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THE FOOD AND FEEDING HABIT OF *OREOCHROMIS NILOTICUS* L. (PISCES: CICHLIDAE) IN LAKE CHAMO, ETHIOPIA

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ABSTRACT: The food of *Oreochromis niloticus* in Lake Chamo, Ethiopia was studied from the stomach contents of 449 adult (290–570 mm total length, TL) and 145 juvenile (61–115 mm TL) fish. *O. niloticus* was found to be essentially phytoplanktivores in Lake Chamo, and the composition of the phytoplankton diet varied seasonally. The diet of both adult and juvenile fish consisted of 10 genera of blue greens whereas green algae and diatoms each contributed 8 genera. Blue greens as a group contributed the bulk of the diet of adult fish. The most frequently encountered genera from the blue greens were *Anabaena* (96–100), *Lyngbya* (85–100), *Microcystis* (81–100) and *Oscillatoria* (41–100). *Cosmarium* (79–100) from the green algae and *Navicula* (82–100) from the diatoms were also frequently observed. In terms of percentage composition by number, the blue greens contributed over 60% of the total food ingested. Of these, more than 50% was due to *Anabaena*, *Lyngbya* and *Microcystis*. Zooplankters occurred on rare occasions in the stomach contents of both adult and juvenile fish. The feeding pattern of adult *O. niloticus* was observed to have a diel rhythm. *O. niloticus* in Lake Chamo is a continuous feeder during the day and peaked at 16 hr. Daily ingestion of phytoplankton was estimated to be about 3.7% of its wet body weight at an average water temperature of 26° C.

Key words/phrases: Ethiopia, Food, Lake Chamo, *Oreochromis niloticus*

INTRODUCTION

The distribution of *Oreochromis niloticus* in Ethiopia is quite similar to that of other African countries, and it is one of the most important species in the ecology and fisheries of almost all Ethiopian inland waters (Shibru Tedla, 1973).

Generally, Tilapia have a diversified diet that is composed of both vegetation and animal components. The vegetation component is usually dominant, and consists of mainly phytoplankton (Balarin and Hatton, 1979). However, the food habit of *O. niloticus* is extremely variable within a water body, depending on the size and age of the fish, the habitat occupied and the time of the year (Philipart and Ruwet, 1982).

Studies on the food of *O. niloticus* in Ethiopia (*e.g.*, Getachew Teferra, 1987; 1993; Tudorancea *et al.*, 1988; Zenebe Tadesse, 1988) showed that the fish is omnivorous when young, but it consumes a large quantity of various species of phytoplankton at later stages. In addition to some species of phytoplankton, juvenile *O. niloticus* (less than 60 mm total length, TL) feed also on chironomid larvae, copepods and rotifers in Lake Ziway (Zenebe Tadesse, 1988) whereas on nematodes and zooplankton in Lake Awassa (Tudorancea *et al.*, 1988). This is consistent with the finding of Moriarty *et al.* (1973) that the fish feed more phytoplankton as they grow older and upon reaching 60 mm TL, phytoplankton form almost the entire diet.

Tilapia in general tend to show a diel feeding periodicity. Some species are active during the day while others are nocturnal feeders (Balarin and Hatton, 1979). *O. niloticus*, for example, feeds mainly during the daytime in Lakes Awassa (Getachew Teferra, 1987) and Ziway (Zenebe Tadesse, 1988). Feeding periodicity studies based on rate of gastric evacuation showed that the fish ingests about 11.5 and 7.6% of its body weight per day in Lakes Awassa, and Ziway, respectively (Getachew Teferra and Fernando, 1989; Getachew Teferra and Zenebe Tadesse, 1998). Getachew Teferra (1993) also studied the food of *O. niloticus* in Lake Chamo based on samples taken only in July 1988. Thus, a frequent sampling over a year time range may show a better picture, as the composition of the diet of *O. niloticus* varied seasonally, and depended on the composition of the phytoplankton available in the lakes (Getachew Teferra. 1987; Zenebe Tadesse, 1988).

The present study was, therefore, conducted to determine the food and feeding habit of the fish, and to investigate if these vary seasonally and with fish length.

