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BREEDING SEASON, MATURATION AND FECUNDITY OF *OREOCHROMIS NILOTICUS* L. (PISCES: *CICHLIDAE*) IN LAKE CHAMO, ETHIOPIA

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ABSTRACT: The reproductive biology of *Oreochromis niloticus* in Lake Chamo, Ethiopia was studied from samples collected every month for a period of thirteen months between March 1996 and March 1997. A total of 1349 fish ranging in size from 125 to 610 mm total length (TL) were caught using gill nets (120, 140, 200 and 240 mm, stretched mesh). The mean monthly gonadosomatic index (GSI) of the males ranged from 0.21 to 0.61 whereas that of females ranged from 0.75 to 1.61. Higher GSI values were observed between March and June for females and between March and May for males. The pattern of gonad development for both sexes was more or less similar. Ripe males occurred at high frequency (ranged: 39–60%) between March and May whereas high frequency of ripe females (ranged: 47–53%) occurred between March and June. Thus, it was concluded that *O. niloticus* in Lake Chamo spawns throughout the year with peak breeding activity between March and June. The smallest sexually mature female was 385 mm TL, whereas the male was 395 mm TL. However, the 50% maturity length was about 420 mm TL for both sexes. *O niloticus* were all mature above 500 mm TL. Mean fecundity of *O. niloticus* was 2493 ± 300, N = 209 (ranged: 390–540 mm TL and 1300–2650 g total weight). The smallest count was 1047 (fish length = 420 mm TL) whereas the largest was 4590 (fish length = 510 mm TL). In general, fecundity of *O. niloticus* in Lake Chamo was linearly related to total length (F = 201.85TL – 6801), total weight (F = 1.91TW – 1197.8) and gonad weight (F = 55.59Gw + 467.2).

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

INTRODUCTION

Tilapia in equatorial waters tend to breed almost throughout the year, but those in lakes distant from the equator tend to have well defined breeding seasons (Lowe-McConnell, 1982). Nevertheless, some individuals in breeding condition can be caught at any time of the year even in seasonally breeding Tilapia (Demeke Admassu, 1996). *O. niloticus* breeds throughout the year, but breeding activity is intensive during the periods from December to March in Lake Zwai (Zenebe Tadesse, 1988), January to April and July to September in Lake Awassa (Demeke Admassu, 1996). In Lake Tana, unlike the rift valley lakes, *O. niloticus* seems to have longer-spawning season lasting from March to August (Zenebe Tadesse, 1997).

The main breeding activity of fish species in the tropics has been associated with light intensity, temperature, rainfall and water level or seasonal flooding (Lowe-McConnell, 1982). Abundance of food has also been considered as an important factor in timing of breeding in some species (Mckaye, 1977). Demeke Admassu (1996) found the peak breeding period of *O. niloticus* in Lake Awassa to be coincident with increase in phytoplankton biomass.

The length of sexual maturity of Tilapia is extremely variable, and depends on the species, growth rate and environment (Balarin and Hatton, 1979). For instance, species in small ponds and in cultures mature at a much younger age and smaller size than the same species living in lakes (Lowe-McConnell, 1987). *O. niloticus* individuals which are in poor body condition mature at a smaller size than those in good condition (Balarin and Hatton, 1979). Furthermore, size of sexual maturity may also vary between sexes of the same species. For example, female *O. niloticus* in Lakes Zwai and Awassa mature at a smaller size than males (Zenebe Tadesse, 1988; Demeke Admassu, 1994). Babiker and Ibrahim (1979) have similarly reported for *O. niloticus* in White Nile. However, both sexes may also mature at approximately the same age (Lowe-McConnell, 1987).

Fecundity of *O. niloticus* depends mainly on the body condition of the fish. It is related to the total length, body weight and gonad weight of the fish (Fryer and Iles, 1972). Zenebe Tadesse (1988) and Demeke Admassu (1994) observed curvilinear relationship between fecundity and total length of *O. niloticus* in Lakes Zwai and Awassa. Babiker and Ibrahim (1979), however, found fecundity to be linearly related to fish size of the same species in the White Nile.

