# STUDIES ON THE BIOLOGY AND COMMERCIAL CATCH OF *Clarias mossambicus* Peters (Pisces: Clariidae) in Lake Awassa, Ethiopia

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to

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by

Elias Dadebo

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## SUMMARY

Certain aspects of the biology of the catfish *Clarias mossambicus* in Lake Awassa, Ethiopia, were studied from February 1987 - March 1988. The results of catch-per-unit effort revealed that *C. mossambicus* was most abundant at Tikur Wuha (21.82 kg per 100 hooks per 12 hours), the north-eastern side of the lake, and least abundant at Blazar (11.37 kg per 100 hooks per 12 hours), the eastern side of the lake. Average individual weight of the fish increased with the depth of the sampling site. Average individual weight of catfish at Tikur Wuha, which is the shallowest of the sampling stations (2m), was 2036 grams, while at Deset, the deepest station (12m), average weight was 2622 grams. The overall average weight was 2235 grams.

*Clarias mossambicus* was found to be carnivorous in its feeding habits and fish constituted the bulk of its food (81.4% by volume). A cichlid fish (*Oreochromis niloticus*) was the most utilized prey of the catfish. It accounted for 72% by volume, of the food eaten by juvenile fish (163-350 mm total length) and 79% by volume of the food of the adult catfish. Other food items found in the stomachs included insects, fertilized fish eggs (spawn), snails, nematodes and zooplankton.

Breeding started at the beginning of the early rains in February and continued until June, after which the proportion of the breeding females declined gradually, while the proportion of the males declined sharply. The sex ratio was not significantly different from unity, where 49.6% males and 50.4% females were caught during the investigation. The ripe ovaries contained between 435 and 1176 eggs per gram of wet weight with the mean at 669/gram.

The average monthly Fulton's condition factor of the males ranged from 0.640-0.719 while the average monthly Fulton's condition factor of the females ranged from 0.664-0.745. The average Fulton's condition factor of the males was 0.690 while that of the females was 0.702. The overall average Fulton's condition factor was 0.696.

The incidence of parasitic infestation was very high (84.6%). The average number of nematodes in each body cavity was 28 and the range was 4 to 300.

The commercial catch of <u>Clarias mossambicus</u> was very low (1388 kg/month) for most of the months. During the fasting periods (February 22 - April 16, 1987; August 7 - 21, 1987) the average catch was 12300 kg/month.

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# CHAPTER I

## INTRODUCTION

# INTRODUCTION

There is considerable knowledge of the biology of the catfish Clarias mossambicus (Peters)* (= C. gariepinus = C. lazera = C. senegalensis) in other parts of Africa. However, little has been done on the basic biology of the species in Ethiopia. Such area specific information is needed for sound management. Clarias mossambicus is widely distributed throughout Africa and it is one of the most important individual commercial freshwater fish species in many parts of Africa (Clay, 1977; Willoughby & Tweddle, 1978; Viveen et al., 1986; Jubb, 1967; Cambray & Jubb, 1977; Bell-Cross, 1976). It is known for its adaptability and hardiness with regard to adverse environmental conditions (Clay, 1979b). In tropical swamps, rivers and lakes, the low solubility of oxygen at high temperatures and the decomposition of organic matter can often combine to produce low concentrations of oxygen, particularly during the dry season. To increase the availability of oxygen the catfish has developed a tree-like chambers on top of the gill cavity. Because of this respiratory organ, the catfish is able to live in stagnant, warm waters with very low dissolved oxygen (Payne, 1986). Due to the above fact, Clarias mossambicus is able to survive in

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* Viveen et al. (1986) reported that the African catfish which was formerly known to have different names in different parts of Africa, is only one species.

desicated environments (Donnelly, 1973; Viveen *et al.*, 1986) or even in highly polluted bodies of water (Groenewald, 1964). Since it is able to respire atmospheric oxygen, it can also survive out of water for several hours depending on the humidity of the environment. If the humidity of the environment is kept relatively high *Clarias mossambicus* can be transported alive for 24 hours or more after harvest and survive such treatment (Hora, 1934).

As a predator the catfish *Clarias mossambicus* is able to utilize a wide variety of food items, other than fish, including terrestrial and aquatic insects, snails, zooplankton and several benthic organisms (Fryer, 1959; Gaigher, 1969; Van der Waal, 1972; Viveen *et al.*, 1986).

Information on the reproductive biology of the catfish has been reported by several authors (Willoughby & Tweddle, 1978; Viveen *et al.*, 1986; Greenwood, 1955, 1957; Clay, 1979a; Van der Waal, 1974). In all areas for which data are available, the catfish breeds in the flood plains of the feeder streams after the onset of the major rains. After spawning the spent fish return to the lake. Migration among the catfish populations has also been reported by Corbet (1961) and Thomas (1966).

In Ethiopia, the lakes and the river systems have great potential for the production of *Clarias mossambicus*.

In fact it is one of the main commercially important fish species in Ethiopia. It is of considerable importance in the traditional fishery of Lake Awassa. Since it is a fast growing fish (Willoughby & Tweddle, 1978; Clay, 1979b; Van der Waal, 1974) and an indiscriminate feeder (Groenewald, 1964; Thomas, 1966; Bruton, 1978c, 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 study is therefore to elucidate certain aspects of its life history such as feeding, breeding seasons and sites, fecundity and condition.

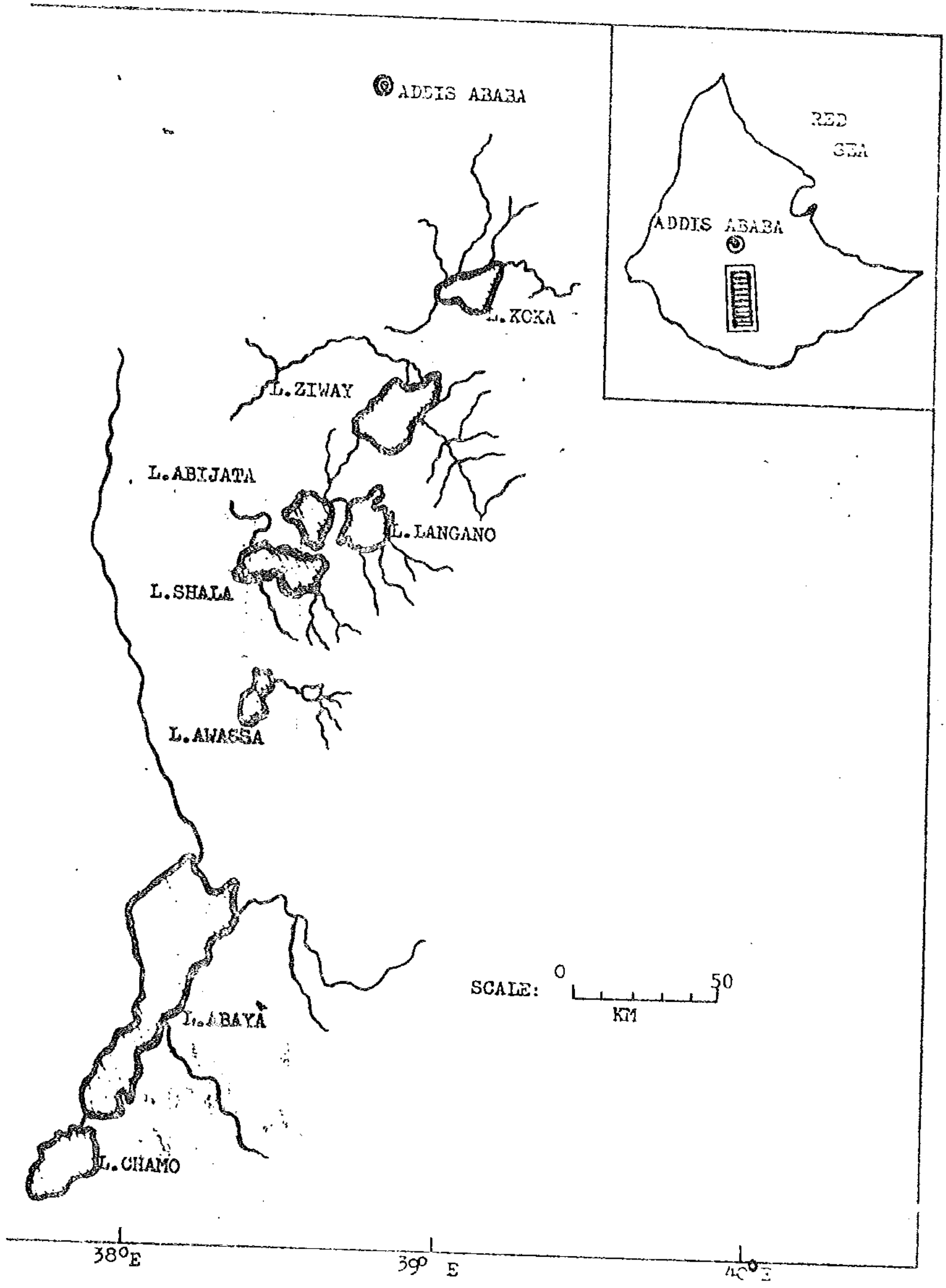
# CHAPTER - II

# DESCRIPTION OF STUDY AREA

## DESCRIPTION OF STUDY AREA

The Rift Valley in Ethiopia runs along the middle of the country in a north-south direction and extends from Lake Turkana in the south to the Afar depression in the north. Seven small to moderately large lakes are located along the southern part of the Rift (Fig. 1). According to Von Damm and Edmond (1984) these lakes can be divided into three distinct groups. The first group consists of Lakes Ziway, Langano, Abijata and Shalla which are located on the northern part of the Rift. The second consists of the Abaya-Chamo lakes that occupy the southern part of the Ethiopian Rift. The last group is the Awassa-Shallo complex which is found in between the other two groups of lakes.

The Lake Awassa basin is enclosed by faulting and totally separated from the other groups of lakes (Mohr, 1962). According to Makin et al. (1975) Lake Awassa is volcano-tectonic in origion and lies in a caldera with a diameter of about 30km and an area of 1360 $km^2$. The surrounding area of the lake is underlain by quartz and pumice (Mohr, 1960). The main affluent of Lake Awassa comes from the east and drains from the swampy lake called Lake Shallo through Tikur Wuha River. Even though Lake Awassa has no surface outlet, the salinity of the water remains comparatively low (Table 1). Several authors suggest that subterranean outflow by seepage may keep the salinity


ADDIS ABABA
L.KOKA
L.ZIWAY
L.ABIJATA
L.LANGANO
L.SHALA
L.AWASSA
L.ABAYA
L.CHAMO
SCALE: 0 50
KM
38°E
39° E
40°E
RED SEA
ADDIS ABABA

low (Makin et al., 1975; Beadle, 1981). Various freshening mechanisms including burial of alkaline layers and ion removal by aquatic plants may have also operated in this lake (Richardson & Richardson, 1972; Gaudet & Melack 1981).

The climate of the Awassa region is seasonally dry and sub-humid with one dry and one rainy season per year (Gemechu, 1977). Both the mean temperature and the mean rainfall of this region are among the highest in the country (Teferra, 1987). The average monthly rainfall and the average monthly maximum and minimum air temperatures of the area are given in Tables 2 and 3 for five years 1983 to 1987. The four months November to February are the coldest as well as the driest of the years (Gemechu, 1977; Tables 2 and 3). The wettest month is May (Table 2).

The hills surrounding the lake are bare with sparse growth, most of which is low growing vegetation and grass. The practice of cultivating maize, sisal and teff is common on the plains between the lake and the surrounding hills. Other human activities on the catchment area of the lake include grazing, cutting tall growing Typha for roof construction or fuel and tree cutting (Kibret, 1985). These activities have led to considerable soil erosion which has occurred during the rainy season. However, there is no reported evidence of extensive siltation in Lake Awassa.

