*Ethiop. J. Biol. Sci.* **10(1): 1-17, 2011**

**ISSN: 1819-8678**

# BREEDING SEASON, MATURATION, FECUNDITY AND CONDITION FACTOR OF THE AFRICAN CATFISH *CLARIAS GARIEPINUS* BURCHELL 1822 (PISCES: CLARIIDAE) IN LAKE CHAMO, ETHIOPIA

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**ABSTRACT:** Some aspects of reproductive biology, length-weight relationship and condition factor of *Clarias gariepinus* (Burchell) were studied from January - December 1999 in an Ethiopian rift-valley lake (Lake Chamo). Except in some months and size classes, sex ratios didn't differ significantly from 1:1, with season and size class. Males were more numerous than females in 20.0- 29.9 cm, 60.0-69.9 cm and >90 cm size classes ($x^2$ = 4.50, p<0.05; $x^2$ = 3.88, p<0.05; $x^2$ = 16.00, P < 0.001, respectively). Significantly more males than females were also caught in January ($x^2$ = 4.46, p<0.01), March ($x^2$ = 10.79, p<0.01) and October ($x^2$ = 10.45, p<0.01). *C. gariepinus* spawned over an extended period, and the main pulse in reproductive activity occurred during the rainy months of March - June. Length at first maturity ($L_{m50}$) of females was 58 cm while $L_{m50}$ of the males was 52 cm. Fecundity ranged from 5,000 -1,240,000 eggs with the mean at 337,700. Ripe ovaries contained 625 - 2,760 eggs $g^{-1}$ of wet weight with the mean of 1,110 eggs. The relationships between total length and fecundity, and total weight and fecundity were curvilinear while the relationship between ovary weight and fecundity was linear. Length-weight relationship for *C. gariepinus* is best expressed by the equation TW = $0.0035TL^{3.19}$. Mean monthly Clark's condition factor of the females ranged from 0.274 ± 0.036 - 0.350 ± 0.030 while that of males ranged from 0.278 ± 0.02 - 0.343 ± 0.028.

**Key words/phrases:** *Clarias gariepinus*, Condition factor, Lake Chamo, Reproduction.

## INTRODUCTION

The African catfish *Clarias gariepinus* is widely distributed in African freshwaters in the Niger and Nile River systems, extending to southern Africa, in the Limpopo, Orange-Vall, Okavango River systems and most of the East African rift lakes (de Moor and Bruton, 1988). In Ethiopia it is widely distributed in most of the lakes and the river systems (Shibru Tedla, 1973). The species is extremely tolerant of adverse environmental conditions. The presence of an accessory organ enables it to breath air when very active or under dry conditions.

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Various workers have studied the reproductive biology of *C. gariepinus* in some African waters (Van der Waal, 1974; Willoughby and Tweddle, 1978; Kolding *et al*., 1992; Baijot and Moreau, 1997; Tesfaye Wudineh, 1998; Elias Dadebo, 2000). The available information indicates that breeding takes place during the rainy season in flooded deltas. The fishes make lateral migrations towards the inundated plains to breed and return to the river or lake soon afterwards (Payne, 1986). This phenomenon is often indicated as a mechanism of dispersion as well as a means of finding a favorable environment for the development of the eggs. Following fertilization the eggs are placed in some suitable flooded area with a rich food supply that the young can use after hatching (Payne, 1986).

*C. gariepinus* is one of the most commercially important fish species in eastern, central and southern Africa (Willoughby and Tweddle, 1978) and it is highly regarded by local people as food fish because it has few intra-muscular bones in its flesh. In Lake Victoria, it was indicated that *C. gariepinus* and *B*agrus *docmak* (Forskål) were the major food sources for the local people (Benda, 1979; Marten, 1979). In Lake Chamo *C. gariepinus* is of low commercial importance in its contribution to the fishery. However, with the recent over-fishing of other fish species such as *Lates niloticus* (L.), *Labeo horie* (Heckel), and *Oreochromis niloticus* (L.) the importance of *C. gariepinus*, as human food has considerably increased (Reyntejns and Tesfaye Wudineh, 1998). There is no published information on the biology and ecology of *C. gariepinus* in Lake Chamo. The objective of this work was therefore, to study some aspects of reproductive biology, length-weight relationship and condition factor of *C. gariepinus* in Lake Chamo. The scientific information obtained is important for proper management and utilization of the stock in the future.

