BREEDING SEASON, LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF INTRODUCED FISH, *TILAPIA ZILLII* GERVAIS 1948 (PISCES: CICHLIDAE) IN LAKE ZWAI, ETHIOPIA

Alemayehu Negassa and Abebe Getahun [*]

Department of Biology, Faculty of Science, Addis Ababa University, PO Box 1176
Addis Ababa, Ethiopia. E-mail: abebeg@bio.aau.edu.et

ABSTRACT: Breeding season, length-weight relationship and condition factor of *Tilapia zillii* were studied in Lake Zwai from samples collected over 12 months between January and December, 2001 using gillnets of 60 and 100 mm stretched mesh. State of gonad maturation and Gonadosomatic index (GSI) values showed that *T. zillii* in Lake Zwai breeds all year round with peak activities between April and September. The relationship between total length (TL) (5.5–32 cm) and total weight (TW) (3.8–676.9 g) of the fish was found to be curvilinear and represented as TW = $0.02TL^{2.9813}$, $R^2 = 0.99$, $P < 0.001$, n = 848. Mean monthly Fulton condition factors (FCF) and Relative condition factors (RCF) of the population of *T. zillii* were 2.06 and 1.01, respectively. Two factor ANOVA indicated a significant seasonal fluctuation ($p < 0.001$) in the condition of both sexes, but not between female and male *T. zillii* ($p = 0.127$ and 0.135 for FCF and RCF, respectively). Poor body conditions coincided with time of peak breeding activity. The interaction effects of sex and month on Fulton's and Relative condition factors were not significant (p=0.127 and 0.138 respectively).

Key words/phrases: Breeding season, Ethiopia, Lake Zwai, length-weight relationship, *Tilapia zillii*

INTRODUCTION

Tilapia zillii was introduced into various water bodies of Ethiopia including Lake Zwai. The fish was originally imported from Uganda and introduced into Lake Zwai in 1975 (Shibru Tedla and Fisseha H. Meskel, 1981). Since then it has successfully established itself and become an important component of the commercial catch (pers. obs.). However, catch per unit effort records of *T. zillii* were non-existent during the study period probably because it was confused with the related *Oreochromis niloticus*, or since fishing is focused in the pelagic zone where *T. zillii* is rare or absent as the target of fishermen was mainly *O. niloticus* which has wider acceptance.

It is a polyphilic and euryhaline species, widely distributed from west Africa to the Nile basin and is a resident of Lakes Albert and Turkana (Trewavas, 1982). *T. zillli* is a monogamous biparental guarder (El-Zarka, 1956), and it is known to breed throughout the year in equatorial waters including Lakes Naivasha (Siddiqui, 1977, 1979) and Victoria (Welcomme, 1967). However, in Lake Quarun (a subtropical region) spawning in the fish is limited to 5 months (May to September) with a highest rate of breeding in mid-summer (July and August) (El-Zarka, 1962). There are no data on the biology of the species in Ethiopian waters (Abebe Getahun and Stiassny, 1998). The present study was, therefore, conducted to examine the breeding season, length-weight relationship and condition factor of *T. zillii* in Lake Zwai. This information is undoubtedly vital for proper management and development of culture fisheries in the country.

Study area: Lake Zwai

Lake Zwai with a surface area of 434 km² and mean depth of 2.5 m (Schroder, 1984), is the most northerly of the upper rift natural lakes in the country located at 7° 52′–8° 8′N Latitude and 38° 40′–38° 56′E Longitude, and lies at an altitude of 1636 m (Makin *et al.*, 1975). The lake is fed by a number of rivers of which Meki and Katar are the major ones and drains south via the Bulbula River.

The lake lies in a region characterized by semi-arid climate. The climatic condition of the region is fairly constant as the mean daily air temperature ranges between 15.37 ($\pm$ 0.97) and 27.38 ($\pm$ 0.38) °C (Fig. 1). However, variations have been noted with the rainy and dry seasons. Peak rains occurred in May, July and August; a small rain in March, while the months between October and February were generally dry (Fig. 1a).

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[*] Author to whom correspondence should be addressed.