Table 2: Mean monthly rainfall (mm) for the Awassa region.

| | Rainfall | | | | |
|---|---|---|---|---|---|
| | 1983** | 1984* | 1985* | 1986** | 1987** |
| January | 42.8 | 0.0 | 9.2 | 0.0 | 0.0 |
| February | 62.7 | 0.0 | 0.0 | 42.4 | 17.3 |
| March | 56.5 | 36.5 | 75.7 | 44.4 | 125.9 |
| April | 150.0 | 17.5 | 202.0 | 115.3 | 87.1 |
| May | 235.0 | 170.2 | 93.3 | 257.9 | 246.4 |
| June | 71.3 | 70.7 | 106.9 | 152.6 | 59.1 |
| July | 91.0 | 96.1 | 146.1 | 195.7 | 104.5 |
| August | 99.7 | 92.7 | 80.7 | 167.0 | 105.5 |
| September | 142.8 | 165.7 | 115.3 | 160.2 | 75.7 |
| October | 93.3 | 27.4 | 50.2 | 46.1 | 95.3 |
| November | 23.1 | 34.5 | 12.8 | 20.1 | 0.0 |
| December | 7.8 | 0.0 | 8.3 | 32.2 | 2.3 |

* Teferra (1987)

** Meteorological data of IAR (Institute of Agricultural Research) recorded in Awassa Station.

Table 3: Mean monthly maximum and minimum air temperature for Awassa region.

| | Maximum temperature (°C) | | | | | Minimum temperature (°C) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ** 1983 | * 1984 | * 1985 | ** 1986 | ** 1987 | ** 1983 | * 1984 | * 1985 | ** 1986 | ** 1987 |
| Jan. | 27.5 | 28.5 | 28.9 | 29.0 | 28.3 | 8.9 | 8.3 | 8.5 | 7.7 | 9.4 |
| Feb. | 28.2 | 29.5 | 29.3 | 29.4 | 29.8 | 12.1 | 7.2 | 10.0 | 12.2 | 10.7 |
| Mar. | 30.2 | 30.6 | 30.1 | 29.1 | 28.0 | 13.6 | 10.1 | 11.2 | 11.7 | 14.1 |
| Apr. | 27.2 | 30.5 | 25.5 | 26.5 | 27.7 | 13.6 | 12.0 | 12.5 | 14.6 | 13.0 |
| May | 25.6 | 25.9 | 25.3 | 26.7 | 26.9 | 14.1 | 13.4 | 12.4 | 13.4 | 14.3 |
| Jun. | 26.0 | 23.8 | 24.8 | 23.9 | 25.8 | 13.0 | 13.4 | 12.5 | 14.5 | 14.7 |
| Jul. | 24.1 | 23.4 | 22.9 | 23.6 | 25.5 | 12.8 | 13.1 | 12.6 | 13.4 | 13.8 |
| Aug. | 23.9 | 24.1 | 23.5 | 24.7 | 26.1 | 14.8 | 12.9 | 13.3 | 11.9 | 13.0 |
| Sep. | 24.3 | 24.3 | 24.6 | 24.9 | 26.3 | 12.9 | 11.6 | 12.7 | 12.3 | 12.5 |
| Oct. | 25.3 | 27.7 | 26.2 | 26.8 | 27.0 | 11.4 | 11.0 | 10.5 | 10.5 | 11.5 |
| Nov. | 26.8 | 28.1 | 27.6 | 28.2 | 29.3 | 9.2 | 9.0 | 8.8 | 8.6 | 8.6 |
| Dec. | 27.2 | 27.8 | 28.1 | 27.6 | 29.7 | 9.0 | 8.1 | 7.8 | 9.1 | 9.4 |

* Teferra (1987)

** Meteorological data of IAR (Institute of Agricultural Research) recorded in Awassa Station.

Figure 2:- Bathymetric map of Lake Awassa. Depth contours in 4 meters. (J. Herrmann, unpublished).

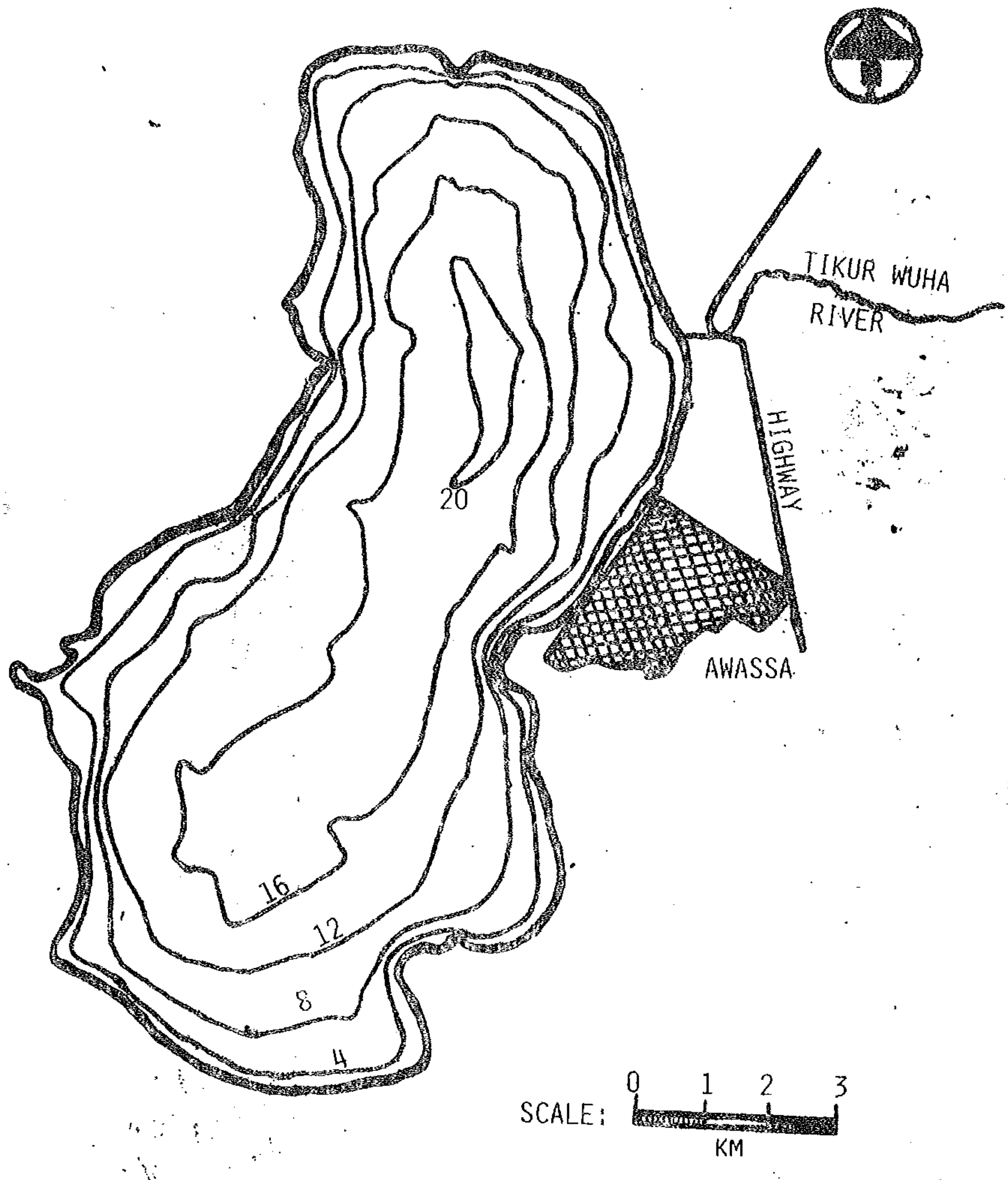
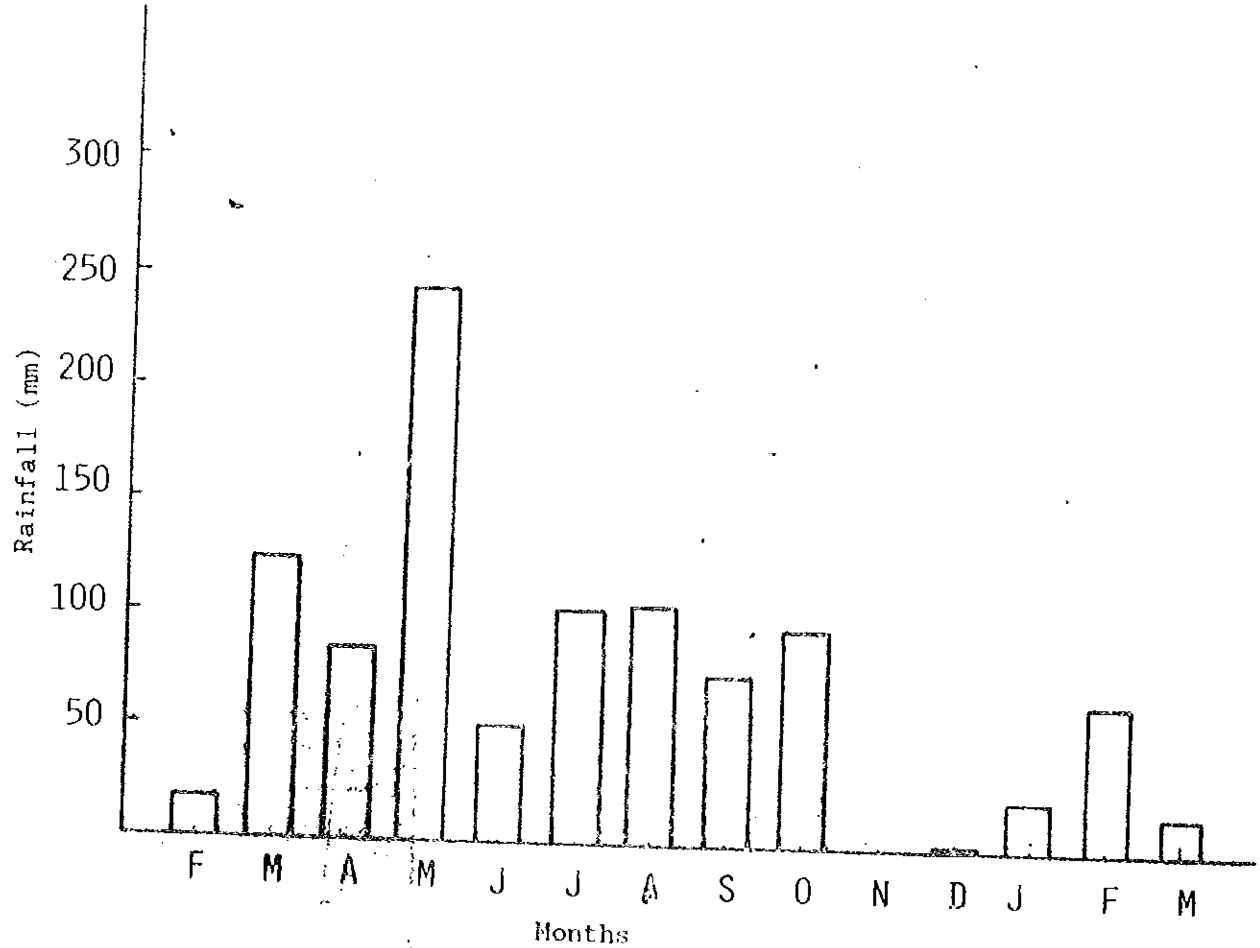
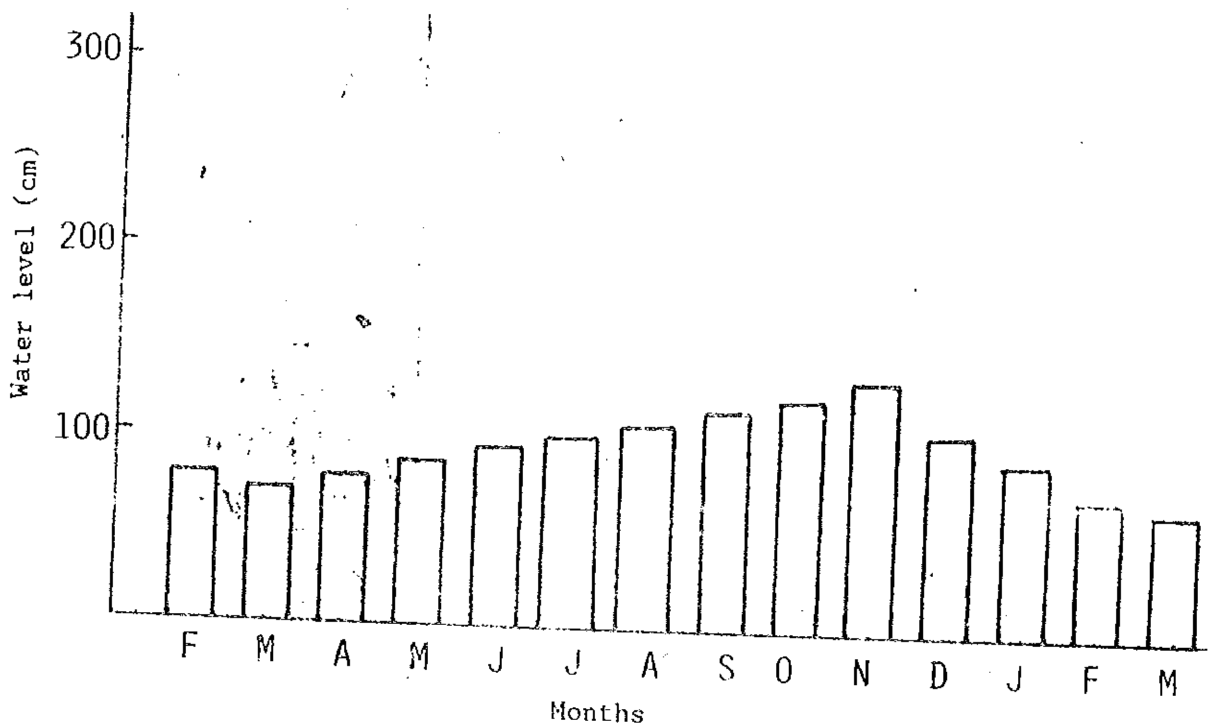

TIKUR WUHA
RIVER
HIGHWAY
AWASSA
20
16
12
8
4
SCALE:
0
1
2
3
KM

Fig. 3: Seasonal variation in rainfall (mm) for the Awassa region (a) and the water level of Lake Awassa (b) (depth in cm of an installed gauge). February 1987 - March 1988.




a) Rainfall




b) Water level

The swampy Lake Shallow may act as a settling area for silt coming from the mountains of the eastern wall of the Rift Valley (Kibret, 1985; Teferra, 1987).