## MATERIALS AND METHODS

### Description of the study area

Lake Chamo (5°42′- 5°58′ N; 37°27′- 37°38′ E) is the most southern of the Ethiopian rift valley lakes (Fig. 1b, c) and lies at an altitude of 1,108 m. It has a surface area of approximately 551 $km^2$ and a maximum depth of 16 m (Amha Belay and Wood, 1982). Lake Chamo lies to the east of the Precambrian block of the Amaro Mountains, within the less intensely faulted basin (Mohr, 1962).

The surrounding region receives two rainy seasons per year, March - May (big rains) and September - October (little rains). The mean annual rainfall of the area is about 1,000 mm (Daniel Gamachu, 1977). The main affluent of the lake is Kulfo River, which flows in at the north end of the lake and the less important feeders, are the Sile and Sago Rivers entering from the west (Fig. 1c). During the past three decades the water level of the lake has declined considerably and this has resulted in significant shrinkage of the lake's surface area.

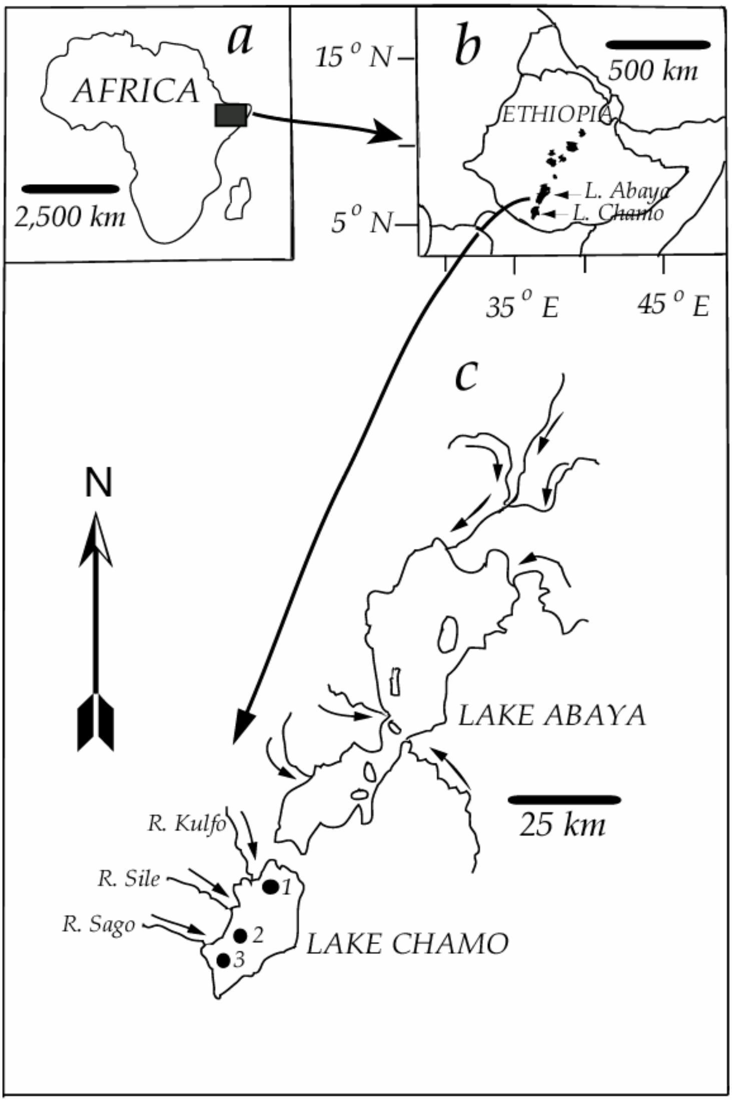


Fig. 1. Map of Africa with the relative position of the Horn of Africa highlighted (a), map of Ethiopia with the relative position of the Ethiopian rift valley lakes indicated (b) and map of Lakes Abaya and Chamo with the sampling stations in Lake Chamo indicated (c) (1- Deset, 2- Bedena, and 3- Bole). Arrows indicate direction of river flow.

## Sampling

*C. gariepinus* were collected each month between January-December 1999 using stationary longlines at three sites in the pelagic area of the lake (Fig. 1c). In addition, beach seine and small hook and line gear were used in the shallow littoral area of the lake to obtain a wider range of fish size and cover a full array of habitats in which the species thrives. The commercial gillnet catch was also sampled. The hooks were usually set during the afternoon and lifted the following morning. Total length (TL) of all fish was measured to the nearest millimeter immediately after capture. Total weight (TW) and eviscerated weight (EW) of fish under 1,000 g were weighed to the nearest gram whereas those between 1,000 g and 2,000 g were weighed to the nearest five grams. Larger specimens were weighed to the nearest 25 g.

