ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

REPRODUCTION, FOOD, LENGTH -WEIGHT RELATIONSHIP AND CONDITION FACTOR OF AFRICAN CATFISH *Clarias gariepinus* (BURCHELL) IN LAKE BABOGAYA, ETHIOPIA

LEMMA ABERA

June 2007

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude and sincere appreciation to my advisor, Dr. Demeke Admassu for suggesting the research topic, provision of relevant literature, committed guidance, critical and constructive comments, advice and invaluable help at all times. I also express my gratitude to Dr. Zenebe Tadesse, for his valuable advice during the entire research period.

I would like to express my sincere appreciation to Dr. Abebe Getahun for providing relevant literature, constant encouragement and valuable advice during the entire research period. I am also greatly indebted to Dr. Seyoum Mengistou who has been a constant source of help and inspiration. Considerable thanks are also due to Dr. Demeke Kifle who helped me in many aspects of the study.

My friends at Babogaya, Delie, Samson, Abera, Zelalem, Sisay, Mamo, Wrkeiae and Tigist deserve special thanks for their help in sampling and several other field activities, especially around the beginning of the study when things were relatively strange and more difficult. I also extend my sincere thanks to the fisherman of Lake Hora; “Gash” Tesfaye, who helped me by giving relevant information.

I would like to thank the Ethiopian Agricultural Research Training Project (EARTP) for financial support and Oromia Agricultural Research Institute (OARI) for sponsoring my studies. I acknowledge, gratefully, administrative staff of Adami Tullu Agricultural

Research Center, especially Asnie, Abe and Yosef who facilitated timely availability of the budget for field trips. My special thanks also extend to Mesee, of center manager secretary, for her consistent support and cooperation in various ways.

I also wish to thank all staff members of Debre-Zeit Agricultural Research Center, particularly, Fisume, “ Gash” Tekalenge ,Derebie and Getahun for their unreserved help in laboratory work, acquisition of meteorological data and in various other aspects.

All staff members of Zwai Fishery Research Center are gratefully acknowledged for helping me in many ways. In particular, my friends Abreham (Abrish) G/ Tsadik, Hensene (Mimie), “gash Daba” and Ahmed deserve special thanks in solving some personal problems, and also for their constant encouragement and support throughout the study.

The Department of Biology, AAU, is gratefully appreciated for giving me the opportunity to study for my M.Sc. at the department, and for assisting me with material and other resources during my thesis work. I am extremely grateful to Dr. Dawit Abate who was very cooperative to me in so many ways. My thanks also extend to department Secretaries, particularly Mulualem and Banchu deserve special thanks for their consistent support. I would like to thank Menbere for her help on my tedious work of egg counting in the limnology laboratory and my best friends at the university, ‘Aqua’ and Moges are highly acknowledged due to their important comments during preparation of the thesis. Abe of AAU museum is acknowledged for his cooperation in printing.

The help, care and love rendered by my father, Abera, my mother, Tejitu (Degera), my Brothers (Worku, Chuse, Sol, Tadie, Beshie) and my Sisters (Emuie, Mimie) during my study period are also greatly appreciable. I also thank my true friends (Dane, Sis, Mandie, Mime, Moke, Kaset, Eso) and I appreciate all friends whom I did not mention their names here but who helped me in any sort towards completing my study.

Finally, I gratefully appreciate the patience, understanding, encouragement, and moral support for my friend Hamrawit Abebe who endured loneliness with courage.

Above all, I praise God for giving me the strength to withstand all ups and downs....

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DECLARATION

I, the undersigned, hereby declare that this thesis is my original work, has not been presented for a degree in any other University and all source of materials used for the thesis have been duly acknowledged.

Name: Lemma Abera

Signature: ______________________________

Place: Addis Ababa University

Date of Submission: _____________________

This work has been presented with my approval as supervisor.

Name: Demeke Admassu (Ph.D)

Signature: _______________________________

Date: ___________________________________

ABSTRACT

Some aspects of reproduction, food and feeding habits as well as length weight relationship and condition of *Clarias gariepinus* in Lake Babogaya were studied at Lake Babogaya located in the vicinity of Bishoftu town at about 45 Km East of Addis Ababa. Samples of *C.gariepinus* were collected monthly during September (2005) through to August (2006) using hook - and - line method and gillnets of various mesh sizes. Sex ratio was not significantly different from 1:1 except in samples taken in April and July, and in length groups between 25 and 54 cm total length (TL) in the total sample. In all these cases, there was a preponderance of females over males. In the total sample, for instance, females were about 1.26 more numerous than males. The 50% sexual maturity length (L_{50}) was estimated at 50 cm TL for females and 56 cm TL for males. Estimated fecundity, which was linearly related with fish and gonad sizes ranged from 398 to 1165 eggs per gram with a mean of 945. Absolute fecundity was estimated to range from 11,000 to 580,571 with a mean of 159,660. Gonadosomatic index and frequency of ripe gonads suggested that *C. gariepinus* in Babogaya breeds throughout the year with intensive breeding activity during March to July and less intensively in September. Intensive breeding was coincident with the rainy seasons. *C. gariepinus* was found to ingest a variety of organisms of plant and animal origins, as well as items including detritus and sand grains. However, insects, zooplankton and fish (*Oreochromis niloticus*) were found to be the most important food of *C. gariepinus* in Babogaya. Thus, the fish is considered to have a mainly carnivorous feeding habit. The major food items ingested were all size groups of the fish during all sampling months of the study. However, the importance of insects and zooplankton tended to decrease whereas that of fish tended to increase with the TL of *C. gariepinus*. Thus, it appeared that the fish feeds progressively more *O. niloticus* as it grows larger. However, based on predator to prey size ratio of which 85 % range between 1:5 to 1:30, there was no direct correlation between the size of *C. gariepinus* (predator) and that of its prey (*O. niloticus*). High incidence of empty stomachs was observed during the whole sampling period. But, the frequency of empty stomach was high during the rainy season, which could be associated with breeding activity. The contribution of insects and zooplankton to the diet of *C. gariepinus* was relatively highest towards the end of the main rainy season, whereas the contribution of *O. niloticus* was relatively high during the rainy season. The relationship between total length (25 to 102 cm) and total weight (165 to 7000 g) was curvilinear and represented as $TW = 0.0156\ TL^{2.934}$, $R^2 = 0.942$, $P < 0.05$. Fulton condition factor (mean ± SE) was 0.66 ± 0.04 for females, 0.63± 0.03 for males and 0.64 ± 0.01 combined for both sexes.

Key Words/Phrases: *Lake Babogaya, C. gariepinus, Reproduction, Food, length weight relation, condition factor, Ethiopia*

1. INTRODUCTION

Providing adequate food for a rapidly increasing human population is one of the greatest challenges in the world. The problem is particularly acute in countries like Ethiopia where, besides population explosion, natural and man-made calamities have aggravated the problem. In addition to increasing food production from land agriculture, it is, necessary to sustainably exploit the aquatic ecosystems to contribute towards the effort of food security by virtue of their high productivity. Ethiopia's fish resources could undoubtedly offer one of the solutions to the problem of food shortage in the country.

Ethiopia is endowed with sizable amount of lotic (running) and lentic (stagnant water) environments whose fishery potential has not yet been fully realized (Brook Lemma, 1987). The inland water body of the county is estimated at about 7,400 km^2 of lake area and about 7,000 km total length of rivers (Shibru Tedla, 1973). These water bodies harbour more than a hundred edible fish species, and the annual potential fish yield of the main lakes is roughly between 30,000 and 40,000 metric tons (FAO, 1995). However, current exploitation is about 20 % of the potential, and a few species contribute to the fishery (FAO, 1995). Therefore, though some stocks show signs of overfishing, the fishery could be expanded so that it can contribute to food security and the economy. Such an opportunity is provided by Lake Babogaya; one of the Bishoftu crater Lakes. Lake Babogaya harbours the African catfish, *Clarias gariepinus*, and two tilapiine species (*Oreochromis niloticus* and *Tilapia zilli*), which were introduced in to the Lake by MOA (Ministry of Agriculture) with the aim of fishery development. Needless to say, sustainable exploitation requires scientific knowledge of the resource.

C. gariepinus is a widely distributed species, and contributes greatly to the fishery of Africa (Willoughby and Tweddle, 1978; Viveen *et al*., 1986) and Ethiopia (Shibru Tedla, 1973; Zenebe Tadesse, 1998). In Ethiopia, it is believed to occur almost in all water bodies containing fish (Shibru Tedla, 1973), and about 95 % of the fish catch is due to *O. niloticus*, *C. gariepinus* and different species of barbs (Zenebe Tadesse, 1998). Therefore, *C. gariepinus* is both ecologically and economically among the most important fish in Ethiopia. Hence, knowledge on its biology, such as feeding and reproduction, would have significant importance. However, such knowledge on *C. gariepinus* in lake Babogaya is totally lacking.

According to studies conducted elsewhere, *C. gariepinus* is an indiscriminate carnivore able to utilize a wide variety of food items including small crustaceans, insects, mollusks, oligochaetes and other fish (Fryer, 1959, Groenewald, 1964; Thomas, 1966; Van dar Waal, 1972; Bruton, 1978; 1979; Tesfaye Wudneh, 1998, Elias Dadebo, 2000). Fish, particularly tilapia, have been found to be important prey of *C.gariepinus* in some waters (Thomas, 1966; Elias Dadebo, 1988 and 2000), but it has also been considered as inefficient piscivore as compared to other species such as the Nile perch, *L. niloticus* (Willoughby and Tweddle, 1978, Leul Teka, 2001). Some investigators have also reported that *C.gariepinus* can utilize detritus, humus and macrophytes (Willoughby and Tweddle, 1978, Leul Teka, 2001), but others believe that these items were ingested by the fish accidentally (Groenewald, 1964; Kirk, 1967; Spataru et al., 1987; Elias Dadebo, 1988).

C.gariepinus is both a nocturnal and a daytime feeder, and vision is not considered to be a major factor in the search and capture of food (Hecht and Appelbaum, 1987). Most feeding takes place at night on active benthic organisms, but they may also feed during the day and at the water surface (Bruton, 1979). Seasonality in feeding activity or intensity is also likely to occur in *C.gariepinus*, as feeding is dependent on variation in availability of food and spawning activity (Fryer and Iles, 1972; Wootton, 1990).

Information on the reproductive biology of *C.gariepinus* has been reported by several authors (Van der Waal, 1974; Willoughby and Tweddle, 1978; Clay, 1979; Viveen *et al*., 1986; Elias Dadebo, 2000). In most cases, catfish breeds in flood plains of feeder streams after the onset of the major rains. After spawning the spent fish return to the lake. In water bodies with feeder streams, the breeding stocks move to the inundated areas of the shore for spawning, after which they move back to deeper waters.

Since, *C.gariepinus* is fast growing fish (Clay, 1979) and an indiscriminate feeder (Bruton, 1978; 1979; Spataru *et al*., 1987; Elias Dedebo, 1988) it can be cultured to produce large quantity of inexpensive animal protein (Viveen *et al*., 1986). In addition, clarias can be used to control undesirable recruitment of tilapia in culture systems. Therefore, *Clarias* is among important fish species in aquaculture production and management.

Nevertheless, scientific knowledge on *C.gariepinus* in Ethiopia is limited. As cited above, the only detailed studies are those of Elias Dedebo (1988; 2000), Tesfaye Wudneh (1998) and Leul Teka (2001). Elias Dadebo (1988, 2000) investigated some aspects of feeding, reproduction and commercial catch of the fish in Lake Awassa. Tesfaye Wudneh (1998) investigated reproduction patterns, growth and mortality of *C.gariepinus* in Lake Tana. Leul Teka (2001) investigated the feeding habits and some morphologic parameters of the fish in Lake Langano. These studies provide baseline information useful for sustainable exploitation and management of fisheries. However, the lack of such knowledge for the Lake Babogaya *C.gariepinus* population hinders rational exploitation and management. Therefore, the present study, with the objectives stated below, would be an important development.

General objective:

- To generate baseline information on the reproductive biology, feeding, length-weight relationship and condition factor of *C.gariepinus* that could assist in the proper exploitation and management of the fishery of Lake Babogaya.

Specific objectives:

- To study sex ratio, size at maturity, breeding season and fecundity of *C. gariepinus* in Lake Babogaya.
- To study feeding habits and feeding periodicity of the fish.
- To study Length-weight relationship and condition of the fish.

The results from this study possibly will provide basic information upon which rational exploitation and management of C.*gariepinus* fishery can be made. It could also provide base-line information for future aquaculture development in the country.