The fish community of the lake is composed of both native and introduced species. The native species comprise *O. niloticus* and some *Barbus* species whereas the introduced ones are *T. zillii*, *Clarias gariepinus* and *Carassius auratus*. The potential yield of the Lake fishery is estimated in the range of 1000 to 6000 tones per year (LFDP, 1998).
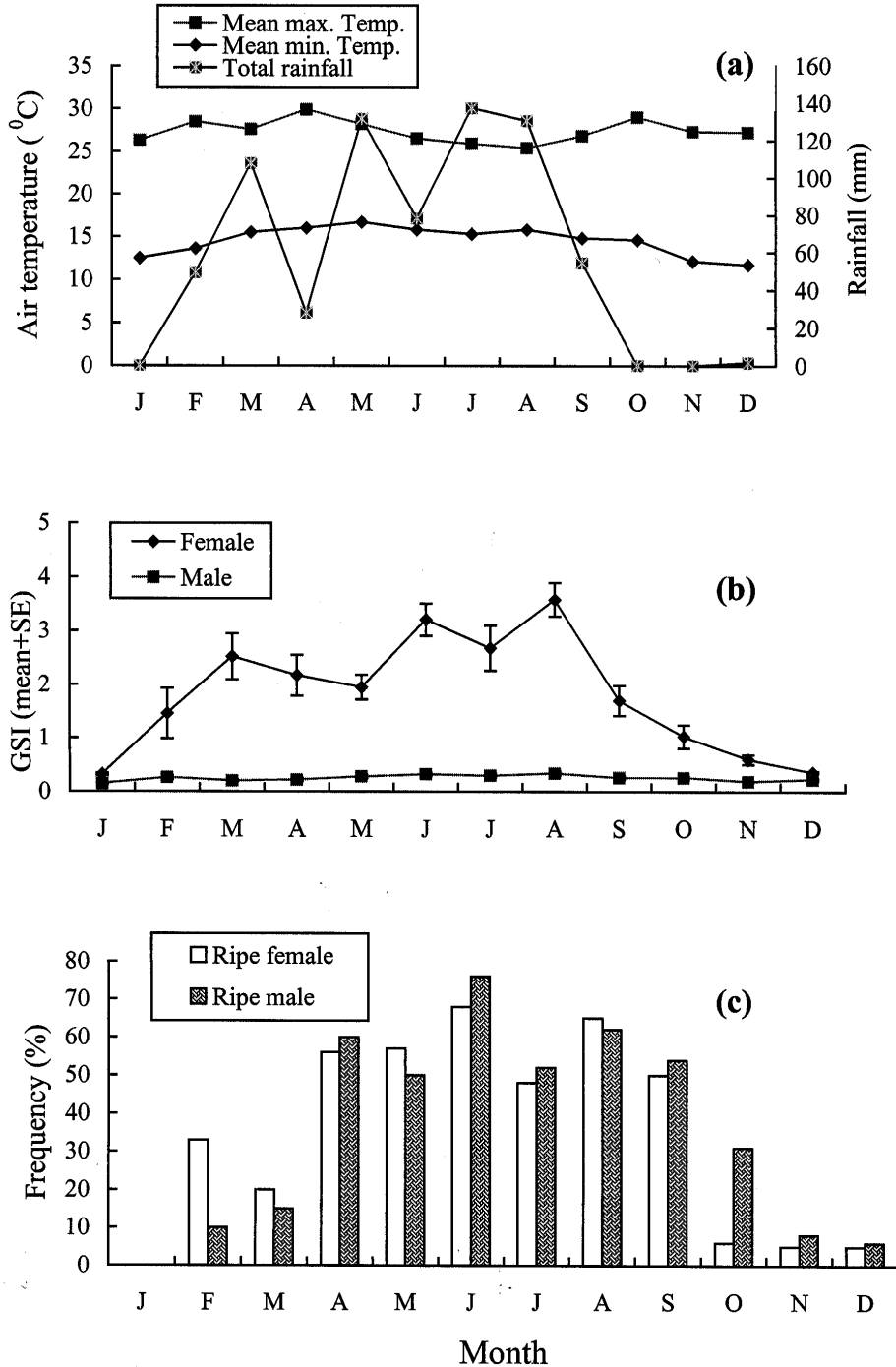

Fig. 1. Monthly mean minimum and maximum temperature and total rainfall around Lake Zwai during the year 2001 (a), Seasonal variation in Gonadosomatic index of female and male *T. zillii* (b) and Frequency of ripe female and male gonads of *T. zillii* (c).

