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FEEDING HABITS OF THE NILE PERCH, *LATES NILOTICUS* (L.) (PISCES: CENTROPOMIDAE) IN LAKE CHAMO, ETHIOPIA

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ABSTRACT: Diet composition and ontogenetic diet shift of the Nile perch, *Lates niloticus* (L.) were studied from 411 fish samples (1.9 cm to 192 cm TL) collected from February 1995 to May 1996. Most fish samples (n=221, 53.8%) had empty stomachs. Except the two smallest fry (1.9 cm and 2.3 cm TL) fish samples (n=188) that contained food in their stomachs consumed only fish. The cyprinid fish *Labeo horie* (Heckel) was the most important prey organism of juvenile and adult *L. niloticus* and occurred in 49.4% of the stomachs examined, constituted 38.02% of the total number and 70.44% of the total volume of the prey. *Oreochromis niloticus* (L.) occurred in 22.35% of the stomachs accounted for 19% of the total number and 24.82% of the total volume of food consumed. *Hydrocynus forskahlii* (Cuvier) occurred in 14.12% of the stomachs, constituted 9.92% of the total number and 2.72% of the total volume of prey consumed. Cannibalism was observed in 19.4% of juvenile fish (n=62, 48.5–73.2 cm TL) and smaller *L. niloticus* constituted 26.1% of the total volume of food consumed within this size range. *H. forskahlii*, *O. niloticus* and *L. niloticus* were the main prey of fish <90 cm TL while *L. horie* was important prey of fish >90 cm TL. Based on index of relative importance (IRI) *L. horie* was the most important prey (5359) followed by *O. niloticus* (979), *L. niloticus* (392) and *H. forskahlii* (178.5). Fry and fingerlings of *L. niloticus* (n=20) ranging from 1.9 to 7.1 cm TL were caught using a beach seine of 6 mm mesh size. The two smallest fish (1.9 cm and 2.5 cm TL) had eaten insect larvae while the remaining 18 fish had all eaten 1–3 fry of *O. niloticus* that ranged from 0.8 to 1.9 cm TL.

Key words/phrases: Cannibalism, diet composition, *Lates niloticus*, ontogenetic diet shift, predation

INTRODUCTION

The Nile perch, *Lates niloticus* (L.) is a predatory freshwater fish widely distributed in Africa in the Niger, Zaire and Nile River Basins including Lakes Chad, Albert, Turkana (Robins *et al*., 1991). In Ethiopia its distribution is restricted to the Baro River Basin in the West, the Omo River Basin and the Ethiopian Rift Valley Lakes Abaya and Chamo in the south.

Knowledge of the biology of *L. niloticus* in African water bodies is limited. Several investigators reported the diet and feeding habits of *L. niloticus* in Lake Victoria (Okedi, 1970; Okemwa, 1983; Acere, 1985; Ogari and Dadzie, 1988). These authors reported *Haplochromis* as the main component of the diet of *L. niloticus* in Lake Victoria. Schilbeids were the most important prey organisms of adult *Lates* in Lakes Chad whereas in Lake Turkana, cyprinids and cichlids were important prey organisms of the fish (Hopson, 1972; 1982).

During the early 1990s there had been huge increases in fishing effort and production of fish from the inland water bodies of Ethiopia. Between 1992 and 1997, the total production increased by 220% (from 3,250 to 10,400 tones) (Reyntjens and Tesfaye Wudineh, 1998). The most dramatic increase in fish landings occurred in Lake Chamo, where there had been a ten-fold increase just in four years (Reyntjens and Tesfaye Wudineh, 1998). As a result of this fishing pressure stock of *L. niloticus* in Lake Chamo has declined sharply. Consequently, all fishing activities for *L. niloticus* have been banned in order to allow the rehabilitation of the stock.

So far no study has been conducted on the feeding habits of the Nile perch in Lake Chamo. The objective of this study was, therefore, to provide basic information on the food habit of *L. niloticus* in Lake Chamo. Information on the feeding habits is important to understand the trophic status of the stock.

MATERIALS AND METHODS

Study site

The lakes of the Ethiopian Rift system are located in southern part of the country in three separate internal drainage basins, the Ziway-Shala, the Awassa-Shallo and the Abaya-Chamo basins (Elizabeth Kebede *et al*., 1994; Fig. 1a, b). The Abaya-Chamo basin is part of a much larger drainage basin that includes Lakes Chew Bahir (formerly Lake Stephanie) and Turkana (Von Damm and Edmond, 1984).