The limnology and plankton of the lake have been studied by several authors (Kebede, 1987; Kifle, 1985; Mengistu, unpublished data; Gebre-Mariam, unpublished data). The major groups of phytoplankton of the lake are Botryococcus braunii, Microcystis spp. and Lyngbya nyassae (Kebede, 1987).

The dominant groups of zooplankton include the cyclopoid copepods (Mesocyclops) and cladocera (Diaphanosoma sp.) (Mengistu, unpublished data). Detailed information on the benthic fauna of the lake has been produced by Kibret (1985). The ostracods, chironomids and midges are among the dominant benthic forms

The dominating macrophyte of the lake is Paspalidium germinatum (Kibret, 1985). Other mocrophytes include Cyprus spp., Nymphea caerulea, Potomogeton spp., Typha angustifolia, T. latifolia and Chara spp. (Kibret, 1985; Kebede, 1987; Teferra, 1987). The macrophyte flora at the mouth of Tikur Wuha River differs from that found in other parts of the lake. Species at the mouth of Tikur Wuha River are Cyprus papyrus, Ludwingia stolinfera, Lemna minor and Wolfia arrhiza. Kibret (1985) attributes this difference in macrophyte species composition to lower content of sodium in the river water.

The fish species of the lake are Oreochromis niloticus, Clarias mossambicus, Barbus intermedius, Barbus amphigramma, Garra sp. and Apocheilichthyes sp. The commercial fishery depends mainly on Oreochromis niloticus.

The bird species that are supported by the lake are numerous and varied. The dominant bird species are Pelecanus onocrotalus, Leptoptilos crumeniferus, Threskiornis aethiopicus, Phalacrocorax carbo, Alopochen aegyptiaca and Haliaeetus vocifer (Williams & Arlott, 1986; Urban & Brown, 1971).

# CHAPTER - III

# MATERIALS AND METHODS

## 3. MATERIALS AND METHODS

3.1 Capture Method - Specimens were caught between February 1987 and March 1988 using stationary longlines. Monthly sampling was done at 5 different sites of the lake (Tikur Wuha - 2m, Dore - 4m, Minch - 6m, Blazar - 8m, Deset - 12m) (Fig. 4) with 100 baited hooks at each site. The size of the hooks used is given in Fig. 5. Previous work has shown that cichlid fishes are one of the most favoured prey species of *Clarias mossambicus* (Thomas, 1966; Spataru *et al.*, 1987). Due to this fact pieces of the cichlid fish *Oreochromis niloticus* were used as bait. The hooks were usually set during the afternoon and lifted the following morning. The long-lines were set parallel to the vegetation. In addition to the fish caught by stationary longlines, specimens were caught with beach seines and small hook and line gear. This was done to provide a wider range of fish size and hence to supplement the data on certain aspects of the biology of the fish.

3.2 Length-weight relationship - All fish were measured to the nearest centimeter. Fish under 1000 grams were weighed to the nearest gram and fish between 1000 grams and 2000 grams were weighed to the nearest 5 grams. Larger specimens (over 2000 grams) were weighed to the nearest 25 grams. Total lengths and weights of 918

Figure 4:-- The map of Lake Awassa with the sampling stations indicated.

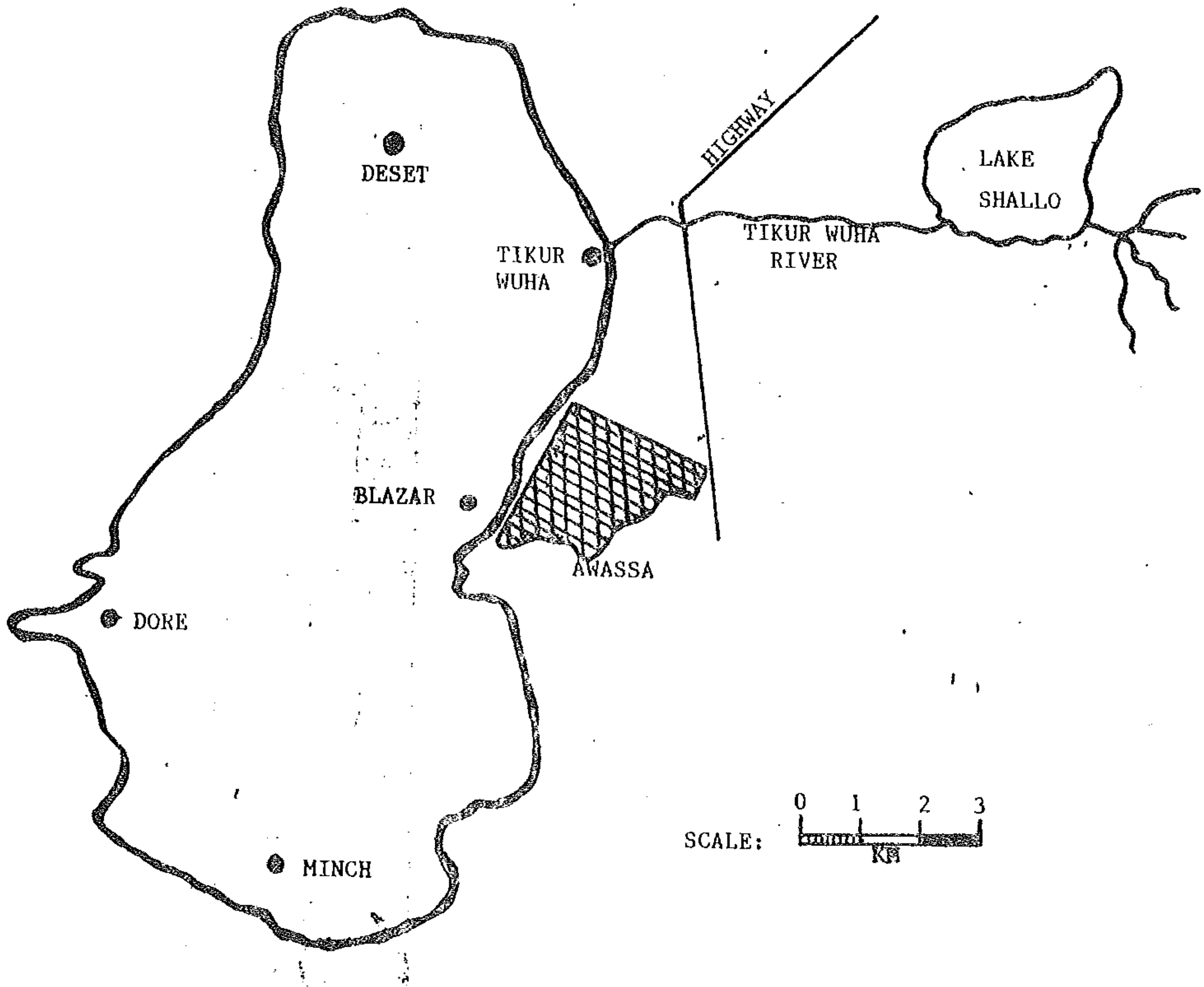
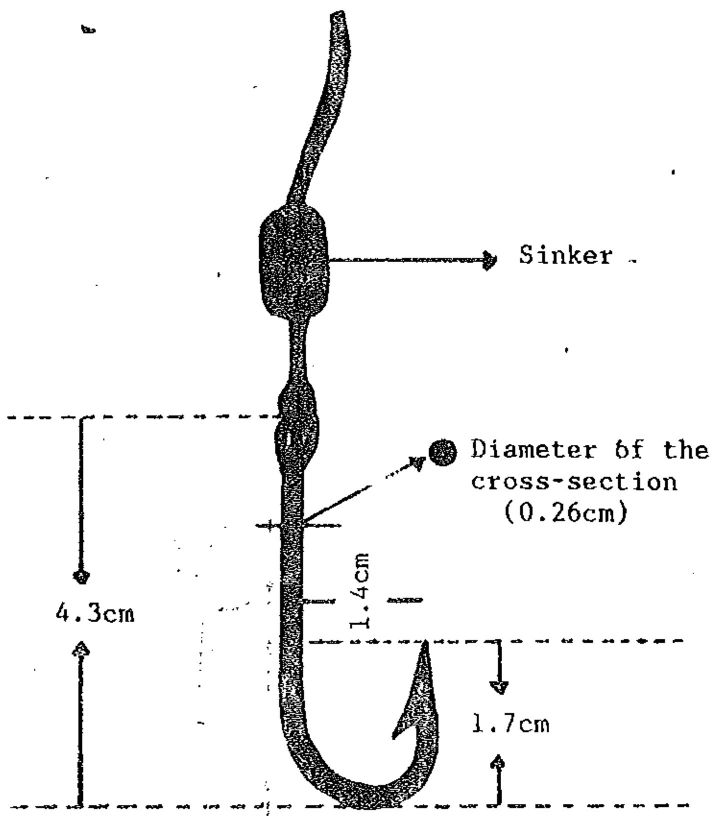



FIG. 4: THE MAP OF LAKE AWASSA WITH THE SAMPLING STATIONS INDICATED.

Figure 5:- Size of hook used during sampling.


Sinker
Diameter of the cross-section (0.26cm)
1.4cm
4.3cm
1.7cm

specimens were used to calculate the length - weight relationship. The least squares regression technique was used in this analysis. Preliminary work showed that there was no significant difference between male and female length - weight relationships, so the sexes were treated together in subsequent analysis.

3.3 Food and feeding - Stomach contents from *Clarias mossambicus* were collected and preserved in 4% formalin. Identification of the stomach contents was done visually in case of larger food items and a dissecting microscope was used for smaller organisms. In order to determine differences in the food composition related to the size of fish, the stomach contents from fish caught by stationary longlines (3800-1100m TL) and fish caught with beach seines and small line and hook gear (163-350mm TL) were analysed separately. The analysis of food composition was done according to the following methods.

3.3.1 Frequency of occurrence - the number of stomach samples containing one or more of a given type of food item was expressed as a percentage of all non-empty stomachs examined (Bagenal, 1978). The proportion of the population that fed on certain food items was estimated by this method.

3.3.2 Numerical analysis - the number of food items of a given food type that were found in all samples examined was expressed as a percentage of all food items (Bagenal, 1978). This estimated the relative abundance of that food item in the diet.

3.3.3 Volumetric analysis - the 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 (Neilsen & Johnson, 1983). Since the food items were from a wide range of sizes, 250ml, 100ml and 25ml graduated cylinders were used to achieve reasonable accuracy. The volume of water displaced by each category of food items was then expressed as a percentage of the total volume of the stomachs (Bagenal, 1978).

3.4 Breeding - The sexes of all fish and the maturity stages of the gonads were determined. The maturity stages were determined by visual examination using maturity keys. A five point maturity scale was used for this purpose (Holden & Raitt, 1974). Ripe ovaries were preserved in modified Gilson's fluid (100ml 60% ethanol, 880ml water, 15ml 80% nitric acid, 18ml glacial acetic acid and 20g mercuric chloride) (Simpson, 1951). This fixative hardens eggs and helps to liberate them from the ovarian tissue (Bagenal, 1978; Nielsen & Johnson, 1983). In order to assist penetration by preservative the ovaries were split longitudinally and turned inside out (Begenal, 1978). Fecundity was estimated by wieghing all the eggs in the ovaries, then weighing two sub-samples of 1000 eggs and thence calculating the total number. The method outlined by Simpson (1959) was used for this purpose.

3.5 Condition factor - Condition factors are used to compare the well-being or fatness of fish. These factors are based on the hypothesis that the heavier fish of a given length are in better condition. In this analysis the Fulton-type Condition Factor was used.

$$K = \frac{100\ W}{l^3}$$

where:

K = Condition factor

W = The eviscerated weight of fish in grams

l → Total length of fish in centimeters.

3.6 Parasitic infestation - The degree of parasitic infestation was determined by counting the parasites found in the body cavity. The effect of these parasites on the condition of the fish was also observed. To compare the difference on the condition factor of fish that were not infested by nematodes (0 nematodes) and highly infested (>50 nematodes) a t-test was conducted on 30 randomly selected fish from each group.

3.7 Commercial catch - The importance of Clarias mossambicus for the traditional fishery of Lake Awassa was determined by taking records of the commercial catch three times a week for 16 months. The annual catch of C. mossambicus was estimated based on the available data.

# CHAPTER - IV

# RESULTS

4.1 Abundance and distribution - The total weights and numbers of *Clarias mossambicus* caught during the sampling period are shown in Table 4. *C. mossambicus* was most abundant at Tikur Wuha and least abundant at Blazar. From the results indicated in Table 5, it is evident that the average individual weight of the fish tends to increase as the depth of sampling station increases, with the exception of Blazar, where the total number as well as the individual weight of the specimens were low. The average weights of *C. mossambicus* caught per 100 hooks per 12 hours for the period of investigation are given in Table 5.

4.2 Length-weight relationship - The relationship between the total length in cm(L) and total weight in g(W) is described by the equation:

$$\log_{10}W = 3.042 \log_{10}L - 2.214 (n = 918)$$

The least squares regression technique was used to plot $\log_{10}W$ an abscissa and $\log_{10}L$ as ordinate. There was a highly significant ($P \leq 0.001$, $r^2 = 0.981$) regression between $\log_{10}W$ and $\log_{10}L$.