## Reproduction

The sex and maturity stage of each fish were determined. The maturity stages were determined by visual examination of the gonads and using a five-point maturity scale. This maturity scale describes the development of gonads based on their sizes and the space they occupy in the body cavity of fish (Holden and Raitt, 1974). According to this maturity scale, gonad maturity is categorized as immature (I), recovering spent or developing virgin (II), ripening (III), ripe (IV) and spent (V). Ripe ovaries were removed, weighed to the nearest 0.1 g, and preserved in Gilson's fluid. In order to assist penetration by the preservative, the ovaries were split longitudinally and turned inside out (Bagenal and Braum, 1978).

The breeding season was determined from the percentages of fish with ripe gonads taken each month. Since fish with ripe gonads could be found at any time of the year, breeding season was taken as the period of the year where relatively higher proportion of fish were in breeding condition. A chi-square test was used to determine if the sex ratio varied between different size classes and months of the year (Frank and Althoen, 1994). Gonado-somatic index (GSI), gonad weight as a percentage of total body weight was calculated for ripe fish.

The length at which 50% of the fish were mature ($L_{m50}$) was determined from the relationship between the percentages of mature fish (P) of length class (L) as described by the logistic function (Echeverria, 1987):

$$P = e^{(\alpha + \beta)} / (1+ e^{\alpha + \beta L}) \quad (1)$$

and the value of $L_{m50}$ was estimated from the expression:

$$L_{m50} = -\alpha/\beta \quad (2)$$

The individuals of fish used in the estimation of $L_{m50}$ were collected during the spawning season of the fish (i.e. March - June 1999). The proportion of mature fish for each 5-cm length class was calculated for both males and females and α and β were estimated using Marquardt's (1963) algorithm for non-linear least squares regression.

We estimated fecundity by weighing all the eggs in the ovaries and weighing three sub-samples of 1g of eggs from various parts of the ovaries and then the average number of eggs $g^{-1}$ wet weight was calculated. It was then possible to calculate the total number of eggs $ovary^{-1}$ since the mean number of eggs $g^{-1}$ and total weight of each ovary were known (Snyder, 1983). The relationship between fecundity and some morphometric measurements, TL, TW and ovary weight (OW) were determined using least squares regression. Diameters of mature eggs were measured with an ocular micrometer to the nearest 0.01 mm.

**Length-weight relationship and condition factor**

We used TL and TW to calculate length-weight relationship using the following formula:

$$TW = aTL^b \quad (3)$$

where TW is in g and TL in cm; *a* and *b* are parameters.

Clark's condition factor (K) was used to determine the mean monthly female and male condition factors of *C. gariepinus*. EW and TL were used to determine K values (Bagenal and Tesch, 1978):

$$K = EW/TL^b x100 \quad (4)$$

where *b* is the coefficient of the length-weight relationship.

ANOVA and Tukey's multiple comparisons of the means were used to determine seasonal and sex based variations in the condition factor (Frank and Althoen, 1994).

## RESULTS

Of the 894 fish samples of *C. gariepinus*, 410 (45.9%) were females while the remaining 484 (54.1%) were males. The total ratio of males to females was 1:0.85. This ratio was significantly different from the hypothetical ratio of 1:1 ($x^2 = 6.13$, $P < 0.05$). Sex ratio was also calculated for months of the year (Table 1) and different size classes (Table 2). Significantly more males were caught in January ($x^2 = 4.46$, $P < 0.05$), March ($x^2 = 4.46$, $P < 0.05$) and October ($x^2 = 10.45$, $P < 0.01$). There were no significant differences in the overall sex ratios of fish caught in the other months of the year ($P > 0.05$). The ratio of females to males was significantly different from unity at size classes 20.0 - 29.9 cm ($x^2 = 4.50$, $P < 0.05$), 60.0 - 69.9 cm ($x^2 = 3.88$, $P < 0.05$) and $\geq$ 90 cm ($x^2 = 16.00$, $P < 0.001$) (Table 1). The longest male caught was 113 cm TL and weighed 9,500 g. The longest female caught was 107.7 cm TL and weighed 11,600 g. Females were generally heavier than the males for a given length.