Study area

Lake Chamo is believed to be part of a much larger drainage basin, which extends further south up to Lakes Chew Bahir and Turkana (Von Domm and Edmond, 1984). Discontinuous river flows have in the past linked Lakes Abaya, Chamo and Chew Bahir to Lake Turkana and then to the White Nile (Grove *et al.*, 1975).

Lake Chamo (Lat.: 5°42'- 5°48' N; Long: 36°30'- 38°30' E) is located at an altitude of 1108 m, and about 518 km south of Addis Ababa (Makin *et al.*, 1975). The lake covers an area of 551 km^2 and is the second largest among the rift valley lakes and the third in the country. According to earlier records (Amha Belay and Wood, 1982) Lake Chamo had a maximum depth of 20 m, but Elizabeth Kebede (1996) reported a maximum depth of 13 m. However, measurements done at the time of sampling in the present study did not exceed 9m. The mean depth of the lake may have changed since the lake has receded by about half a kilometer in the last two decades, resulting in a decrease of the surface area.

The fish fauna of Lake Chamo, and that of Lake Abaya, is Soudanian species (Beadle, 1981). This is believed to be due to a free passage of the Nile fauna up into Lake Abaya and Chamo as a result of previous inter-connection of Lakes Abaya, Chamo, Chew Bahir and Turkana with the Nile system. As a result, the fish fauna in Lakes Chamo and Abaya is the most diversified in the rift valley lakes, and is composed of more than 20 species. Out of these species, *Lates niloticus*, *O. niloticus*, *Labeo horii*, *Bagrus docmac*, *Clarias gariepinus* and *Barbus* sp. are of great economic importance to the lake fishery industry (LFDP, 1996).

MATERIALS AND METHODS

a) Diet Composition

Samples of *O. niloticus* were collected over a twelve - months period between March 1996 and March 1997 using gillnets (120, 140, 200 and 240 mm, stretched mesh). About 30–40 specimens with full stomach were selected from the fish caught every month. The stomach contents of each fish were kept in a separate plastic bag containing 5% formaldehyde solution. Similarly, the stomach contents of juvenile *O. niloticus* caught during February 1997 and March and June 1996 were preserved in 5% formaldehyde solution. The natural food of *O. niloticus* was studied from the stomach contents of 449 adult (290-570 mm TL) and 145 juvenile (61-115 mm TL) fish caught during the sampling occasions.

The stomach contents preserved in 5% formaldehyde solution were examined using a compound light microscope at magnification between 100x and 400x. Food items were identified to the lowest taxa possible (Blomqvist, 1981). The relative importance of the different food items found in the stomach contents were determined using numerical method, both percentage frequency of occurrence and percentage composition by number (Windell and Bowen, 1978).

b) Diel feeding rhythm

In addition to the diet composition in the stomach contents of *O. niloticus*, the feeding periodicity of the fish was also studied. A total of 202 specimens of *O. niloticus* were collected for diurnal study at intervals of four hours during a 24 hours period using gillnets of 180 and 220 mm stretched mesh. The stomach was isolated and weighed. The pH of the stomach contents was measured using a pH meter with glass electrodes. The stomach was then washed off its contents and weighed. The difference in weight between the full and washed stomach gave the wet weight of the stomach contents. The number of empty stomachs was also recorded for each time interval. Percent stomach fullness (%SF) [(Wt. of stomach content multiplied by 100 and divided by the body weight)] was plotted against time of capture. Water temperature was measured at each time of capture.

Rate of gastric evacuation was determined using two parameters: percent stomach fullness index and time of capture. Then, a regression relationship was estimated between the two parameters, stomach fullness and time of the day, starting with the time when the highest percent stomach fullness was observed. The slope of this regression relationship was then used to express rate of gastric evacuation (Lauzanne, 1978).

RESULTS AND DISCUSSION

The diet *O. niloticus* in Lake Chamo was found to consist 10 genera of blue greens, 8 genera of green algae, and 8 genera of diatoms (Table 1). Although these genera were not equally represented in the diet, the wide choice available to the fish suggests that when one food item is in short supply, others were in abundance.