Lake Chamo (5°42´–5°58´ N and 37°27´–37°38´E) is located at about 515 km south of the capital city Addis Ababa and lies at an altitude of 1108 m. It has a surface area of approximately 551 km^2 and a maximum depth of 16 m (Amha Belay and Wood, 1982). During the past three decades the water level of the lake has declined considerably and this resulted in significant shrinkage of the lake's surface area. According to the recent mapping of the lake (Ethiopian Mapping Agency, 1988; Scale: 1:50,000), its surface area has declined to about 335 km^2.

Lake Chamo lies to the east of the Precambrian block of the Amaro Mountains, within the less intensely faulted basin (Mohr, 1962). The main inlet of the lake is Kulfo River, which flows in at the north end of the lake and the less important feeders are Sile and Sago Rivers entering from the west (Fig. 1c). A broad channel connects Lake Chamo to the Segen River, which rises close to the eastern corner of the lake. Previously Segen River was used as the outlet of Lake Chamo in periods of high water level. At present, the water level of the lake is lower than that of the outlet channel, thus the lake has no obvious surface outlet.

The morphometric, physical and chemical characteristics of Lake Chamo are given (Elizabeth Kebede, *et al*., 1994). Sodium is the dominant cathion while carbonate and bicarbonate are the dominant anions. The concentration of S_iO^2 in Lake Chamo has decreased consistently over the years from 28 mg l^{-1} in 1964 (Wood and Talling, 1988) to less than 1 mg l^{-1} S_iO^2 in 1991 (Elizabeth Kebede *et al*., 1994). The probable reason for this decline was suggested (Elizabeth Kebede *et al*., 1994) as the removal of silicate from solution by diatoms. The surrounding region receives two rainy seasons per year, March- May (big rains) and September-October (little rains). The mean annual rainfall of the area is about 1000 mm (Daniel Gamachu, 1977). Diatoms and blue-greens dominate the phytoplankton community of the lake (Elizabeth Kebede, 1996). Dominant zooplankton groups include the genera *Thermocyclops*, *Mesocyclops* and *Moina* (Seyoum Mengistou, personal communication). Benthic and weed-bed macroinvertebrates are high in abundance and diversity. Different insect groups including Hemiptera, Coleoptera, Odonata and Diptera are the dominant ones (Tudorancea *et al*., 1989).

The ichthyofauna of Lake Chamo, and also that of the neighbouring Lake Abaya, is Soudanian species (Beadle, 1981). The fish species are more diverse than that of the other Rift Valley lakes of the country probably as a result of the northward migration of the Soudanian species when the lake was in contact with the Nile system in the recent past (Beadle, 1981). There are more than 20 fish species in Lake Chamo and the inflowing rivers (Getachew Teferra, 1993). The commercially important species are *Oreochromis niloticus* (L.) *Labeo horie* (Heckel), *Bagrus docmak* (Forsskål) and *Clarias gariepinus* (Burchell). Capture of *L. niloticus* has been banned as a result of sharp decline of the stock due to over-fishing.

Sampling

Monthly fish samples were obtained from commercial landings at four sites of the lake (Fig. 1c) from February 1995 to May 1996. The commercial gill nets used for *L. niloticus* fishery are polyfilament nets of 28, 32, 36, 40 and 44 cm stretched mesh size. Fishermen usually set their gill nets in the open water late in the afternoon and lift them the following morning. Smaller specimens were obtained from commercial gill nets that were set to capture *O. niloticus* and *L. horie* (14–18 cm stretched mesh size). In addition, a beach seine was used in the shallow littoral area to obtain a wider range of fish size and habitats. Total length (TL) of all fish was measured to the nearest centimetre and total weight (TW) to the nearest 100 g. Specimens smaller than 2 kg were weighed to the nearest 5 g. Fry and fingerlings of *L. niloticus* were caught using a beach seine of 6 mm mesh size in the shallow littoral area of the lake.

Stomach content analysis

Stomach contents were preserved in 5% formalin solution and brought to the laboratory for further analysis. The relative importance of food items was determined using frequency of occurrence, percent composition by number and volumetric analysis.