Table 1. Number of males and females and the corresponding sex ratios in samples of *C. gariepinus* from Lake Chamo.

| Length (cm) | Males | Females | Sex-ratio (Male: Female) | Chi-square |
|---|---|---|---|---|
| 10.0 – 19.9 | 6 | 4 | 1: 0.67 | 0.40 |
| 20.0 – 29.9 | 108 | 79 | 1: 0.73 | 4.50* |
| 30.0 – 39.9 | 112 | 119 | 1: 1.06 | 0.21 |
| 40.0 – 49.9 | 66 | 57 | 1: 0.86 | 0.66 |
| 50.0 – 59.9 | 44 | 30 | 1: 0.68 | 2.65 |
| 60.0 – 69.9 | 41 | 25 | 1: 0.61 | 3.88* |
| 70.0 – 79.9 | 32 | 36 | 1: 1.13 | 0.24 |
| 80.0 – 89.9 | 45 | 54 | 1: 1.20 | 0.82 |
| ≥ 90.0 | 30 | 6 | 1: 0.20 | 16.00*** |
| Total | 484 | 410 | 1: 0.85 | 6.13* |

Samples were grouped in 10-cm size classes. Significant *, (P < 0.05), very highly significant ***, (P < 0.001).

## Reproductive season

Reproductive season of *C. gariepinus* was determined from the percentages of fish with ripe gonads taken each month (Fig. 2a). Even though fish with ripe (stage IV) gonads could be found at any time of the year, most breeding occurred from March - June 1999 where 70.0 - 91.3% of the females and 75.0 - 86.8% of the males had ripe gonads. The proportions of fish with ripe gonads were relatively low in January and February 1999 where 34.5 - 45.9% of the females and 28.2 - 32.3 % of the males had ripe gonads (Fig. 2a). The proportions of fish with ripe gonads were also low during the months of August - December 1999 where 10.8 - 20.0% of the males and 7.7 - 24.1% of the females had ripe gonads (Fig. 2a). Intensive breeding activity generally coincided with the time of the year where the amount of precipitation was high (Fig. 2b). GSI of 83 ripe females ranged from 1.11 - 16.21 with the mean of 8.09 and GSI of 68 ripe males ranged from 0.31 - 1.40 with the mean of 0.83.

Table 2. Number of males and females and the corresponding sex ratios of *C. gariepinus* in different months of the year from Lake Chamo.

| Month | Males | Females | Sex-ratio Male: Female) | Chi-square |
|---|---|---|---|---|
| January | 59 | 40 | 1:0.68 | 4.46* |
| February | 29 | 38 | 1:1.31 | 1.21 |
| March | 90 | 51 | 1:0.57 | 10.97* |
| April | 32 | 35 | 1:1.09 | 0.13 |
| May | 30 | 21 | 1:0.70 | 1.59 |
| June | 45 | 59 | 1:1.31 | 1.88 |
| July | 25 | 18 | 1:0.72 | 1.14 |
| August | 20 | 25 | 1:1.25 | 0.56 |
| September | 15 | 22 | 1:1.47 | 1.32 |
| October | 57 | 41 | 1:0.72 | 10.45** |
| November | 45 | 31 | 1:0.69 | 2.58 |
| December | 37 | 29 | 1:0.78 | 0.97 |
| Total | 484 | 410 | 1:0.85 | 6.13* |

*, significant ($P < 0.05$), **, highly significant ($P < 0.01$).

## Length at first maturity

Average length at first maturity has been defined as the length at which 50% of the individuals of both sexes reach maturity (Willoughby and Tweddle, 1978). The percentages of female and male *C. gariepinus* having gonad stages III, IV and V (Holden and Raitt, 1974) were plotted against length for each sex using data from the breeding season (March - June 1999). The length at which 50% of the females first reached maturity was 58 cm TL, while that of the males was 52 cm TL (Fig. 3). The smallest mature female sampled was 32.0 cm and weighed 235 g, while the smallest mature male captured was 30.0 cm and weighed 200 g.

