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REPRODUCTIVE BIOLOGY AND FEEDING HABITS OF THE CATFISH *CLARIAS GARIEPINUS* (BURCHELL) (PISCES: CLARIIDAE) IN LAKE AWASSA, ETHIOPIA

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ABSTRACT: Breeding and feeding habits of the catfish *Clarias gariepinus*, in Lake Awassa Ethiopia, were studied from samples collected between February 1987 and March 1988. Breeding started at the beginning of the early rains in February and continued until June, after which the proportion of breeding females declined gradually while the proportion of breeding males declined sharply. The sex ratio was not significantly different from unity, because 50.4% females and 49.6% males were caught during the investigation. The smallest ripe female in the catch was 34.0 cm total length (TL) and the smallest ripe male caught was 33.0 cm TL. The weight of ripe ovaries ranged from 11.2 to 962.0 g and the number of eggs ranged from 8,800 to 650,000 eggs. The number of wet weight of preserved eggs per gram ranged from 435 to 1176 with a mean of 669. *C. gariepinus* was found to be carnivorous in its feeding habit and fish was the most important food item. It contributed 81.7% of the food items of the juveniles and 86.8% of the food of the adults by volume. A cichlid fish (*Oreochromis niloticus*) was the most utilized prey of *C. gariepinus*. *O. niloticus* accounted for 71.0% of the food eaten by juvenile fish (16.3–35.0 cm TL) and 77.5% of the food of adults by volume. Other food items found in the stomachs of *C. gariepinus* include insects, fish eggs, gastropods, pieces of macrophytes, detritus and zooplankton.

Key words/phrases: ***Clarias gariepinus*, food, Lake Awassa, piscivory, reproduction**

INTRODUCTION

The catfish *C. gariepinus* is widely distributed throughout Africa, and it is one of the most important commercial freshwater fish species in many parts of the continent (Willoughby and Tweddle, 1978; Viveen *et al.*, 1986). It is known for its adaptability and hardiness to adverse environmental conditions (Clay, 1979a). The ecology of *C. gariepinus* in waters of other African countries is relatively well known (Willoughby and Tweddle, 1978; Clay, 1979b), however, virtually nothing is known about the species in Ethiopian waters.

Reproductive biology of the fish has been reported by several authors (Van der Waal, 1974; Willoughby and Tweddle, 1978; Clay, 1979b; Viveen *et al.*, 1986). In most water bodies for which data are available, the catfish breeds in the flood plains of feeder streams after the onset of major rains. After spawning spent fish return to the lake. In water bodies with no feeder streams the breeding stock move to inundated shoreline for spawning, after which they return to deeper waters.

As a predator *C. gariepinus* mainly feeds on fish, *Oreochromis niloticus* constituting the bulk of its food items (Willoughby and Tweddle, 1978; Spataru *et al.*, 1987). *C. gariepinus* also utilizes a variety of other food items including insects, gastropods, zooplankton and several benthic organisms (Viveen *et al.*, 1986).

Ethiopian lakes and river systems have great potential for the production of *C. gariepinus*. It is one of the commercially important fish species in the country in general and in the commercial fishery of Lake Awassa in particular. Since it is a fast growing fish, and an indiscriminate feeder (Bruton, 1978, 1979; Spataru *et al.*, 1987), it can be used to produce large quantities of inexpensive animal protein. In spite of its importance very little work has been done on its biology in this country. The aim of this work was therefore, to study some aspects of its reproduction and feeding biology.

DESCRIPTION OF STUDY AREA

The lake

The Lake Awassa basin is enclosed by faulting and it is totally separated from other rift valley lakes (Mohr, 1962). The lake (6°33′–7°33′N and 38°22′–39°29′E) lies in a caldera with a diameter of about 30 km and an area of 1360 km^2. It has an altitude of 1680 m. Lake Awassa is the smallest of the Ethiopian rift valley lakes. It has an area of 88 km^2, a maximum depth of 22 m and a mean depth of 11 m. It's main affluent comes from the swampy lake called Lake Shallo through the Tikur Wuha River, but it has no obvious surface outlet.