The type of food items found in the stomach of *O. niloticus* were quite similar to what has been reported for several other tilapine species. Fish (1955) reported that *T. esculenta* feed mainly on phytoplankton. Fagade (1978) showed that many tilapine cichlids feed on blue greens, green algae and diatoms. Adebisi (1978) reported blue greens to represent the main diet of *S. galilaeus*.

Previous studies by Getachew Teferra and Fernando (1989) have shown that *O. niloticus* feeds on zooplankton when young. Chironomid larvae were also noted in the stomach of this species in Lake Awassa (Tudorancea *et al.*, 1988). The present work also confirms that juvenile *O. niloticus* consumes zooplanktonic and benthic organisms. These are dominated by rotifers, mainly *Branchinous* sp. and *Keratella* sp., and copepods while a few chironomid larvae were also represented in the diet. When the animal component of the diet of juvenile *O. niloticus* in Lake Chamo is compared with the plant component, phytoplankton diet constituted the major portion (Fig. 1a). However, Tudorancea, *et al.* (1988) reported that the juveniles in Lake Awassa fed mainly on zooplankton. The difference may be due to the size range of the juveniles. Wheras juveniles in the present study ranged from 61-115 mm TL, Tudorancea, *et al.*, (1988) considered very small sized juveniles (less than 30 mm). Thus, there is a distinct size difference in what is referred as juvenile by the present study and Tudorancea *et al.* (1988). According to Demeke Admassu (1998), tilapia juveniles in Lake Chamo grew more rapidly than fish of comparable ages in Lakes Awassa and Ziway. It was suggested that the small amount of good quality food ingested, the low fish density in the lake and the high temperature of the water could be the major factors responsible for making *O. niloticus* a fast-growing fish in the lake (Getachew Teferra, 1993). According to Moriarty *et al.* (1973), phytoplankton forms almost the entire diet of juvenile *O. niloticus* when they reach 60 mm TL. Thus, juvenile *O. niloticus* considered in this study may have already shifted to the phytoplankton diet.

Table 1. Percentage of occurrence of algae and zooplankton present in the stomach contents of adult and juvenile *O. niloticus* in Lake Chamo.

Phytoplankton	% Occur. (Range)	
	Adults	Juveniles
Cynophyta (Blue greens)		
Anabaena	96–100	92–100
Microystis	82–100	83–96
Oscillatoria	41–100	51–97
Lyngbya	85–100	20–70
Merismopedia	42–85	0–70
Chroococcus	42–100	20–70
Raphidiopsis	12–97	20–35
Aphanizomenon	12–86	0–35
Anabaenopsis	15–23	0–25
Spirulina	8–23	0–10
Chlorophyta (Green algae)		
Cosmarium	79–100	93–100
Scenedesmus	42–82	73–90
Chlorella	8–85	25–100
Tetraedron	18–59	0–67
Oocystis	6–55	20–55
Coelastrum	10–41	7–35
Pediastrum	6–26	0–30
Ankistrodesmus	0–25	0–5
Bacillarophyta (Diatoms)		
Navicula	82–100	90–100
Nitzschia	25–61	0–30
Cyclotella	10–62	40–87
Pinnularia	6–35	53–80
Aulacoseira	6–27	0–20
Cymbella	0–36	0–3
Surirella	0–29	10–15
Rhopalodia	0–15	15–20
Zooplankton		
Copepoda	0–10	7–45
Rotifera	0–19	0–30
Others		
Nematode	——	7–20
Chironomid larvae	——	0–35
Macrophytes	Abundant	rare

In terms of numerical percentage, the blue greens contributed over 60% of the food ingested by adult *O. niloticus* (Fig. 1b). Out of this, 20% was *Anabaena* sp. and 10% *Oscillatoria* sp. Similarly, blue greens were found in great abundance in the stomach contents of *O. niloticus* in Lakes Awassa (Getachew Teferra, 1987; Tudorancea *et al.*, 1988) and Ziway (Zenebe Tadesse, 1988). Munro (1967) also reported the same results in Lake Victoria, where blue greens, *Lyngbya* sp. and *Microcystis* sp., contributed about 80% and 40% of the fish diet, respectively. Furthermore, *O. niloticus* in Lake Turkana consumes large quantities of blue green algae, but mainly *Spirulina* and *Anabaenopsis* (Harbott, 1975).