2. DESCRIPTION OF THE STUDY AREA

2.1. Lake Babogaya

Lake Babogaya is one of the volcanic crater lakes found in the vicinity of Bishoftu town at about 45 Km East of Addis Ababa (Fig.1). The lake is small, roughly circular and fairly deep, and is found at an altitude of 1870 m and at about 9^0N latitude and 39^0E longitude (Prosser *et al.,* 1968; Wood, *et al*., 1984). Like the other volcanic crater lakes of the area, it is a closed system surrounded by very steep and rocky hills. The vertical distance from the lake's surface to the crater rim is 20 m, and this affords moderate protection from wind (Baxter, 2002). The lake is fed primarily by precipitation falling directly on its surface and run-off from its small catchment area (Prosser *et al*., 1968), which was formed from volcanic rocks of basalt, rhyolite and tuff (Mohr, 1961).

Drier slopes around the lake support various tree species such as *Acacia* spp. where disturbance and grazing are minimal. Severely eroded areas are either bare or carry highly drought-tolerant shrubs, scramblers and succulents, the most conspicuous of which are *Carissa edulis*, *Euphorbia tirucalli*, *Pterolobium stellatum*, *Caesalpina spinosa* and *Opuntia ficus-indica* (Prosser *et al.,* 1968; Wood *et al*., 1984).

Limnological studies made on Lake Babogaya described its bathymetry (Prosser *et al*., 1968) (Table 1), water chemistry (Prosser *et al*., 1968; Wood *et al.,* 1984; Rippey and Wood, 1985; Zinabu Gebre-Mariam, 1994; Baxter, 2002; Zinabu Gebre-Mariam, 2002), thermal stratification and mixing (Baxter and Wood, 1965; Wood *et al*., 1976; 1984), chlorophyll *a* and phytoplankton (Wood and Talling, 1988; Zinabu Gebre-Mariam, 1994; Zinabu Gebre-Mariam and Taylor, 1997), bacterial abundance (Zinabu Gebre-Mariam and Taylor, 1997) and zooplankton associations (Green, 1986).

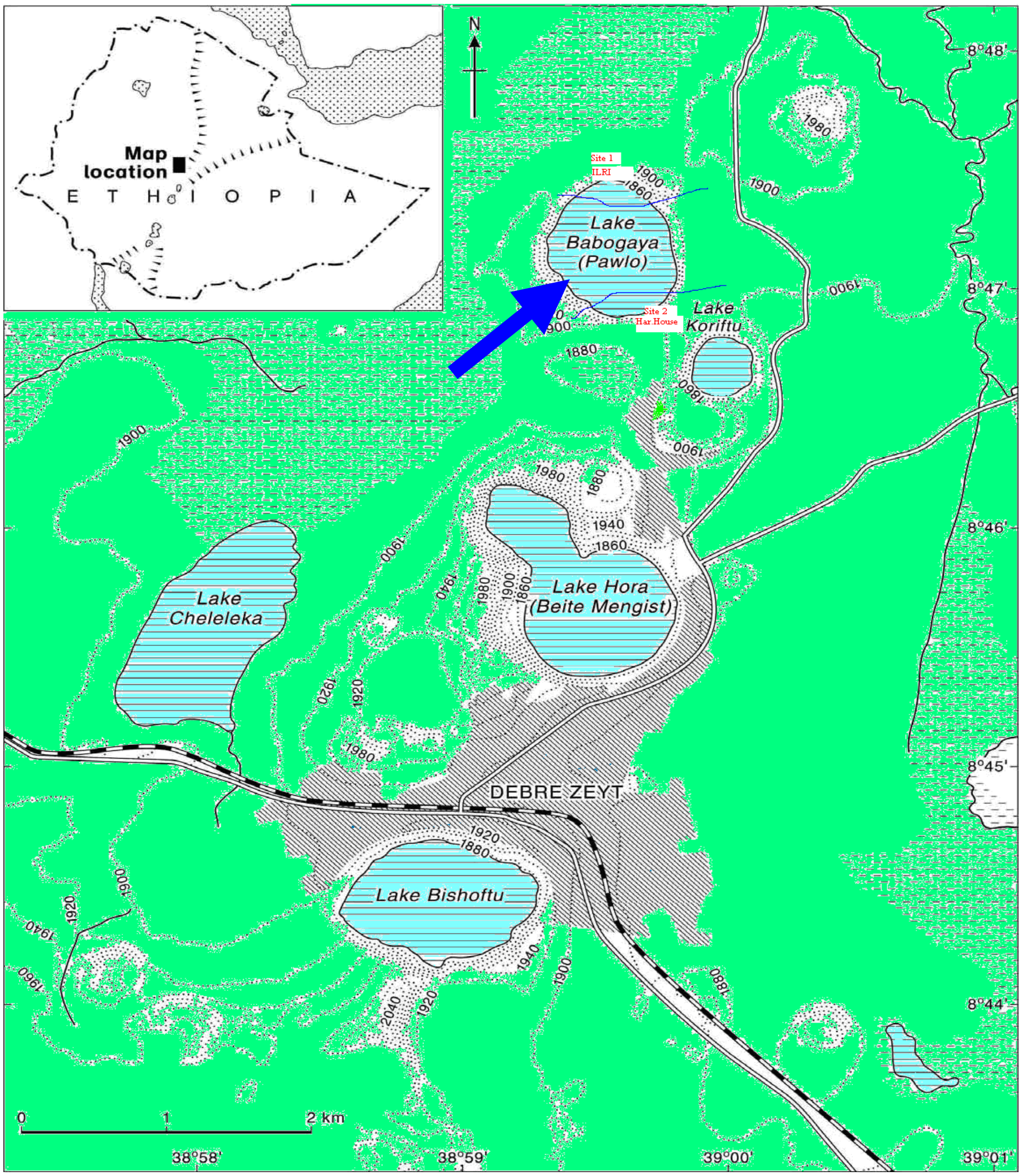


Figure 1. Location of Lake Babogaya in relation to the other Bishoftu Crater Lakes (Lamb, 2001)

Lake Babogaya is a dilute lake with Na^+ as the dominant cation and carbonate-bicarbonate as the dominant anion (Table 1). The lake water is alkaline, with the erosion of basaltic and hyper-alkaline rocks surrounding the lake playing an important role in increasing the alkalinity of the water (Wood and Talling, 1988).

The phytoplankton community is dominated by blue-green algae, particularly *Microcystis aeruginosa* (Kutz.) (Wood and Talling, 1988), while the zooplankton is composed of copepods (*Afrocyclops gibsoni*, *Lovenula africana*), rotifers (*Asplancha sieboldi*, Brachionus *calyciflorus* and *Hexarthra jenkinae*) (Green, 1986), and cladocera (Yeshimebet Major, 2006). The fish community found in Lake Babogaya is composed of *O.niloticus*, *C.gariepinus* and *Tilapia zilli*. From these, *C.gariepinus* is the most dominant species next to *O.niloticus*.

Prior to the beginning of the present study, there was limited fishing activity on Lake Babogaya. The lake was mainly used for recreation and domestic water-use purposes. The reason for limited fishing activity in the lake could be due to lack of fishing gears and lack of knowledge on the fishery resource of the lake. Currently, however, there is an intensive fishing activity on Lake Babogaya.

2.2. Meteorological Data

Data on mean total monthly maximum and minimum air temperature, and monthly total rainfall of the lake region were obtained from Debre-Zeit Agricultural Research Center (Ethiopian Agricultural Research Institute). According to the data, which plotted in figure 2,

Table1. Some morphological, physical and chemical characteristics of Lake Babogaya ([d] Prosser *et al*., 1968 ; [c] Zinabu Gebre-Mariam, 1994 ; [b] Yeshemebet Major, 2006)

Parameters	Values
Latitude	9^0N and 39^0E[d]
Altitude (m)	1870 [d]
Surface area (Km^2)	0.58 [d]
Volume (Km^3)	0.022 [d]
Maximum depth (m)	71 [b]
Mean depth (m)	38 [d]
Conductivity,K_{25} (μscm^{-1})	900[c]
Alkalinity (meq l^{-1})	10.2[b]
pH	9.2[b]
Salinity (gl^{-1})	0.9[b]
$SiO\text{-}_2$ (meq l^{-1})	< .1[b]
Alkalinity (meq l^{-1})	10.80[b]
Na+ (meq l^{-1})	5.50[b]
Cl^- (meq l^{-1})	0.90[b]
Sum of cations (meq l^{-1})	11.7[b]
Sum of anions (meq l^-)	11.4[b]

mean monthly minimum air temperature ranged from 11.2 to 13.5^{0}C, while the maximum mean monthly air temperature varied from 21.6 to 31.5 ^{0}C. Monthly total rainfall varied from 2.1 mm (January 2006) to 239.5 mm (July 2006). Although the region was described by Baxter and Wood (1965) as having two rainy periods, the minor one extending roughly from February to April and the major one between June and September, appreciable quantities of rainfall were recorded throughout from February to August, 2006 including September, 2005, and peaking in July. Rippey and Wood (1985) also documented that the lake area has moderate rainfall, varying around about 850 mm per annum. The present meteorological data also show an annual mean rainfall of about 877.2 mm.

Surface water temperature of the lake is reported to be mostly between 22^{0}C and 24.5^{0}C while the bottom temperature was almost constant (19.2^{0}C-19.4^{0}C) (Wood, *et al.*, 1976 and 1984). In a recent study (Yeshemebet Major, 2006), the water temperature and dissolved oxygen of the lake range from 23^{0}C to 27^{0}C and 7 mg l^{-1} to 14 mgl^{-1}, respectively.

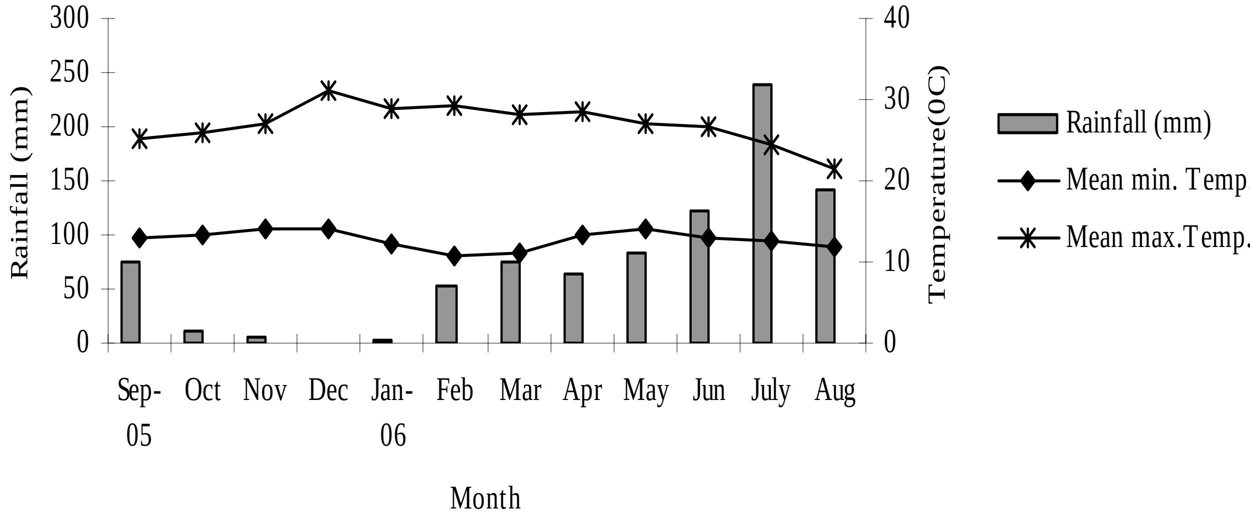


Figure 2. Monthly total rainfall, mean minimum and maximum air temperature of the lake region.

3. MATERIALS AND METHODS

3.1 Field Sampling and measurement

Samples of *C.gariepinus* were collected monthly between September 2005 and August 2006 using hook - and - line and gill nets from two sites. Site one (Harmeniawian House) is located about 20 m offshore at a depth of 4 to 12 m. Site two (ILRI) is 2 to 7 m deep and 10 m close to the shore; where there is a relatively dense macrophyte vegetation. Pieces of tilapia were used as bait for the hooks and the two gears were set parallel to the shoreline in the afternoon (05:00 pm) and lifted in the following morning (7.00 am). In addition, samples of fish caught by fishermen were also included to obtain a wide range of fish size and to increase sample size. Then immediately after capture, total length (TL) and total weight (TW) of each specimen were measured to the nearest 0.1 cm and 0.1g, respectively. Each specimen was then dissected and its sex determined by inspecting the gonads. The stomach was checked if it contained any food. If it was empty, this was recorded, whereas stomach with contents was preserved in 5% formaldehyde solution. Gonads of each specimen were removed and weighed to the nearest 0.01 gram and their maturity stages was visually rated and recorded. A five-point maturity scale was used for this purpose (Holden & Raitt, 1974). The ovaries were split longitudinally and turned inside out, to ensure the penetration of the preservative before they were stored in labeled jars (Bagenal and Tesch, 1978). Finally, ripe ovaries were preserved in Gilson's fluid to estimate fecundity (Simpson, 1959). Preserved samples were then transported to Addis Ababa University, Department of Biology, for further laboratory analysis.

