.0	28
06 Chironom. pupae	0.4	21	1.8	55
07 cf. *Tanypus* spp.	0.1	13	0.2	18
08 cf. *Pentaneura* spp.	0.03	3	0.6	13
09 cf. *Procladius* spp.	0.0	0	0.5	28
10 cf. *Glyptotendipes* spp. 4th instar	0.5	24	1.2	21
11 Chiron. 4th instar	1.2	42	2.0	58
12 3rd	2.3	47	10.0	87
13 2nd	2.5	53	21.2	89
14 1st	6.7	55	11.3	92
15 Total Chironominae	12.7	92	44.5	95
16 Fish scales	0.1	30	0.1	10
17 Plant seeds	0.2	5	3.0	28
18 Invertebr. eggs	0.2	8	0.7	13
19 Oligoch. setae	—	3	—	21
20 Phytoplankton	—	5	—	37
21 Protozoa	—	present	—	present
22 Mineral particles	—	60	—	84
23 Anim. soft remnants	—	58	—	92
24 Ins. hard remnants	—	16	—	32
25 Plant remnants	—	87	—	100

Less than 10 % of the fishes contained *Chironomus* group *plumosus*, and this at very low rates. Therefore it is probable that the majority of the undetermined Chironominae larvae are also belonging to the genus cf. *Glyptotendipes*.

13 to 28 % of the guts contained cf. *Tanypus* spp., *Pentaneura* spp. and cf. *Procladius* spp. larvae (Chironomidae, Tanypodinae). However, Chironominae are more abundant than Tanypodinae larvae.

Among the non-Diptera organisms, the Rotifera are numerically the dominant prey. Their mean numerical value is relatively high in the gut (n = 21) (stomach occ. % = 21 %, gut occ. % = 55 %) (Table 1).

The occurrence of the following food items varies in stomach or gut between 13 % and 30 % : Hydracarina, Trichoptera larvae, Copepoda, Oligochaeta (« minute » setae), plant seeds and phytoplankton (predominantly *Microcystis* sp.) and undetermined wormlike structures. A number of prey are only rarely present in the digestive tract and are not given in Table 1. Their mean values do not exceed n = 1 and the occurrence percentage lies below 10 %. These prey are : Cladocera, *Chaoborus* larvae and pupae, *Chironomus* group *plumosus* larvae, Ostracoda, Ephemeroptera nymphs, case structures of unknown origin, Lepidoptera scales and Tardigrada.

The only fish remnants encountered are ctenoid fish scales. No attempt was undertaken to clarify the origin of the scales, since only a very small number was found.

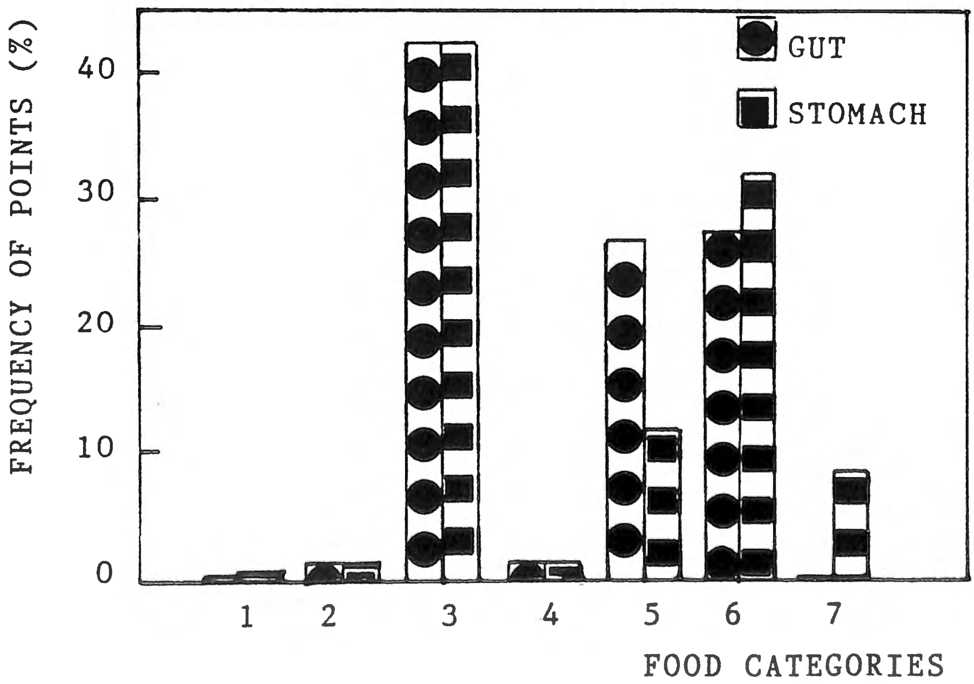

Fig. 2. — Stomach and gut contents of *H. burtoni*. Relative importance of the food items represented in 7 food categories and expressed as volume % of the food bulk in the respective zones, according to the method of points. Food category 1 = zooplankton ; 2 = Ostracoda-Rotifera- Oligochaeta- undetermined larvae ; 3 = Diptera ; 4 = non-Diptera Arthropoda ; 5 = animal remnants ; 6 = plant material ; 7 = fish scales.