4.3 Food and feeding - Nine hundred and eighty-eight stomachs were collected during the period of investigation, of which 642 (65%) were completely empty. Out of the remaining 346(35%) stomachs, 77 were collected from juvenile catfish (163-350mm total length) caught by beach seine and small hook and line gear.

Table 4: Numbers and weights of Clarias mossambicus caught at sampling stations (Feb. 1987 - Mar. 1988).

| Sampling station | Depth (m) | Number of fish caught at station | % total No. of fish at station | Weight of fish caught at station (kg) | % total weight of fish caught at station |
|---|---|---|---|---|---|
| Tikur Wuha | 2 | 262 | 28.8 | 533.52 | 26.3 |
| Dore | 4 | 243 | 26.8 | 524.93 | 25.9 |
| Minch | 6 | 187 | 20.6 | 456.63 | 22.5 |
| Blazar | 8 | 98 | 10.8 | 204.67 | 10.1 |
| Deset | 12 | 118 | 13.0 | 309.45 | 15.2 |
| Total | - | 908 | - | 2029.2 | - |

Table 5: Average weights and average individual weights of *Clarias mossambicus* caught per 100 hooks per 12 hours to indicate catch per unit effort (February 1987 – March 1988).

| Sampling station | Depth (m) | Total weight (kg) of fish caught at station | Average weight (kg) of fish caught per 100 hooks per 12 hours | Average weights(g) of individual fish during the whole sampling period |
|---|---|---|---|---|
| Tikur Wuha | 2 | 533.52 | 21.8 | 2036 |
| Dore | 4 | 524.93 | 20.03 | 2160 |
| Minch | 6 | 456.63 | 17.11 | 2442 |
| Biazar | 8 | 204.67 | 11.37 | 2088 |
| Deset | 12 | 309.45 | 13.38 | 2622 |

By the numerical method, fish accounted for 0.31 - 0.54% of all food items and occurred in 28.40 - 38.62% of all adult fish examined (380-1100 mm total length). (Table 6, 7 and Figs. 6, 7). In volumetric analysis of the stomach contents of adult Clarias mossambicus (specimens collected from October 1987 to March 1988) fish accounted for 81.2% of food eaten (Table 7, Fig. 7). The results of the stomach content analysis of juvenile Clarias (163-350 mm total length) also show that fish is the most important food component which represented 22.7% numerically, 71.4% by frequency of occurrence method and 81.5% volumetrically (Table 8, Fig. 8).

Oreochromis niloticus was the most important food item found in the stomachs of Clarias mossambicus (Table 6, 7 and 8). Most of the preyed Oreochromis were smaller than commercial size ranging in size from 6.5cm to 18cm TL(total length). In one stomach of Clarias (TL = 52.5cm, W = 1100g) a specimen of O. niloticus 23.5cm long and 210g W (total weight) was found Two canibalistic individuals were encountered. The 83 and 78cm catfish had eaten other catfish which were 18cm and 22.2cm respectively. Canibalism was also observed by Groeneweld (1964) among Clarias gariepinus population in Transvaal, South Africa. Fish species that were of minor importance in the diets of the catfish included Barbus intermedius and Garra sp. (Table 6). Other food

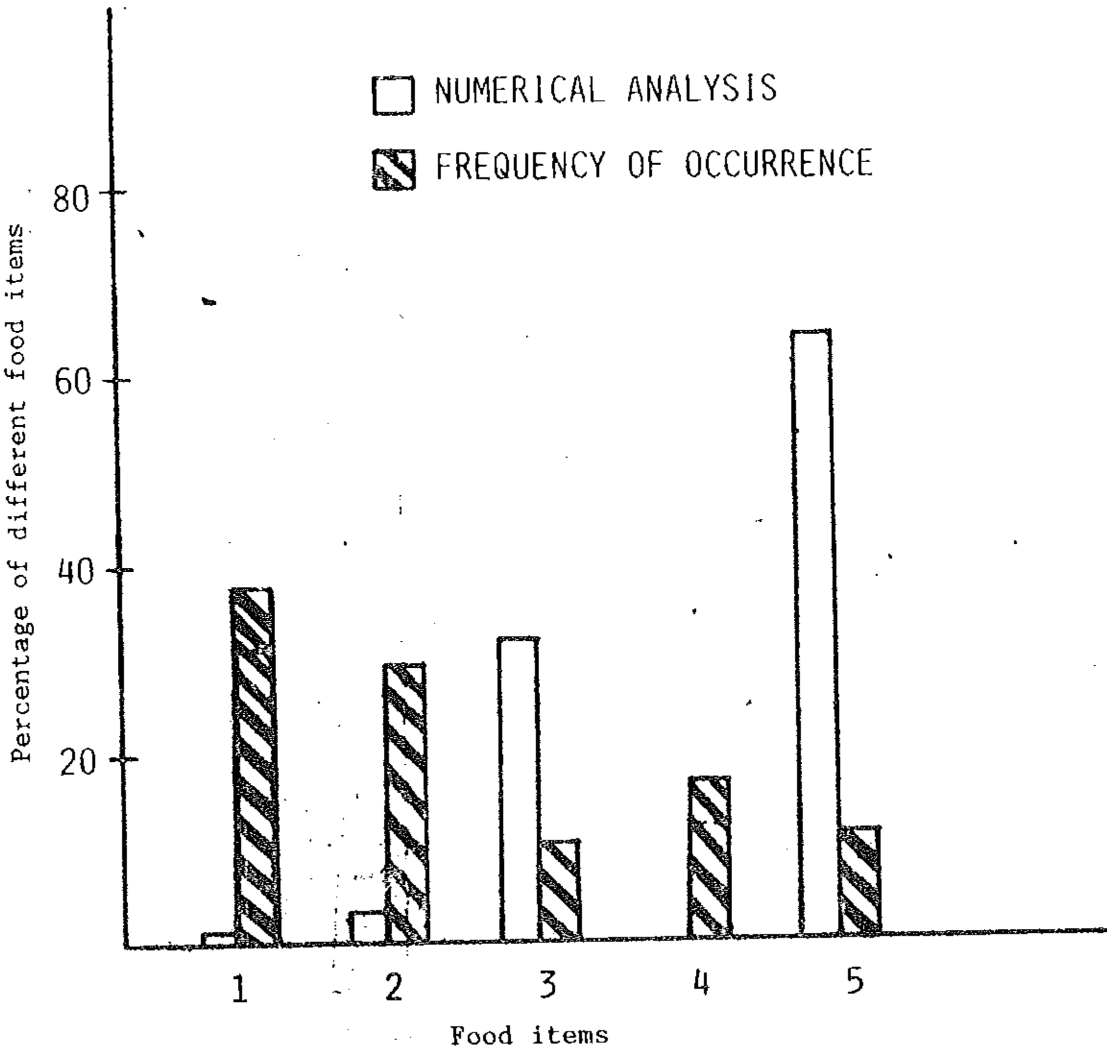
Table 6: Summary of the food items of 188 *Clarias mossambicus* ranging in size from 380mm - 1060mm (total length) (February 1987 - September 1987).

| | Numerical analysis. | | Frequency of occurrence | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| PISCES | | | | |
| *Oreochromis niloticus* | 50 | 0.46 | 48 | 33.10 |
| *Garra* sp. | 4 | 0.04 | 4 | 2.76 |
| *Barbus intermedius* | 2 | 0.02 | 2 | 1.38 |
| *Clarias mossambicus* | 2 | 0.02 | 2 | 1.38 |
| INSECTA | | | | |
| Diptera | | | | |
| -Cyclorrhapha | 13 | 0.12 | 2 | 1.38 |
| -Simulidae | 12 | 0.10 | 3 | 2.07 |
| -Chironomid larvae | 166 | 1.52 | 21 | 14.48 |
| Odonata | | | | |
| -Zygopteran larvae | 21 | 0.19 | 10 | 6.7 |
| -Anisopteran larvae | 10 | 0.09 | 5 | 3.45 |
| Coleoptera | | | | |
| -Hydrophilidae | 17 | 0.16 | 6 | 4.14 |
| Orthoptera | | | | |
| -Acrididae | 5 | 0.05 | 5 | 3.45 |
| Hemiptera | | | | |
| -Notonectidae (Anisops) | 71 | 0.65 | 9 | 6.21 |

Contd..... 30

| | Numerical analysis | | Frequency of occurrence | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| SPAWN | 3531 | 32.31 | 22 | 15.17 |
| MACROPHYTA | - | - | 32 | 15.17 |
| HUMUS | - | - | 6 | 4 14 |
| ZOOPLANKTON | | | | |
| Cladocera -*Diaphanosoma* sp. | 3307 | 30.26 | 12 | 8.28 |
| Cyclopoid copepod -*Mesocyclop* sp. | 3718 | 34.02 | 12 | 8.28 |

Figure 6: Summary of stomach content analysis of 188 adult *Clarias mossambicus* that range in size from 380mm - 1060mm (total length) from L. Awassa (February 1987 - September 1987).




1. PISCES
2. INSECTA
3. FERTILIZED FISH EGGS (SPAWN)
4. MACROPHYTA
5. ZOOPLANKTON

Table 7: Summary of the food items of 81 adult Clarias mossambicus that range in size from 420 to 1100mm (total length)(October 1987 - March 1988).

| | Numerical analysis | | Frequency of occurrence | | Volumetric analysis | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Volume (cc) | Percent |
| PISCES | | | | | | |
| Oreochromis niloticus | 22 | 0.27 | 21 | 25.93 | 381.3 | 78.73 |
| Garra sp. | 3 | 0 04 | 2 | 2.47 | 11.8 | 2.44 |
| INSECTA | | | | | | |
| Diptera | | | | | | |
| -Chironomid larvae | 87 | 1.08 | 7 | 8.64 | 0.6 | 0.12 |
| -Simulidae | 60 | 0.74 | 4 | 4.94 | 0.4 | 0.08 |
| Orthoptera | | | | | | |
| -Acrididae | 3 | 0.04 | 3 | 3.70 | 9.8 | 2.02 |
| Odonata | | | | | | |
| -Zygopteran larvae | 14 | 0.17 | 7 | 8.64 | 3.3 | 0.68 |
| MACROPHYTA | - | - | 11 | 13.58 | 21.7 | 4.48 |
| HUMUS | - | - | 12 | 14.8 | 48.0 | 9.91 |
| SNAILS | 251 | 3.11 | 2 | 2.47 | 3.3 | 0.68 |
| SPAWN | 1671 | 20.73 | 18 | 22.22 | 4.1 | 0.85 |
| ZOOPLANKTON | | | | | | |
| Cladocera | | | | | | |
| -Diaphanosoma sp. | 3300 | 40.94 | 5 | 6.17 | - | - |
| Cyclopoid copepod | | | | | | |
| -Mesocyclops | 2650 | 32.87 | 5 | 6.17 | - | - |

Figure 7: Summary of the stomach content analysis of 81 adult *Clarias mossambicus* that range in size from 420-1100mm (total length) (October 1987 - March 1988).

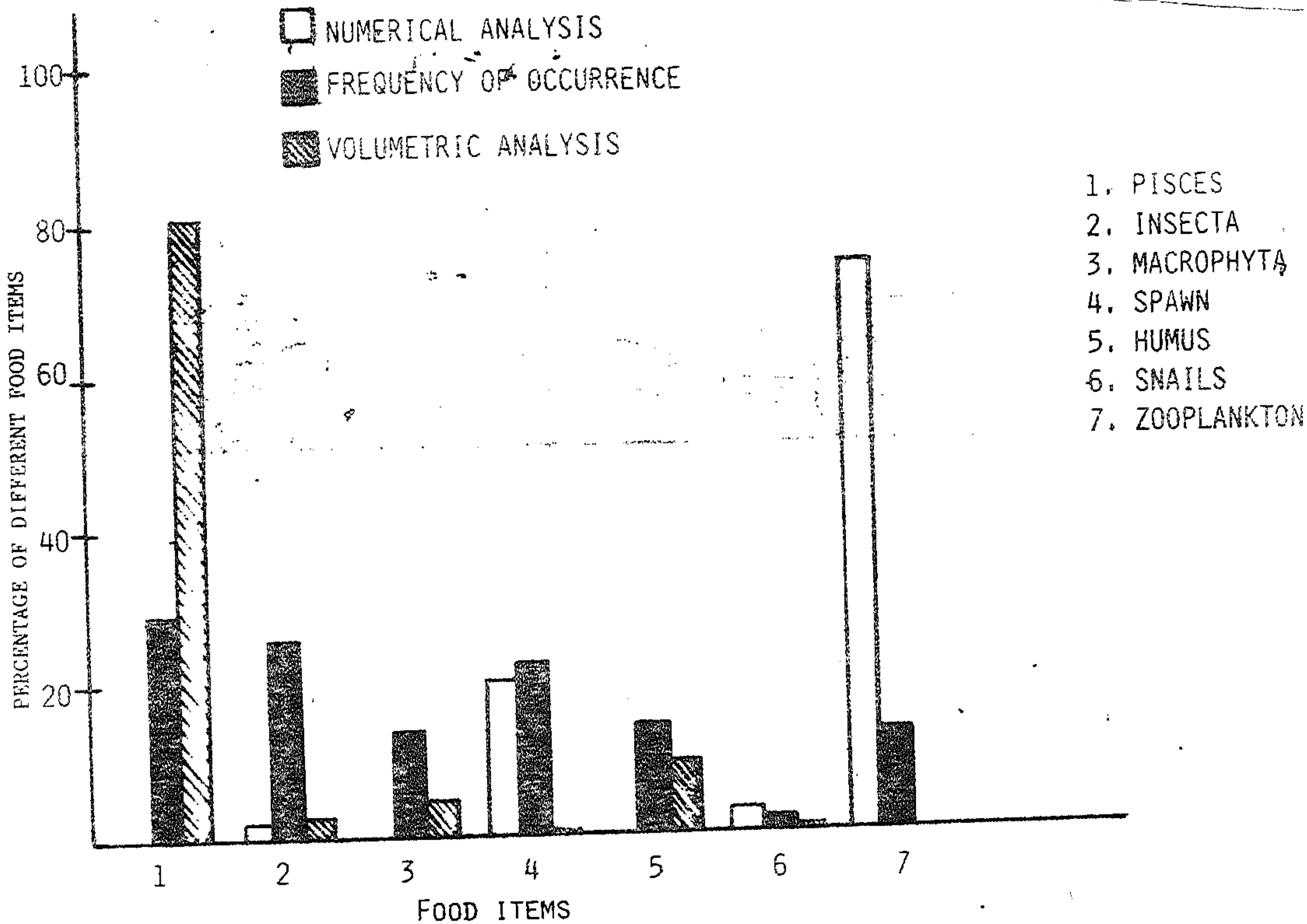



FIG. 7: SUMMARY OF THE STOMACH CONTENT ANALYSIS OF 81 *C. mossambicus*
OCTOBER 1987 - MARCH 1988.