3.2. Reproductive Biology

3.2.1 Estimation of sex - ratio and length at maturity

The number of female and male *C.gariepinus* caught was recorded for each sampling occasion. Sex-ratio (female: male) was then calculated for each month, for different length classes and for the total sample. Chi-square test was employed to test if sex ratio varied from one - to - one in monthly samples, in various size classes and in the total sample as in Demeke Admassu (1994).

The average length at first maturity (L_{50}) has been defined as the length at which 50 % of the individuals in a given length classes reach maturity (Willoughby and Tweddel, 1978). Thus, after classifying data by length class, the percentages of male and female *C. gariepinus* with mature gonads were plotted against length to estimate L_{50} (Tweddle and Turner, 1977).

3.2.2 Determination of breeding season

The breeding season of *C. gariepinus* was determined from monthly frequency of fish with ripe gonads and gonado somatic index (GSI). The GSI for each fish was computed as the weight of the gonads as the percentage of total body weight as follows:

$$\textbf{GSI = (GW/TW - GW) X 100}$$

Where, GSI = Gonadosomatic index

GW = Gonad weight in g.

TW = Total weight in g.

3.2.3 Fecundity estimation

The fecundity of ripe gonads preserved in Gilson's fluid was estimated gravimetrically (Simpson, 1959). The size of fish considered ranged from 40 to 102 cm total length, and their weight was between 700 and 7000 g. To estimate fecundity the preservative was replaced with water, and the eggs were washed repeatedly, decanting the supernatant.

The fecundity estimate was then obtained by weighing the entire eggs, and two sub-samples of 1000 eggs, each of which were all similarly, dried. The eggs were counted and weighed using a sensitive balance. The total number was computed using the following ratio:

$$\mathbf{N/n = W/w}$$

Where, N = Unknown total number of eggs

n = Number counted in sub sample (1000)

W = Weight of all eggs (g)

w = Weight of the sub sample (g)

Least squares regression was then used to find the relationship between fecundity and total length, total weight and gonad weight (Demeke Admassu, 1994).

3.3 Food and feeding habit study

3.3.1 Stomach content analysis

Preserved content of each stomach was transferred in to petri dishes. Larger food items were identified by eye, whereas small sized food items were microscopically examined using a WILD type stereoscope (magnification 6X to 50X), and each food item was identified to the lowest taxon possible using description, illustrations and keys in the literature (Macan, 1959, 1976; Borror and Delong, 1964; Harding and Smith, 1974; Edington and Hildrew, 1981; Defaye, 1988). In addition, smaller food items, such as phytoplankton, were examined at high magnifications (100X to 400X) under a compound research microscope.

After identification, a list of items found in the stomach content was prepared, and each item counted whenever appropriate. Counting was performed using the whole stomach content for the majority of the samples. In some cases, however, counting was done from a sub-sample of 10 ml stomach content. All counts were converted to number per total volume of stomach content.

3.3.2 Determination of relative importance of food items

The relative importance and contribution of each food item to the diet of *C.gariepinus* was determined using the standard methods, i.e., the frequency of occurrence method and percent composition by number (the numerical analysis) (Hynes, 1950; Windell and Bowen, 1978; Hyslop, 1980). Brief description of each method is given below:

a. Frequency of occurrence

The number of stomach samples in which one or more of a given type of food item was found was expressed as a percentage of all non-empty stomachs examined. This was considered as the proportion of the population that feeds on that particular food item and is referred to as frequency of occurrence.

b. Percent composition by number

The number of food items of a given food type that were found in all stomachs was recorded. The total numbers of individuals of each food item was then expressed as a percentage of all food items (Bagenal and Tesch, 1978). This estimated the relative abundance of that food item in the diet.

3.3.3 Estimation of fish- size and food habit relationship

To study whether there is ontogenetic shift in the food habit of *C. gariepinus*, results from each method were plotted against length of fish. Food items were grouped into major taxonomic groups for this purpose.

3.3.4 Estimation of predator-prey size relationship

An attempt was made to study the relationship between the size of *C.gariepinus* (predator) and that of its major prey fish. This was done by plotting (scatter plot) the total length of the prey fish against the total length of *C. gariepinus*. The length of prey fish (*O.niloticus*) was measured from undigested individuals. The scatter plot was then compared with theoretical lines passing through known prey to predator size ratios (Hailu Anja, 1996).

3.3.5 Estimation of feeding periodicity

Seasonal difference in food habit of *C.gariepinus* was studied from the frequency of empty stomachs, and also from results on relative contribution of major items as determined from frequency of occurrence, and numerical abundance methods.

3.4 Length - Weight relationship and Condition factor

Length-weight relationship of *C.gariepinus* was calculated using least squares regression analysis (Le Cren, 1951; Bagenal and Tesch, 1978).

$$\mathbf{TW = a \times TL^{b},}$$

Where, TW = Total weight in grams

TL = Total length in centimeters

a and b = intercept and slope of the equation, respectively

The condition or well being of each fish was determined by computing Fulton condition factor (Bagenal and Tesch, 1978). The condition factor of individual fish was calculated and then monthly mean values were determined for each sex separately. Fulton condition factor was calculated as:

$$\mathbf{FCF = TW / TL^{3} \times 100}$$

Where, FCF = Fulton condition factor

TW = Total weight in grams

TL = Total length in centimeters

Significance of length-weight relationships and of differences in condition factors of *C.gariepinus* between sexes, sampling periods, and sex by month interaction was tested using ANOVA (Sokal and Rohlf, 1981).

4. RESULTS

4.1 Size composition of the sample

A total of 948 (528 female and 420 male) *C. gariepinus* individuals were caught during the study .The total length of the fish ranged from 25 to 102 cm for females and from 25 to 95 cm for males. The corresponding total weight ranged between 170 and 7000 grams for females and 165 to 5550 grams for males.

As shown in Figure 3, the greater proportion of the sampled female fish ranged in size between 35 and 54 cm, whereas more males were caught between size classes 35 and 64 cm, the peak being between 45 and 54 cm for females and 35 to 44 cm for males. This length group alone was about 30% for females and 24% for males in the total sample. Fish over 85 cm and below 35 cm TL were least represented in the sample (Fig.3).

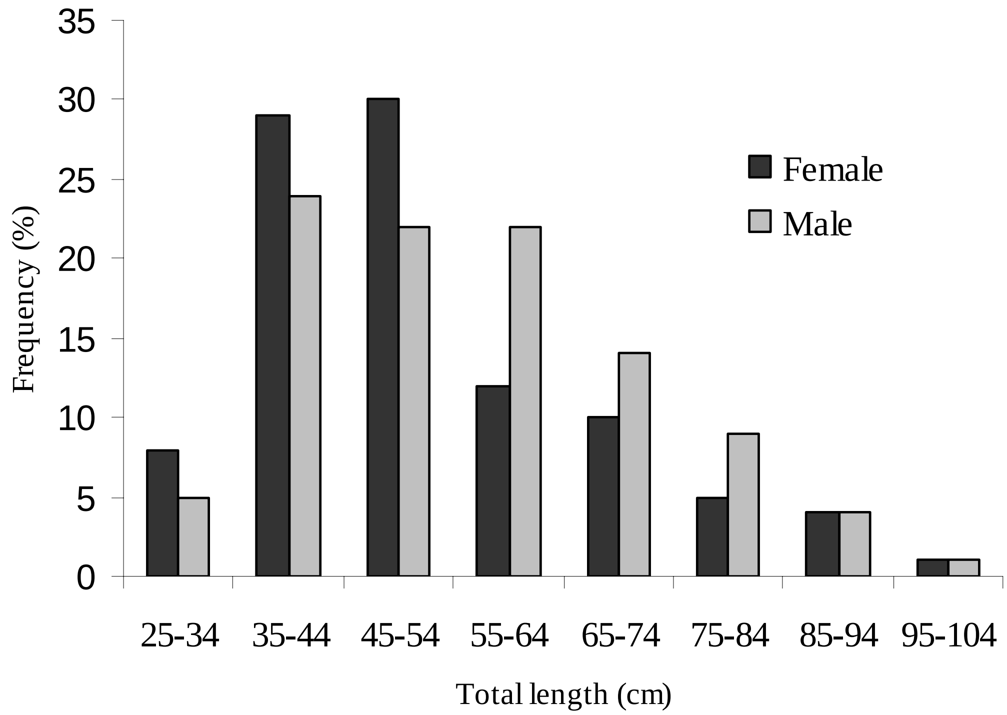


Figure 3. Length-frequency distribution of *C.gariepinus* from Lake Babogaya

4.2 Reproductive biology

4.2.1 Sex ratio and length at maturity

Sex ratio results are presented in Tables 2 and 3. The ratio was not significantly different from 1:1 for all sampling months, except in April and July when there was preponderance of females over males (Table. 2). Sex ratio of *C. gariepinus* was also similar to 1:1 for length classes above 54 cm (Table 3). However, females significantly outnumbered males in length classes ranging from 25cm to 54 cm (Table 3). In addition, the overall sex ratio (1.26:1) was also significantly different from 1:1 showing a preponderance of the females (Table 2 and 3).

The smallest sexually mature fish that was caught in this study was a female fish of 30 cm TL and a male fish of 32 cm TL. The 50% maturity length (L_{50}) was estimated to be 50 cm TL for females (Fig. 4a) and 56 cm TL for males (Fig. 4b). On the average, females appeared to attain sexual maturity at a relatively smaller size than males.

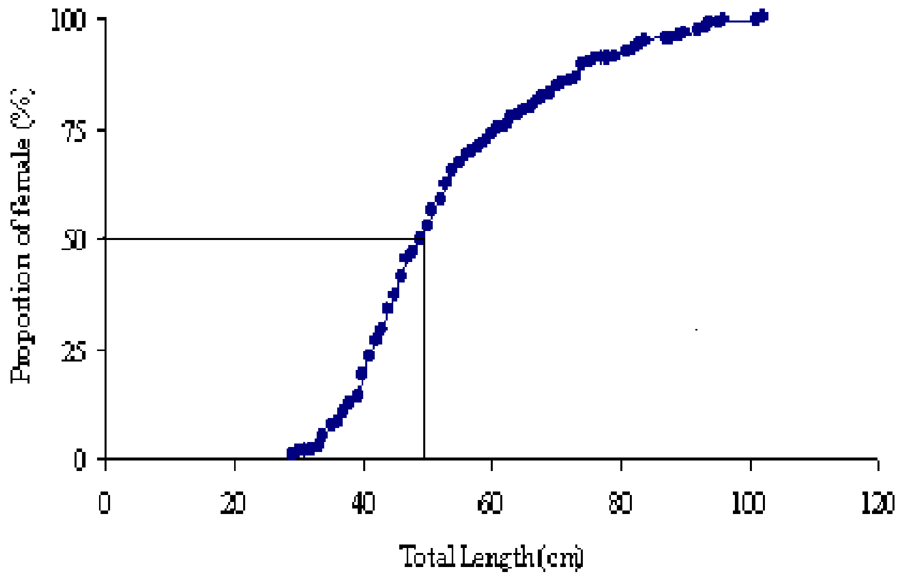
Table 2. Monthly number of females and males and sex ratio of *C. gariepinus* in Lake Babogaya (* means significant at 5% level).