The reproductive biology of *O. niloticus* has been studied in most rift valley lakes of Ethiopia (Zenebe Tadesse, 1988; Demeke Admassu, 1994; 1996). These studies have undoubtedly provided basic knowledge on the biology of the fish based on which proper management of the resources can be made. However, such knowledge is not available for the *O. niloticus* stock in Lake Chamo, and this has hindered proper management of the fisheries. The present study was, therefore, conducted for the first time in Lake Chamo to contribute to the knowledge of *O. niloticus*, one of the most exploited species.

Study area

Lake Chamo (5°42'-5°48' N;36°30'-38°30' E) is located at an altitude of 1108 m, and covers an area of 551 km^2 with a maximum depth of 20 m (Amha Belay and Wood, 1982).

Data on rainfall and temperature of the lake region during the period from 1990 to 1996, obtained from the Agro-meteorological station of the North Omo Agricultural Development Enterprise, indicate that the rainy season extends from March to October, the peak being in April and May. The minimum air temperature ranged from 15.0 to 21.5° C whereas the maximum air temperature ranged from 25.8 to 34.4° C. Data on total monthly rainfall and mean air temperature of Lake Chamo region for 1996 are presented in Fig. 1-b. Mean air temperature ranged from 22.6 to 25.6° C, and was relatively high from January to April (above 24° C). Low temperature was measured in July and September.

Water temperature of Lake Chamo, measured at time of sampling by a concurrently conducted study (Demeke Admassu and Zenebe Tadesse, unpublished manuscript) showed that high water temperature ranged from 23 to 29° C. Getachew Teferra (1993) has also reported that an average surface water temperature of Lake Chamo is about 25° C all year round.

MATERIALS AND METHODS

A total of 1349 *O. niloticus* were collected from March 1996 to March 1997 using gill nets (120, 140, 200 and 240 mm, stretched mesh) from two reference sampling stations (open water Zmax=5m and littoral macrophyte areas) in Lake Chamo. Of these 658 were males and 691 were females ranging in size from 130 to 610 mm TL and from 125 to 580 mm TL, respectively. After dissection the gonads of each fish was weighed to the nearest 0.1g and ripe ovaries were kept in Gilson's fluid for fecundity study.

Breeding season of *O. niloticus* was determined based on the level of gonad maturation and gonadosomatic index (GSI). A five-stage gonad maturation scale was used to determine the stage of maturation of the fish using the modification (Demeke Admassu, 1996) of the descriptions reported by Babiker and Ibrahim (1979). The proportion of the different gonad stages was estimated at different seasons and a GSI was calculated as gonad weight as a percentage of total body weight (including the gonads). *O. niloticus* ranging in size from 370 to 610 mm TL were used for calculating the GSI. The percentage frequency of ripe fish and GSI were then plotted by month. Seasonal variations in GSI were tested statistically using a single factor ANOVA. The time of the year when the frequency of ripe fish and GSI were high was considered as the peak-breeding season of the fish.

Average size at first sexual maturity (the size at which 50% of the fish are mature) was also determined according to Bagenal and Tesch (1978). Size at 50% maturity of both sexes was estimated from the maturity index, indicating the proportion of mature female and male *O. niloticus* of 50 mm TL interval.

Ripe ovaries, which were kept in Gilson s fluid, were used for fecundity estimates. Repeated washing separated oocytes, and fecundity was determined by counting all eggs. Least square regression was then used to find the relationship between fecundity, total length, total weight, and gonad weight of the fish (Sokal and Rohlf, 1981).

RESULTS AND DISCUSSION

Seasonal variation in GSI of both sexes was quite evident (Fig. 1-a). The mean monthly GSI of males ranged from 0.21 to 0.61 whereas that of females ranged from 0.75 to 1.61. GSI varied significantly between months both for females (ANOVA, $F=7.025$, $P<0.0001$) as well as males (ANOVA, $F=8.091$, $P<0.0001$). Higher GSI values were measured between March and June for both sexes. The GSI value for the males was also higher in September. The GSI value of the females dropped rapidly after June, and lower values were recorded between September and December, whereas in the males dropped in June and July, and lower values were measured between October and November. The seasonal fluctuation in GSI observed in this study was more or less similar to the fluctuations in temperature and rainfall (Fig. 1).