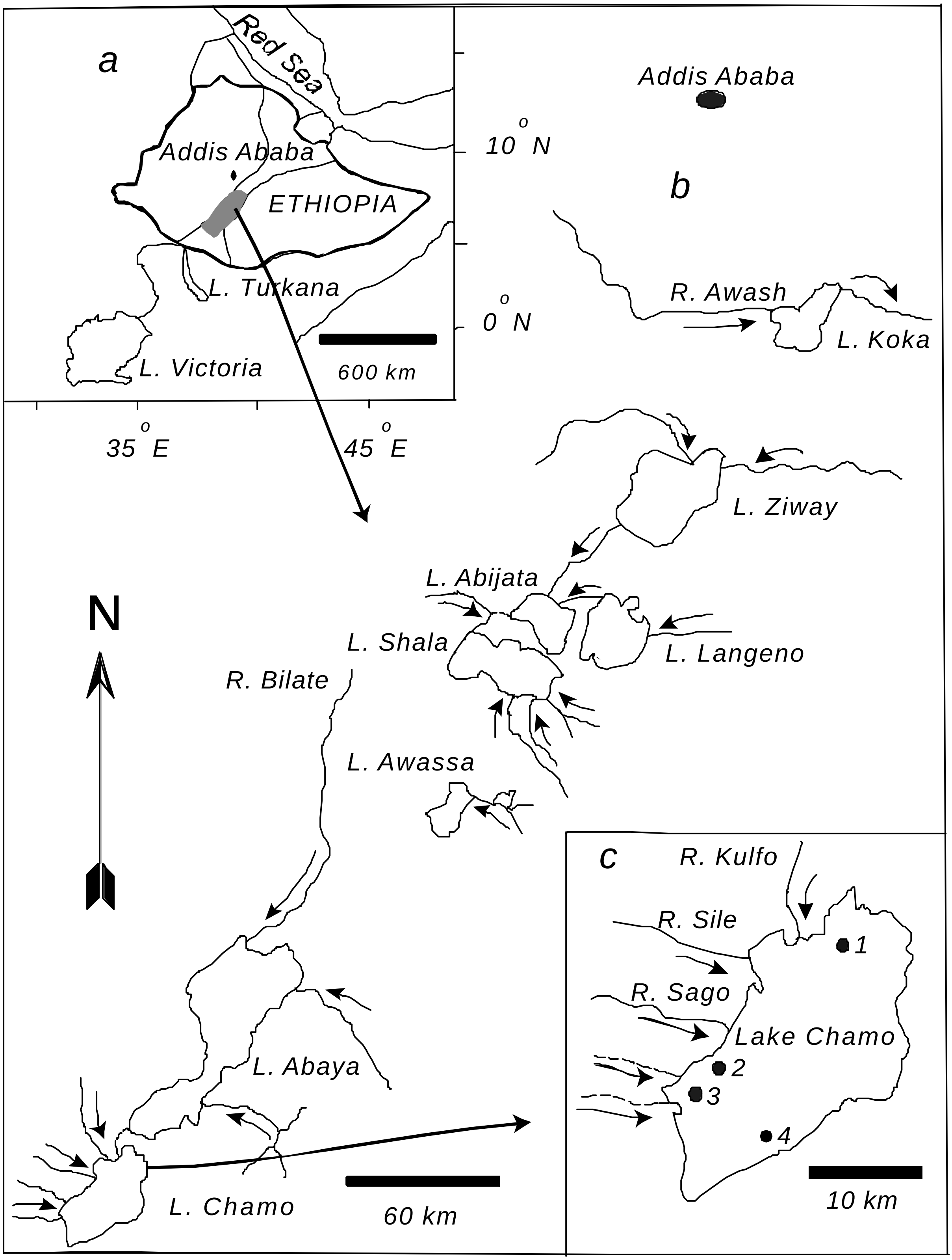

Fig. 1. Map of eastern Africa with the relative position of the Ethiopian Rift Valley lakes highlighted (a), the Rift Valley lakes of Ethiopia (b) and Lake Chamo with the sampling stations indicated (c) (1- Deset, 2- Bedena, 3- Bole, 4- Suga).

In frequency of occurrence method, the number of stomachs in which a given category of food item occurs is expressed as a percentage of the total number of non-empty stomachs examined (Windel and Bowen, 1978). In numerical method, the number of items in each food category was counted in all stomachs examined. The volume of each category of food items in each stomach was measured in a partially filled graduated cylinder in the volumetric method of analysis.