MATERIALS AND METHODS

Adult fish samples of *T. zillii* ranging in length between 12.5 and 32 cm were collected over a twelve months period during the year 2001 using gill nets (60 and 100 mm stretched mesh) from the two sampling sites. Sampled fish were taken to the Zwai Fisheries Resources Development Research Centre laboratory soon after capture. In the laboratory, total length (TL) and total weight (TW) of all specimens were measured to the nearest 0.1 cm and 0.1 g using a measuring board and sensitive balance (EK-1200A), respectively. Each adult specimen was sexed by visual examination of the gonads and the stage of gonad maturation was determined following a five stage maturity keys of El-Zarka (1962). The percentage of ripe fish was computed considering stage IV. Each gonad was also weighed to the nearest 0.1 g.

Breeding season of *T. zillii* was determined based on the frequency of the various gonad stages identified and gonadosomatic index (GSI) values. GSI was calculated as gonad weight in percent of total body weight (including the gonads).

$$GSI = \frac{Gonad\ wt}{Body\ wt} \times 100$$

The percentage frequency of breeding fish and GSI were then plotted by month. The time of the year when the frequency and GSI were high was considered as the peak-breeding season for the fish. Length-weight relationship and condition factor of *T. zillii* were computed from the total weight (TW) and total length (TL) measurements following the procedures employed by Le Cren (1951) and Bagenal and Tesch (1978). Accordingly, the length-weight relationship was calculated using least square regression analysis and Fulton and Relative condition factors as follows:

a) Fulton condition factor (FCF) = $100T*W*TL^{-3}$
b) Relative condition factor (RCF) = TW/aTL^b

where, *a* and *b* are the intercept and slope of the length-weight regression, respectively. The condition factor of individual fish was calculated and monthly mean values were determined for the sexes separately.

RESULTS

Breeding season

Monthly variation in GSI of both female and male *T. zillii* was evident (Fig. 1-b). The mean monthly GSI $\pm$ SE of females ranged from 0.32 $\pm$ 0.02 (in January) to 3.58 $\pm$ 0.31 (in August) and that of males ranged from 0.15 $\pm$ 0.02 (in January) to 0.34 $\pm$ 0.04 (in August). GSI values were high from February to September and low between October and January.

The percentage of ripe female and male *T. zillii* ranged from 5–68% and 6–76%, respectively with high percentage values between April and September (Fig. 1-c). From the above observations, it is evident that *T. zillii* in Lake Zwai breeds almost continuously throughout the year, with peak months between April and September.

Length-weight relationship and condition factor

The Length-weight relationship of female and male *T. zillii* in Lake Zwai was curvilinear and best described by the following regression equations.

Females: TW = $0.0299TL^{2.8768}$, $R^2 = 0.9502$, n = 309
Males: TW = $0.0271TL^{2.9041}$, $R^2 = 0.9487$, n = 394

Comparison of the above two equations showed no significant difference in length-weight relationship between the sexes (ANOVA, $p > 0.05$). Therefore, an equation common to the sexes and the young ones was fitted to data of 848 fish ranging in length between 5.5 and 32.0 cm and total weight between 3.8 and 676.9 g. The relationship was curvilinear with a slope ($b = 2.98 \pm 0.05$) very close to the theoretical value $b = 3$ (Fig. 2). Values of the slopes determined separately for the sexes as well as the common slope are significantly different from zero (ANOVA, $p < 0.001$).