Month	Female	Male	Sex-ratio	X^2
Sep. 2005	25	27	0.93:1	0.077
Oct.	29	25	1.16:1	0.296
Nov.	40	35	1.14:1	0.333
Dec.	29	26	1.12:1	0.164
Jan. 2006	39	34	1.14:1	0.342
Feb.	46	39	1.18:1	0.576
Mar.	52	47	1.11:1	0.253
Apr.	64	42	1.52:1	4.566*
May.	35	33	1.06:1	0.59
Jun.	63	48	1.31:1	2.027
Jul.	59	34	1.74:1	6.72*
Aug.	47	30	1.57:1	3.753
Total	528	420	1.26: 1	12.304*

Table 3. Number of female and male and sex ratio of *C. gariepinus* in various size classes in Lake Babogaya (* means significant at 5% level)

Size class in cm	Females	Males	Ratio (F: M)	Chi-sq
25-34	40	22	1.82:1	5.226*
35-44	152	111	1.29:1	6.392*
45-54	157	102	1.44:1	11.68*
55-64	79	81	0.98:1	0.025
65-74	51	53	0.81:1	0.038
75-84	25	30	0.64:1	0.455
85-94	19	18	1.06:1	0.027
95-104	5	3	1.67:1	
Total	528	420	1.26:1	12.304*

(a)



(b)

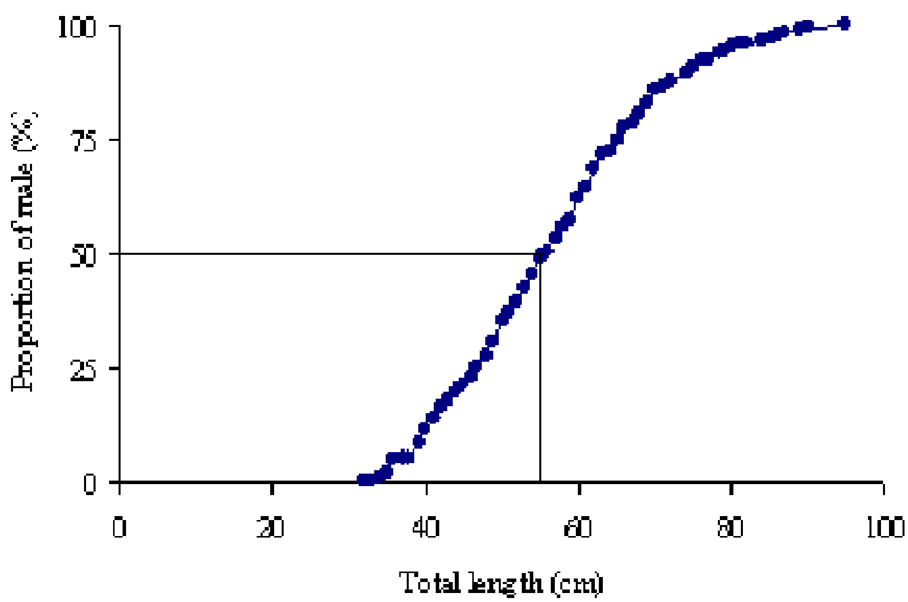


Figure 4. The proportion in different length groups of mature females (a) and males (b) *C. gariepinus* from Lake Babogaya

4.2.2 Breeding season

Monthly variation in Gonadosomatic Index (GSI) of both males and females *C.gariepinus* was evident (Fig 5). GSI values (mean ± SE) of females (Fig. 5a) ranged from 1.083 ± 0.04 (in January) to 6.317 ± 0 .1 (in June) and that of males (Fig.5b) ranged from 0.614 ± 0.02 (in December) to 0.884 ± 0. 07 (in April). GSI values of the females decreased from a high in September (2005) towards lowest value in January (2006). After January, GSI increased during the rest of the sampling months except a slight decrease in August (Fig. 5a). Also GSI values of the males decreased from a high value in September (2005) towards lowest value in December. After January, GSI increased and slight variation for the rest of the sampling year was evident (Fig.5b).

The frequency of ripe females and males *C.gariepinus* ranged from 1-25% and 2-17%, respectively, with high frequency occurring in September, and also between March and August (Fig. 6). The variation in GSI values was also reflected in monthly variation in the frequency of fish with ripe gonads (Fig. 5 and 6). Hence, lowest frequency of ripe fishes was recorded at times of lowest GSI values, i.e., between October (2005) and February (2006) (Fig.6). The result suggests that, while some fish in breeding condition may be present throughout the year, intensive breeding takes place during March to July and in September.

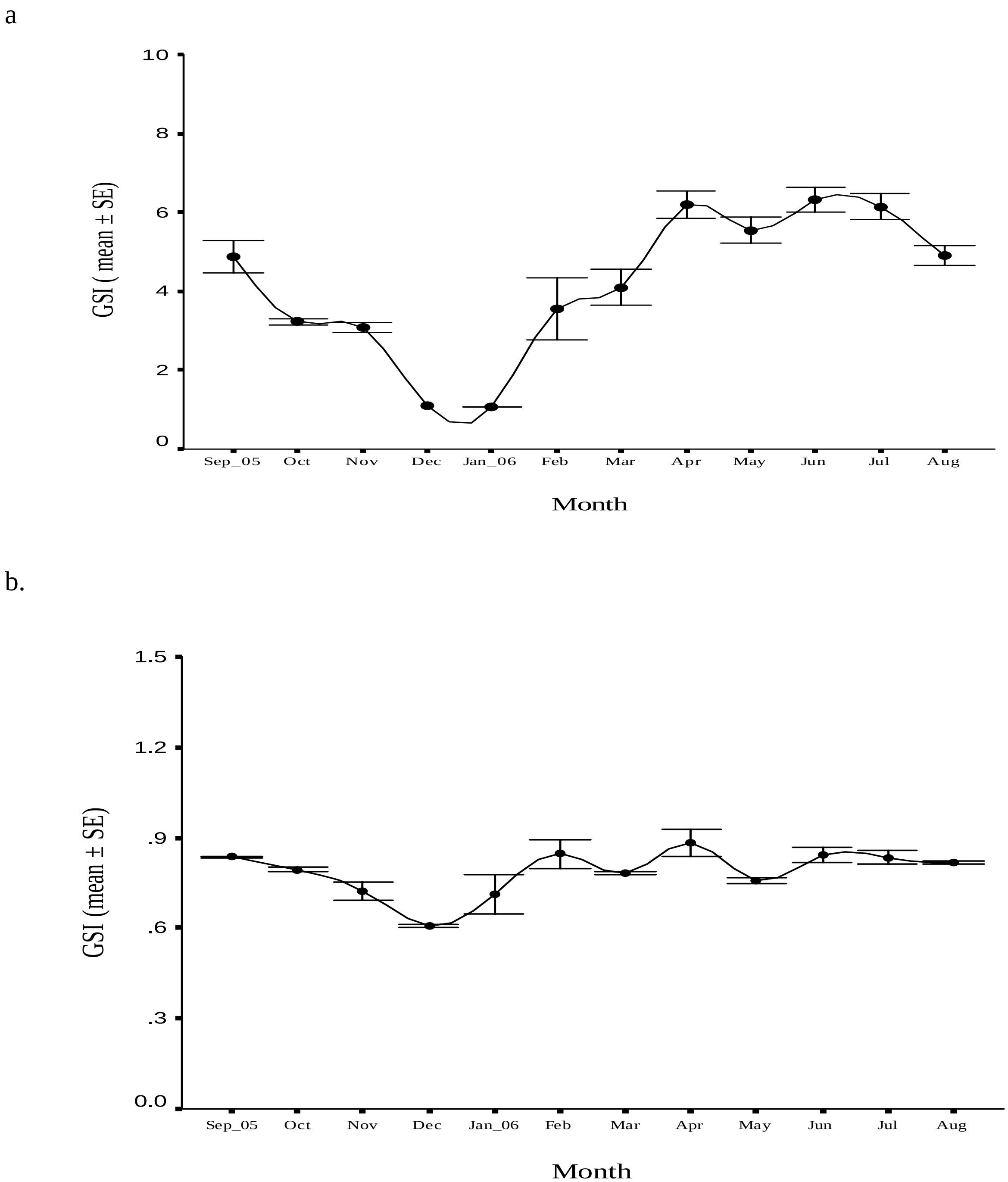


Figure 5. Seasonal variation in Gonado somatic index of female (a) and male (b) *C.gariepinus* from Lake Babogaya

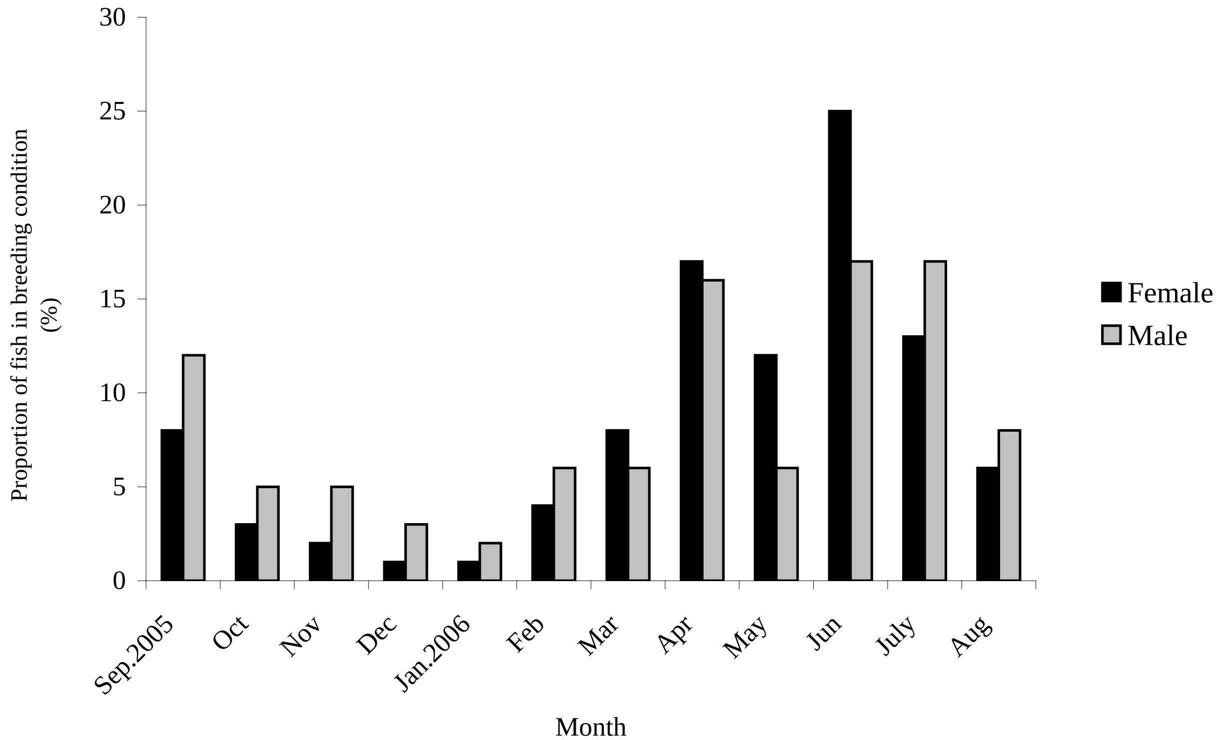


Figure 6.Temporal variation in frequency (%) of ripe female and male *C.gariepinus* in Lake Babogaya

4.2.3 Fecundity estimation

Fecundity was estimated for 110 ripe females whose total length and total weight ranged from 40 cm to 102 cm and 700 g to 7000 g, respectively. Fecundity of ripe ovaries ranged from 398 to 1165 eggs per gram with a mean of 945 per gram. Absolute fecundity was estimated to range from 11,000 to 580,571 with a mean of 159,660. Fecundity was linearly related to total length, total weight and gonad weight (Figs.7, 8, 9).