O. niloticus were caught at various stages of gonad development and reproduction in almost all months. However, their frequency varied with the month of capture. The seasonal pattern of gonad development for both sexes was almost similar. Ripe males occurred at high frequencies (ranged: 39–60%) from March to May and in September. High seasonal frequency of ripe females (ranged: 47–53%) occurred from March to May and in June (Fig. 2-a). Low frequency of ripe fish of both sexes was recorded between November and January. Ripe fish of both sexes were not caught in October. But, 3% of the males and 8% of the females were spawning (ripe running) during this month. The percentage of spawning females ranged from 8–43% and males from 3–60% with seasonal values highest in June for both sexes and lowest in October for the males and in February for the females

(Fig. 2-b). Therefore, *O. niloticus* in Lake Chamo breeds actively between March and June.

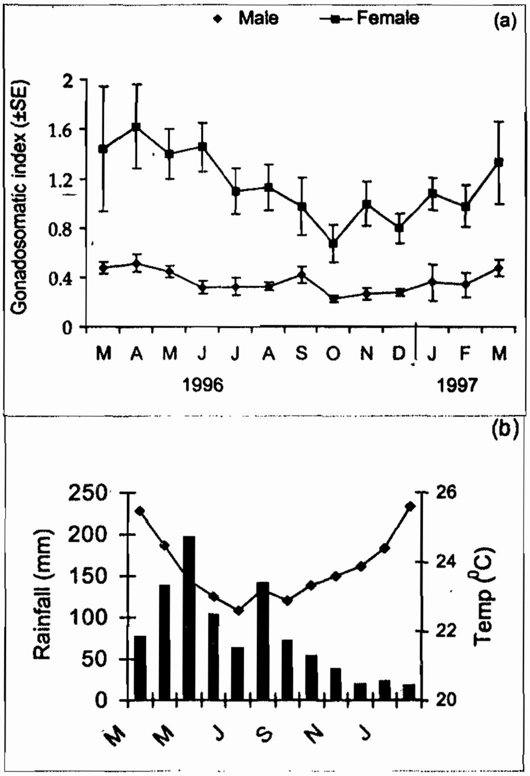

Fig. 1. Seasonal variation in gonadosomatic index (mean ± standard error) of *O. niloticus* (a), total monthly rainfall (bars) and mean air temperature (curves) (b) for Lake Chamo region in 1996.

Annual peak of reproduction activity for *O. niloticus* has been reported in many Ethiopian lakes (Getachew Teferra, 1987; Zenebe Tadesse, 1988; Demeke Admassu, 1994, 1996; Kebede Alemu, 1995). Stewart (1988) reported that *O. niloticus* in Lake Turkana breeds continuously, but has an increased breeding activity from March to July. The principal breeding season for most species of Tilapia in Lake Victoria is at high water levels in January to March (Lowe-McConnell, 1987). The macrophyte vegetation grows extensively during this period, providing suitable nurseries and sufficient cover for *O. niloticus* juveniles. Therefore, the recruitment of juveniles is timed with conditions allowing maximum growth and survival (Welcomme, 1967; Billard and Breton, 1978).