The fish species and fisheries

There are six fish species in Lake Awassa, namely, *O. niloticus*, *Barbus* sp, *B. amphigramma*, *C. gariepinus*, *Garra* sp. and *Aplocheilichthyes* sp. The commercial fishery depends mainly on *O. niloticus*. *C. gariepinus* and the large barbs (*Barbus* sp.) are under-utilized contributing only 7.0% and 3.0%, respectively of the total catch of about 500 tons per year (LFDP, 1996). However, the contribution of *C. gariepinus* rises up to 20% of the total landing during the fasting periods of the Orthodox Church followers (March-April, early half of August). Demand for fish increases during these periods. Therefore, in addition to the gill net fishery for *O. niloticus*, most fishermen set longlines to catch *C. gariepinus*. Although in small numbers, *C. gariepinus* is also incidentally caught in gill nets set to catch *O. niloticus*.

MATERIALS AND METHODS

Sampling

Samples of *C. gariepinus* were caught in each month between February 1987 and March 1988 using stationary longlines constituting 500 baited hooks distributed in five different locations of the lake (Fig. 1). Previous work has shown that cichlids are the most favoured prey species of *C. gariepinus* (Spataru *et al.*, 1987). Thus, pieces of the cichlid fish *O. niloticus* were used as bait. The hooks were usually set during the afternoon and lifted the following morning. In addition to stationary longlines, beach seine and small hook and line gear were also used in order to sample a wide range of fish sizes and habitats. Total length (TL) of all fish was measured to the nearest millimetre immediately after capture. Fish under 1000 g were weighed to the nearest gram whereas those between 1000 g and 2000 g were weighed to the nearest five grams. Larger specimens were weighed to the nearest 25 g. In all cases total weight (TW) was taken. Length-weight relationship was calculated using least squares regression analysis. Ripe ovaries were preserved in Gilson's Fluid (Bagenal and Braum, 1978).

