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# A CONTRIBUTION TO THE STUDY OF THE FOOD OF SIX CYPRINID FISHES IN THREE AREAS OF THE LAKE VICTORIA BASIN, EAST AFRICA

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## Abstract

An account of the food of six species of cyprinid fish from the Lake Victoria basin is given. All the species studied possess tubular stomachs and analysis was carried out on entire guts, the relative importance of the various dietary items being assessed by the frequency occurrence method. Results indicate that these species are omnivorous, and their food ranges from debris, diatoms through algae, insect larvae to molluscs. Comparison of the food of *Barbus* spp. from the lake and river shows that riverine fish ingest more plant material than lake fish.

## Introduction

Apart from the information contained in the general survey of the fisheries of Lake Victoria (Graham, 1929), the only major contribution to the study of the food of the non-cichlid fishes of the African continent has been that of Corbet (1961). Other published works include descriptive studies made by EAFFRO (Annual Reports 1949-53), McDonald (1956), Munro (1967), Okedi (1971) and Blake (1977) on the food of mormyrids. Investigations made by Welcomme (1969) on the fish ecology of a seasonal stream include general observations on the food of some cyprinids. However, cyprinids, particularly *Barbus* spp. which are by far the most successful in terms of numbers and species in the affluent rivers of Lake Victoria such as the Nzoia, Kagera and Yala, have been little studied. Although *Barbus* spp. do not frequently feature in the fish markets around the Lake, they form a major subsistence activity of the inland river fishing communities. Whitehead (1960) suggested that they may, also, be of some value in the biocoeneses of rivers and floodwater pools where predators such as *Clarias* are caught in large numbers on their spawning runs.

This paper is an attempt to provide more information on the food of the non-cichlid fishes particularly the cyprinids of River Nzoia, Napoleon Gulf and Bugungu stream of the Lake Victoria basin. An attempt is also made to compare the food of the *Barbus* spp. in the riverine and lacustrine habitats.

It has been pointed out (Corbet, 1961) that more studies of the food of non-cichlid fishes should be made in order to help establish the ecological relationships among fish species of the basin especially with the introduction of the large predatory *Lates niloticus* (Nile Perch).

In 1976, EAFFRO initiated follow-up investigations of the work which had been little covered by earlier research projects. The work presented here started with a survey of the fisheries of River Nzoia. It became clear that among the fishes collected (Appendix 1), the cyprinids had received very little attention in the past. It was therefore, decided that attention be focussed on *Barbus* spp.

Greenwood (1966) reported that more species have been referred to *Barbus* than to any other freshwater non-cichlid genus in Africa and that because of the high intraspecific variability in the genus, many so-called species should be considered as geographical variants. Whitehead (1960) has described three new species of *Barbus* viz. *Barbus nyanzae, Barbus cercops* and *Barbus yongei* while another species, originally described as *Barbus radiatus profundus* Greenwood is now referred to simply as *Barbus profundus.* These species in addition to, *B. altianalis,*

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*B. kerstenii, Barbus paludinosus* were among material studied.

Because of the limited number of trips made (2) and therefore of specimens at hand, additional material was collected from two other areas; it was not possible to get enough material of *B. nyanzae* for this study. It is therefore suggested that the present work should at best be regarded as preliminary.

**Study areas**

The areas studied consisted of River Nzoia, the northern part of Lake Victoria forming Napoleon Gulf and a small stream called Bugungu or Kafunta (see Fig. 1).

*River Nzoia*
This is the largest of the westward flowing rivers affluent to Lake Victoria. Arising on the easterly slopes of Mt. Elgon, it enters the lake at Port Victoria. It is subject to heavy seasonal flooding particularly in its lower course. It is rocky and sandy for most of its course.

*Napoleon Gulf*
This is about 2.0 km wide and forms the headwaters of the River Nile. After exceptionally heavy rains between 1961 and 1964, the shoreline of this gulf became indented with a number of shallow and weedy lagoons. Except for these lagoons and the offshore zone, the bottom of the gulf can be described as sandy and rocky (hard).

*Bugungu (Kafunta) stream*
This is a seasonal stream whose course only becomes distinct from its swampy environment during the rains. It has been artificially altered by channels which serve irrigation purposes of a prison farm nearby. The fish ecology of this stream has been dealt with by Welcomme (1969).