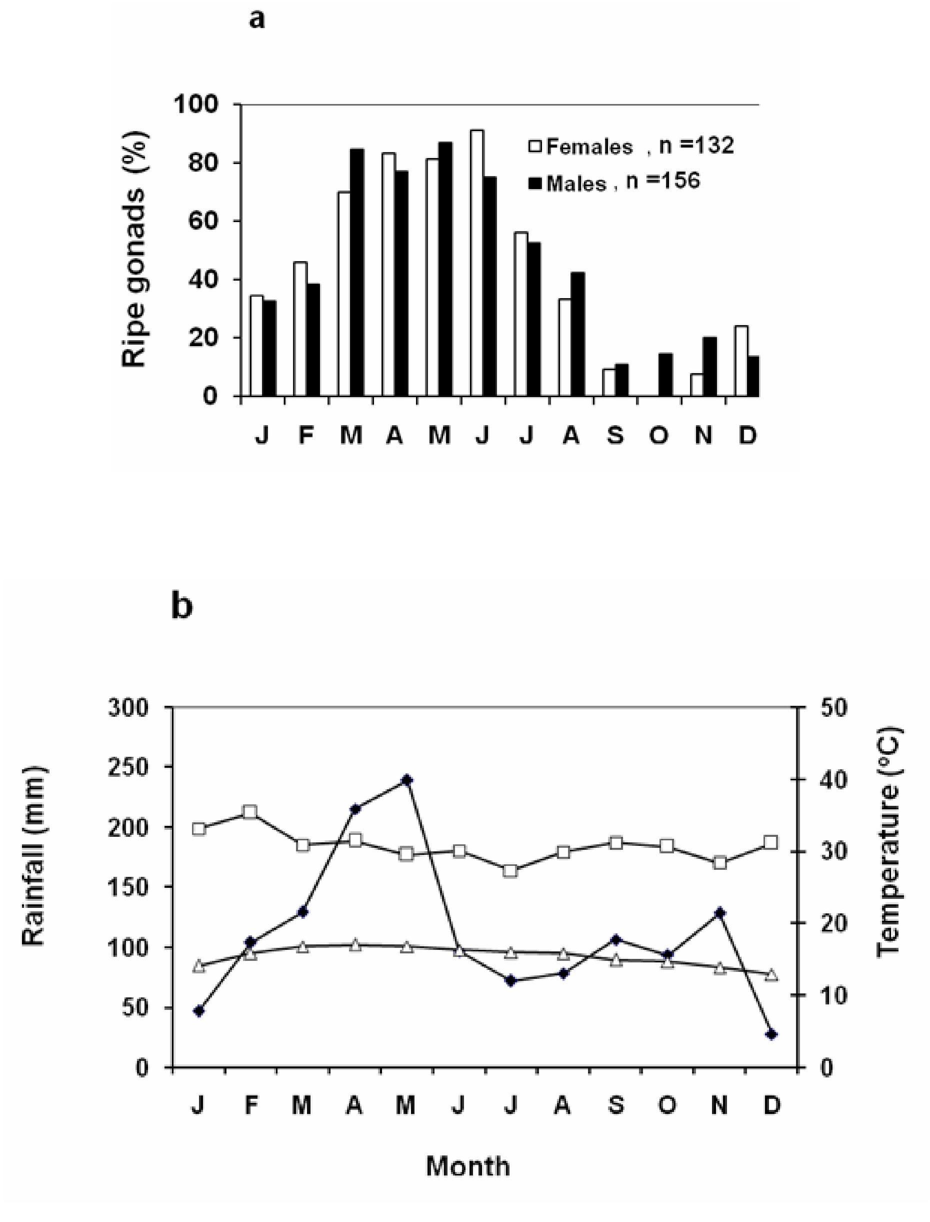


Fig. 2. Reproductive season of *C. gariepinus* as indicated by the percentages of fish with (a) ripe gonads, and (b) monthly rainfall (◆), as well as, maximum (□) and minimum (△) air temperatures of Lake Chamo region. From the total number of fish sampled (484 males and 410 females) 156 males and 132 females were found to have gonads in stage IV.

## Fecundity

The number of eggs in ripe ovaries ranged from 5,000 to 1,240,000 and the mean was 337,700. The number of eggs g-1 of preserved wet weight of ovary ranged from 625 to 2,760 with the mean number of 1,110. The diameter of ripe eggs of *C. gariepinus* ranged from 0.47 - 1.36 mm with mean at 0.98 mm.

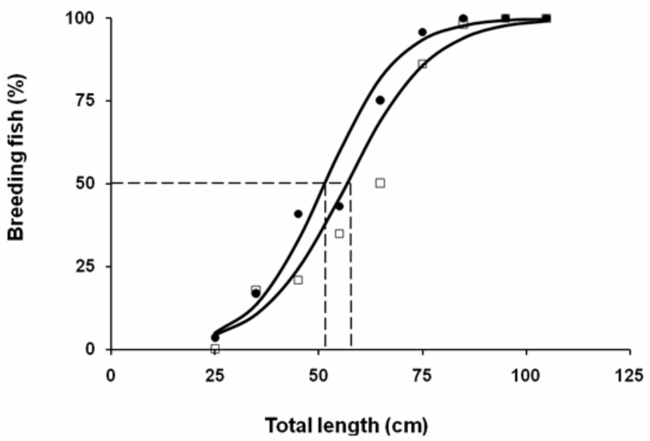


Fig. 3. Length at first maturity for *C. gariepinus* from Lake Chamo. Gonads at maturity stages III, IV and V (◆ - males), □ -females). Data points n = 9: total N = 198 for females and 243 for males.