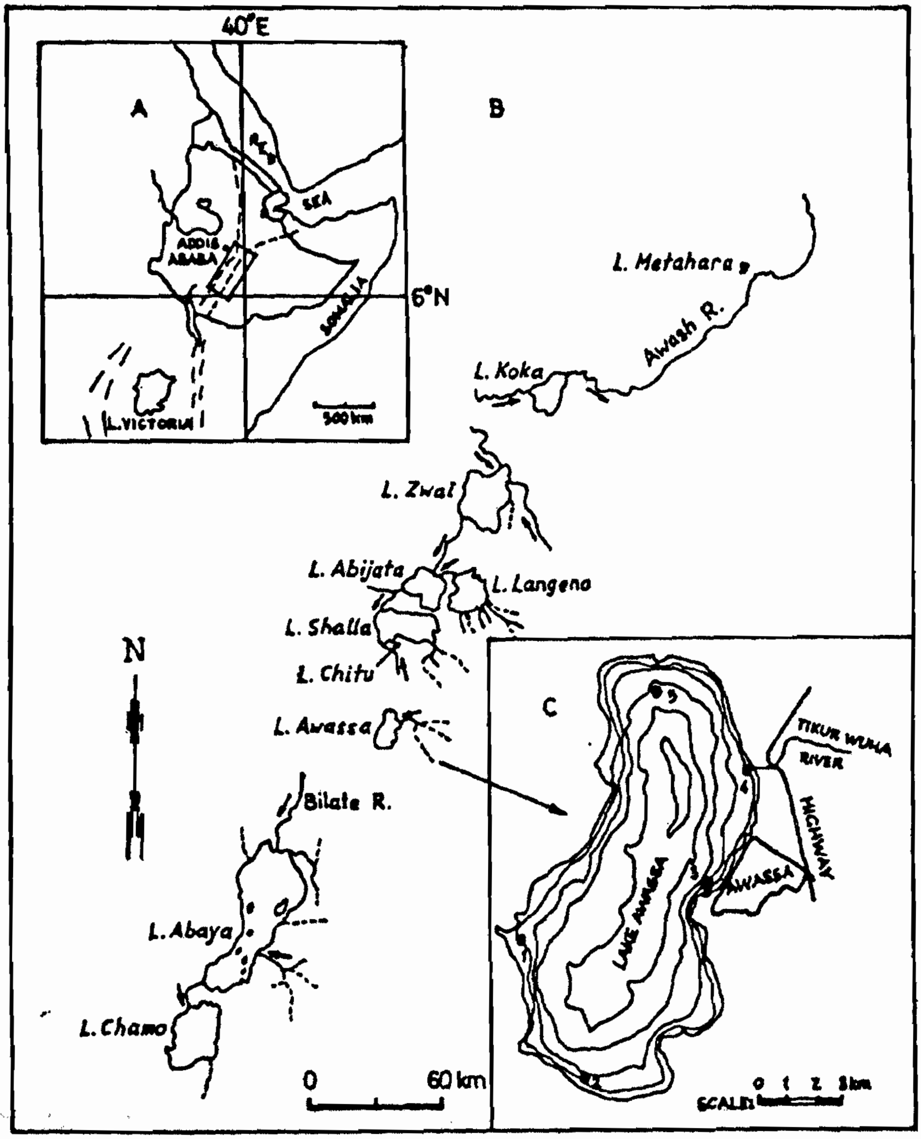

Fig. 1. The map of Ethiopia with the relative position of the Rift Valley lakes (A); the Rift Valley lakes of Ethiopia (B); and the map of Lake Awassa (C); with the sampling stations indicated. (1, Dore; 2, Minch; 3, Blazar; 4, Tikur Wuha; 5, Deset).

Breeding

The sex and maturity stages of each fish were determined. The maturity stages were determined by visual examination of the gonads and using a five-point maturity scale. This maturity scale describes the developmental stages of gonads based on their sizes and the space they occupy in the body cavity of fish (Holden and Raitt, 1974). According to this maturity scale fish are categorized as immature (I), recovering spent or developing virgin (II), ripening (III), ripe (IV) and spent (V). Fecundity was estimated by weighing all the eggs in the ovaries, then weighing three sub-samples of 1000 eggs and thence calculating the total number (Synder, 1983). The relationship between fecundity and some morphometric measurements (TL, TW and ovary weight) were determined using least squares regression. The breeding season of the fish was determined from the percentages of fish with ripe gonads taken each month.

Food and feeding

Identification of the stomach contents was done visually in the case of large food items, but a dissecting microscope was used for smaller organisms. The relative importance of food items was investigated using the frequency of occurrence and volumetric methods. In frequency of occurrence the number of stomach samples containing one or more of a given food type was expressed as a percentage of all non-empty stomachs examined (Windell and Bowen, 1978). The proportion of the population that fed on certain food items was estimated by this method. In volumetric analysis food items that were found in the stomachs were sorted into different taxonomic categories and the water displaced by the group of items in each category was measured in a partially filled graduated cylinder (Bowen, 1983). The volume of water displaced by each category of food items was then expressed as a percentage of the total volume of the food items in all the stomachs.

In order to determine fish-size-based differences in food composition, stomach contents from juvenile fish caught by beach seine and small hook and line gear (16.3–35.0 cm TL) and fish caught by stationary longlines (38.0–110.0 cm TL) were analyzed separately. The degree of stomach fullness of both juveniles and adults was designated as empty, quarter-full, half-full, three quarters-full or full.

RESULTS AND DISCUSSION

Length-weight relationship

The relationship between TL (cm) and TW (g) was described by the equation:

$\mathrm{Log_{10}TW} = 3.04 \log_{10}\mathrm{TL} - 2.21$ ($n = 918$, $r^2 = 0.981$), which was highly significant (ANOVA, $p < 0.001$).

Sex ratio

Out of 918 fish that were caught during the investigation, 463 (50.4%) were females whereas 455 (49.6%) were males. Sex ratio in the total catch was not significantly different from 1:1 (Chi-square test, $p < 0.05$).

Breeding season

The smallest ripe female caught was 34.0 cm TL whereas the smallest ripe male caught was 33.0 cm TL. Although some fish with ripe gonads were caught throughout the year, they were highly frequent between February and June 1987 with the peak occurring in April for females (43.0%) and in June for males (34.0%) (Fig. 2a). Evidently breeding is strongly associated with environmental factors such as rainfall and temperature. Rainfall was highest between February and June, and the maximum air temperature was low and the minimum air temperature was high during this period (Fig. 2b). The proportion of fish with ripe gonads was also high between February and March 1988. In February 1988, 38.0% of the females and 31.0% of the males had ripe gonads while in March 43.0% of the females and 38.0% of the males had ripe gonads (Fig. 2a).