When looking at the relative volume of the food items in the total food bulk (Fig. 2), macrophytes and animal remnants (soft animal remnants as well as hard invertebrate structures, cfr. *supra*) represent each 25 % of the food volume in the gut.

Diptera are the main prey types, scoring 43 % of the food volume in both zones, while the other animal prey each represent less than 3 % of the total food volume.

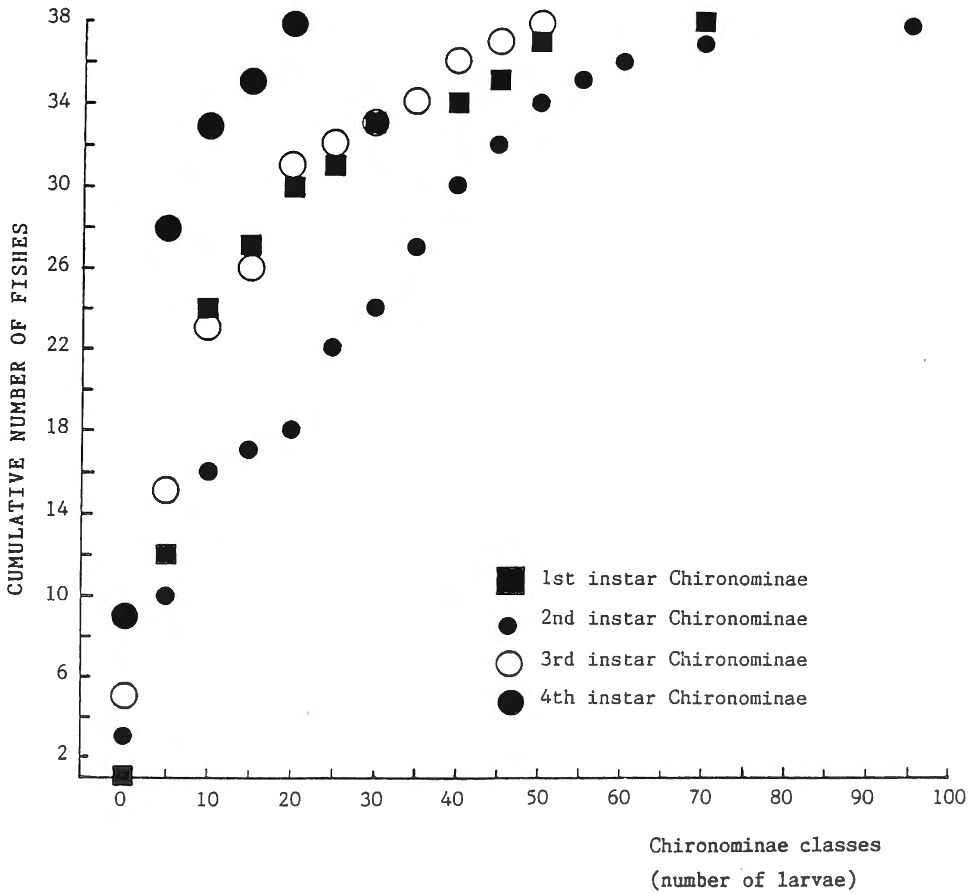

Fig. 3. — Graphical representation of the ingestion frequency of the four Chironominae growth stages in *H. burtoni* (illustration of the non-parametrical Smirnov test). The abcissa generates classes of each 5 midge larvae, from 0 (first class) to 96-100 larvae (last class). In the ordinate are given the 38 fishes. The graph represents the number of fishes (in a cumulative way) containing consecutively 0 larvae of each growth stage, 1 to 5 larvae of each growth stage, 6 to 10 larvae etc. until the maximum is reached.

Although the percentages of occurrence of the four Chironominae larval stages are higher in the gut than in the stomach (which is a general trend in our data, due to the larger gut volume), their mutual order is similar in both zones. In order to assess if the fishes do predate more frequently on one or another growth stage, all Chironominae larvae of stomach and gut are taken into account in the non-parametrical one-way Smirnov test (CONOVER, 1980). The one-way Smirnov test showed that second instar larvae are consumed significantly more ($P < 0.025$) than the other growth stages and the fourth instar larvae less (Fig. 3).