Although adult *O. niloticus* feeds mainly on phytoplankton, it is not uncommon to find its stomach full of detritus (unidentified macrophytes). Bowen (1980) has shown that *O. niloticus* feeds on abundant amorphous detritus in Lake Valencia, Venezuela. Thus, this food source is also probably important for *O. niloticus* in Lake Chamo. The ability to utilize these wide varieties of food items available in the habitat may account for the prominence of this species in the lake.

Blue greens were observed in large quantity (above 40%) in almost all sampling occasions whereas green algae were found with high frequencies in stomach contents of the fish caught during March, April and May. Diatoms were abundant in the diet of the fish caught between March and June, and during November and December (Fig. 1b). Therefore, seasonal variation in algal species composition in the diet of adult *O. niloticus* in Lake Chamo was quite evident. This could influence the quality of the food ingested by the fish. For instance, diatoms are highly digestible because the pores in the frustules allow entrance of enzyme into the cytoplasm to enhance digestion (Harbott, 1975).

As is the case in Lakes Ziway and Awassa (Getachew Teferra, 1987; Zenebe Tadesse, 1988), *O. niloticus* in Lake Chamo also fed continuously during the day (Fig. 2a and b). It started feeding at about 8 hr and a steady increase in stomach fullness was observed through the day and peaked at 16 hr. The same species in Lake George in Uganda fed continuously shortly before dawn until about dusk (Moriarty *et al.*, 1973). Daytime feeding activity of Tilapia appears to be triggered mainly by temperature (Balarin and Hatton, 1979).

The study showed that food had an instantaneous effect in secretion of acid in the stomach, because low stomach pH in *O. niloticus* coincided with large volume of food (Fig. 2a). Moriarty *et al.* (1973) also suggested that the presence of food acted as a stimulus for acid secretion. A mean pH value as low as 1.9 was measured when the stomach was full at 16 hr.