**Materials and methods**

In the present study the following species were examined for gut contents:
*Barbus altianalis* Worthington
*Barbus paludinosus* Peters
*Barbus kerstenii* Peters
*Barbus cercops* Whitehead
*Barbus yongei* Whitehead
*Barbus profundus* Greenwood

The fishes were obtained from each of the three study areas (Fig. 1) as described below:

*River Nzoia*
A fleet of multifilament gill nets ranging in mesh size from 25.4 mm to 127.0 mm (1″ to 5″) was used at the river mouth (Port Victoria). Nets were set in the afternoon and lifted in the early morning hours. Many specimens of the relatively big *Barbus altianalis,* and *Barbus kerstenii* were collected in this way.

A mosquito seine net was used for the rest of the other sampling sites along River Nzoia. The choice of these sites was governed partly by a suitable shore and bottom for seining, and, their accessibility from land. This method yielded most of the material included in the appendix. It was thus possible to obtain the smaller *Barbus* spp. such as *Barbus kerstenii, Barbus profundus, Barbus cercops* and *Barbus yongei.*

*Bugungu (Kafunta) Stream*
Some collections mainly of *B. kerstenii* were made from this stream. These were collected using a small hand-made lift net and a seine net.

*Napoleon Gulf*
Additional material of *Barbus altianalis* was collected aboard the EAFFRO research vessel, m.v. 'IBIS' by trawling.

After basic biometric data had been taken, the size of each fish being expressed as the 'total length' (distance from snout to end of candal fin), samples of fish specimens were identified from EAFFRO Laboratories using from snout to end of candae fin), samples of fish specimens were identified from EAFFRO Laboratories using keys by Boulenger (1915), Greenwood (1966) and Whitehead (1960). Some specimens were sent to The British Museum (Natural History) for confirmation of these identifications and retention.

Because of the size of the stomach compared to the rest of the alimentary canal in these species the contents of the whole gut were examined. Further, the semi-tubular morphology of the stomach even when containing food (Fig. 2) makes little distinction between the stomach and the gut.

The occurrence method (the number of fish in which each food item occurs is listed as a percentage) (Hynes, 1950), proved to be the most suitable and was therefore used. This method proved to be suitable as Hynes (1950) points out that,