The relationships between TL and Fecundity (F) (Fig. 4a) and TW and F (Fig. 4b) were curvilinear. The relationship between OW and F was linear (Fig. 4c). The best-fit relationships respectively were:

$$F = 0.003TL^{4.25} \ (r^2 = 0.90; P < 0.001) \quad (5)$$

$$F = 13.68TW^{1.21} \ (r^2 = 0.89; P < 0.001) \quad (6)$$

$$F = 877.5OW^{-4728} \ (r^2 = 0.90; P < 0.001) \quad (7)$$

The lowest fecundity of 5,000 was in a fish that was 32.5 cm TL and weighed 235 g. Its ovaries weighed 2.6 g (1.1% of the body weight). The highest fecundity of 1,240,000 eggs was in a fish of 102.4 cm TL and 9,800 g TW. Its ovaries weighed 1,035 g (10.6% of the body weight).

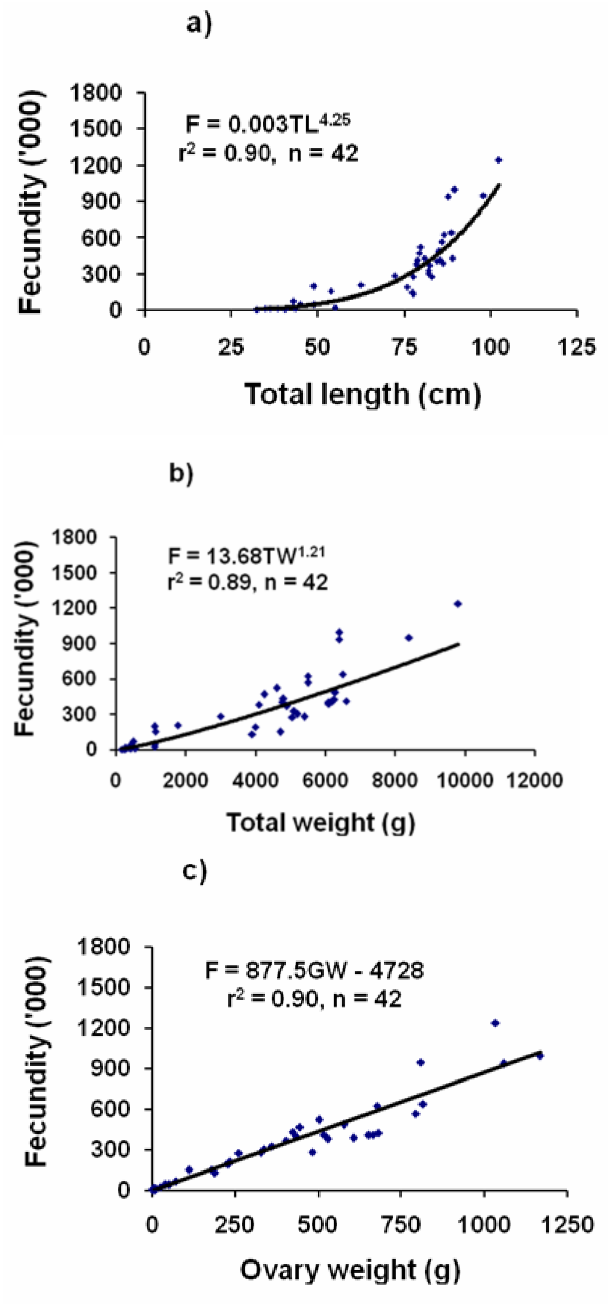


Fig. 4. Relationship between fecundity and some morphometric measurements (a-fecundity and total length, b- fecundity and total weight, and c- fecundity and ovary weight) of *C. gariepinus* from Lake Chamo, n = sample size.