Table 8: Summary of the food items of 77 juvenile *Clarias mossambicus* caught by beach seine and small hook and line gear. (November 1987 - March 1988) (size range: 163-350mm total length; night and day data combined).

| | Numerical analysis | | Frequency of occurrence | | Volumetric analysis | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Volume (cc) | Percent |
| PISCES | | | | | | |
| *Oreochromis niloticus* | 273 | 19.83 | 38 | 49.35 | 86.1 | 71.63 |
| *Apocheilichthyes* sp. | 40 | 2.90 | 17 | 22.08 | 11.8 | 9.82 |
| INSECTA | | | | | | |
| Odonata | | | | | | |
| -Zygopteran larvae | 30 | 2.18 | 19 | 24 67 | 5.4 | 3.16 |
| -Anisopteran larvae | 19 | 1.38 | 6 | 7 79 | 1.6 | 1.33 |
| Diptera | | | | | | |
| -Chironomid larvae | 267 | 19.39 | 17 | 22.08 | 1.3 | 1.08 |
| -Stratiomyidae | 35 | 2 54 | 2 | 2.60 | 0.7 | 0.58 |
| -Simulidae | 41 | 2 98 | 1 | 1.30 | 0.3 | 0.25 |
| -Cyclorrhapha | 12 | 0.87 | 1 | 1.30 | 0.6 | 0.50 |
| Coleoptera | | | | | | |
| -Hydrophilidae | 12 | 0.87 | 3 | 3.90 | 0.3 | 0.25 |
| Hemiptera | | | | | | |
| -Notonectidae (Anisops) | 6 | 0.44 | 1 | 1.30 | - | - |
| -Corixidae (Micronecta) | 21 | 1.53 | 5 | 6.49 | 0.2 | 0.17 |

Contd. .35

| | Numerical analysis | | Frequency of occurrence | | Volumetric analysis | |
|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Volume (cc) | Percent |
| ZOOPLANKTON | | | | | | |
| Cladocera | | | | | | |
| -Diaphanosoma sp. | 66 | 4.79 | 2 | 2.6 | - | - |
| Cyclopoid copepod | | | | | | |
| -Mesocyclops | 121 | 8.79 | 2 | 2.6 | - | - |
| MACROPHYTA | - | - | 19 | 24.67 | 6.5 | 5.41 |
| NEMATODA | 18 | 1.31 | 6 | 7.79 | 0.8 | 0.67 |
| SPAWN | 377 | 27.38 | 15 | 19.48 | 1.1 | 0.91 |
| SNAILS | 39 | 2.83 | 2 | 2.6 | 1.3 | 1.08 |
| HUMUS | - | - | 2 | 2.6 | 2.7 | 2.25 |

organisms that were found relatively frequently were insects, zooplankton and fertilized fish eggs. Macrophytes and humus were also relatively common and occurred mostly in stomachs containing food other than fish. The presence of insects, fertilized fish eggs and snails was strongly associated with macrophytes and humus in catfish stomachs. Fertilized fish eggs (spawn), snails and zooplankton were relatively unimportant as food items because of their small volume (Tables 7 and 8).

An attempt was made to determine differences in the food composition related to the size of fish. A dwarf fish (Apocheilichthyes sp.) was an important food organism for juvenile fish (Table 8) but it was not encountered in the diets of the larger specimens. Two fish species Barbus intermedius and Garra sp. that were of minor importance in the diets of adult Clarias mossambicus were not encountered at all in the stomachs of the juveniles. Moreover, insects contributed greater volume of the food consumed in the case of juveniles than adults (Tables 7 and 8). The majority of the large specimens were found with empty stomachs and those stomachs with food in them were on the average less than half full. On the other hand the feeding intensity of the juveniles (< 35cm total length) was found to be high The degree of fullness of the stomachs was on the average more than three quarters.

Diurnal variation in food type consumed and feeding intensity of juvenile Clarias mossambicus was evident from stomach content analysis of 54 fish caught during the day and 47 fish caught during the night. Of the 54 fish caught during the day 21 (38.9%) had empty stomachs, while only 3(6.4%) of the 47 night sampled fish had empty stomachs. The results of variation in food and feeding habits are presented in Table 9. Dragonfly larvae (Zygoptera) was an important food item during the day accounting for 4.3% by number, 42.4% by occurrence method, and 21.7% by volumetric method, but at night dragonfly larvae accounted for 0.9% by number, 11.4% by occurrence method and 1.6% by volumetric method. Fry of Oreochromis niloticus were the most important food items at night during which time they contributed 29.6% by number, 77.3% by occurrence method and 86.0% by volumetric method. However, during the day light hours they contributed only 3.1% by number, 12.1% by occurrence method and 22.8% by volumetric method. Cyclopoid copepods and cladocera occurred in the diet only at night. Nematodes were also found at night.

## 4.4 Breeding

4.4.1 Sex ratios - The sex ratios of fish sampled at each of the five stations and the overall sex ratio are given in Table 10. There were slight differences among the

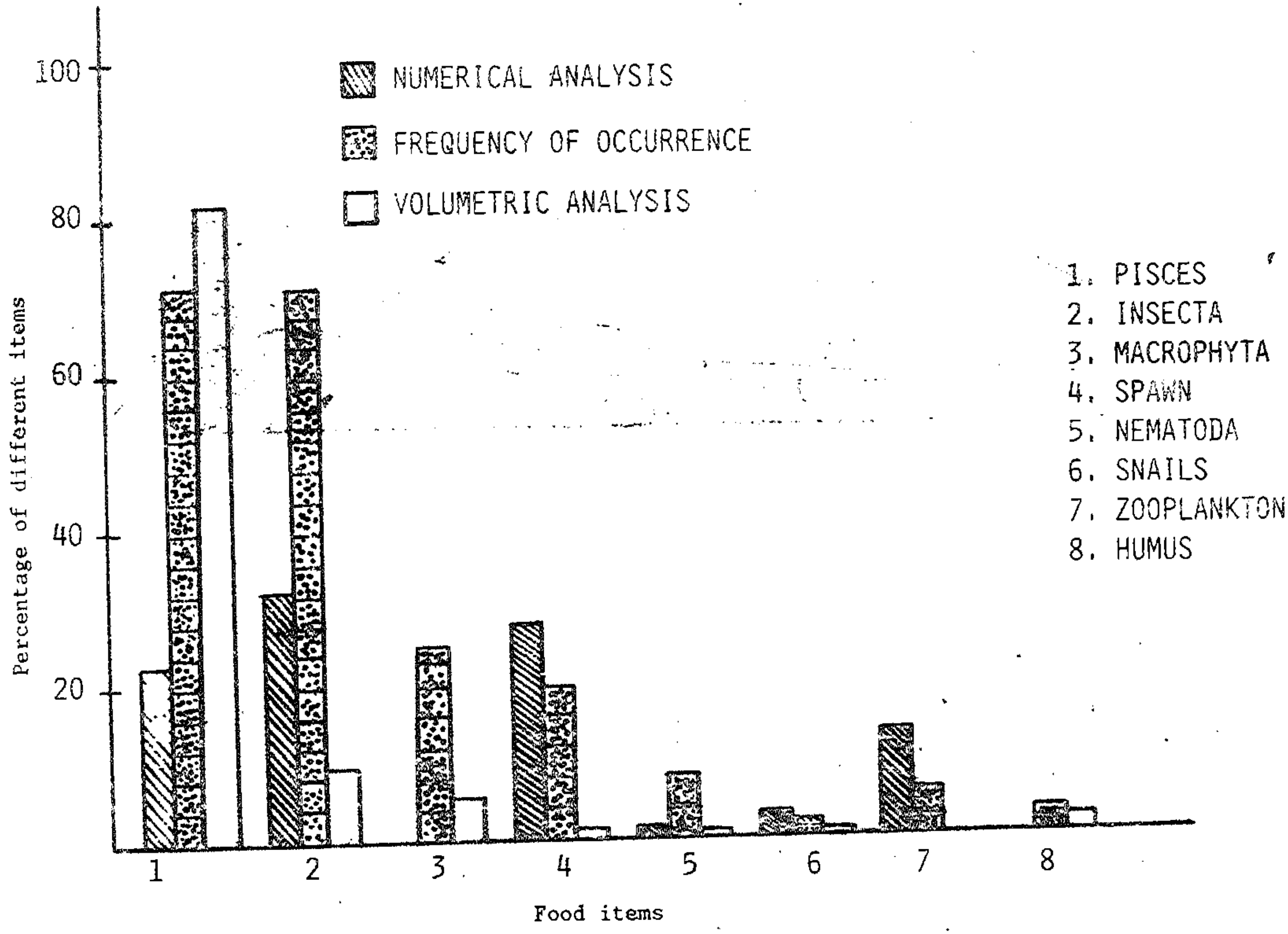

100
80
60
40
20
Percentage of different items
NUMERICAL ANALYSIS
FREQUENCY OF OCCURRENCE
VOLUMETRIC ANALYSIS
1. PISCES
2. INSECTA
3. MACROPHYTA
4. SPAWN
5. NEMATODA
6. SNAILS
7. ZOOPLANKTON
8. HUMUS
1
2
3
4
5
6
7
8
Food items

Table 10: Number of specimens of each sex caught at each station and the corresponding sex ratios.

| Sampling station | Male | Female | Ratio (Male:Female) |
|---|---|---|---|
| Blazar | 50 | 48 | 1.00 - 0.96 |
| Deset | 54 | 64 | 1.00 - 1.18 |
| Minch | 91 | 105 | 1.00 - 1.15 |
| Dore | 116 | 127 | 1.00 - 1.09 |
| Tikur Wuha | 144 | 118 | 1.00 - 0.82 |
| Total | 455 | 462 | 1.00 - 1.01 |

sex ratios of fish caught at the five sites. At Blazar and Tikur Wuha a slightly higher number of males were caught while at Deset, Minch and Dore a higher number of females were caught during the whole sampling period. The overall sex ratio is, however, very close to 1:1.

4.4.2 Length at maturity - The average length at first maturity has been defined as the length at which 50% of the individuals reach maturity (Willoughby & Tweddle, 1978). The percentages of male and female Clarias mossambicus with mature gonads in each length group were plotted against length for each sex using data from the breeding season, February - June 1987 (Fig. 9). The proportion of breeding fish between 55 and 75cm TL was very low. The average lengths at maturity for males and females, estimated from the corrected curves (Fig. 9) were 65cms and 60.5cm respectively. The smallest ripe male caught was 33cm TL and the smallest ripe female found in breeding condition was 34cm TL.

4.4.3 Breeding seasons and sites - The breeding season of Clarias mossambicus was determined from the percentage of fish with mature gonads taken each month (Fig.10). Although a few fish were found in breeding condition throughout the year, most breeding occurred from February - June 1987, with the peak occuring in April for females (43%) and in June for males (34%). Specimens collected between

Fig. 9: Average length at first maturity for Clarias mossambicus in L. Awassa: (-.-.). the maximum percentage of mature fish in any length group; (...), 50% of the maximum percentage of mature fish which is taken as the average length at maturity; (---), corrected curve in order to calculate the average length at maturity. (a) males; (b) females.