Finally, the quantitative importance of each prey group in the diet was determined using the index of relative importance (IRI) (Pinkas *et al*., 1971), defined as:

$$IRI = \%F\ (\%N + \%V) \qquad (1)$$

Where: %F = frequency of occurrence of the food item

%N = numerical percentage of a food item in the stomachs; and

%V = percentage by volume of the food item in the stomachs.

RESULTS

A total of 411 fish samples were obtained from the commercial landings and beach seining in the littoral areas of Lake Chamo. Of the total number of fish samples 221 (53.8%) had empty stomachs. Except the two smallest fry fish (1.9 cm and 2.3 cm TL) that consumed insect larvae, the remaining fish samples (n=188) that contained food in their stomachs consumed only fish. The fish samples collected from the commercial landings ranged from 30 cm to 192 cm TL and weighed from 350 g to 108,000 g TW. The largest specimen was a female with its ripe ovaries weighing 5,600 g. The biggest male sampled measured 163 cm TL and weighed 53,000 g TW whereas the heaviest male was 156 cm TL and weighed 59,000 g TW. The fry and fingerlings (n=20) sampled using a beach seine ranged in length from 1.9– 7.1 cm TL.

The cyprinid fish *L. horie* was the most important prey of *L. niloticus* in Lake Chamo. It occurred in 49.41% of the stomachs examined, constituted 38.02% of the total number and 70.44% of the total volume of the prey (Table 1). *O. niloticus* occurred in 22.35% of the stomachs and accounted for 19% of the total number and 24.82% of the total volume of food consumed (Table 1). *H. forskahlii* occurred in 14.12% of the stomachs, constituted 9.92% of the total number and accounted for 2.72% of the total volume of food consumed (Table 1).

Cannibalism was relatively common in juvenile fish (n=62, 48.5 cm– 73.2 cm TL) and occurred in 20 (11.76%) individuals. These cannibalistic individuals consumed one to nineteen individuals of their kind with the mean number of 4.9 per stomach. *L. niloticus* occurred in 11.76% of the stomachs, constituted 31.4% of the total number and accounted for 1.95% of the total volume of prey fish. One cannibalistic individual (64.5 cm TL, 3525 g TW) consumed 19 fry of its kind ranging from 2.5–4.7 cm TL. Cannibalism was not observed in adults (n=108, 90.5–192 cm TL and 9900–108,000 g TW). *C. gariepinus* and *Synodontis schall* (Block and Schneider) were relatively unimportant prey fish of *L. niloticus* (Table 1).

Table 1. Index of Relative Importance (IRI) of different food items of juvenile and adult *L. niloticus* from Lake Chamo (n=170).

Food item	F	%F	N	%N	V	%V	IRI
L. horie	84	49.41	92	38.02	48,576	70.44	5359
O. niloticus	38	22.35	46	19.0	17,122	24.82	979
H. forskahlii	24	14.12	24	9.92	1,874	2.72	178.5
L. niloticus	20	11.76	76	31.4	1,344	1.95	392
C. gariepinus	2	1.18	2	0.83	26	0.04	1.03
S. schall	2	1.18	2	0.83	17	0.03	1.01