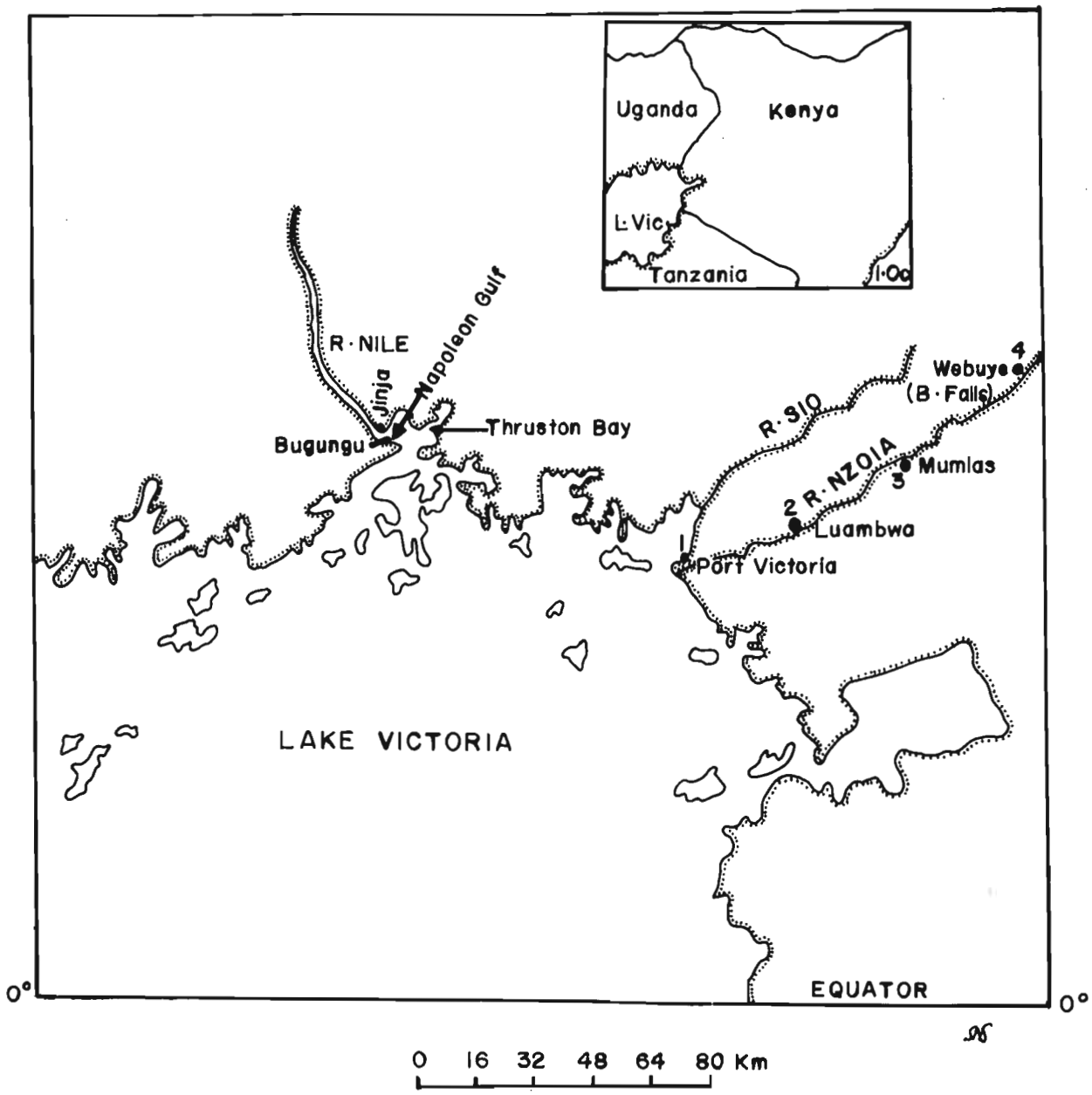


Fig. 1. Map of part of The Lake Victoria basin showing sampling areas, and (inset), location of Lake Victoria.

(i) for any fish with a generalized diet, provided a large number of specimens is examined, any of the commonly accepted methods (e.g. occurrence, number, volumetric and points methods) of assessing the composition of the diet of fish from gut contents would give substantially the same result, the main food items standing out clearly.

(ii) the number method distorts the result for a fish species which eats large numbers of a particularly small species, and

(iii) allocation of points for food items of fish like Cyprinidae which chew their food and possess an elongate U-shaped stomach, is difficult.

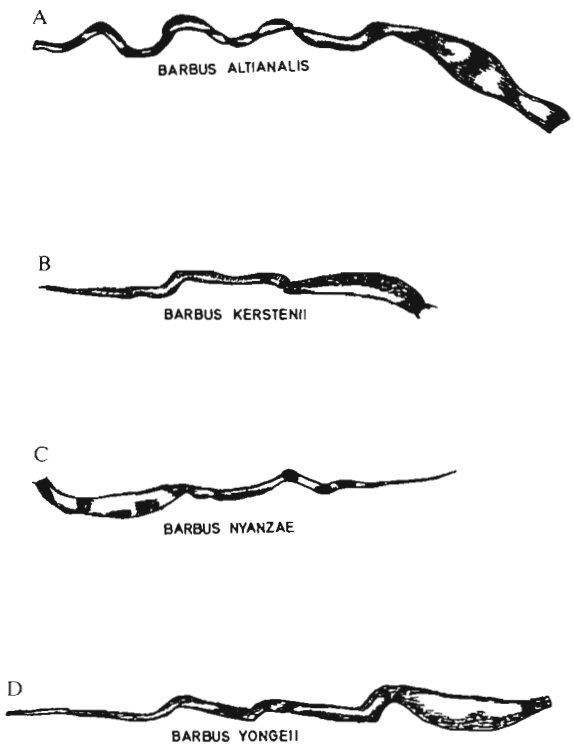


Fig. 2. Morphology of intestinal tracts in some *Barbus* spp.
A. Stands for *Barbus altianalis*
B. Stands for *Barbus kerstenii*
C. Stands for *Barbus nyanzae**
D. Stands for *Barbus yongei*

* Not part of the study but possesses a more or less similar intestinal arrangement to the other *Barbus* spp. Intestinal tracts of *B. paludinosus, B. profundus* and *B. cercops* are not illustrated.