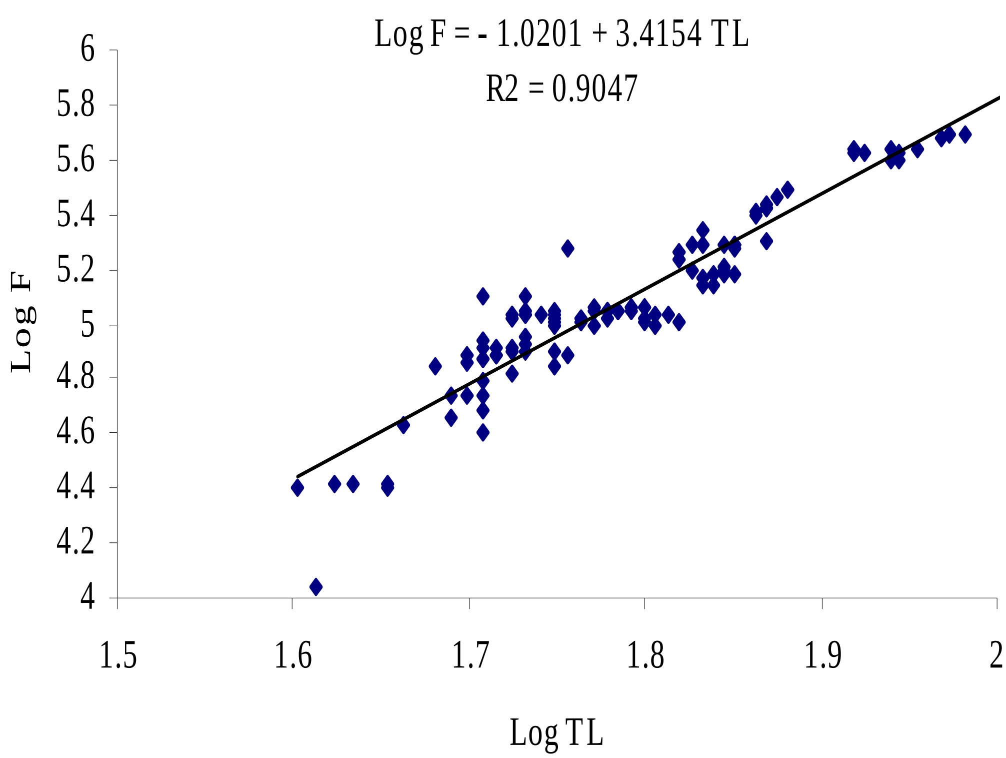


Figure 7. Relationship between fecundity (F) and total length (TL) of *C. gariepinus* in Lake Babogaya

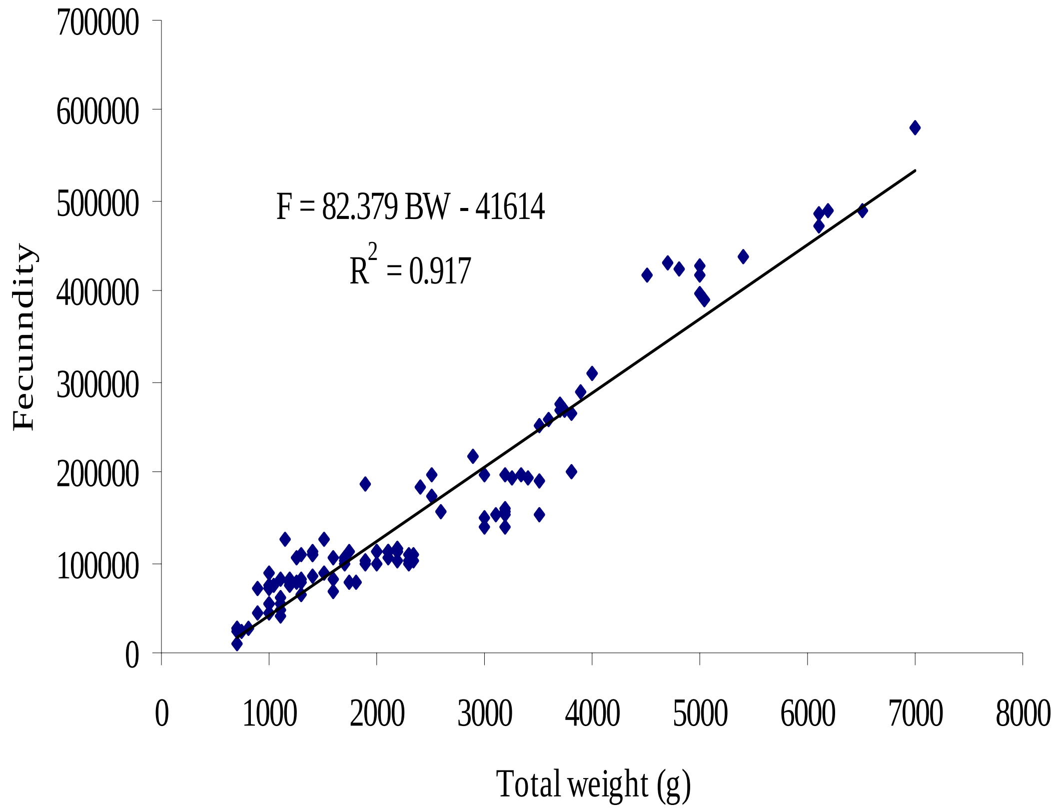


Figure 8. Relationship between fecundity (F) and total weight (TW) of *C.gariepinus* in Lake Babogaya

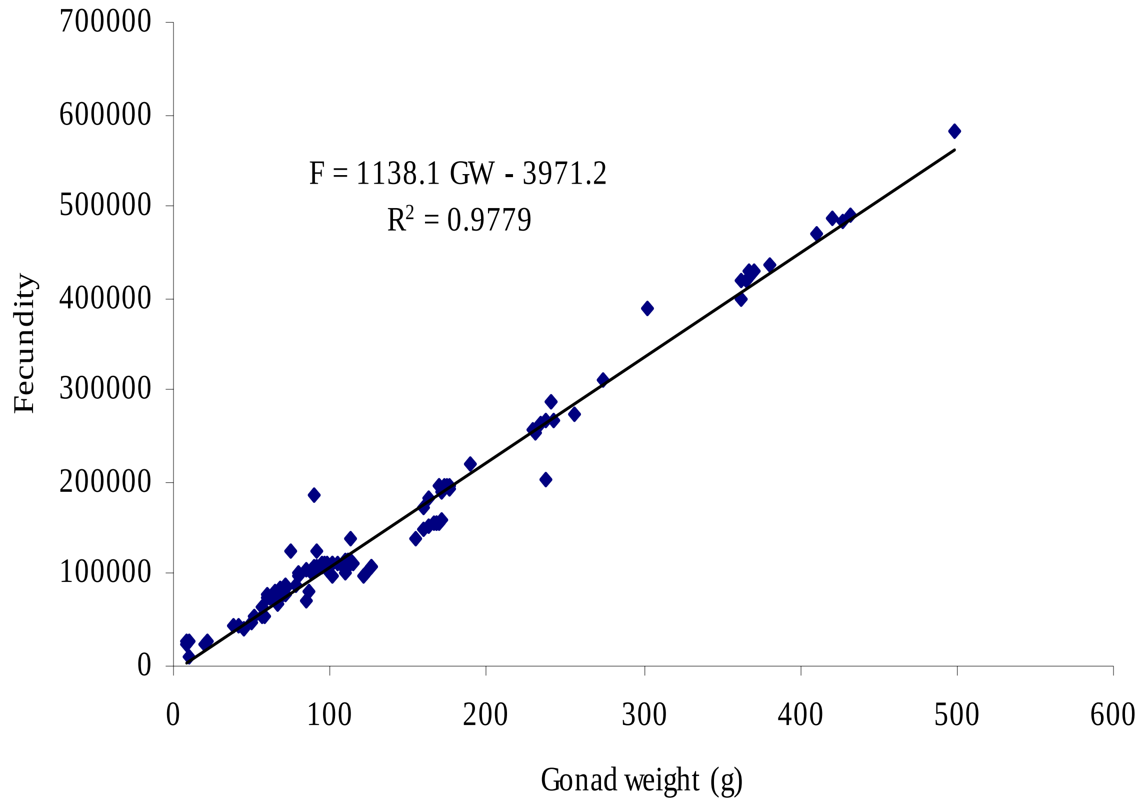


Figure 9. Relationship between fecundity (F) and gonad weight (GW) of *C.gariepinus* in Lake Babogaya

4.3 Food and feeding habits

4.3.1 Stomach contents

A total of 726 stomach samples of fish varying in length between 25 and 102 cm TL were examined for food composition study. Of these 386 (53%) were completely empty. The list of items observed in the stomach contents of the fish is presented in Table 4. The stomach content was found to be composed of diverse items of both plant and animal origins and detritus and sand grains (Table 4).

The plant food was made up of phytoplankton, particularly *Microcystis* sp. and filamentous algae, and macrophytes which were represented by shoots, roots, fruits and seeds. Items of animal origin were quite diverse and included fish, insects, nematodes, mollusks and zooplankton (Table 4). In addition, fish eggs, detritus, unidentified fragments of animal parts and sand grains were also encountered frequently in the stomach content of the fish (Table 4).

O. niloticus was the only fish species ingested by *C. gariepinus*. Various developmental stages of insects belonging to Odonata, Hemipetra, Coleopetra, Diptera, Ephemeroptera, Trichoptera and ants were also ingested by the fish (Table 4). Zooplankton groups ingested by the fish included Copepoda and Cladocera (Table 4).

Table 4. A List of items identified from stomach content of *C.gariepinus* from Lake Babogaya

Taxon (Food item)
Oreochromis niloticus
INSECTA
Odonata
Anisoptera larvae
Hemiptera
Notonectidae
Coleoptera larvae
Diptera
Chironomid larvae
Ephemeroptera
Trichoptera
Ants
NEMATODS
MOLLUSKS
Snail
ZOOPLANKTON
Copepoda
Cladocera
MACROPHYTES (shoots, roots, fruits and seeds)
FISH EGGS
ALGAE (*Microcystis* sp. and filamentous algae)
DETRITUS
UNIDENTIFIED ANIMAL FRAGMENTS
SAND GRAINS

4.3.2 Relative importance of major food items

a. Frequency of occurrence

Organisms that were found relatively more frequently were fish (*O. niloticus*), insects, zooplankton and macrophytes. Of these, the majority of *C. gariepinus* (81.8%) frequently ingested different groups of insects. The next important food items, which were ingested by most fish, were zooplankton (60.3 %) and macrophytes (61%), which were followed by *O. niloticus* (26.8 %) (Table 5). Fish eggs and sand grains were also ingested by about 16 % and 14 %, respectively, of the fish whose stomach contained food. Detritus, nematodes and snails occurred at frequencies ranging from 2.4 % to 5.9 % (Table 5).

The high frequency of insects was mainly due to Hemiptera (74 %) and Diptera (62 %). Most of the percentage frequencies of the other insects were below 15 %. The frequency of zooplankton was lower than that of insects, and the highest frequency was for Copepoda (55 %) (Table 5). *O. niloticus* occurred in 27% of the stomachs. On average, therefore, insects were the most frequent food in the diet of *C.gariepinus* in L. Babogaya.

Among the other groups, macrophytes were almost as frequent as Diptera (61%). The frequency of nematodes and snails were about 3 % and 2%, respectively. The other items frequently ingested by the fish were sand grains and detritus, which occurred in 14 % and 6%, respectively, of the stomachs examined (Table 5).

Table 5. Relative importance of different items present in the stomach content of *C. gariepinus* from Lake Babogaya

Food items	Frequency (%)	Numerical (%)
O. niloticus	26.8	0.42
INSECTA	81.8	2.87
Hemiptera	73.5	0.84
Diptera	61.8	0.98
Odonata	13.5	0.13
Ephemeroptera	12.4	0.64
Coleoptera	8.8	0.14
Trichoptera	1.2	0.03
Ants	5.9	0.11
NEMATODS	2.7	0.05
MOLLUSKS		
Snail	2.4	0.95
ZOOPLANKTON	60.3	88.17
Copepoda	55.3	77.88
Cladocera	6.2	10.29
MACROPHYTES	61.3	-
FISH EGGS	15.6	7.38
DETRITUS	5.9	-
SAND GRAINS	14.4	-

b. Numerical abundance

Based on percentage composition by number, zooplankton was the most important diet of *C.gariepinus* in L Babogaya, which contributed 88.2% of the total food ingested (Table 5). Among zooplankton Copepoda and Cladocera contributed 77.9% and 10.3%, respectively, of the total food counted (Table 5).

Among insect groups Hemiptera, Diptera and Ephemeroptera contributed each about 0.6 to 1%. The remaining insects were each less than 0.15 % of the total number of food items encountered in the stomach content of *C.gariepinus* (Table 5). The other important food of the fish was *O. niloticus* and eggs, which contributed 0.4% and 7.4 %, respectively, of the total number of food items counted (Table 5). Numerical abundance of the other items of animal origin, which includes snails and nematodes, was below 1% each. The remaining item like macrophyte tissues, sand grains and detritus were also observed frequently in the diet but, as it was difficult to count them, could not be compared numerically.

In general, zooplankton, insects and fish each as a group contributed to the bulk of the diet, and they were the most important food of *C.gariepinus* in the lake.

4.3.3 Fish size and feeding habit relationship

The relationship between size of *C.gariepinus* and its feeding habit, which was studied based on the frequency of major food items (insect, zooplankton and fish), is shown in Figure 10. The major food items were ingested by individuals belonging to all length classes ranging from 25 cm to 94 cm. The bulk of the food of *C.gariepinus* below 75 cm TL was composed of insects and zooplankton, whereas for larger fish the frequencies of the three major items were more or less similar. Generally, however, frequency of occurrence tended to increase for fish (*O. niloticus*), whereas it tended to decrease for insects and zooplankton with increase in TL of *C.gariepinus* (Fig.10).