Monthly Fulton's condition factor (mean $\pm$ SE) values of *T. zillii* in Lake Zwai ranged from 1.93 $\pm$ 0.06 in April to 2.38 $\pm$ 0.30 in January for females and from 1.88 $\pm$ 0.04 in April to 2.41 $\pm$ 0.1 in March for males (Fig. 4A). Mean FCF $\pm$ SE was found to be 2.08 $\pm$ 0.03 for females, 2.05 $\pm$ 0.01 for males and 2.06 $\pm$ 0.01 for both sexes in general. FCF varied significantly among months in both sexes (ANOVA, $p < 0.001$), but not between females and males ($p = 0.127$).
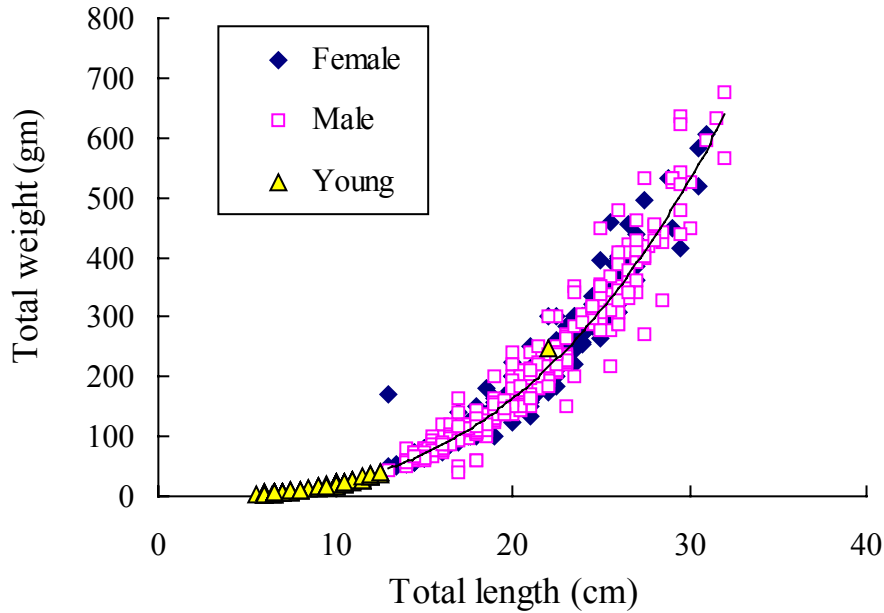
Fig. 2. Length-weight relationship of *T. zillii* in Lake Zwai. (TW =0.0216TL $^{2.9813}$, R ^{2} = 0.99 n = 848).

Monthly mean Relative condition factor (RCF $\pm$ SE) values of *T. zillii* ranged from 1.03 $\pm$ 0.03 in April to 1.26 $\pm$ 0.16 in January for females and from 1.00 $\pm$ 0.02 in April to 1.28 $\pm$ 0.05 in March for males (Fig. 4B). Mean RCF $\pm$ SE was found to be 1.10 $\pm$ 0.01 for females, 1.09 $\pm$ 0.01 for males and 1.10 $\pm$ 0.01 for both sexes. RCF values were significantly different (ANOVA, p < 0.001) between months in both sexes, but not between females and males (p = 0.135). The interaction effect of sex and month on the relative condition factor of the fish was not significant (p= 0.907).

DISCUSSION

The study showed that the population of *T. zillii* in Lake Zwai is characterized by an overall preponderance of males. Sex ratio in favor of males has also been reported for the species from Lake Quaraun (El-Zarka, 1962). In samples collected during January, March and July the proportion was equal or nearly equal to that of females and in May the proportion is slightly less (Table 1). However, in samples collected during the remaining months males outnumbered females. From the present study it was not possible to give a definite explanation for the biased sex ratio.

Nevertheless, studies on other species have suggested sex reversal (Hughes, 1992), activity difference between sexes during spawning and the type of gear and sampling site used (Demeke Admassu, 1994), as possible causes of biased sex ratio.

In *T. zillii*, seasonal variations in GSI and the percentage of ripe fish (Figs. 1-b and 1-c) were quite apparent and the pattern was more or less similar in both sexes. Indeed, fish with well-developed gonads and ripe eggs were noted almost throughout the year. GSI values and percentage of ripe fish indicated that breeding in *T. zillii* was year round peaking from April to September. Zenebe Tadesse (1988) also reported that the related species, *O. niloticus* in the same study area reproduces continuously throughout the year with a high peak of activity between December and March. The presence of individual breeding fish in Lake Zwai at all times of the year may be partly attributed to the low seasonal fluctuations in temperature (Fig. 1-a). Lowe-McConnell (1982) also stated that in the tropics seasonal fluctuations in temperature and photo-period are generally very low and this might be favorable for fish species to spawn at any time of the year.

Table 1. Number of male and female, and sex-ratio (M:F) of *T. zillii* in monthly samples collected from Lake Zwai during the year 2001. (* = significant at 5% level).