The above result (Fig. 2a) suggests that *C. gariepinus* in Lake Awassa starts to spawn at the beginning of the early rains in February. Payne (1986) reports that there is a migratory phase of *C. gariepinus* in which the maturing fish enter the in-flowing rivers prior to spawning in the floodwater pools. This migration provides a mechanism for dispersion as well as finding a favourable environment for development of the eggs. However, there is no strong evidence to suggest that breeding fish migrate through the small inlet, Tikur Wuha River for spawning in Lake Awassa. In addition, significant differences were not observed in the proportion of fish with ripe gonads between fish caught at the mouth of

Tikur Wuha River and the other four stations throughout the breeding season (ANOVA, P>0.05).

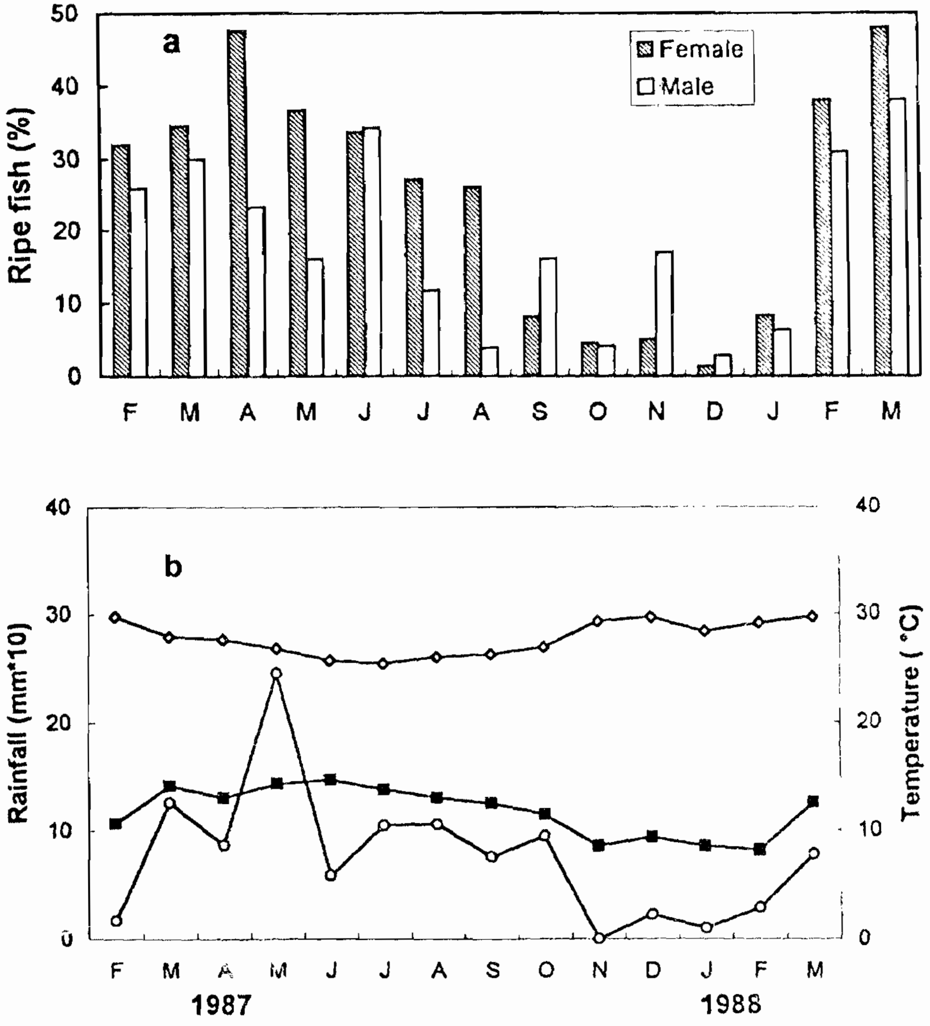

Fig. 2. **Breeding season of *C. gariepinus* as indicated by the percentage of fish with ripe gonads (a), and rainfall (○), maximum (■) and minimum (◇) air temperature of Awassa region (b).**

The final stimulus to spawn in *C. gariepinus* is not clearly understood. Viveen *et al.* (1986) associates this to a rise in water level and inundation of marginal areas. According to Payne (1986), migratory responses in catfish occur when the rain and flood begin to increase resulting in changes in water level or current speed. In addition, internal factors such as hormone-coordinated rhythms are also believed to induce migratory responses in *C. gariepinus* (Payne, 1986).