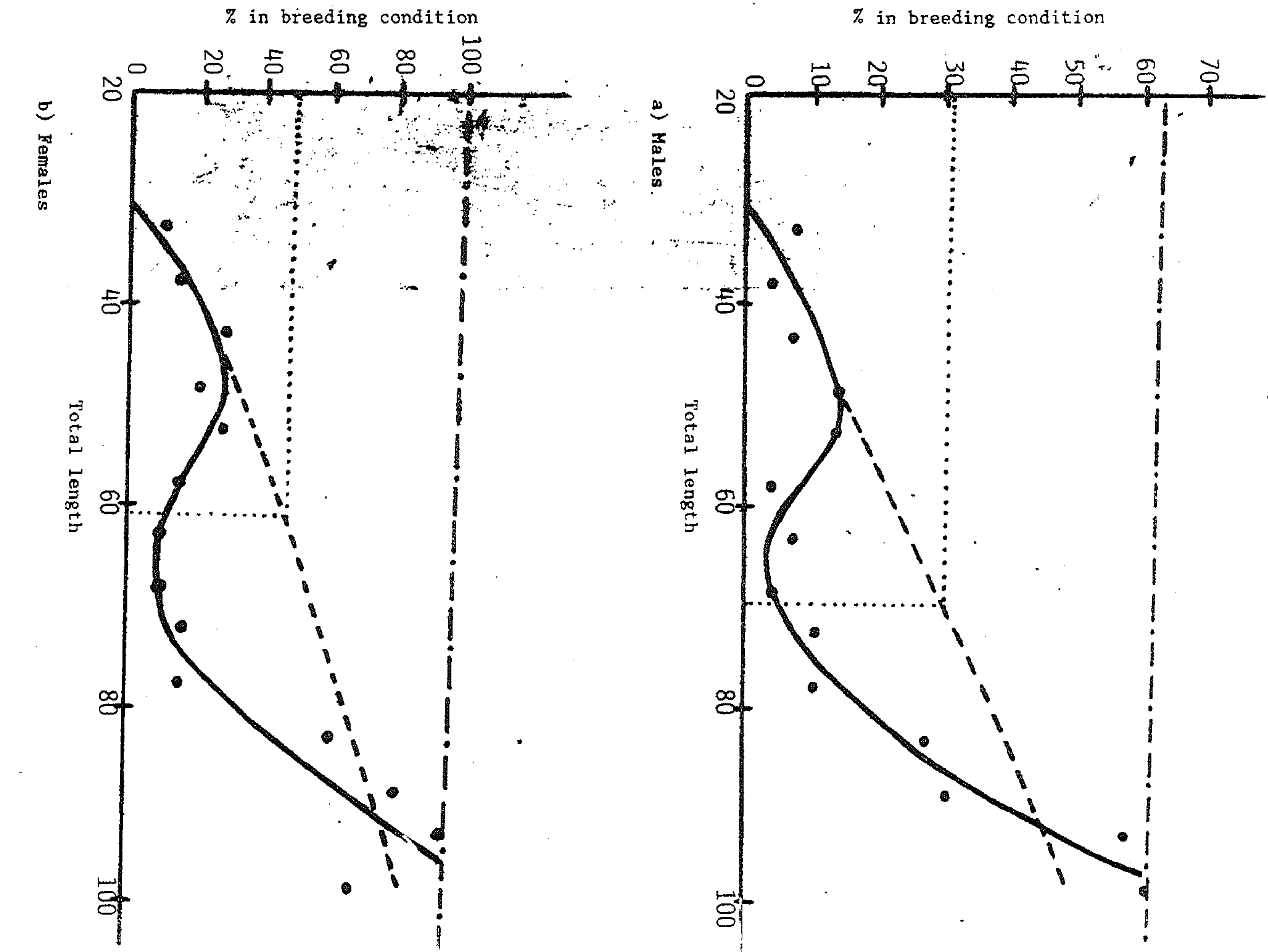
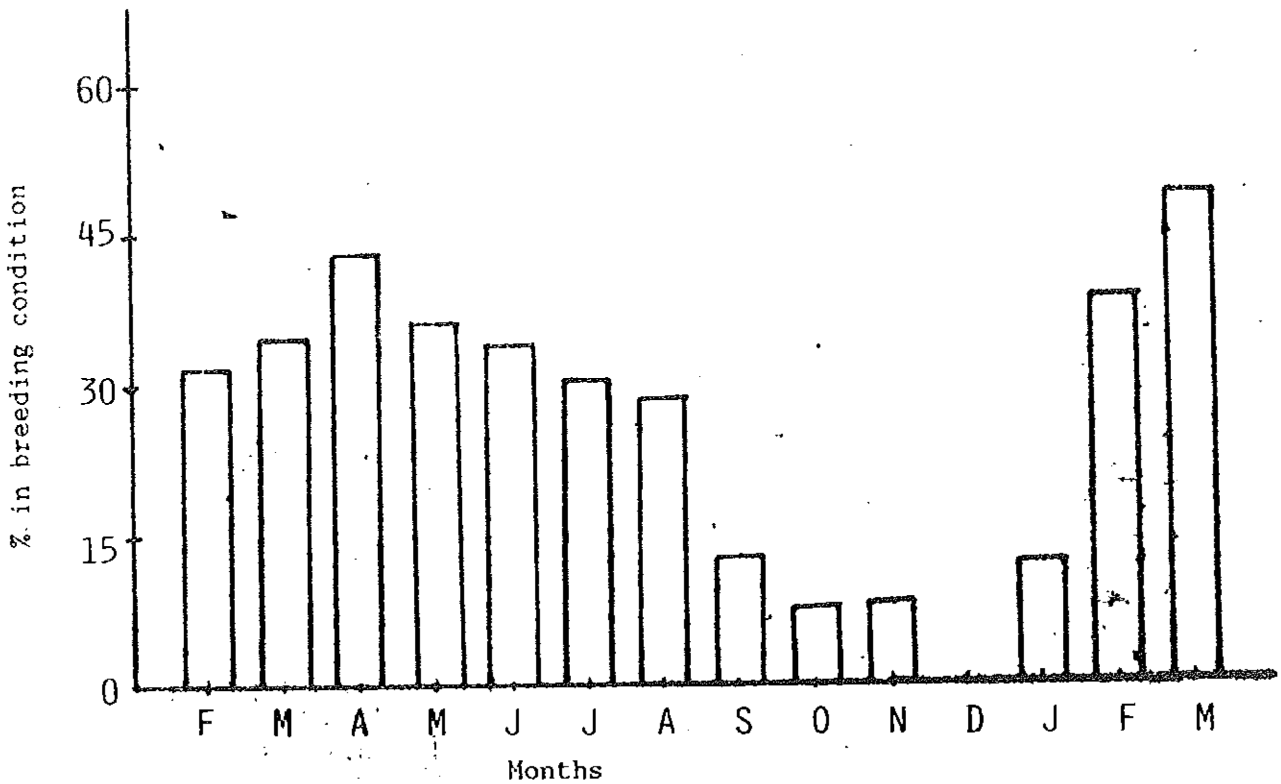
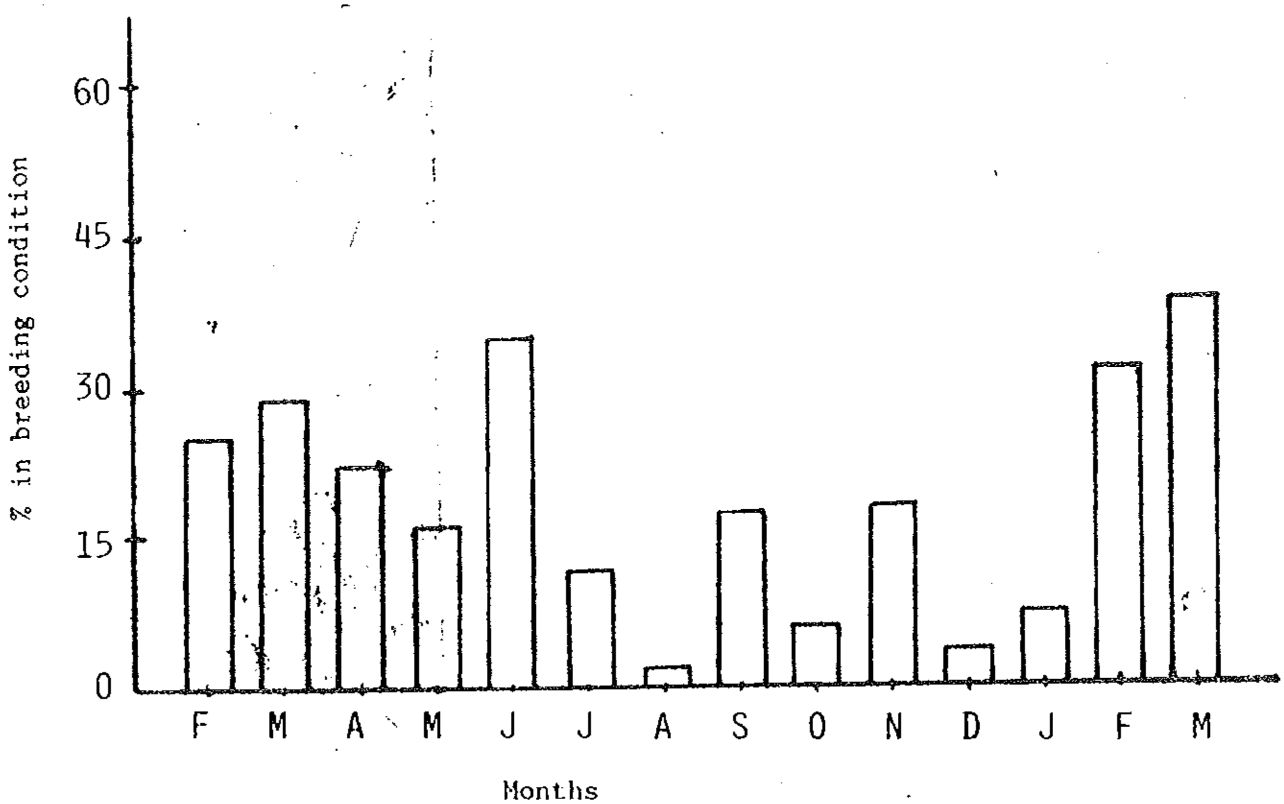

% in breeding condition
a) Males
Total length
% in breeding condition
b) Females
Total length

Figure 10: Breeding season of *Clarias mossambicus* indicated by percentages of mature fish in breeding condition in each month.




a) Females




b) Males

February and March 1988 also show high proportions of fish with ripe gonads. In February 1988, 31% of the males and 38% of the females were in breeding condition, while in March 38% of the males and 48% of the females were in breeding condition.

There were considerable differences in the proportions of breeding and non-breeding Clarias mossambicus at the five sampling stations. The porportion of breeding males was lowest at Blasar (22%) and highest at Minch (39%), while the proportion of breeding females was lowest at Deset (31%) and highest at Dore (49.5%) (Table 11).

4.4.4 Fecundity - The fecundity of Clarias mossambicus is shown in Fig. 11 relating total number of eggs to total length, total weight and ovarian weight. The relationship between fecundity and the independent variables is explained by the following formula.

$$\log_{10}F = \log_{10}a + b\log_{10}x$$

where:

F = fecundity

x = the independent variable

a = the Y-intercept of the fitted line

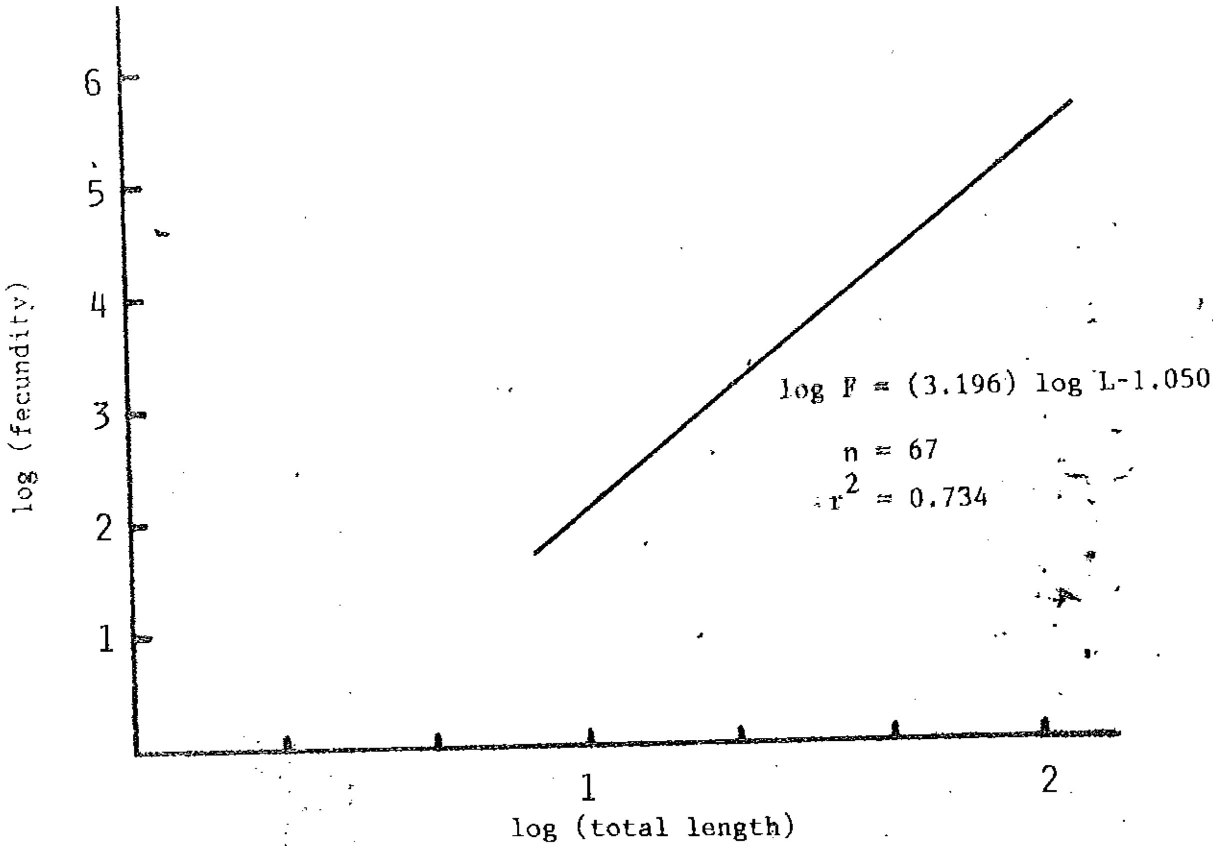
b = the slope

There were significant regressions between fecundity and total length ($P < 0.001$, $r^2 = 0.734$), fecundity and total