From the above points and the morphology of the guts of *Barbus* spp. (Fig. 2), the occurrence method proved to be the most suitable. It soon became clear that quantitative results of microscopic food items or of stomachs containing only traces and remains of food in different stages of digestion would be misleading. Special attention was paid to looking for as many dietary items as facilities could allow. This involved washing out the guts or sections showing food through their walls and observing the stirred suspension under a dissecting microscope of magnification up to 40. Slides were also prepared for viewing under a light microscope, sometimes with an oil immersion lens. In this way, a lot of food material ranging in size from insects to diatoms respectively could be identified.

## Results

Various food types were found. These were grouped into closely related categories as annotated below:

(a) Algae: Includes both filamentous and non-filamentous forms. Of these, the filamentous type tended to be more common.

(b) Higher plant material: Sections of plant cells that could have been bitten off plants.

(c) Insect remains: Both aquatic and terrestrial forms. Includes Diptera, Trichoptera, Odonata (Anisoptera and Zygoptera) and other insects whose orders could not be readily discerned. The stomachs frequently contained insect mouthparts, limbs, thoracic and abdominal segments and remains of wings.

(d) Ephemeroptera: Free living nymphs belonging to Beatidae and Caenidae. Identified from the three long and segmented filaments at the end of the abdomen. Ephemeroptera only occurred in *Barbus altianalis* from the lake (Napoleon Gulf).

(e) Insect larvae Mainly Chironomidae and occasionally Chaoboridae.

(f) Debris: Comprises sand grains, small stones or pebbles and unidentifiable organic matter.

(g) Molluscs: Only bivalves and gastropods. Gastropods always predominated in such a diet.

(h) Other organisms: Includes blue-green algae such as *Anabeana* and *Microcystis,* and protozoa and desmids. Also found and grouped under this category are copepod crustaceans which occurred in a few *Barbus profundus.*

The percentage occurrences of the above food types in the fishes examined are displayed in Table 1.

*The food of Barbus spp:*

It can be seen from the table that most of the food types are utilized by all the six species albeit to varying degrees.

(i) *Barbus altianalis:* In River Nzoia, the gut contents of this species show a diet predominated by algae and followed by higher plant material. Insects form the third most common food type.

In the lake, the gut contents of *Barbus altianalis* indicate a diet heavily centred on molluscs. Other items which may be ingested with more or less the same frequency are insects, Ephemeroptera, insect larvae and debris.

It is noteworthy that whereas gut contents of lake *Barbus altianalis* contained molluscs and Ephemer-

TABLE 1: % OCCURRENCE OF VARIOUS FOOD TYPES IN SIX MEMBERS OF BARBUS FROM THE AREAS INVESTIGATED

| | B. altianalis | | B. kerstenii | | B. paludinosus | B. profundus | B. cercops | B. yongei |
|---|---|---|---|---|---|---|---|---|
| Areas* Food type: | A | B | C | A | A | A | A | A |
| Algae | 100 | 16.2 | 65.5 | 7.7 | 50 | 28.6 | 30.8 | 45.5 |
| Higher Plant material | 65 | 13.9 | 6.0 | 65.7 | 30.4 | 4.8 | 22.4 | 63.6 |
| Insect larvae | 5 | 45.9 | 3.4 | 3.8 | 21.3 | 69.0 | 3.5 | 4.5 |
| Ephemeroptera | - | 59.4 | - | - | - | - | - | - |
| Insect remains | 45 | 64.8 | 65.5 | 7.7 | 30.4 | 19.0 | 72.4 | 45.5 |
| Debris | 20 | 43.2 | 58.6 | 76.9 | 43.5 | 14.3 | 20.9 | 86.4 |
| Molluscs | - | 94.6 | 10.3 | - | 2.2 | - | - | - |
| Other Organisms | 20 | 2.7 | 17.2 | - | 4.3 | 47.6 | 17.2 | 40.9 |
| Number examined | 20 | 37 | 29 | 26 | 46 | 21 | 58 | 22 |
| Size range (T.L. in cm) | 7.9-26.0 | 8.0-31.0 | 4.0-9.1 | 5.2 - 8.8 | 8.5-12.3 | 3.1-7.0 | 3.0-8.0 | 3.0-4.4 |

Areas* A = Nzoia, B = Napolean Gulf (L. Victoria), C = Bugungu Stream

optera river fish did not. River fish also tend to ingest more algae and higher plant material than lake fish.