## Length-weight relationship

Length-weight relationships of both sexes were curvilinear and statistically significant ($r^2$ = 0.99, P < 0.001). The regression equations fitted to the data of the females, males and both females and males combined are:

Females: $TW = 0.003TL^{3.23}$ ($r^2$ = 0.99, P < 0.001) (8)

Males: $TW = 0.0039TL^{3.16}$ ($r^2$ = 0.99, P < 0.001) (9)

Females and males: $TW = 0.0035TL^{3.19}$ ($r^2$ = 0.99, P < 0.001) (10)

Condition factor

Clark's condition factor (Mean ± SE) of female *C. gariepinus* ranged from 0.274 ± 0.036 - 0.350 ± 0.030 while that of males ranged from 0.278 ± 0.02 - 0.343 ± 0.028 (Fig. 5). The smallest condition factor values were recorded in July for females and in August for males (Fig. 5). The largest condition factors were recorded in November for both females and males (Fig. 5). The values did not vary significantly (ANOVA, F = 2.67, P > 0.05) between sexes. The interaction term between month and sex was also insignificant suggesting a similar seasonal fluctuation pattern in conditions of both females and males. ANOVA test revealed a significant variation in condition factors among different months (F = 8.41, P < 0.01). Using the Tukey's Studentized Range (HSD) test, months with means that were significantly higher were October to May while the values of condition factor were relatively lower between June and September, which seem to coincide with the time of the year when most fish had spent gonads.

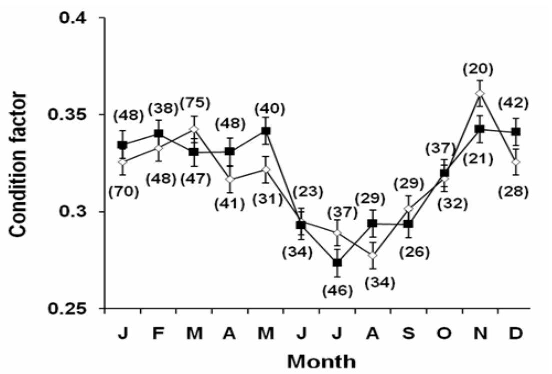


Fig. 5. Mean monthly Clark's condition factor (data points) of *C. gariepinus* from Lake Chamo from January 1999 to December 1999. n = monthly sample size in brackets; bars indicate standard deviation.

## DISCUSSION

The overall sex ratio as well as the sex ratio in size class > 90 cm TL was significantly different from 1:1 during the present study where the number of males dominated in the catch. Significantly more males than females were caught within the size class > 90 cm TL probably because the growth rates of both sexes are different. The period of faster growth of *C. gariepinus* coincides with the breeding season (Yosef Tekle-Giorgis, unpubl. data). The slower growth of the females could be because of relatively more energy being channeled into gonad development (Willoughby and Tweddle, 1978). Gonado-somatic index that is the best estimator of reproductive effort is very different in the case of females and males. In this study, the highest GSI of females was 16.2%, while the highest GSI of males was 1.4%. Willoughby and Tweddle (1978) working in Shire Valley, Malawi and Van der Waal and Schoonbee (1975) working in Transvaal, South Africa have also reported that males grew faster than the females and the majority of large specimens caught were males.

In Lake Chamo *C. gariepinus* exhibited a long breeding season where intensive breeding activity occurred during the months of March to June. During the other months, even though a considerable proportion of fish were found with ripe gonads, their proportion was much lower than the main breeding season. In Lake Hawassa, a rift valley lake about 270 km north of Lake Chamo, *C. gariepinus* was also found to have long spawning season from February to August (Elias Dadebo, 2000). Several environmental factors could be responsible for the high breeding activity of *C. gariepinus* in Lake Chamo during the months of March to June. The major rainy season of the area falls within that period (Fig. 1b). High rainfall and subsequent rise in water level were implicated as the triggering factors for spawning of *C. gariepinus* in many parts of Africa (Van der Waal, 1974; Willoughby and Tweddle, 1978; Tesfaye Wudineh, 1998; Elias Dadebo, 2000). Dadzie and Okach (1989) suggested that decline in water conductivity as a result of flooding could be a positive spawning stimulus in *B. docmak* in Lake Victoria.