Fecundity

The weight of ripe ovaries ranged from 11.2 to 962.0 g and contained between 8,800 and 650,000 eggs. The number of preserved eggs per gram wet weight ranged from 435 to 1176 with a mean of 669.

There were significant relationships between fecundity (F) and TL (ANOVA, $p < 0.001$, $r^2 = 0.734$), F and TW ($p < 0.001$, $r^2 = 0.729$) and F and ovarian weight (O) ($p < 0.001$, $r^2 = 0.960$).

The relationships between F and the independent variables were explained by the following formulae:

$$\log_{10}F = 3.2 \log_{10}TL - 1.05 \ (n = 67)$$
$$\log_{10}F = 1.23 + 1.06 \log_{10}TW \ (n = 67)$$
$$\log_{10}F = 2.91 + 0.95 \log_{10}O \ (n = 67)$$

Food and feeding

From the 918 stomachs that were investigated during the sampling period, 597 (65.0%) were completely empty. Out of the remaining 321 (35.0%) stomachs, 77 were collected from juvenile catfish (16.3–35.0 cm TL) caught by beach seine and small hook and line gear. All juveniles collected contained food.

O. niloticus was found to be the most important food item for both juvenile and adult *C. gariepinus* (Tables 1 and 2). The size of *O. niloticus* eaten by adult *C. gariepinus* ranged from 6.5 cm to 18.0 cm TL and was smaller than the commercial size of *O. niloticus* in Lake Awassa. A single *C. gariepinus* (TL = 52.5 cm, TW = 1100 g) had ingested *O. niloticus* of 23.5 cm long and 210 g in weight. Other fish species that were of minor importance in the diet of *C. gariepinus* were *Barbus* sp. and *Garra* sp. (Table 2).

Table 1. Food items identified from the stomach contents of 77 juvenile *C. gariepinus* from Lake Awassa.

	Frequency of occurrence		Volumetric analysis	
	Number	Per cent	Volume (ml)	Per cent
Crustacia				
Diaphanosoma exisum	2	2.6	-	-
Thermocyclops equatorialis	2	2.6	-	-
Mollusca (gastropodes)	2	2.6	2.7	2.2
Insecta				
Odonata				
Anisopteran larvae	19	24.7	5.4	4.5
Zygopteran larvae	6	7.8	1.6	1.3
Diptera				
Chironomidae larvae	17	22.1	1.3	1.1
Stratiomydae	2	2.6	0.7	0.6
Simulidae	1	1.3	0.3	0.2
Cyclorrhapha	1	1.3	0.6	0.5
Coleoptera				
Hydrophilidae	3	3.9	0.3	0.2
Hemiptera				
Notonectidae	1	1.3	-	-
Corixdae		6.5	0.2	0.2
Fish eggs	15	19.5	1.1	0.9
Macrophytes (shoots and roots)	19	24.7	6.5	5.4
Detritus	2	2.6	2.7	2.2
Pisces				
Oreochromis niloticus	38	49.4	86.1	71.0
Aplocheilichthyes sp.	17	22.1	11.8	9.7

Table 2. Food items identified from the stomach contents of 244 adult *C. gariepinus* from Lake Awassa.

	Frequency of occurrence		Volumetric analysis	
	Number	Per cent	Volume (ml)	Per cent
Crustacia				
Diaphanosoma exisum	17	7.0	1.0	0.07
Thermocyclopes equatorialis	17	7.0	1.0	0.07
Insecta				
Diptera				
Cyclorrhapha	2	0.8	0.7	0.05
Simulidae	7	2.9	1.5	0.1
Chironomidae larvae	28	11.5	2.0	0.1
Odonata				
Anisopteran larvae	17	7.0	4.4	0.3
Zygopteran larvae	5	2.0	1.0	0.07
Coleoptera				
Hydrophilidae	6	2.5	0.4	0.03
Orthoptera				
Acrididae	8	3.3	27.7	1.9
Hemiptera				
Notonectidae	9	3.7	0.3	0.02
Fish eggs	40	16.4	8.4	0.6
Macrophytes (shoots and roots)	49	20.1	60.2	4.0
Detritus	18	7.4	89.5	6.0
Pisces				
Oreochromis niloticus	55	22.5	1151.8	77.5
Garra sp.	6	2.5	41.0	2.8
Barbus sp.	2	0.8	34.6	2.3
Clarias gariepinus	2	0.8	63.0	4.2