(ii) *Barbus kerstenii:* The samples analyzed (Table 1) show that in the river *B. kerstenii* feeds mainly on debris. Plant material may also be important in the diet. The two (plant material and debris) appear to form the main food of this species.

In Bugungu Stream, the gut contents of *Barbus kerstenii* indicate a diet that includes insects and algae as the main foods. Also taken are debris, and some molluscs as by *B. altianalis* in lacustrine, environments.

(iii) *Barbus paludinosus:* Results show that the diet of this species in the river habitat is centred around algae, debris, plant material, insects and insect larvae. Molluscs and other items seem to play a minor role in the diet of *B. paludinosus.*

The food of *Barbus profundus, Barbus cercops* and *B. yongei* is here described for the first time.

(i) *Barbus profundus:* The diet of this species in the river is composed mainly of insect larvae. Other organisms (copepod crustaceans, diatoms and desmids) are also taken. Adult insects, algae and debris seem to be supplementary to a main diet of insect larvae.

(ii) *Barbus cercops:* Data in Table 1 show that insects are by far the most important food items ingested by this species in the river habitat. Also ingested are algae and debris. Other organisms play a minor role in the diet of this species.

(iii) *Barbus yongei:* Debris occurred most frequently in the guts of the specimens examined (Table 1) and are followed by higher plant material. Algae, insects and other organisms also play a significant role in the diet of this species.

It will be seen from the table that most of the eight food categories are utilized by most of the species. The table also shows that no one food type is utilized to the same extent by more than one species. *Barbus altianalis* from the lake displays the most generalized diet, taking in varying proportions of all the eight food types. *B. kerstenii* from the stream displays a more or less similar pattern as does *B. paludinosus* from the river.

## Discussion

Considering that the various food items consumed by the *Barbus* species studied have only been grouped into

closely related categories (food types) in order to minimize erroneous taxonomic treatment of prey organisms, it can be realised that the data (Table 1) actually cover a wider spectrum and most foods are utilized. The ingestion of a wide range of food organisms indicates versatile feeding habits. This versatality is seen more clearly in *Barbus altianalis* from the lake and river. Graham (1929) and Corbet (1961) found that molluscs form the main food of *B. altianalis* in the lake. In the present study, it was confirmed further that molluscs predominated in the gut contents of lacustrine *B. altianalis*. Molluscs were followed by insects remains and Ephemeroptera. On the other hand, the main food of *B. altianalis* from the river was found to be algae and higher plant material. This change from one food type in one habitat to a different type in another is especially necessary for the survival of this species which migrates up affluent rivers for breeding purposes. Algae and higher plants are likely to be more abundant in riverine than in lacustrine habitats. It is therefore unlikely that algae and higher plants can be limiting in riverine conditions, rather, animal life might be more restricted.

*Barbus kerstenii* and *B. paludinosus* in the river also rely to some extent on algae and higher plants. Welcomme (1969) suggested that plant material probably contributes little to the food of *B. paludinosus* and *B. kerstenii* because cells of the ingested filamentous algae were unchanged during their passage through the gut. Bourn's (1974) investigations of the fishes of Lake Chilwa revealed a mainly zooplankton and non-filamentous algal diet of *Barbus paludinosus*. In the present study, besides confirming that riverine fish ingest more plant material than lake fish as reported by Welcomme (op cit.), it is suggested that algae may actually be utilized as food, as has been demonstrated by Gunn *et al.* (1974). A look at the figures for *Barbus altianalis* in Table 1 would seem to indicate that riverine fish selected for algae instead of molluscs. The data in the table also indicate that algae and higher plants play some role in the diet of all the species studied.

The presence of debris in the gut contents indicates a detritus-based diet. It is likely that debris are an important source of nutrient for the *Barbus* spp. as they usually consist of unicellular algae and protozoa. Debris could also help in the digestion of the algae.

Most of the *Barbus* spp. studied can be said to include more or less the same food types in their diet. This tends to obscure any trophic divergence within the members. Hence, it is difficult to group the species studied into specific trophic classes; no species can be said to have clearly diverged as to occupy a separate ecological niche.