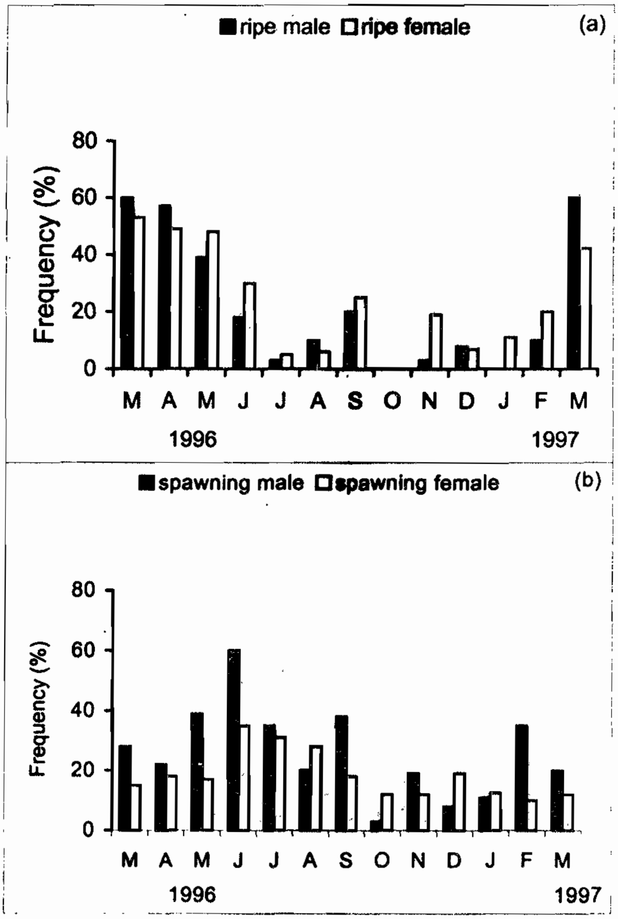

Fig. 2. Seasonal frequency (%) of ripe (a) and spawning (b) *O. niloticus* in Lake Chamo.

The present study has also observed higher GSI values of the males and large proportion of ripe fish in September. This can be considered as a second but less pronounced peak breeding activity of *O. niloticus* in Lake Chamo. The main breeding peak of *O. niloticus* in Lake Chamo is associated with warm temperature whereas the less pronounced breeding activity in September is associated with the increase in rainfall in August. Generally, GSI of the fish begins to rise with increase in temperature from January to April, and also during the peak rainy season in April and May.

The smallest sexually mature female and male that were caught in this study was 385 mm TL and 395 mm TL, respectively. However, the 50% maturity length was about 420 mm TL for both sexes (Fig. 3). *O. niloticus* were all sexually mature above 500 mm TL.

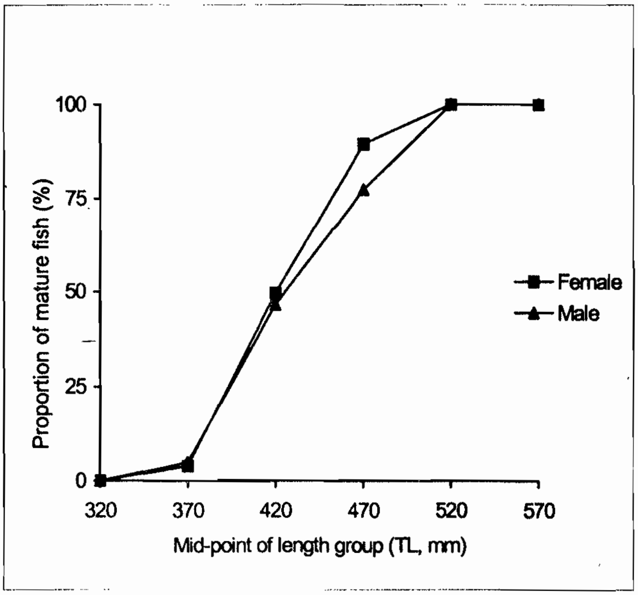

Fig. 3. The proportion of mature male and female *O. niloticus* out of the total fish caught in 50 mm-length interval.

Size of maturation of many fish species depends on demographic conditions and is determined both by genes and the environment (Lowe-McConnell, 1987). The size at sexual maturity of *O. niloticus* in Lake Chamo is very large when compared with that of the same species in Lakes Awassa and Zwai. In Lakes Awassa and Zwai the species mature at about 180 mm TL (Zenebe Tadesse, 1988; Demeke Admassu, 1994). The larger size at maturity of *O. niloticus* in Lake Chamo could be due to the fact that *O. niloticus* in Lake Chamo grows more rapidly than fish of comparable ages in Lakes Awassa and Zwai (Demeke Admassu and Ahlgren, 2000).

The smallest egg count was 1047 (fish length=420 mm) and the largest was 4590 (fish length=510 mm). Average fecundity of *O. niloticus* ranging in length from 390 to 540 mm TL and in weight from 1300 to 2650 g was 2493 ± 300 (N= 209). In general, fecundity was linearly related to total length, total weight as well as to gonad weight (Fig. 4-a, b & c).