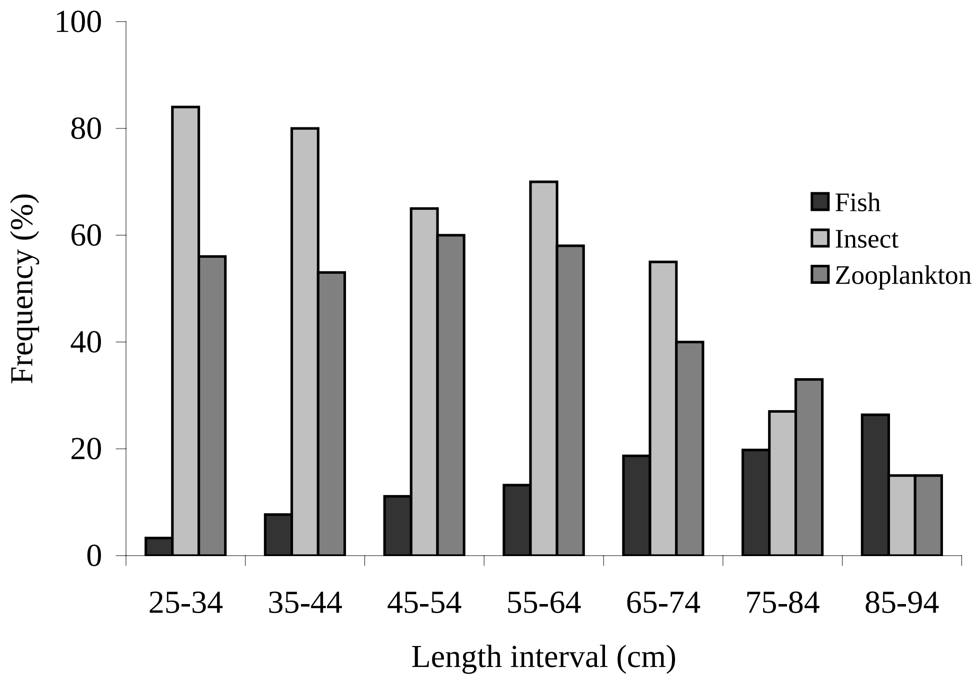


Figure 10. Relationship between length of *C.gariepinus* and its food habit based on frequency of occurrence method.

4.3.4 Predator - prey size relationship

The TL of the predator (*C. gariepinus*) in this part of the study ranged from 35 to 95 cm whereas that of prey length (*O.niloticus*) ranged from 1.5 to 16 cm TL. An individual *C. gariepinus* of 77 cm had ingested an *O.niloticus* of 2 cm TL, and another predator of 49 cm TL had ingested a prey (*O.niloticus*) of 13 cm TL. *C. gariepinus* individuals that had ingested *O.niloticus* had a prey to predator ratio between (1:5 - 1:10), (1:10 -1:20) and (1:20 - 1:30) with their respective percentages of 39, 31 and 15 % (Fig. 11). The ratio was either above 1:5 or below 1:30 for about 7% of the *C. gariepinus* studied (Fig.11).

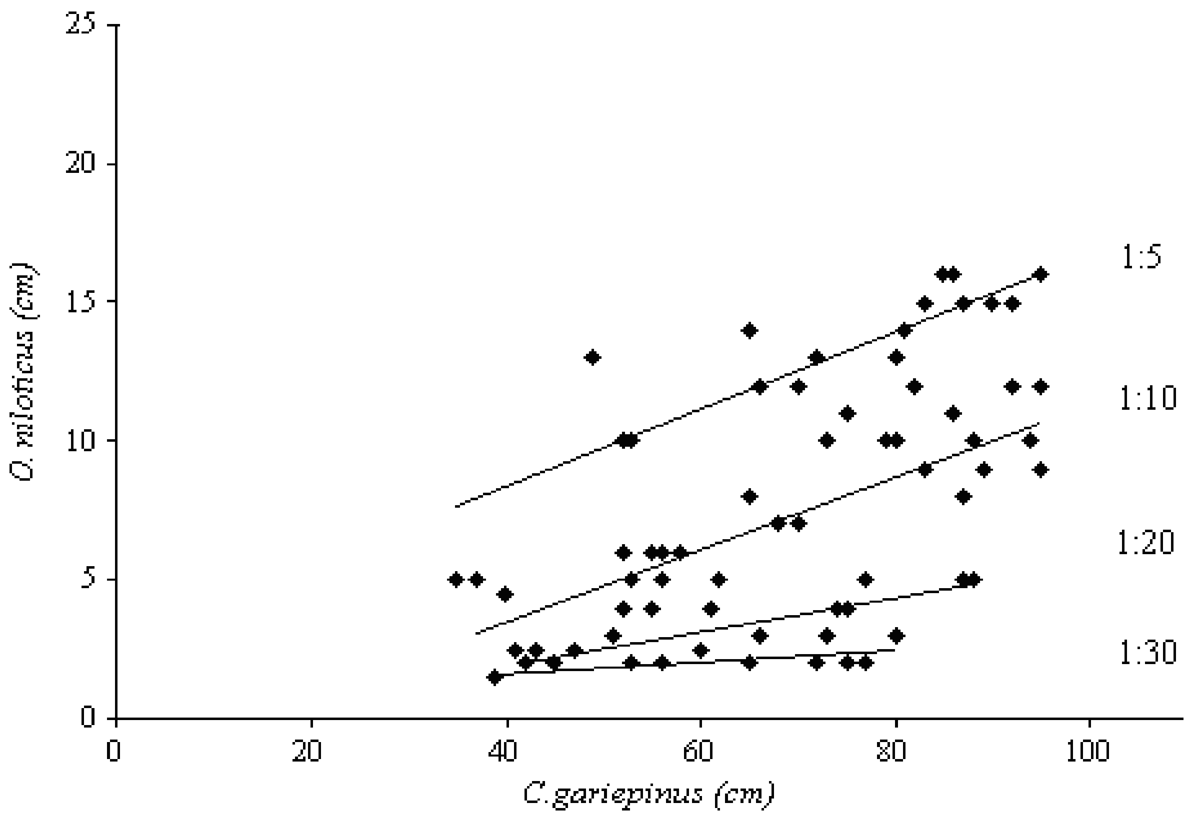


Figure 11. Relationship between length of *C.gariepinus* (Predator) and length of its prey (*O.niloticus*) in Lake Babogaya

4.3.5 Feeding periodicity

In general, fish with empty stomachs, which accounted for about 53 % of the total, occurred in all sampling months, but they were more frequent in July (75 %), June (66 %), April and August (65 % each). The frequency was the lowest in January (28 %) (Fig.12).

High frequency of *C.gariepinus* with empty stomach occurred during the rainy period, which was from March to August, and also in September (2005). The frequencies were less pronounced during the rest of the sampling period and appeared coincident with the dry season (Fig.12).

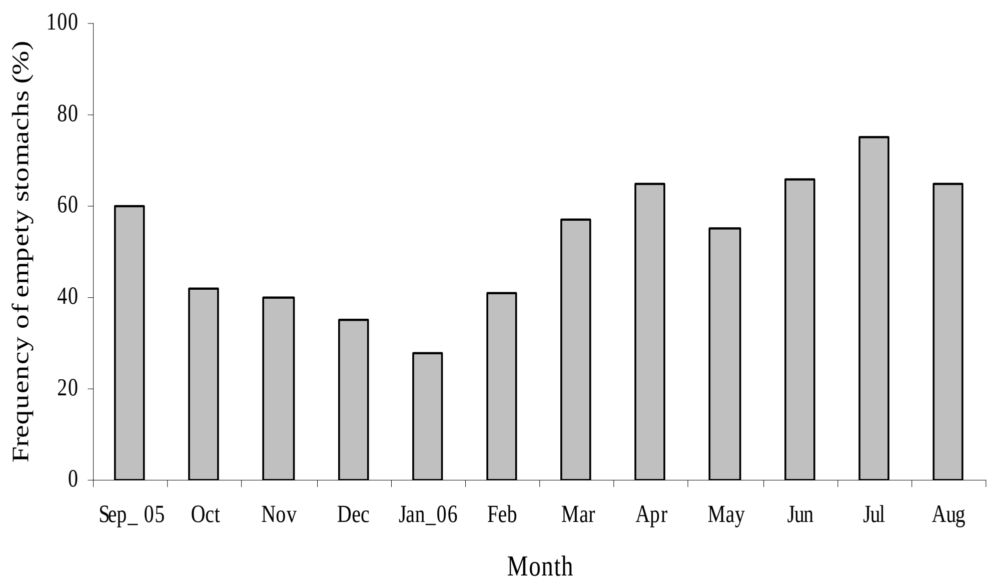


Figure 12. Frequency of *C.gariepinus* with empty stomach from Lake Babogaya

Periodicity was also indicated by frequency of occurrence and numerical abundance of major food items (insects, zooplankton and fish). Frequency of occurrence of insects was relatively high throughout the sampling year. But, it was above 80 % between September and January (2006). On the other hand, there was a decreasing trend in the frequency of occurrence of zooplankton and fish from September (2005) towards January (2006), and generally an increasing trend from January towards August (Fig.13).

Numerically, zooplankton were the dominant food items of *C.gariepinus* throughout the study period (Fig.14). In addition seasonal fluctuation in their numerical abundance was not evident except that their number decreased in September (2005) and in July (2006) when that of insects was the highest as compared to other months. On the other hand, seasonality was quite evident in the numerical importance of fish (*O. niloticus*) to the diet of *C. gariepinus*. Thus numerical abundance of fish was low between October and January, but it was relatively high in September and also during February to August (Fig.14).

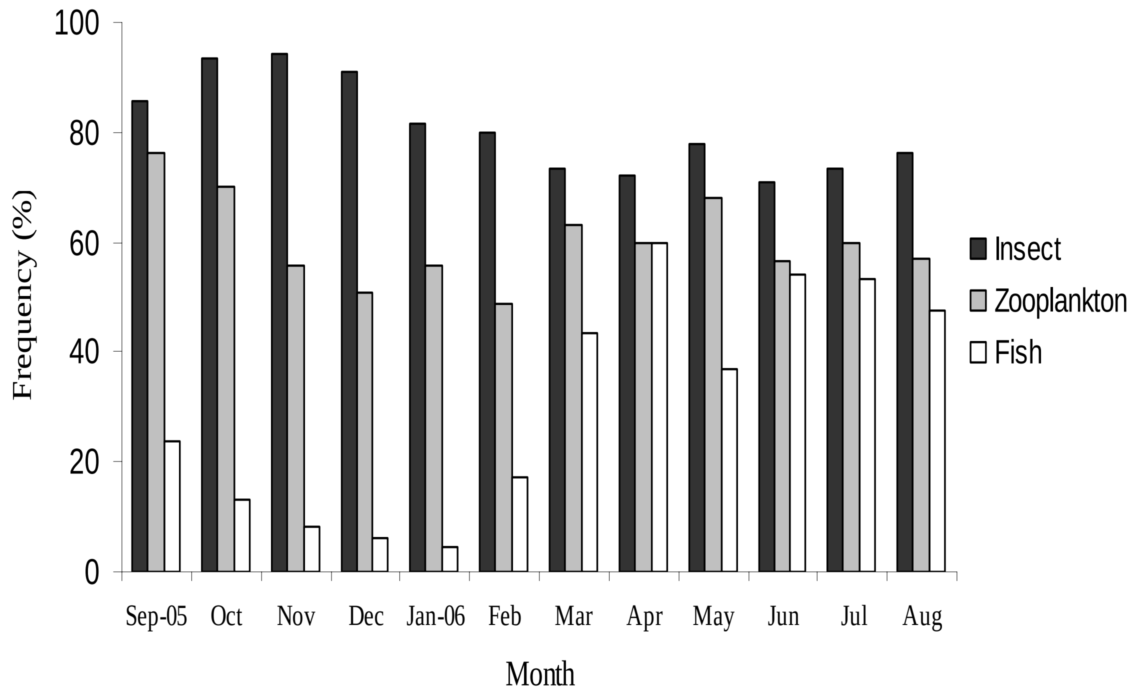


Figure 13. Seasonal fluctuation in frequency of occurrence of major food items of *C.gariepinus* from Lake Babogaya