Other food organisms that were ingested relatively frequently were insects, fish eggs, zooplankton, macrophytes and detritus. Macrophytes and detritus were ingested by *C. gariepinus* that had food items other than fish in their stomach. The presence of gastropods, fish eggs and zooplankton was strongly associated with macrophytes and detritus. Gastropods, fish eggs and zooplankton were less important, because they represented relatively smaller volume of the bulk of the food consumed (Tables 1 and 2). Their importance could be under-estimated as a result of digestion, since the fish had stayed on the hooks for several hours.

By the frequency of occurrence method, fish accounted for 71.5% of all juvenile *C. gariepinus* examined (Fig. 3a, Table 1). In the volumetric analysis of the stomach contents of juveniles, fish accounted for 80.7% of all the food consumed (Fig. 3a, Table 1). The result of stomach content analysis of adult *C. gariepinus* also shows the role of fish as the most important food because they represented 26.5% by frequency of occurrence and 86.8% by volume of the food eaten (Fig. 3b, Table 2).

Cannibalism was found to be rare in *C. gariepinus* in Lake Awassa. Only two cannibalistic individuals were encountered in this study. A catfish measuring 83.0 cm TL was found containing another catfish of 18.0 cm TL, and another catfish measuring 78.0 cm TL had eaten 22.2 cm TL of its kind.

In *C. gariepinus* the type of food items consumed varied slightly depending on the size of the fish. *Aplocheilichthyes* sp. was an important food organism for juvenile fish, but it was not found in the stomachs of the larger specimens (Table 1). Two fish species, *Barbus* sp. and *Garra* sp., were of minor importance in the diets of adult fish, but they were not encountered at all in the stomach of the juveniles. Moreover, insects contributed to the greater volume of the food consumed by the juveniles than the adults (Fig. 3). This difference could be due to habitat differences between the juveniles and adults. Juveniles normally live in shallow water among the macrophytes where the density of invertebrates is usually high while the adults prefer the deeper water (Bruton, 1978).

Diel variation in the food type consumed and feeding intensity of the juveniles was evident from the analysis of 44 fish caught during the day and 33 fish caught during the night (Fig. 4). Among fish caught during the daytime, 17 (38.6%) had nearly empty stomach whereas only 2 (6.1%) of those caught at night had less than half-full stomach. Dragonfly larvae (Anisoptera) were important food items during the daytime accounting for 42.4% by frequency of occurrence method and 15.9% by volume of food consumed. In the night-collected specimens, this food item represented only 11.4% by frequency of occurrence and 1.6% by volume of the food consumed. Fry of *O. niloticus* were the most important food items at night during which time they contributed

77.3% by frequency of occurrence and 84.8% by volume (Table 3). However, during the daytime they accounted for 12.1% by frequency and 16.7% by volume (Table 3). A similar finding was reported by Bruton (1978) where the efficiency of predation of *C. gariepinus* on cichlid fish increases at low light intensity particularly in shallow water in Lake Sibaya, South Africa. Two zooplankton species, *Thermocyclops equatorialis* and *Diaphanosoma exisum* were consumed by *C. gariepinus* only at night in the present study.