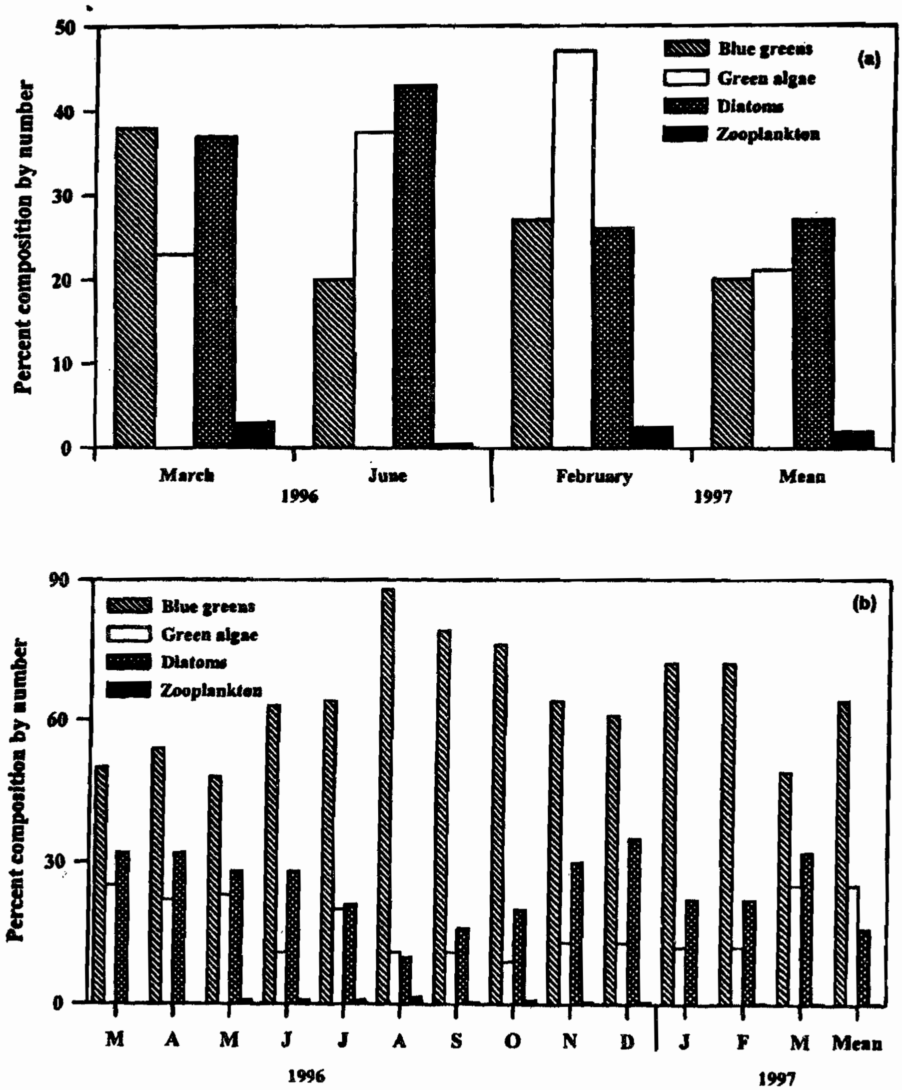

Fig. 1. Relative contribution of the major phytoplankton groups and zooplankton in the diet of (a) juvenile and (b) adult *O. niloticus* in Lake Chamo.