Fecundity of *O. niloticus* in Lake Chamo ranged from 1047 to 4590 eggs. For the same species from Lakes Zwai and Awassa, Zenebe Tadesse (1988) and Demeke Admassu (1994) estimated values ranging from 198 to 934 and from 304 to 967 eggs, respectively. *O. niloticus* in Lakes Awassa and Zwai is much smaller in size (fish above 30 cm TL occasionally caught) than the species in Lake Chamo. Therefore, *O. niloticus* in Lake Chamo grew to a bigger size (up to 60 cm TL) and produce large number of eggs and broods.

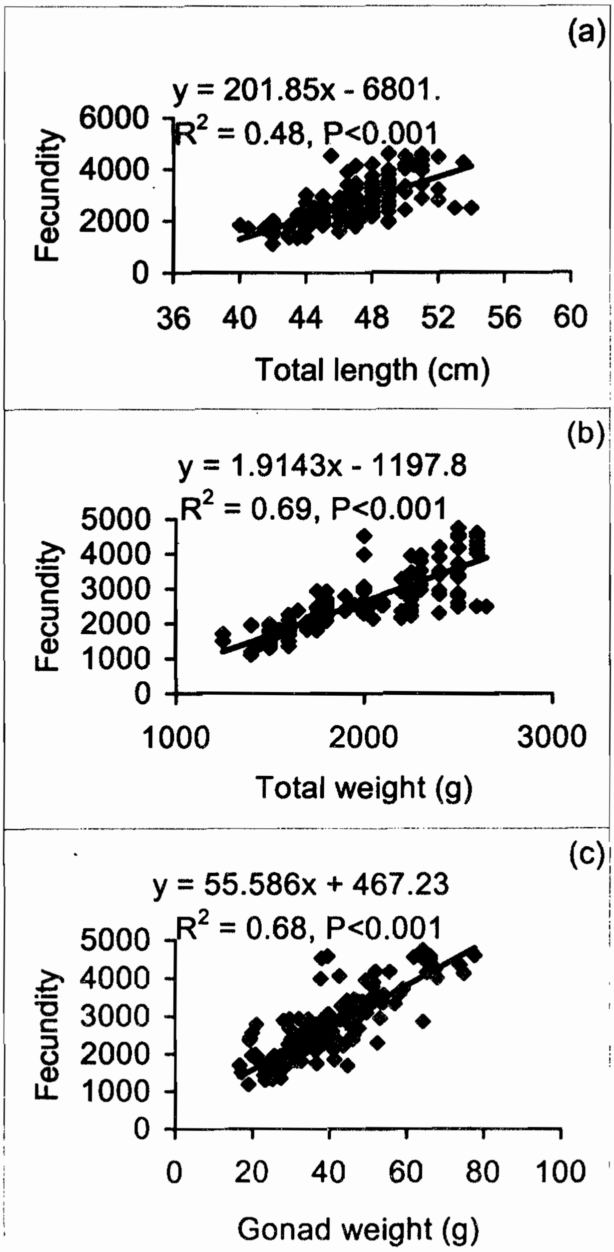

Fig. 4. Fecundity of *O. niloticus* in Lake Chamo in relation to: (a) total length, (b) total weight and (c) gonad weight of the fish (N=209).

In this study, it was found that fecundity and total length have linear relationship. This is in contrast to the curvilinear relationship reported by Zenebe Tadesse (1988) and Demeke Admassu (1994) for *O. niloticus* in Lakes Zwai and Awassa. This may be due to the narrower range of size group used for the analysis. Most of the fish used for this analysis were above 400 mm TL. Similar results were also reported for *O. niloticus* in the White Nile (Babiker and Ibrahim, 1979), as well as for several other mouth brooding species of Tilapia (Siddiqui, 1977; Harbott and Ogari, 1982).

In conclusion, *O. niloticus* in Lake Chamo breeds almost throughout the year with a peak reproduction activity between March and June. It is advisable to reduce commercial fishing of *O. niloticus* during the peak breeding seasons in order to minimize the capture of breeding fish. The size at which 50% of the fish sexually mature was about 420 mm TL for both sexes. Therefore, *O. niloticus* under 420 mm TL should not be caught commercially in Lake Chamo.

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