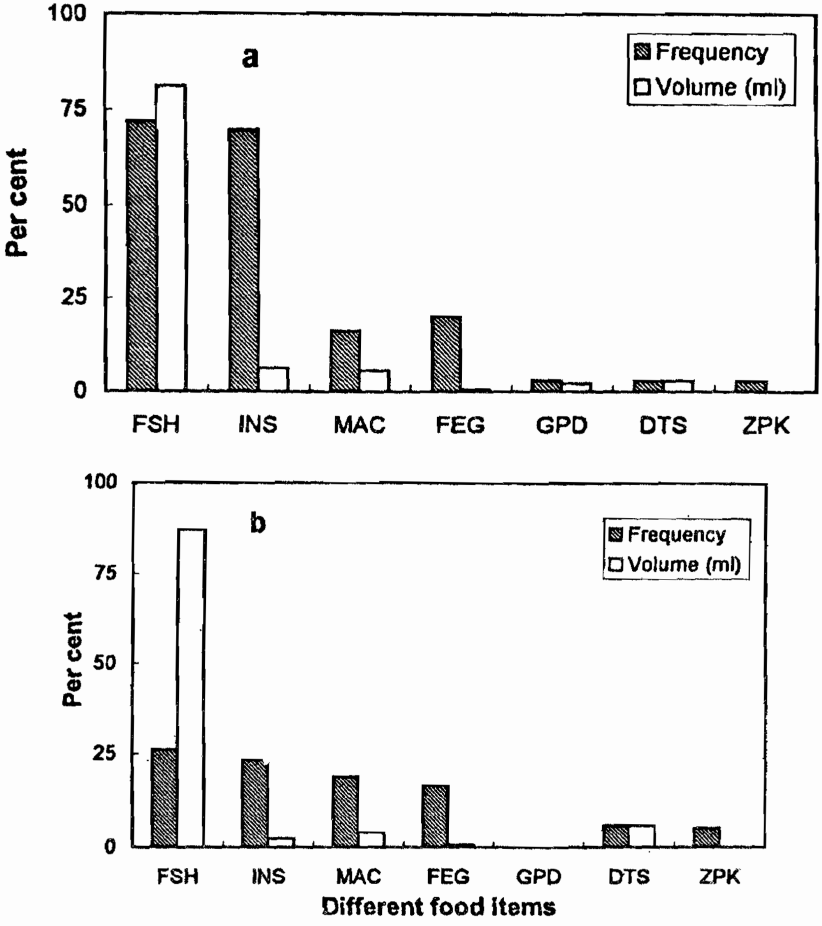

Fig. 3. **Percentage frequency of occurrence and percentage volume of various food items in the stomach of juvenile (a), and adult (b) *C. gariepinus* in Lake Awassa.** (FSH, fish; INS, insects; FEG, fish eggs; MAC, macrophytes, DTS, detritus; GPD, gastropodes; and ZPK, zooplankton).

Table 3. Food items identified from the stomach contents of 44 juvenile *C. gariepinus* (19.3-32.5 cm TL) caught at night and 33 juvenile *C. gariepinus* (16.3-35.0 cm TL) caught during the daytime from Lake Awassa.

	Frequency of occurrence				Volumetric analysis			
	Number		Per cent		Volume (ml)		Per cent	
	Day	Night	Day	Night	Day	Night	Day	Night
Crustacia								
D. exisum	-	2	-	4.5	-	-	-	-
T. equatorialis	-	2	-	4.5	-	-	-	-
Mollusca (gastropodes)	1	1	3.0	2.3	1.9	0.8	7.8	0.8
Insecta								
Odonata								
Anisopteran larvae	14	5	42.4	11.4	3.9	1.5	15.9	1.6
Zygopteran larvae	4	2	12.1	4.5	1.2	0.4	4.9	0.4
Diptera								
Chironomid larvae	2	15	6.1	34.1	-	1.3	-	1.4
Stratiomydae	2	-	6.1	-	0.7	-	2.9	-
Simulidae	1	-	3.0	-	0.3	-	1.2	-
Cyclorrhapha	1	-	3.0	-	0.6	-	2.5	-
Coleoptera								
Hydrophilidae	3	-	9.1	-	0.3	-	1.2	-
Hemiptera								
Notonectidae	1	-	3.0	-	-	-	-	-
Corixidae	5	-	15.2	-	0.2	-	0.8	-
Macrophytes	14	5	42.4	11.4	5.1	1.3	20.8	1.3
Fish eggs	11	4	33.3	9.1	0.8	0.3	3.3	0.3
Detritus	2	-	6.1	-	2.7	-	11.0	-
Pisces								
O. niloticus	4	34	12.1	77.3	4.1	82.0	16.7	84.8
Aplocheilichthyes sp.	3	14	9.1	31.8	2.7	9.1	11.0	9.4