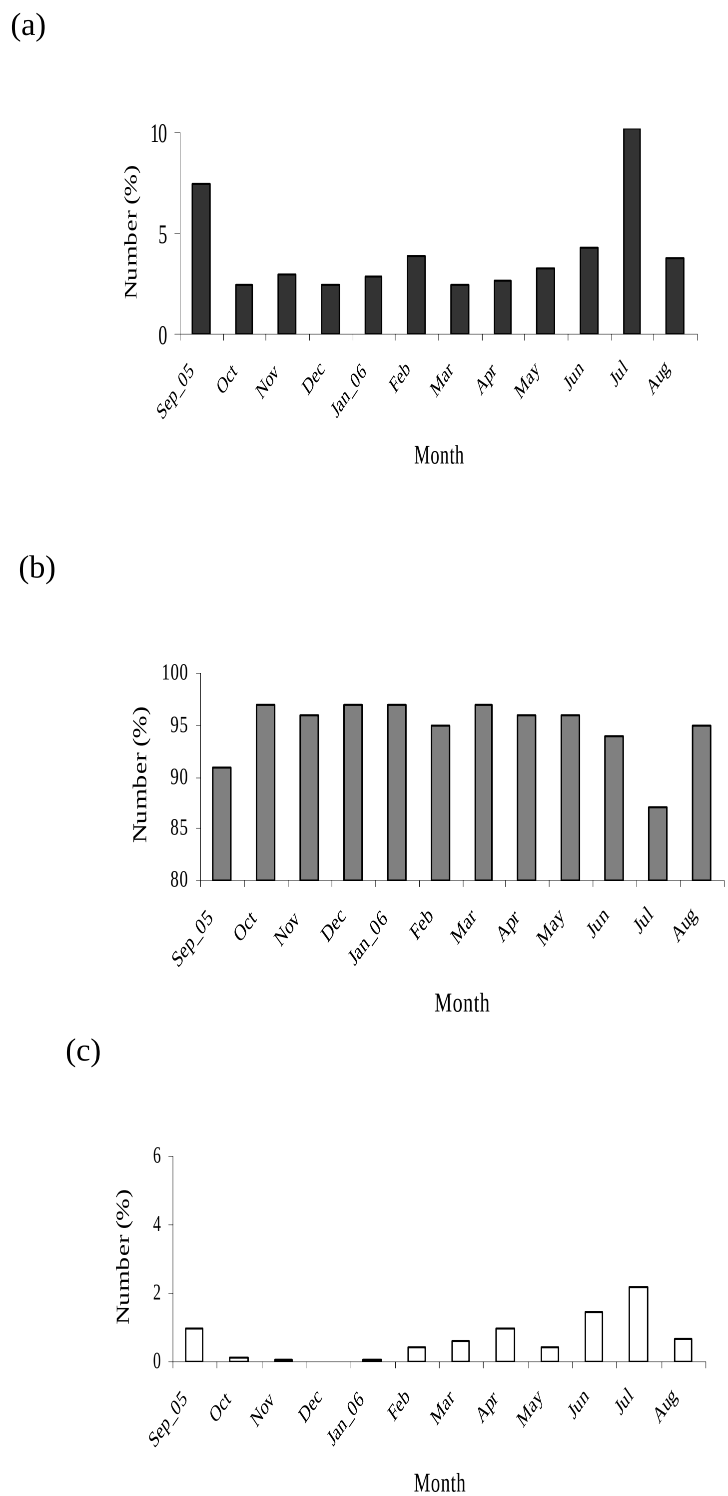


Figure.14. Seasonal fluctuation in numerical abundance of insects (a), zooplankton (b) and fish (c) in gut content of *C. gariepinus* from Lake Babogaya

4.4 Length - Weight relationship and condition factor

The Length-weight relationship of *C. gariepinus* in Lake Babogaya was curvilinear and statistically highly significant (P<0.05). The equations separated by sex were as follows.

Males: $TW = 0.0174 \times TL^{2.9029}$, $R^2 = 0.9673$, n = 420

Females: $TW = 0.0143 \times TL^{2.9525}$, $R^2 = 0.955$, n = 528

Comparison of the above two equations showed no significant difference between the sexes (ANOVA, P>0.05). Therefore, an equation combined for sexes was fitted and shown in Figure 15. The equation was for fish ranging in length from 25 to 102 cm, and in total weight from 165 to 7000 g. The slope (b=2.93) was close to the theoretical value of 3.

Monthly Fulton condition factor (FCF) values (mean ± SE) of *C. gariepinus* ranged from 0.63 ± 0.05 (in June) to 0.70 ± 0.09 (in December) for females (Fig. 16 a), and from 0.61± 0.04 (in July) to 0.67 ± 0.05 (in January) for males (Fig. 16 b). Mean FCF (± SE) was found to be 0.66 ± 0.04 for the females and 0.63 ± 0.03 for the males. The overall mean FCF was 0.64 ± 0.01.

FCF varied significantly between sampling months and between sexes (ANOVA, P<0.05). Generally, the females had higher FCF values than the males. However, sex by month interaction was insignificant (ANOVA, P>0.05) suggesting that temporal variation in FCF was similar for both sexes (Fig. 16). Thus, FCF of both sexes was high during November (2005) to January (2006), but low during the rest of the months (Fig. 16).

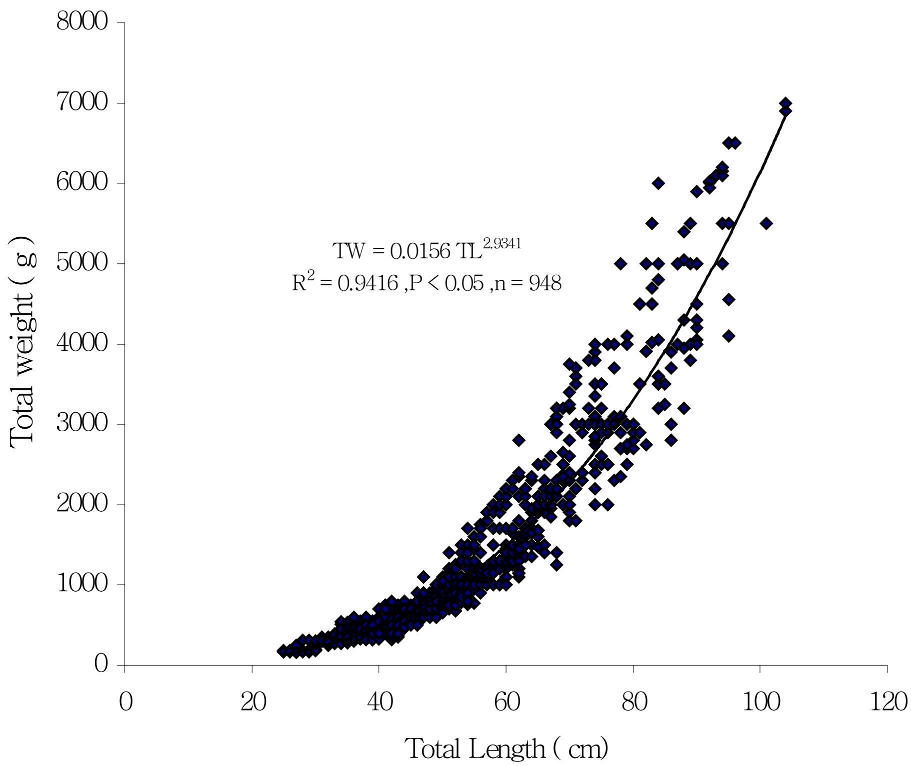
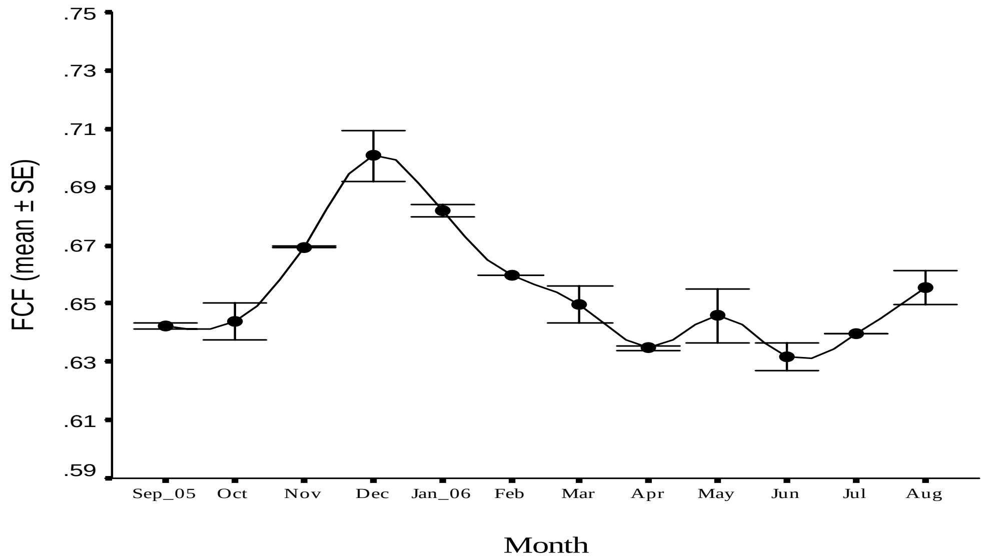
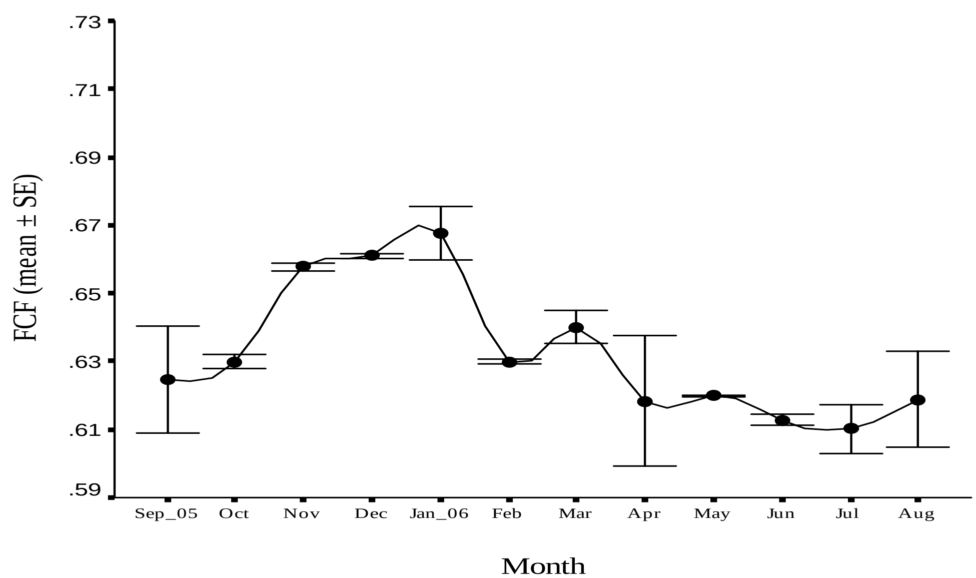


Figure 15. Length-weight relationship of *C. gariepinus* in Lake Babogaya

a.



b.



Figurer 16. Monthly Fulton condition factor (mean ± SE) of female (a) and male (b) *C.gariepinus* from Lake Babogaya

5. DISCUSSION

The study showed a balanced sex ratio for samples taken throughout the sampling period except in April and July, and in length class above 54 cm TL. However, significantly more females than males were caught in April and July, and also in length classes below 55 cm TL, which resulted in an over all preponderance of females over males in the total sample. The females were about 1.26 X more numerous than the males in the total sample. The result is similar to the result for the same species in L. Langeno (Leul Teka, 2001), but different from the 1:1 ratio reported for the species in L. Awassa (Elias Dadebo, 1988). The unbalanced sex ratio found in the present study is difficult to explain. Probably, it could be attributable to behavioral differences between the sexes, which might have made females more vulnerable and passive to gears such as gill nets and hook - and - line. Although for *O. niloticus*, preponderance of females has been attributed to sexual segregation during spawning, activity differences, gear type and fishing site (Demeke Admassu, 1994). Hence, further study is required to see if the same factors could be responsible for sex ratio results for *C. gariepinus*.

The size of 50% sexual maturity (females 50 cm, and males 56 cm) (Fig. 4) of *C. gariepinus* in this study was smaller than values estimated for the same species in L. Awassa (Elias Dadebo, 1988). Length of maturity in many fish species depends on demographic conditions, and is determined by genes and the environment (Fryer and Iles, 1972; Lowe-McConnell, 1987). Generally, fish in poor condition mature at smaller size than those in good condition (Lowe-McConnell, 1958; 1959; 1987). Thus, smaller length at maturity of the fish in L. Babogaya than that in Awassa could be due to differences in body condition, because the condition of the fish in Babogaya was relatively lower than that of the fish in Awassa.

The study showed that females mature at a relatively smaller length than males (Fig. 4). The same was found for the species in L. Awassa (Elias Dadebo, 1988), L. Tana (Tesfaye Wudneh, 1998) and in L. Zwai (Daba Tugie and Meseret Taye, 2004). This could be due to the fact that the onset of sexual maturity is more costly in females than in males (Lowe-McConnell, 1982; Demeke Admassu, 1989; 1994).