Finally the presence of parasitical Nematoda in both stomach ($n = 1.5$; occ. = 32 %) and guts ($n = 0.5$; occ. = 28 %) is noted. Two forms are encountered : the adult stage of *Rhabdochona (?) pasci* BAYLIS, 1928 and the juvenile stage of Dioctophimatidae cf. *Eustrongylides* JÄGIRSKIÖLB, 1909 (F. PUYLAERT, pers. comm.).

The Relative Gut Index of the analysed population of *H. burtoni* is 2.24.

DISCUSSION

H. burtoni is considered to be a species endemic to Lake Tanganyika and the rivers associated with this lake (GREENWOOD, 1979).

Therefore it is rather surprising to find this species in Lake Mugesera (Rwanda), a part of the Akagera system, which is clearly separated from the Tanganyika system.

In this area, *H. burtoni* has also been collected in Lake Cyohoha, Sake, Rweru and the smaller lakes in between. However, the species is not found upstream in Lake Muhazi, nor downstream in the depression of the Middle-Akagera river (see Fig. 1).

Two hypotheses could be postulated to explain this distribution. Firstly, the presence of *H. burtoni* could be regarded as a remnant of an earlier local connection between the two systems (Tanganyika and Akagera). However, there is no other ichthyogeographical evidence to confirm this thesis. Secondly, more likely, the presence of *H. burtoni* in the Akagera system could be a byproduct of the introduction of an allochtonous fish species. Unregistered introductions and transfers, mainly involving *Tilapia*-species, have been made quite frequently in Rwanda (see *e.g.* DE VOS *et al.*, in press).

Concerning the food of *H. burtoni,* until now almost no data were reported, except for some data from POLL (1953), who characterized the species as omnivorous, with as stomach and gut contents fish bones, insect larvae, Diatomeae, filamentous algae, undetermined plant detritus and sand particles. We found all these items in our study too. The fact that we found a high occurrence of mineral particles in the digestive tract indicates that the fish is a benthic feeder.

Following the Relative Gut Index (RGI) scale applied to the cichlid fishes of Lake Tanganyika (FRYER and ILES, 1972), *H. burtoni* has a RGI value of 2.24 which lies between the typical values found in omnivorous cichlids (RGI = 0.8-3.2) and those of herbivorous cichlids (RGI = 1.7-8.0) of Lake Tanganyika.

H. burtoni shows a wide prey range. The numerically dominant prey are Chironominae larvae and pupae (especially cf. *Glyptotendipes* spp.), and Rotifera. Since a large part of the food bulk is composed of plant material, it seems quite probable that some prey species (*e.g.* Rotifera and Chironomini larvae) are associated with macrophytes and thus ingested at the same time. Therefore we may assume that *H. burtoni* is feeding as well on a benthic (mineral) substrate as on an organic substrate (plants in a detrital or living form). Since Diptera larvae represent more than 40 % of the mean food volume in stomach and gut, *H. burtoni* can be characterized as a predominantly insectivorous fish.

A large amount of animal and vegetal detritus in the food bulk also indicates a detritivorous behaviour.

Finally, the presence of zooplankton, such as Cladocera, Copepoda and *Chaoborus* larvae (partially planktonic), as well as the presence of plant seeds in the food bulk, emphazises again as well the omnivorous, as the detritivorous character of the species.

As IVLEV (1961) pointed out, more investigations on the abundance and the availability of the prey, and on the use of space and time by the fishes is needed to achieve a better understanding of their trophic ecology. A factor analysis on the same data (JANSSENS DE BISTHOVEN and OLLEVIER, 1988) suggests a day-time dependent feeding behaviour of the fishes and a possible trophic niche difference between male and female fishes.

In order to assess whether the prevalence in uptake of second instar Chironominae larvae over the other growth stages and of Chironominae over Tanypodinae would be a result of selective feeding or of a higher availability of these larvae in the environment, a quantitative study of the benthos is needed.

CONCLUSIONS

Haplochromis burtoni (GÜNTHER, 1893) is an omnivore : it is a benthic insectivore as well as a detritivore. Its volumetrically dominant food items are Chironominae larvae (mostly larvae of cf. *Glyptotendipes* spp.), and macrophytes. Rotifera are numerically abundant, but their relative volume in the food bulk is not large. The presence of plant seeds and zooplankton emphasizes the omnivorous character of the species.

The capture of *H. burtoni,* a species believed to be endemic to the Lake Tanganyika system, in the Akagera system may be explained as a by product of introductions of *Tilapia* species in the area.

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