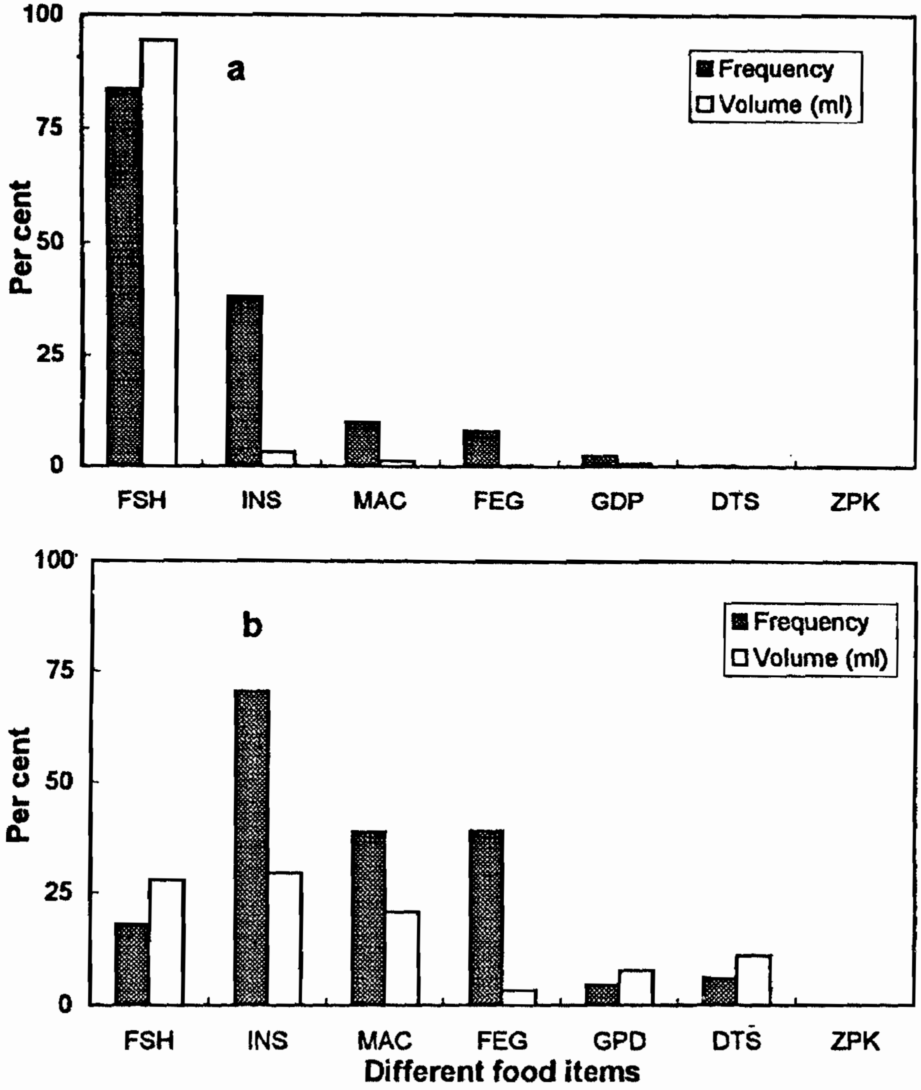

Fig. 4. Percentage frequency of occurrence and percentage volume of various food items in the stomachs of juvenile *C. gariepinus* sampled at night (a), and during the day (b). (FSH, fish; INS, insects; MAC, macrophytes; FEG, fish eggs, and GPD, gastropodes; DTS, detritus; ZPK, zooplankton).

The majority of adults were found with empty stomach and even those containing food were on the average less than half-full. On the other hand feeding intensity of the juveniles was high. For juveniles stomach fullness was on the average greater than three-quarters. Several reasons could be responsible for the relatively high occurrence of empty stomachs in adults. First, since the fish were left for several hours on the longlines, the stomach contents may have been lost by regurgitation or digestion. The importance of small organisms such as zooplankton and certain benthic fauna may be under-estimated due to their faster rate of digestion. Second, the feeding habit of the fish may be also responsible for the high incidence of empty stomachs. Piscivorous fishes tend to feed less frequently and need not feed continuously, because they feed on larger size prey obtaining higher proportion of the food they require with less expenditure of energy (Thomas, 1966).

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