The average lengths at first maturity, 58 cm for females and 52 cm for males were much larger than those reported by other investigators. The average length at first maturity of *C. gariepinus* ranged between 29 - 37.5 cm TL in different parts of Africa for which data are available (Willoughby and Tweddle, 1978; Kolding et al., 1992; Baijot and Moreau, 1997; Tesfaye Wudineh, 1998). Size at maturity is negatively correlated to the degree of fishing mortality. As the fishing mortality increases, fish populations respond to the new environmental circumstances by changing their life history pattern in order to compensate for the losses imposed by fishing activity (Garrod and Horwood, 1984; Wootton, 1998). For instance, in Lake George (Uganda) average length at first maturity of *O. niloticus* was lowered following years of intensive fishing activity (Gwahaba, 1973). In Lake Chamo the fishing pressure on *C. gariepinus* is low because of its low demand as food fish. In addition to fishing pressure other factors such as water temperature and altitude could be responsible for the larger size of *C. gariepinus* at first maturity in Lake Chamo. The water temperature of the lake is much higher than the other rift valley lakes of Ethiopia. Demeke Admassu (1998) measured surface water temperature of Lake Chamo (mean±standard deviation) between 1130 to 1200 hr and found it to be $28.2\pm 0.5^0$C. This mean value is more than $2.5^0$C higher than the mean water temperatures of Lakes Ziway and Langeno that are situated in the central part of the Ethiopian rift valley, about 350 km to the north of Lake Chamo (Demeke Admassu, 1998).

Fecundity increased in proportion to 4.25 power of the length and 1.21 power of the weight (Fig. 4a, b). In many tropical freshwater fish species, fecundity increased in proportion to 2.81-3.96 power of total length (Lowe-McConnell, 1975; Clay, 1979). Bagenal and Braum (1978) reported that the value of b (slope of the fitted line) is about three when fecundity is related to length and about one when it is related to weight. *C. gariepinus* in Lake Chamo has higher fecundity compared to the general pattern of relationship of fecundity to length and weight of many tropical species. In the present study variability was high when fecundity was related to length, weight and ovary weight of *C. gariepinus*. This suggests that other factors are also involved in affecting fecundity, in addition to morphometric measurements of fish, such as egg size, spawning conditions and fat reserves of fish prior to gonad development (Bagenal and Braum, 1978; Treasurer, 1981; Barbin and McCleave, 1997). Prinsloo et al. (1990) studied fecundity of two strains (red strain and normal strains of the sharptooth catfish *Clarias gariepinus* ) in South Africa and reported that the normal catfish were more fecund than the red strain, in the smaller size classes, but around approximately 1 kg, the fecundity of the two strains was comparable.

Estimates of length-weight regression coefficients (3.16 for males and 3.23 for females) in this study show slight allometric growth pattern. Similar results have been reported by other investigators working on *C. gariepinus* in different parts of Africa (Willoughby and Tweddle, 1978; Bruton, 1979;

Quick and Bruton, 1984). However, these investigators reported the regression coefficients for both sexes combined. Differences in growth pattern related to sex have been observed in different fish species. Such differences are often related to differences in the relative allocation of energy for the production of gametes (Stergiou et al., 1996; Wootton, 1998). In *C. gariepinus*, differences in growth with sex are evident after sexual maturity. Willoughby and Tweddle (1978) attribute this phenomenon to overlapping of faster growth period with the breeding season, in Shire Valley, Malawi. According to Bruton and Allanson (1980) male *C. gariepinus* grow slightly faster than females and modal sizes for the two sexes were 580-590 mm TL for males and 540-555 mm for females. In the present study, males approached isometric growth pattern as they grow while females tended to be more rotund after sexual maturity is reached. This may be probably because of differences in gonad development (Papageorgou, 1979).

Condition factor of both males and females remained relatively high during the breeding season. This suggests that the fat reserve in the body is not seriously depleted during the process of gonad maturation. Stomach contents of *C. gariepinus* indicated that it continued feeding during the period of gonad formation. This is probably why condition factor remained high during the pre-spawning period. Condition factor started to decline after May and remained low until September after which it started to increase sharply. The time of the year when condition factor was low for both sexes coincided with the time when the majority of the fish had spent gonads. Low condition factor after spawning is well documented in temperate fish species (Jones, 1970; Lee, 1972; Wingfields and Grimm, 1977) but no information was available for tropical fish. *C. gariepinus* in Lake Chamo is a zooplankton filterer (Elias Dadebo, unpubl. data). Seasonal abundance of zooplankton could also have a direct effect on fluctuation of condition factor at different times of the year. This study has clearly shown that both the reproductive activity and condition factor of *C. gariepinus* vary significantly during different times of the year. Future studies should focus on identifying the environmental factors that govern these seasonal variations.

## ACKNOWLEDGEMENT

We thank fishermen Asfaw Asire and Mengistu Balcha for their assistance during the fieldwork. Tafere Gebre-Egziabher is acknowledged for his invaluable assistance both in the field and laboratory work. We are grateful to Hawassa College of Agriculture (Hawassa University) and Department of Limnology (Uppsala University) for providing laboratory facilities and the former for logistic support of the field trips. The study was financed by SAREC (Swedish Agency for Research Cooperation with Developing Countries).

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