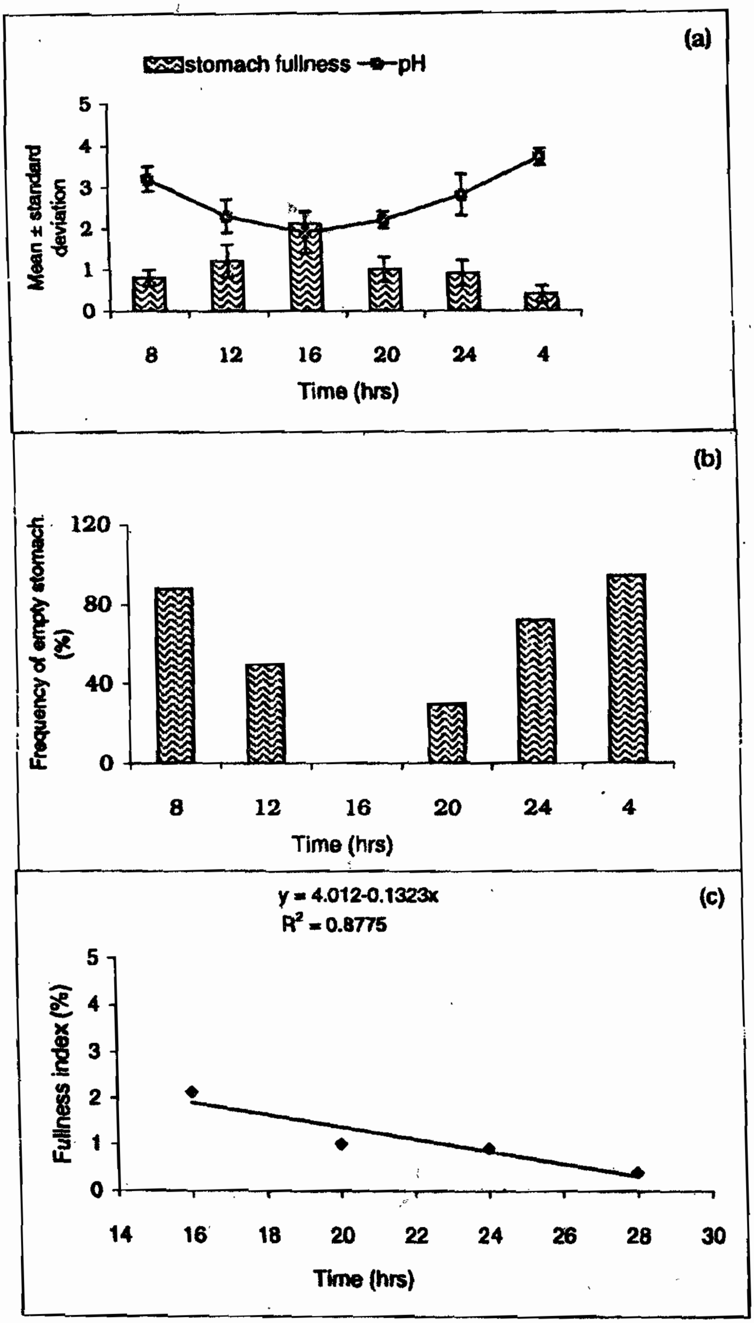

Fig. 2. Diel changes in percent stomach fullness and stomach pH (a), percent empty stomach (b) and rate of gastric evacuation (c) of *O. niloticus* in Lake Chamo.

The frequency of fish with empty stomach varied throughout the 24 hr sampling periods (Fig. 2b). It was low between 12 and 20 hr and high between 24 and 8 hr. No empty stomach was recorded at 16 hr. The rate of gastric evacuation at an average water temperature of 26° C was estimated to be 2.12% at 16 hr and 0.39%at 4 hr or 0.132% hr^{-1} (Fig. 2c). From 8 hr to 20 hr (12 hrs) when the fish were assumed to be eating at the same rate (0.132%/hr) the amount of food evacuated to the intestine is estimated to be 1.58% (0.132x12 hr). As a whole, 3.7% (2.12+1.58) is ingested per day. The same species in Lakes Awassa and Ziway ingest about 11.5 and 7.6% of their body weight per day, respectively (Zenebe Tadesse, 1988). Apparently, *O. niloticus* in Lake Chamo ingests at a lower rate, the reason for which is not clear.

CONCLUSIONS

O. niloticus is essentially phytoplanktivores in Lake Chamo, and the composition of the phytoplankton diet varies seasonally. No significant changes in the food and feeding habit occur between the juvenile and adult fish. Unlike previous reports, zooplankters are a minor component of the juvenile diet.

In Lake Chamo, *O. niloticus* feeds continuously during the day and consumes 3.7% of its body weight per day. Feeding time might have an impact on the fish catch. Since the fish actively feed during the day, and consequently move about actively, the fish catch may increase if gill nets are set during the daytime.

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REFERENCES

1. Adebisi, A.A. (1978). Studies on the ecology, growth and reproduction of the fishes of Upper Ogun River, Nigeria. PhD Thesis, University of Ibadan, Ibadan. 103 pp.
2. Amha Belay and Wood, R.B. (1982). Limnological aspects of algal bloom on Lake Chamo in Gamo Goffa Administrative region of Ethiopia in 1978. *SINET: Ethiop. J. Sci.* 5(1):1–19.
3. Balarin, J.D. and Hatton, J. (1979). Tilapia: *A guide to their Biology and Culture in Africa.* University of Stirling, Scotland, pp. 1–42.
4. Beadle, L.C. (1981). *The Inland Waters of Tropical Africa: An Introduction to Tropical Limnology* 2nd edn, New York, Longmans, 406 pp.
5. Blomqvist, P. (1981). *Vaxtplanktonmpendium.* (Blomqvist, P. ed.), Uppsala University, Uppsala, 185 pp.
6. Bowen, S.H. (1980). Detrital amnio acids are the key to rapid growth of *Tilapia* in Lake Valencia, Venezuela. *Science* **207**:1226–1218.
7. Demeke Admassu (1998). Age and growth determination of tilapia, *Orechromiso niloticus* L. (Pisces: *Cichlidae*) in some lakes of Ethiopia. Unpubl. PhD Dissertation, School of Graduate Studies, Addis Ababa University, Addis Ababa, 115 pp.
8. Elizabeth Kebede (1996). Phytoplankton in a Salinity-Alkalinity series of Lakes in the Ethiopian Rift Valley. Unpubl. PhD Dissertation, ACTA Universitatis Upsaliensis, Upsala, 43 pp.
9. Fagede, S.O. (1978). The food and feeding habits of *Tilapia* species in the Lagos Lagoon. *J. Fish Biol.* **3**:151–156.
10. Fish, G.R. (1955). The food of Tilapia in East Africa. *Ugandan J.* **19**:85–89.
11. Getachew Teferra (1987). Food nutrition and digestive efficiency in *Oreochromis niloticus* L. (Pisces: *Cichlidae*) in Lake Awassa, Ethiopia. Unpubl. PhD Dissertation, University of Waterloo, Canada, 109 pp.
12. Getachew Teferra (1993). The composition and nutritional status of the diet of *Oreochromis niloticus* in Lake Chamo, Ethiopia. *J. Fish Biol.* **42**:865–874.
13. Getachew Teferra and Fernando, C. (1989). The food of an herbivorous fish (*Oreochromis niloticus* Linn.) in Lake Awassa, Ethiopia. *Hydrobiol.* **178**:195–200.
14. Getachew Teferra and Zenebe Tadesse (1998). Diel feeding rhythm and assimilation efficiency of *Oreochromis niloticus* L. (Pisces: Cichlidae) in Lake Ziway, Ethiopia. *Verh. Internat. Verein. Limnol.* 26:2324–2328