On the basis of Corbet's (1961) classification of aquatic habitats, it will seem that the *Barbus* spp. studied can indeed co-exist. This takes place usually in rivers and streams where resident species like *Barbus kerstenii, B. cercops, B. yongei* are joined by the migrants *Barbus altianalis* and *B. paludinosus* while on their spawning runs. This co-existence is probably made convenient for the species by a superabundant and readily available food supply. However, the total environmental conditions which we do not yet know could be playing a major role in the co-existance of these closely allied species. It is therefore difficult to conclude that these species compete for food resources.


## Summary

It is shown that six members of *Barbus* spp. seem to rely to a large extent on the same food resources. These resources cover a wide spectrum and the feeding of *Barbus* spp. indicates that the species are versatile feeders, utilizing favoured foods when they are available and changing to others when occasion demands. Riverine fish ingest more plant material than lake fish and it is suggested that algae may actually be utilized as fish food. It is also suggested that the digestion of algae may be facilitated by debris, a kind of food favoured by some *Barbus* spp. None of the species in the study seem to have clearly diverged as to occupy a separate ecological niche. It is suggested that the co-existance of such closely allied species may be possible in an environment with a superabundant and readily available food supply. However, the total environmental conditions which are not yet known could be controlling the numbers, temporal and spatial distribution of these species.



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Appendix 1:

Systematic list of fish species recorded from River Nzoia during the study:

Greenwood's classification (1966) is followed here.

| | |
|---|---|
| Order: | Isopondyli |
| Suborder: | Mormyroidea |
| Family: | Mormyridae (Elephant-snout fishes) |
| Genus: | *Mormyrus* Linnaeus, 1758 |
| | *Mormyrus kannume* Forsk |
| Genus: | *Marcusenius* Gill, 1862 |
| | *Mercusenius graham* Norman |
| Genus: | *Petrocephalus* Marcusen, 1854 |
| | *Petrocephalus catostoma* Gunther |
| Genus: | *Gnathonemus longibarbis* Hilgend |
| Order: | Ostariophysi |
| Suborder: | Cyprinoidea |
| Family: | Cyprinidae (carps) |
| Genus: | *Barbus* Cuiver and Cloquest, 1816 |
| | *Barbus altianalis* Worthington |
| | *Barbus paludinosus* Peters |
| | *Barbus kerstenii* Peters |
| | *Barbus cercops* Whitehead |
| | *Barbus nyanzae* Whitehead |
| | *Barbus profundus* Greenwood |
| | *Barbus magdalene* Blgr. |
| | *Barbus yongei* Whitehead |
| | *Barbus jacksonii* Gunther |
| | *Barbus radiatus* Peters |
| Genus: | *Labeo* Cuvier, 1817 |
| | *Labeo victorianus* Blgr. |
| Family: | Characidae (Tiger-fishes) |
| Genus: | *Alestes* Muller and Iroschel, 1846 |
| | *Alestes nurse* (Ruppell) |
| | *Alestes jacksonii* Blgr. |
| | *Alestes* sp. (probably *A. macrolepidotus)* |
| Suborder: | Siluroidea (cat-fishes) |
| Family: | Bagridae |
| Genus: | *Bagrus* Cuvier 1817 |
| | *Bagrus docmac* (Forsk.) |
| Family: | Clariidae |
| Genus: | *Clarias* Scopoli, 1777 |
| | *Clarias mossambicus* Peters |
| | *Clarias* sp. (probably *C. alluadi*) |
| Family: | Mochokidae |
| Genus: | *Synodontis* Cuvier, 1817 |
| | *Synodontis victoriae* Blgr. |
| | *Synodontis afrofischeri* Hilgend |
| Family: | Amphiliidae |
| Genus: | *Amphilius* Gunther, 1864 |
| | *Amphilius* sp. (probably *A. platychir*) |
| Order: | Percomorphi |
| Suborder: | Percoidea (perch-like fishes) |
| Family: | Cichlidae* |
| Genus: | *Tilapia* Smith, 1840 |
| | *Tilapia esculenta* Graham |
| | *Tilapia zillii* Gervais |
| | *Tilapia leucostica* Trewavas |
| | *Tilapia variabilis* Blgr. |
| Genus: | *Haplochromis* Hilgendorf, 1888 |
| | (About four species. Identification was not worked out). |

Order: Opisthomi
Family: Mastacembelidae (Spiny eels)
Genus: *Mastacembelus* Scopoli, 1777
*Mastacembelus frenatus* Blgr.

* Also described for the first time and left out of the systematic list were: *Pseudocrenilabrus multicolor* specimens.