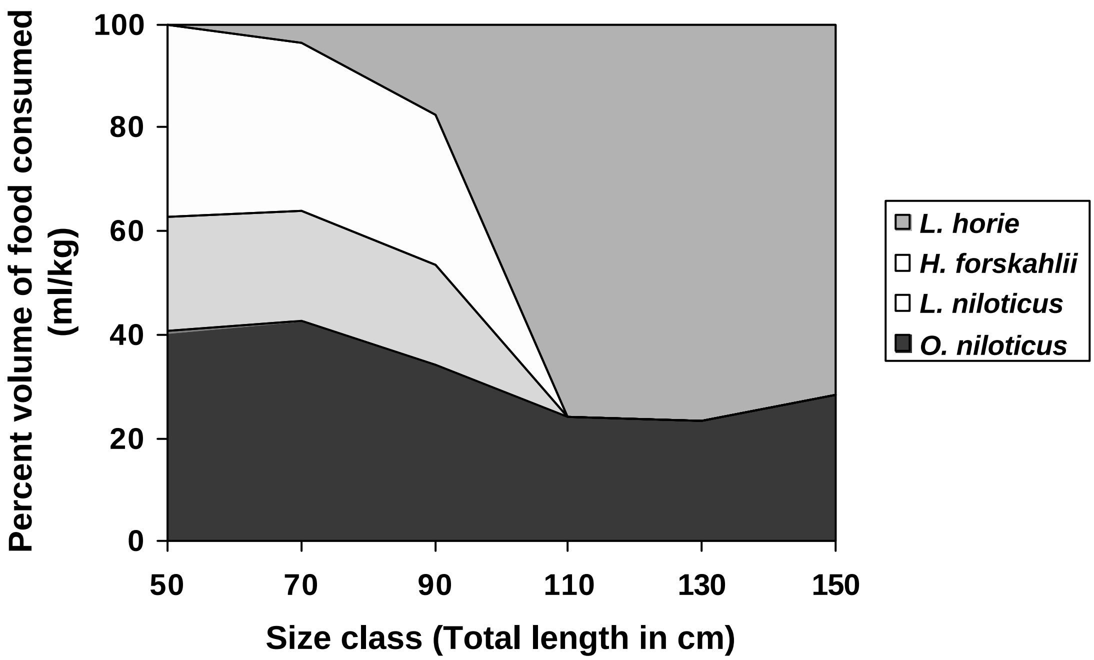

Fig. 2. The contribution of various prey fish in the diet of juvenile and adult *L. niloticus* in relation to size determined with volumetric method in Lake Chamo (n=170).

Based on Index of Relative Importance (IRI), *L. horie* was the most important food item (5359) followed by *O. niloticus* (979) (Table 1). IRI values of *L. niloticus* and *H. forskahlii* were 392 and 178.5 respectively. *C. gariepinus* and *S. schall* were relatively unimportant prey with low IRI values.

Changes in the diet of *L. niloticus* were observed with increasing size of the predator. *L. horie* was an important prey fish of larger fish >90 cm TL (Fig. 2). *H. forskahlii*, *O. niloticus* and *L. niloticus* were the main prey of fish <90 cm TL. Above 90 cm TL, *L. niloticus* predate on only two species, i.e., *L. horie* and *O. niloticus* (Fig. 2). The majority of *L. niloticus* >90 cm TL contained only one prey in their stomachs. In one stomach of *L. niloticus* (158.0 cm TL) two *L. horie* prey measuring 45.8 cm TL and 48 cm TL were found. In another fish (192 cm TL), two *O. niloticus* prey measuring 41.0 TL and 42.5 cm TL were identified. Of the total stomachs examined (n=170) only six individuals contained more than one prey in their stomachs.

In June 1995, 20 fry and fingerlings of *L. niloticus* ranging from 1.9–7.1 cm TL were caught using a beach seine of 6 mm mesh size in the shallow littoral area of the lake. The two smallest fish (1.9 cm and 2.3 cm TL) had eaten insect larvae. The remaining 18 fish (2.5–7.1 cm TL) had all eaten 1–3 fry of *O. niloticus* that ranged from 0.8 to 1.9 cm TL (16–35% of their own body length). The average number of fish fry consumed per fish was 2. One cannibalistic individual, 4.6 cm TL consumed a single fry measuring 1.6 cm TL.

DISCUSSION

L. niloticus in Lake Chamo feeds on a variety of fish species including *O. niloticus*, *H. forskahlii*, *L. niloticus* and *L. horie*. Within the size range investigated, smaller fish (48.5 cm to 73.2 cm TL) mostly fed on *O. niloticus*, *H. forskahlii* and *L. niloticus*. On the other hand, the majority of larger specimens (>90 cm TL) fed on *L. horie* and *O. niloticus*. The difference in prey type of the different size classes could be due to the habitat difference occupied by juveniles and adults. Juvenile *L. niloticus* live in shallow littoral areas where as the adults prefer the deeper pelagic areas (Acere, 1985). Larger fish >90 cm TL *L. niloticus* predate on only two fish species, namely *L. horie* and *O. niloticus*. *L. horie* was the most important prey fish of adult *L. niloticus*. *H. forskahlii*, *O. niloticus* and *L. niloticus* were the most important prey fish of juvenile *L. niloticus*. The shift to the cyprinid fish *L. horie* at larger size could mark the habitat change of the predator to the deeper pelagic areas of the lake. Availability and ease of capture of the prey are probably the main reasons that *L. horie* was the main prey of *L. niloticus*.