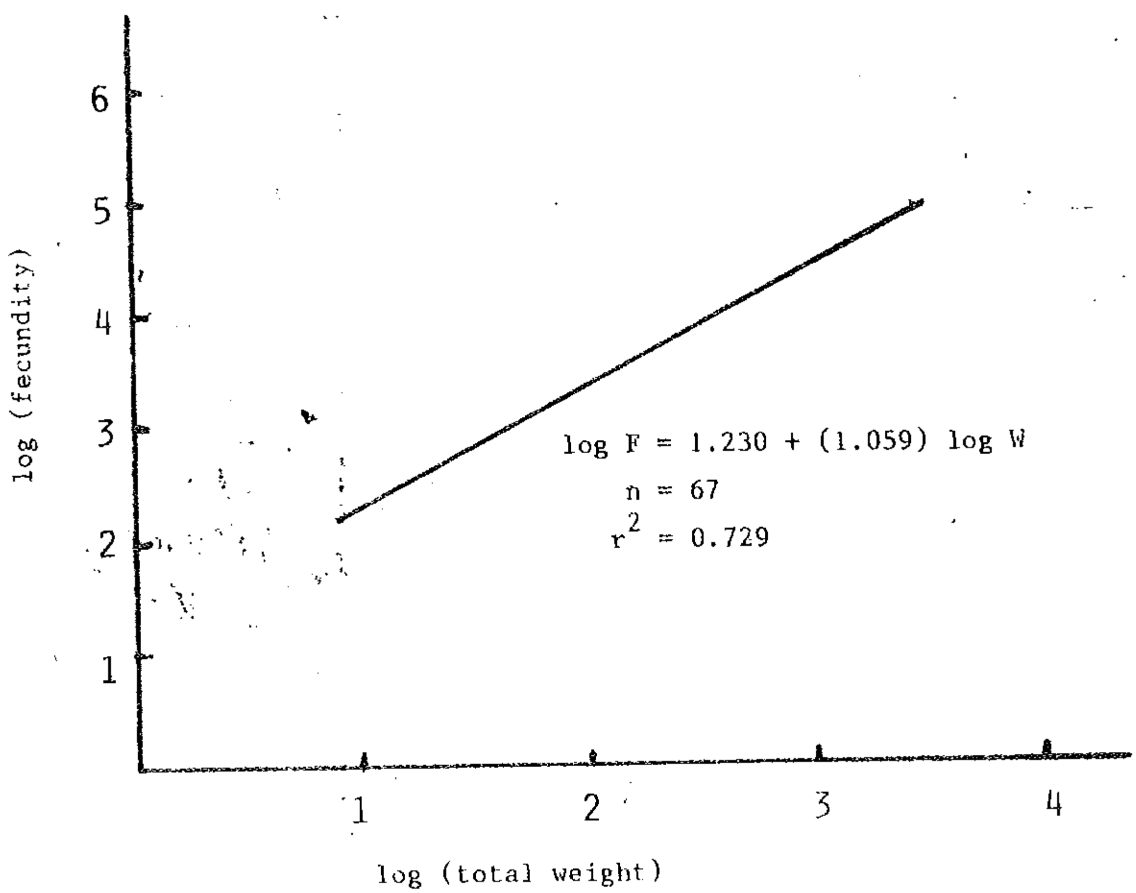
Table 11: The numbers and the percentages of male and female <u>Clarias mossambicus</u> which were in breeding condition at each station during the months February through June, 1987.

| | Sampling Stations | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Blazar | | | | Deset | | | | Minch | | | | Dore | | | | Tikur Wuha | | | |
| | Male | | Female | | Male | | Female | | Male | | Female | | Male | | Female | | Male | | Female | |
| | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % |
| February | - | - | 1 | 50.0 | - | - | - | - | - | - | - | - | 13 | 43.3 | 12 | 46.2 | 6 | 46.2 | 6 | 60.0 |
| March | 3 | 37.5 | 5 | 38.5 | 4 | 40.0 | 3 | 30.0 | 7 | 58.3 | 3 | 21.4 | 4 | 28.6 | 6 | 25.3 | 14 | 58.3 | 10 | 58.8 |
| April | 1 | 20.0 | 3 | 60.0 | 5 | 29.4 | 3 | 42.9 | 3 | 23.1 | 5 | 45.4 | 6 | 33.3 | 7 | 43.8 | 2 | 8.7 | 4 | 33.3 |
| May | - | - | 2 | 22.2 | 1 | 14.3 | 2 | 25.0 | 5 | 25.0 | 8 | 36.4 | 5 | 22.7 | 9 | 60.0 | 2 | 8.3 | 4 | 30.8 |
| June | 3 | 60.0 | - | - | 1 | 20.0 | 1 | 25.0 | 6 | 66.7 | 3 | 42.8 | 6 | 42.9 | 17 | 58.6 | 3 | 13.6 | 3 | 14.3 |
| Total | 7 | 22.0 | 11 | 37.0 | 11 | 28.0 | 9 | 31.0 | 21 | 39.0 | 19 | 35.0 | 34 | 35.0 | 51 | 49.5 | 27 | 25.5 | 27 | 37.0 |

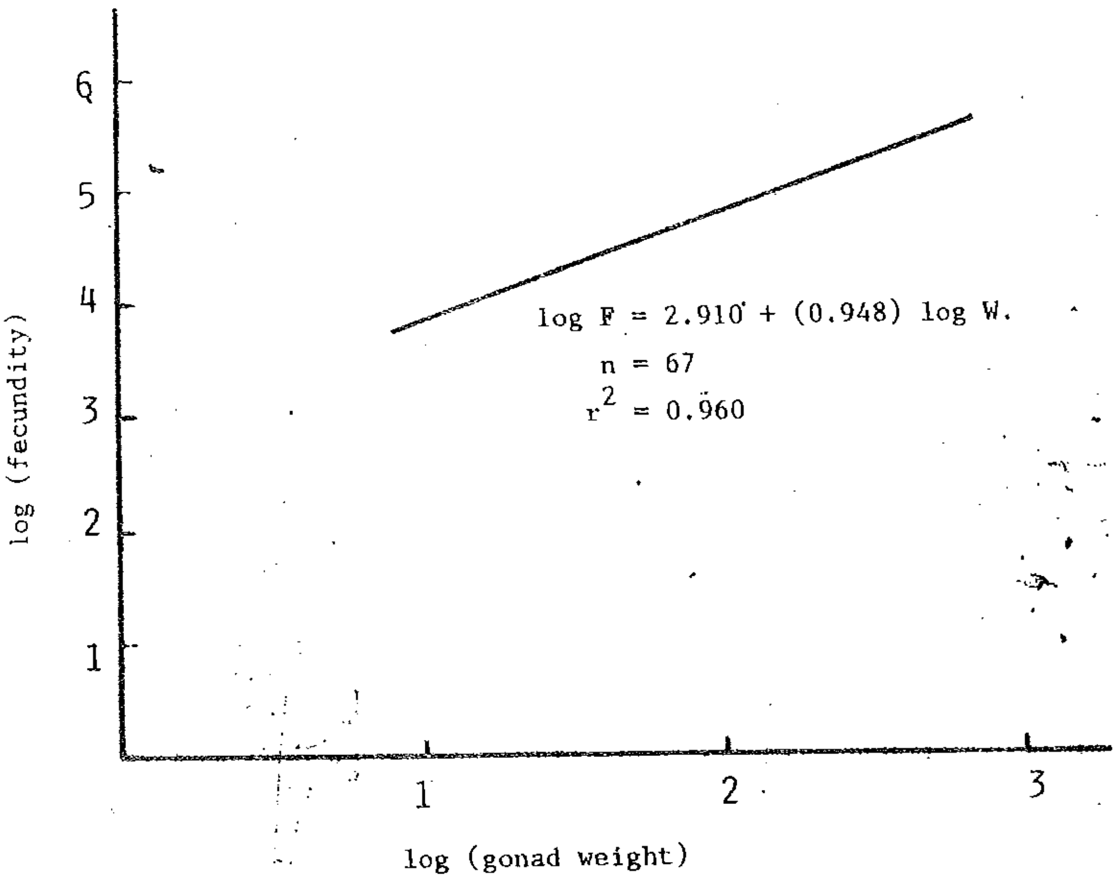
Figure 11: The relationship of egg number to total length (a), total weight (b) and ovarian weight (c).




a) The relationship of egg number to total length.




b) The relationship of egg number to total weight




c) The relationship of egg number to ovary weight.

weight ($P < 0.001$, $r^2 = 0.729$), and fecundity and ovarian weight ($P < 0.001$, $r^2 = 0.960$). The least squares regression technique was used.

The ripe ovaries contained between 435 and 1176 eggs per gram of wet weight with the mean at 669/gram.

4.5 Condition factor - The mean Fulton's condition factor of the males ranged between 0.640-0.719 while the mean Fulton's condition factor of the females ranged between 0.664-0.745 for the period of February 1987 - March 1988 (Table 12). Two way ANOVA and TUKEY tests done on 20 randomly selected samples of fish from each month indicated that there were no significant ($P = 0.077$) differences in the condition of the fish by sex, but there were significant ($P < 0.001$) differences in the condition of fish by month. There was no significant ($P = 0.134$) interaction effect between month and sex (Table 13).

4.6 Parasitic Infestation

A high degree of infestation by nematodes occurred. Of 1230 fish examined, 1040 (84.6%) harboured nematodes in their body cavities. The mean number of nematodes was 28 and the range was 4 to 300. Comparison of 30 randomly selected, parasitized fish ($\geq 50$ nematodes per fish) and 30 randomly selected non-parasitized fish (0 nematodes) revealed no significant effect of parasite infestation on condition factor (t-test. $P = 0.417$). Inspite of heavy

Table 12: The Fulton's condition factor of *Clarias mossambicus* in Lake Awassa. Data are $\bar{X} \pm$ SE, with n in parentheses.

Condition factor

[Gutted weight of the fish x 100/length in cm)$^3$]

| Month | Male | Female |
|---|---|---|
| February, 1987 | 0.693 ± 0.012 (33) | 0.698 ± 0.016 (21) |
| March, 1987 | 0.704 ± 0.094 (20) | 0.696 ± 0.029 (7) |
| April, 1987 | 0.719 ± 0.021 (75) | 0.745 ± 0.019 (50) |
| May, 1987 | 0.704 ± 0.010 (107) | 0.717 ± 0.009 (76) |
| June, 1987 | 0.671 ± 0.010 (61) | 0.674 ± 0.010 (74) |
| July, 1987 | 0.718 ± 0.011 (81) | 0.705 ± 0.015 (56) |
| August, 1987 | 0.686 ± 0.021 (34) | 0.710 ± 0.018 (38) |
| September, 1987 | 0.696 ± 0.019 (33) | 0.733 ± 0.031 (38) |
| October, 1987 | 0.683 ± 0.015 (34) | 0.68 ± 0.012 (42) |
| November, 1987 | 0.667 ± 0.014 (28) | 0.707 ± 0.012 (38) |
| December, 1987 | 0.640 ± 0.012 (30) | 0.673 ± 0.014 (22 |
| January, 1988 | 0.663 ± 0.022 (20) | 0.664 ± 0.011 (32) |
| February, 1988 | 0.713 ± 0.014 (32) | 0.703 ± 0.021 (37) |
| March, 1988 | 0.699 ± 0.012 (53) | 0.723 ± 0.010 (33) |

Table 13: Results of two-way ANOVA and TUKEY tests to determine significant ($\alpha$ = 0.05) differences in fish condition factor. Fulton's condition factor was used. Monthly samples joined by the same line are not significantly different

| | F value | d.f. | Sig. | d.f. | TUKEY |
|---|---|---|---|---|---|
| Month | 3.17 | 10 | $P < 0.001$ | 10 | 5 7 8 11 9 4 2 6 10 1 12 |
| Sex | 1.82 | 1 | P = 0.077 | - | |
| Month x Sex | 0.973 | 10 | P = 0.134 | - | |

infestation (up to 300 nematodes) no significant emaciation was observed. Five severely emaciated fish (with a significantly lower average condition factor, 0.441 instead of the mean 0.696) did not harbour parasites beyond the average burden. The number of nematodes found in these fish ranged from 4-20 with the mean at 11. Infestation of *Clarias mossambicus* by parasitic nematodes was observed in their early life, though the number of worms found was relatively low. In the body cavities of three juvenile *Clarias* (TL = 16.5 cm, 20.0 cm and 22.8 cm; W = 35.4g, 52.5g and 81.5g) 7, 9 and 19 nematodes were found respectively. In the majority of the juvenile fish caught, however, the number of nematodes found was below 5.