15. Grove, A.T., Street, F.A. and Goudie, A.S. (1975). Former lake levels and climatic change in the Rift Valley of Southern Ethiopia. *Geog. J.* 141:177–202.

16. Harbott, B.J. (1975). Preliminary observation on the feeding of *Tialpia nilotica* Linn. in Lake Rudolf. *Afr. J. Trop. Hydrobiol. Fish* 4:27–37.

17. Lauzanne, L. (1978). Etude quantitative de L' alimentation de *Sarotherodon galilaeus* (Pisces: *Cichlidae*) du lac Tchad. *Hydrobiol.* 12:71–81.

18. LFDP (Lake Fisheries Development Project) (1996). *Lake Management Plans.* Working paper number Twenty three, MoA. 31 pp.

19. Makin, M.J., Kingham, J.J., Waddam, A.E., Birchll, C.J. and Teferra Tamene (1975). *Development project in the Southern Rift Valley of Ethiopia.* Land Resource Study 21. Land Resources Division, Ministry of Overseas Development, England, 55 pp.

20. Moriarty, D.J.W., Darlington, J.P.E., Dunn, I.G., Moriarty, C.M. and Telvin, M.P. (1973). Feeding and grazing in Lake George, Uganda. *Proc. R. Soc. London* Ser. B. 184:299–319.

21. Munro, J.L. (1967). The food of a community of East Africa freshwater fishes. J. *Zool. Lond.* 151:389–415.

22. Philipart, J.C. and Ruwet, T.M. (1982). Ecology and distribution of Tilapias. In: *The* Biology and Culture of Tilapias. Proceedings of the international conference, pp. 15–59, (Pullin, R.S.V. and Lowe-McConnell, R.H., ed.) Manila, Philippines.

23. Shibru Tedla (1973). *Freshwater Fishes of Ethiopia.* Haileselassie I University, Addis Ababa, 101 pp.

24. Tudorancea, C., Fernando, C.H. and Paggi, J.C. (1988). Food and feeding ecology of *Oreochromis niloticus* (L) juveniles in Lake Awassa, Ethiopia. *Arch. Hydrobiol. (suppl.)* 79:267–289.

25. Von Damm, K.L. and Edmond, J.M. (1984). Reverse weathering in the closed basin Lakes of the Ethiopian Rift. *Am. J. Sci.* 284:835–862.

26. Windell, J.T. and Bowen, S.H. (1978). Methods for a study of fish diet based on analysis of stomach contents. In: *Methods for the Assessment of Fish Production in Fresh Water.* (Bagenal, T.B., ed.) 3rd edn Oxford, Balckwell, pp. 219–226.

27. Zenebe Tadesse (1988). Studies on some aspects of the biology of *Oreochromisniloticus* L. (Pisces: Cichlidae) in Lake Ziway, Ethiopia. Unpubl. MSc Thesis, School of Graduate Studies, Addis Ababa University. 78 pp.