Based on the results of GSI (Fig. 5) and frequency of ripe gonads (Fig. 6), it is possible to suggest that the fish has a biannual reproduction cycle. The fish breeds intensively during March to July and less intensively during September in L. Babogaya. This result is similar to results found by others for the same species in other lakes. Elias Dadebo (2000), for instance, reported that *C.gariepinus* in L. Awassa breeds intensively during February to August and less intensively during September to October. The same has also been reported for the species in Lake Zwai (Daba Tugie and Meseret Taye, 2004). In addition, some *C. gariepinus* in breeding condition can be present at any time in L. Babogaya as it was the case also in L. Awassa and Zwai (Elias Dadebo, 2000; Daba Tugie and Meseret Taye, 2004) as well as in other tropical water bodies.

Intensive breeding activity of *C.gariepinus* in L. Babogaya was coincident with the rainy season. Thus, rainfall and associated factors may act as cues for spawning by the fish so that offspring are produced at a time of better growth and survival. The role of rainfall in fish spawning is well documented (Fryer and Iles, 1972; Balarin and Hatton, 1979; Lowe-McConnell, 1982). Runoff, for instance, results in increased nutrient concentrations which in turn result in improved food quantity and quality (Jalabert and Zohar, 1982; Zenebe Tadesse, 1988; Demeke Admassu, 1996). Correlation between rainfall and peak breeding activity has also been reported for the same species (Elias Dadebo, 1988) and other species (Zenebe Tadesse, 1988; 1997; Demeke Admassu, 1994; 1996; Yirgaw Teferi, 1997) in Ethiopia, and elsewhere (Fryer and Iles, 1972; Jalabert and Zohar, 1982; Lowe-McConnell, 1982; Stewart, 1988).

Fecundity ranged from 398 to 1165 eggs per g, which was slightly lower than the same species in L. Awassa, which ranges from 435 to 1176 eggs per g (Elias Dadebo, 1988). Low fecundity of *C. gariepinus* in L. Babogaya could be due to its lower body condition and growth as compared to the species in Lake Awassa, which in turn is a reflection of less favorable biotic and abiotic factors. Fish in poor body condition are reported to have less fecundity than those in better condition (Lowe-McConnell, 1959).

C. gariepinus in Lake Babogaya ingests a variety of organisms and items. Organisms identified from the stomach contents of the fish varied from phytoplankton to higher plants (Macrophyta), and from microinvertebrates to fish (Table 4). These organisms are also ingested by the same species in Ethiopian lakes such as Awassa (Elias Dadebo, 1988; 2000), Tana (Tesfaye Wudneh, 1998), Langeno (Leul Teka, 2001) and Zwai (Daba Tugie and Meseret Taye, 2004). The same has also been reported for *Clarias* in other countries; in L. Sibaya, South Africa (Bruton, 1979) and in L. Kinneret, Israel (Spataru *et al*., 1987).

Based on frequency of occurrence insects, and numerically zooplankton were the most important food of *C. gariepinus* in the lake (Table 5). Similarly, insects and zooplankton are the most important food items for the fish in L. Langeno (Leul Teka, 2001) and Zwai (Daba Tugie and Meseret Taye, 2004) in Ethiopia, and in other lakes elsewhere, like, in L. Sibaya (South Africa) (Bruton, 1979) and L. Kinneret (Israel) (Spataru *et al*., 1987). Contrary to this, however, fish is the most important food of *Clarias* in L. Awassa (Elias Dadebo, 1988; 2000). In addition, cichilid fishes are the most important food of *C. senegalensis* in a man-made lake in the Ghanaian savanna (Thomas, 1966). The low contribution of fish to the diet of *C. gariepinus* in L. Babogaya may be related to the relatively low abundance of *O.niloticus* in the lake than other lakes. That the importance of *O. niloticus* showed an increase during the rainy season may indicate increase in the abundance of juvenile *O. niloticus*, which could have occurred due to breeding seasons. Breeding in *O. niloticus* occurs so that juveniles are recruited to coincide with favorable condition for growth and survival (Demeke Admassu, 1996). In addition, Groenewald (1964) has confirmed that catfish become piscivore when there is abundance of fish available in the water bodies.

It is known that *C.gariepinus* is an indiscriminate feeder (Bruton, 1979; Elias Dadebo, 2000). Therefore, it may have ingested detritus, sand grains and macrophyte while searching for preys that are attached to macrophytes and on the sediment. Earlier reports also confirmed our results (Groenewald, 1964; Thomas, 1966; Kirk, 1967; Spataru *et al*., 1987; Elias Dadebo, 2000; Leul Teka, 2001; Daba Tugie and Meseret Taye, 2004). The importance of sand grains to the diet of fish has been controversial. They might be ingested accidentally when the fish is feeding on detritus and benthic organisms. However, it is also believed that they may provide nutritional benefit through the dark coating of organic material on their surface (Getachew Teferra *et al*, 2000). Thus, further investigation, particularly using chemical method, may reveal the role of sand grains in fish feeding.

The major food items (Fish, insects and zooplankton) were ingested by all size groups of *C. gariepinus* all year round (Fig. 10 and 13). Hence, the fish is considered to be carnivorous in the lake. The study showed that smaller fish ingested more of insects and zooplankton, whereas large *C. gariepinus* included progressively more and more fish. This could be due to the fact that large *C. gariepinus* inhabits deeper waters, whereas small ones live in shallow waters among macrophytes where densities of benthic organisms are usually high (Bruton, 1978; Elias Dadebo, 1988; 2000 and Leul Teka, 2001). Similarly, Corbet (1961) showed that *Clarias* in Lake Victoria feeds mainly on ostracods and insects when young but they tend to feed progressively more on fishes, as they grow older. In addition, Munro (1967) also reported that insects are more important in the diet of small *C. gariepinus*. Furthermore, Elias Dadebo (2000) and Leul Teka (2001), who found slight size-based differences in food habit, reported that juvenile *C. gariepinus* feed more on insects than did the adults. Therefore, despite the overall low contribution of *O. niloticus* to the Lake Babogaya *C. gariepinus*, the contribution was high for large individuals.

Most piscivorous predators tend to prey on progressively large-sized fish, as they grow larger. However, in this study there was no definite relationship between the size of *C. gariepinus* and that of its prey fish. The great majority of the predator had ingested *O. niloticus* whose length is between $1/5^{th}$ and $1/30^{th}$ of their own length.

High incidence of empty stomachs was observed during the whole sampling period. But, the frequency of empty stomachs was high during the rainy season, which seems to be associated with breeding activity. As mentioned earlier heavy rainfall and subsequent rise in water level trigger spawning of *C. gariepinus* in African water bodies (Greenwood, 1955; Van der Waal, 1974; Willoughby and Tweddel, 1978) including Lake Tana (Tesfaye Wudneh, 1998), Awassa (Elias Dadebo, 2000) , Langeno (Leul Teka,2001) and Zwai (Daba Tugie and Meseret Taye, 2004) in Ethiopia. Thus, the fish may be engaged more in spawning activity than in feeding. Similar findings and conclusion have been reported for other fish species (Zenebe Tadesse, 1988; 1998). The other reason that could have been responsible for high occurrence of empty stomachs is the method of capture. Since the fish were left for several hours on the gears before they are collected, the stomach contents may have been lost by regurgitation or digestion. Kirk (1967) also showed that regurgitation of stomach contents was very high in *C. gariepinus* caught by gill nets in L. Chilwa (Malawi).

The contribution of insects and zooplankton was relatively highest after the end of the main rainy season, whereas the contribution of prey fish to the diet of *C. gariepinus* was relatively high in the rainy season. The seasonal variation in food habit could be due to the opportunistic nature of the fish, which is capable of shifting from one diet to another depending on temporal and/ or spatial variations in availability of the diet in the lake (Fryer and Iles, 1972; Philipart and Ruwet, 1982; Matipe and De Silva, 1985). The same has been concluded for the species in L. Awassa (Elias Dadebo, 1988, 2000), L. Langeno (Leul Teka 2001) and L. Zwai (Daba Tugie and Meseret Taye, 2004).

The largest *C. gariepinus* caught in the present study was 102 cm (TL) which was comparable to the largest size recorded for the species from Lake Langeno (104 cm; Leul Teka, 2001) but smaller than that from Lake Zwai (117 cm; Daba Tugie and Meseret Taye, 2004). There were a curvilinear relationship between total length and total weight of the fish in the lake (Fig.15). The value of b (2.93) was close to the theoretical value (b = 3), indicating isometric growth. The finding is in agreement with the principle of fish growth (Bagenel and Tesch, 1978), and comparable to the value of b calculated for the same species in L. Langeno (2.9) (Leul Teka, 2001) and L. Zwai (2.84) (Daba Tugie and Meseret Taye, 2004), but slightly lower than that in L. Awassa (3.04) (Elias Dadebo, 1988).

Condition factors, which are used to compare the well-being or fatness of fish, are based on the hypothesis that the heavier fish of a given length are in better condition. Mean FCF in the present study was 0.66 for females and 0.63 for males. The overall mean FCF for the population was 0.64. According to Leul Teka (2001) the corresponding values for the L. Langeno population were 0.63 for females, 0.58 for males and 0.61 for the population in general. The corresponding values for the L. Awassa population were 0.70 for females, 0.69 for males, and 0.70 for the population (Elias Dadebo, 1988). Thus, *C.gariepinus* in Lake Babogaya show a relatively better well-being than that in L. Langeno, but lower than that in L. Awassa.

Additional evidence can also be obtained by using length-weight equations fitted in the present study and that by Elias Dadebo (1988) and Leul Teka (2001). Considering a 30 cm fish length, *C. gariepinus* would be 190 g in L. Awassa, 169.3 g. in L. Langeno, and 185 g in L. Babogaya. In addition, for a 90 cm total length, *C. gariepinus* would weigh 5400 g in Awassa, 4200 g in

Langeno and 4700 g in Babogaya. Generally, *C. gariepinus* in Lake Babogaya would be heavier than a similar sized fish in L. Langeno but lighter than that in Lake Awassa. Hence, it can be concluded that the L.Babogaya *C. gariepinus* population grows relatively faster than that in L. Langano and slower than that in L. Awassa. The reason for this difference may be related to the difference in productivity between the lakes, which in turn determines food quantity and quality. This shows that quantity and quality of the food of *C. gariepinus* may be better in Babogaya than in Langeno, whereas that in Awassa may be better than that in Babogaya. However, a detailed study is required to confirm this conclusion. .

Results of FCF of *C. gariepinus* in L. Babogaya suggest that females are in relatively better condition than males. Our finding agrees with sex-based difference in FCF reported for *C. gariepinus* of L. Awassa (Elias Dadebo, 1988) and Langeno (Leul Teka, 2001). It is also common to find populations whose female members grow superiorly and have better condition than the males (Fryer and Iles, 1972).

6. CONCLUSIONS AND RECOMMENDATIONS

This study is the first of its kind to be conducted on *C. gariepinus* of L Babogaya. Therefore, further detailed studies are required on other aspects (growth, mortality, etc) of the fish, as well as on the limnology of the lake in general and the biology of the other fish species in particular. However, some conclusions and recommendations can be made based on the findings of the present study.

- It was found out that the smallest sexually mature *C.gariepinus* was 30 cm TL for female and 32 cm TL for male, whereas the L_{50} was 50 cm for females and 56 cm for males. Thus, *C.gariepinus* smaller than about 50 cm should be protected for the stock to sufficiently replace itself and for sustained exploitation. Prior to the start of this study there was very little fishing on Babogaya. However, fishing by the local population has intensified afterwards probably learning from the present study about fish abundance and fishing gears. In any case large numbers of small sized fish were being exploited (personal observations). While development of the fishery is possible, proper management actions are required to protect the immature fish. Therefore, gear size and type must be recommended for the fish in the lake.

- Since, the fish breeds intensively during the rainy season on the nursery ground around the shore of the lake. On the other hand, most of the fishing gears employed is operated from the shores area where mostly very small and spawning fish are found. Therefore, the fishery management plan like, prohibiting fishing on spawning ground during the breading season is needed for the lake before the fishery resource become overexploited.

- *C. gariepinus* in L. Babogaya was found to feed mainly on zooplankton, various developmental stages of insects and *O. niloticus*. Therefore, conservation and management plan considering to protect these natural food of the fish would be an important development.

- The sex ratio, fecundity, length weight relation and condition of *C. gariepinus* in Babogaya were comparable to those of the species in some other Ethiopian Lakes (Awassa, Langeno and Zwai). This suggests that the L. Babogaya *C. gariepinus* population may have general characteristics (growth and mortality) similar to the populations in the other lakes. This in turn may suggest the possibility of developing the fishery on L. Babogaya as is currently the case on the other lakes (eg. Zwai, Langeno).

- Prior to this, however, in addition to the studies mentioned above, stock assessment study is strongly recommended to estimate optimum fishing level and sustainable yield.

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