4.7 Commercial Catch

The commercial catch, estimated from regular records taken from the catches of the fishermen (October 1986 - January 1988), was between 933 and 1891kg per month. This excluded the data obtained during the fasting periods (February 22 - April 16, 1987; August 7-21, 1987). The majority of fish were between 35 and 55cm (total length). The fishermen do not set their longlines, except during the fasting periods, because the demand for *C. mossambicus* is low. The catch data given (October 1986 - January 1988) were obtained from the catches of surface gill nets (100mm mesh size) mainly set for a cichlid fish *Oreochromis* *niloticus*) which is the popular fish species in the traditional fishery of the lake. When the fishermen set their gill nets in shallower parts of the lake for *Oreochromis*, the incidental catch of catfish is low. The average catch during these monthes was 1388kg/month.

During the fasting periods the estimated catch ranged from 8500kg - 14000kg per month with an average of 12300kg. This is about 9 times higher than the rate of catch at other times of the year. Throughout the duration of the fasting periods, the fishermen set their longlines and catch catfishes, the majority of which lie within the size range of 45 - 75cm (total length). Fish over 80cm total length were not common in the catches and fish over 100cm (total length) were rarely encountered.

# CHAPTER V

# DISCUSSION

## DISCUSSION

*Clarias mossambicus* was more abundant at Tikur Wuha, Dore and Minch than at Blazar and Dest, indicating that shallower habitats of the former stations are preferred by this fish. At Blazar, the 8 meters depth is very near to a rocky shore and the macrophyte zone is sparse and narrow. This condition would probably explain why the total number as well as the total weight of fish caught from this station were significantly lower than the other stations. Willoughby and Tweddle (1978) reported that *Clarias gariepinus* prefers a cover of vegetation and shelter under mud banks, as a result large numbers can be obtained from shallow weedy swamps. These authors also state that deeper and more open areas of the Elephant Marsh in southern Malawi are less productive. The low catches at Deset (12m station) are consistent with the records of Willoughby and Tweddle (1978). The bathymetric map of Lake Awassa (Fig. 2) shows that stations Tikur Wuha, Dore and Minch are located in areas where bottom slopes gradually and where the shallow sandy bottom extends in some places for about 1500 meters from the margin of the macrophyte zone (Kibret 1985). Gradual slope of these areas with extensive growth of submerged macrophytes creates a favourable habitat for *Clarias mossambicus*. The results of catch-per-unit effort from the five stations (Table 5) also indicate that Tikur Wuha, Dore and Minch have suitable habitats for this fish.

The average weight of the fish caught at the five stations showed significant variations. Generally, specimens obtained from deeper part of the lake had larger average body size than those obtained from shallower part of the lake (Table 5). In this respect, these results are in agreement with those obtained by Ratcliffe (1972) and Bruton (1978c) for Clarias gariepinus from Lake Sibaya (South Africa) and lower Shire River area (Malawi) respectively.

High incidence of empty stomachs was observed during the whole sampling period. Several reasons can be advanced to explain the cause of this high incidence of empty stomachs. First, since the fish were left for several hours on long-lines before they were dissected, the stomach contents may have been lost by regurgitation or digestion. The importance of small organisms such as zooplankton and certain benthic organisms may be underestimated due to their faster rate of digestion in the stomach of the fish. Fish may also regurgitate their food while struggling on the longlines. According to Kirk (1967) regurgitation of stomach contents was very high in Clarias gariepinus caught by gill nets in Lake Chilwa (Malawi). Second, the feeding habits of this species may also be responsible for high incidence of empty stomachs. Thomas (1966) attributes the high proportion of empty stomachs in Clarias senegalensis to the piscivorous nature of the fish. Willoughby and Tweddle (1978) also reported the feeding habits of Clarias gariepinus to be as those of "clumsy piscivors". Piscivorous fishes tend to feed less frequently (Frost, 1954) and need not feed continuously, because the large size of the prey will enable them to get a relatively large quantity of food with a small expenditure of energy and within a short period of time (Allen, 1935).

From the results of the stomach contents analysis it is evident that Oreochromis niloticus is the most important food item and serves as a suitable prey for Clarias mossambicus. Thomas (1966) working with C. senegalensis, Spataru et al. (1987) studying C. gariepinus, both reported the importance of cichlid fishes in the diets of Clarias. As a predator the catfish Clarias mossambicus utilizes a variety of food items, other than fish, including zooplankton, insects and snails (Willoughby and Tweddle, 1978; Munro, 1967; Clay, 1979b; Groenewald, 1964; Fryer, 1959; Gaigher, 1969; Van der Waal, 1972; Viveen et al., 1986). Since the catfish Clarias mossambicus has a broad natural food base, it can shift from one kind of food item to another depending on the availability and emergence of these food items (Munro, 1965; Groenewald, 1964; Clay, 1979b). Due to its broad feeding habits and extreme hardiness the catfish is very adaptable fish for culture. Since it is able to breath atmospheric oxygen, high stocking levels in warm stagnant water could be used. It will even grow in oxidation ponds where the level of dissolved oxygen is nearly zero (Clay, 1979b). The possibility of combining Tilapia species with Clarias is suggested by Clay (1979b). The feeding niches of the two fishes do not overlap very much (Thomas, 1966) and as a predator the presence of the catfish would prevent stunting by exerting continued pressure on small Tilapia fry. As a result more efficient utilization of cichlids might be obtained in production ponds.

Aquatic macrophytes and humus occurred in considerable quantities in the stomachs of the catfish. Many authors have studied the feeding habits of Clarias species in different parts of Africa giving varying interpretations about the diversity of diet. Jubb (1967) described Clarias gariepinus as an omnivorous fish. Willoughby and Tweddle (1978) also suggested that humus and plant detritus could be of some nutritional benefit to the catfish Clarias gariepinus. The suggestion of the latter authors was based solely on the presence of these items in the stomachs of the catfish. The importance of the ingested matter to the nourishment of the fish was not determined. Clay (1981) attempted to determine the utilization of plant proteins by juvenile Clarias gariepinus fed mixtures of maize, soya-extract and sunflower in different proportions.

In this work by Clay (1981), the presence of the enzyme protease in the stomach and anterior intestine of *Clarias gariepinus* was suggested to be responsible for most protein digestion with little or no specialization to either plant or animal protein. Thomas (1966) produced detailed information on the feeding habits of *Clarias senegalensis* in a man-made lake in the Ghanaian savanna. He suggested that this fish must be carnivorous since it has no pyloric caeca in which cellulose digesting organisms could live. Groenewald (1964) and Kirk (1967) also observed that *Clarias gariepinus* was primarly a predatory fish in its feeding habits. The results of the present study suggest that the catfish *Clarias mossambicus* is an indiscriminate feeder and may ingest plant fragments incidentally while pursuing prey that lives in close association with the aquatic macrophytes.

Corbet (1961) studied the feeding habits of *Clarias mossambicus* of different size groups in Lake Victoria and reported that young *C. mossambicus* fed mainly on ostracods and aquatic insects. After the fish reached a size of about 30cm, they started to consume more fish. On the other hand, Thomas (1966) studying *C. senegalensis* and Willoughby & Tweddle (1978) working with *C. gariepinus* found no clear ontogenetic changes in diet. Smaller fish (< 12cm) were however, not caught during their sampling (13.6 - 79.1 cm in the case of the former author and

12.0 - 55.0cm in the case of the latter authors). In the present investigation, the fish sampled were between 16.3 and 111.0cm (total length) and ranged in weight from 55.5 - 9630g. Within this size range the differences between the food items of the various size groups were very slight. Thomas (1966) attributed the lack of ontogenetic change in the diets of Clarias senegalensis to its euryphagous habits. The slight difference noted in the food habits of Clarias mossambicus, during the present study, was that smaller fishes ( 35cm total length) tended to feed more on insects than did the adults. This could be due to habitat differences between the juvenile and the adult fishes. The adults prefer the deeper water while the juveniles live in shallow waters among the macrophytes (Bruton, 1978c; Ratcliffe, 1972) where the densities of the invertebrates are usually high. Munro (1967) studied the food habits of Clarias gariepinus at different size groups (20-40cm; 40-60cm and over 60cm) and found insects to be more important in the diets of smaller fishes.

From stomach contents of Clarias mossambicus (16.3-35cm TL) sampled at shallow waters (1.0-1.5m) during the day and at night, it is evident that diet and feeding intensity vary during diurnal cycle. The majority of the stomachs sampled at night contained only fish, while invertebrates such as zygopteran larvae, anisopteran larvae and Simulidae were important food items during the day. Bruton (1978c) states that the efficiency of predation of C. gariepinus on cichlid fishes increases at low light intensities particularly in shallow water. The results of the present study are also in agreement with the finding of Bruton (1978c).

Rapid maturation of gonads in Clarias species starts during the early rains in all parts of Africa for which data are available (Greenwood, 1955; Thomas, 1966; Kirk, 1967; Willoughby & Tweddle, 1978; Payne, 1986; Viveen et al., 1986). This is often associated with a migratory phase in which the maturing fish enter the inflowing rivers prior to spawning in the floodwater pools (Whitehead, 1959; Corbet, 1961; Thomas, 1966). Migration is common among many non-cichlid fishes of Africa, particularly the characins and cyprinoids. It provides a mechanism for dispersion as well as for finding a favourable environment for the development of the eggs (Payne, 1986). After spawning and fertilization the eggs are placed in some suitable flooded area with a rich food supply which the young can exploit after hatching is completed (Jackson, 1961; Greenwood, 1965; Payne, 1986). Migration to a stream also provides shelter from many kinds of predators for the newly hatched larvae (Fryer, 1965).

The final stimulus to spawn in *Clarias* spp. is not clearly understood. Thomas (1966) considers the increase in food supply and space, due to the flooding of the area, as the original stimuli for migration. Pott (1969) considers an only substance called"Petrichor" in run-off water to be the final stimulant for breeding. Viveen *et al*. (1986) associate this with a rise in water level and inundation of marginal areas. According to Payne (1986) migratory response in catfishes occurs, as the rain and flood begin as a result of interaction between certain external factors such as changes in water level or current speed and internal factors such as hormone co-ordinated rhythms.

*Clarias mossambicus* in Lake Awassa begin to spawn at the beginning of the early rains on February. However, it does not seem probable that all the breeding fish would migrate through the small inlet, Tikur Wuha River, for spawning. Fish with ripe ovaries as well as those with partially spawned out ovaries were caught from all five stations during the breeding season. Moreover, the proportion of fish in breeding condition, during the reproductive period at the mouth of Tikur Wuha River, was not substantially higher than at the other stations. In fact, the proportion of spawning fish at Dore, across the lake from the Tikur Wuha River, was higher than at the rest of stations. The extensive growth of aquatic vegetation and gradual slope of the lake at this site may provide a suitable spawning habitat for the catfish.

Breeding season lasted out for about 5 months (February 1987 - June 1987) during the present study. It is probable that the availability of suitable spawning habitats throughout this period is the main reason for such a long breeding season (Willoughby & Tweddle, 1978). The proportion of breeding fish, of both sexes, between 55 and 75 cm TL was very low, during the present study. This may be because of sampling error which cannot be explained at the moment, or it may be due to the actual breeding behavior of the fish.

The incidence and level of infestation of nematodes in *Clarias mossambicus* in Lake Awassa was very high. Incidence levels of 84.6% and a worm burden of 4 to 300 per fish occurred during the period of investigation. Infestations with nematodes in the body cavities as well as in the intestine of *Clarias* spp. occurred in different parts of Africa. In the Sudan Nile, infestations with nematodes occurred in the body cavities of predators such as *Clarias lazera*, *Bagrus* spp., *Polypterus* spp., *Malapterurus electricus*, *Lates niloticus* and *Alestes nurse* (Paperna, 1980). This author reported 10 to 37% incidence levels and 5 to 36 nematodes per fish. Spataru *et al.* (1987) also reported intestinal infestation with nematodes in

Clarias gariepinus in Lake Kinneret (Israel). Inspite of high degree of infestation with nematodes, the overall effect on Clarias mossambicus, in this study, seemed to be of minor significance. No serious emaciation was observed, even in fish with relatively heavy infestation (up to 300 worms). Paperna (1980) reported that no signficant damage occurred to a large predatory fish such as Clarias or Bagrus spp. even in cases of worm burden up to 100 per fish.

The results of the commercial catch estimated from the catches of the fishermen during the 16 months sampling period indicate that Clarias mossambicus is generally under-utilized. The diet preferences of the surrounding people is the main causes for the under-exploitation of this fish species. Except during the fasting periods the consumption of this fish is very low. As a consequence its market value is low. So, in order to use the under-exploited potential, new methods of transportation, storage and marketing should be developed. Since the fasting period (from Mid February up to the first week of April) concides with the breeding season of Clarias mossambicus, fishing during this time should not be done at shallower part of the lake where spawning activity takes place.

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