Both *L. horie* and *O. niloticus* are widely distributed in the pelagic region of Lake Chamo. But *L. niloticus* predate on mainly *L. horie*. This could be due to ease of capture depending on the body shape and the presence of defence mechanisms of the prey organism (Eklöv and Persson, 1995). *O. niloticus* is a deep-bodied fish with spiny fin rays that make it difficult for the predator to capture and swallow. But *L. horie* is slender bodied fish without any obvious defence mechanisms. Moreover, differences in swimming performance between the two species could affect the success of predator. The body form of *O. niloticus* suggests that it is specialized for maneuverability rather than speed (Wootton, 1998). Prey shape also affects vulnerability by modifying the bite targets of predators. Predators strike bursiform soft-rayed prey in mid-body region, while deep-bodied spiny prey is struck caudally (Moody *et al*., 1983). Moody *et al*. (1983) also indicated that success of predators was lower in the latter case, and suggested that this was due to spines misdirecting attacks from the centre of the mass.

Cannibalism was more common in juvenile *L. niloticus* that live in the shallower region of the Lake. Both intra- and iterspecific competition for food seems to be high in the littoral and shallow offshore regions of the lake. Overcrowding and shortage of food are normally considered to be the major predisposing factors for cannibalistic mode of feeding (Hopson, 1972). In Lake Chamo there are three piscivorous fish species. These are *L. niloticus*, *H. forskahlii* and *B. docmak*. Among these, *B. docmak* exclusively feeds on *S. schall* that is not preyed upon by any other piscivore (Hailu Anja, 1996). Juvenile *L. niloticus* and adult *H. forskahlii* heavily prey upon *O. niloticus* fry that are normally restricted to the littoral region of the lake. It is likely that both factors may lead juvenile *L. niloticus* to cannibalism in Lake Chamo. Cannibalism is common in many freshwater (Giles *et al*., 1986; Hecht and Appelbaum, 1988; Baras *et al*., 1999) and marine (Neuenfeldt and Köster, 2000) piscivorous fish species at certain stages of their life cycle.

Information on the periodicity and intensity of cannibalism is scanty in tropical predatory fish species. Few detailed studies conducted indicate that cannibalism could have an impact on population dynamics of the fish population in question (African catfish *C. gariepinus*, Hecht and Appelbaum, 1988; snakehead *Chana straitus* Bloch, Qin and Fast, 1996; vudu catfish *Heterobranchus longifilis* Valenciennes, Baras *et al*., 1999). Several authors have reported cannibalism in *Lates* species in some African water bodies (Hopson, 1972; Hughes, 1992; Mannini *et al*., 1999). In Lake Chad cannibalism was very common in *L. niloticus* below 7.0 cm accounting for more than half the food intake in the 3.9 to 6.9 cm size classes (Hopson, 1972).

In the present study *L. niloticus* started piscivory at smaller size of 2.5 cm TL. This agrees well with the finding of Hopson (1972) where *L. niloticus* in Lake Chad started feeding on other fish fry when it attained 3 cm TL, although cannibalism was observed as small as 2 cm TL. Hopson (1972) also reported the food of juvenile *Lates* (2.8–5.9 cm TL) in small dams of Ghana constituted only insects. Piscivory was observed in fish >6 cm TL (Hopson, 1972). Worthington (1929) reported the food of 19 juvenile *L. niloticus* (3 to 8.7 cm TL) from Lake Albert and found prawns to be the most important food items. Gee (1966) has examined the food of early juvenile *L. niloticus* from Lake Turkana and noted a change in diet from cladocerans, cyclopoid copepods and ostracods at a length of 1.5 cm to chiefly insect larvae at 2.5 cm. In this study, *L. niloticus* shifted to piscivory at smaller size (>2.5 cm TL).

Juvenile *L. niloticus* fed on *O. niloticus*, *H. forskahlii* and other *L. niloticus*. *L. horie*, was the most important prey fish of adult *L. niloticus* using various methods of analyses. Piscivorous mode of feeding has started very early in life of this fish and fish as small as 2.5 cm in length were found to feed on other fish species. In summary, this study has clearly shown the predation impact of *L. niloticus* on other fish species in Lake Chamo.

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