Month	Male	Female	Sex-ratio	Chi-square
January	21	19	1:0.90	0.10
February	30	12	1:0.40	7.71*
March	20	20	1:1	0.00
April	27	16	1:0.59	2.81
May	22	28	1:1.27	0.72
June	35	28	1:0.80	0.78
July	25	27	1:1.08	0.08
August	58	46	1:0.79	1.38
September	35	30	1:0.86	0.38
October	45	34	1:0.76	1.53
November	45	35	1:0.78	1.25
December	31	14	1:0.45	6.42*
Total	394	309	1:0.78	10.28*

The peak reproductive activity of the fish coincided with rainy seasons of the region (Fig. 1). Several authors (*e.g.*, Lowe-McConnell, 1987) have also concluded that breeding among tilapias has a distinct peak just before or at the onset of the rainy season, and agrees well with the present result. With the advent of the rainy season the lake level rises and due to the flooding of land terrestrial nutrients flush into the lake. As a result, habitats and food resources for fish could expand greatly and hence these might trigger reproduction. According to Jalabert and Zohar (1982) increased lake production and rise in water level provides suitable spawning grounds for adults and feeding and nursery grounds for the young. Previous report also confirmed abundance of food as being an important cue for timing of breeding in fish (Mckaye, 1977).

In the present study size of the biggest fish recorded was 32 cm. The biggest size recorded in west Africa is 21 cm (Teugels and Thys van den Audenaerde, 1992). This suggests that *T. zillii* can reach bigger size in Lake Zwai environment, which is worth investigating. There was a curvilinear relationship between total length and total weight of *T. zillii* in Lake Zwai (Fig. 2). The value of the regression coefficient (*b* = 2.98) was close to the theoretical value (*b* = 3) indicating isometric growth of the fish in the lake. The regression

equation relating TL and TW of the fish can be used to estimate one variable from the other for those between 5.5 cm and 32 cm in TL and 3.8 g and 676.9 g in TW.

The value of *b* for the population of *T. zillii* with total length between 7 and 15 cm in Nigeria was found to be 3.21. Comparison of length-weight relationship curves for the populations of *T. zillii* in Ethiopia and Nigeria shows that the population from Ethiopia are in a better condition than that from Nigeria specially at smaller lengths, that is, the curves for *T. zillii* populations indicate that for a given length the fish from Ethiopia is heavier than that from Nigeria (Fig. 3). However, the condition of population from Nigeria seems to improve with increasing length.

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. The pattern of seasonal variation in Fulton's and Relative condition factor of both sexes in *T. zillii* was similar throughout the year. Condition factor of both sexes of *T. zillii* (Fig. 4-A and B) in Lake Zwai was significantly different (ANOVA, $p < 0.001$) in the different months. A study done on the related *O. niloticus* in the same lake by Zenebe Tadesse (1988) also showed similar result. Numerous authors (Le Cren, 1951; Getachew Teferra, 1987; Zenebe Tadesse, 1988; 1997; 1999) agree that such variations could arise due to

seasonal fluctuations in environmental factors, food supply and quality, feeding rate, degree of parasitization and reproductive activity. From the present study it was clear that poor body conditions (Figs. 4-A and B) coincided with peak breeding activity (Figs. 1-b and c). Zenebe Tadesse (1988) also reported the same for *O. niloticus*. This may indicate that production of sperms in males and eggs in females during breeding season may drain metabolic energy. Also engagement in breeding activity as well as parental care could possibly suppress somatic growth, as the fish devote less time for feeding during the breeding season.
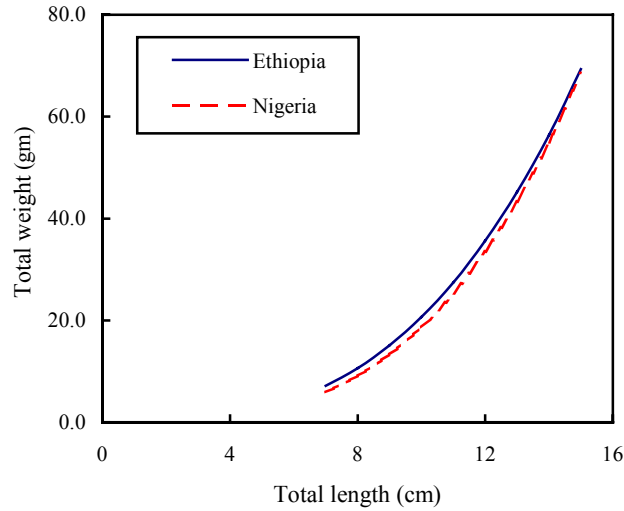

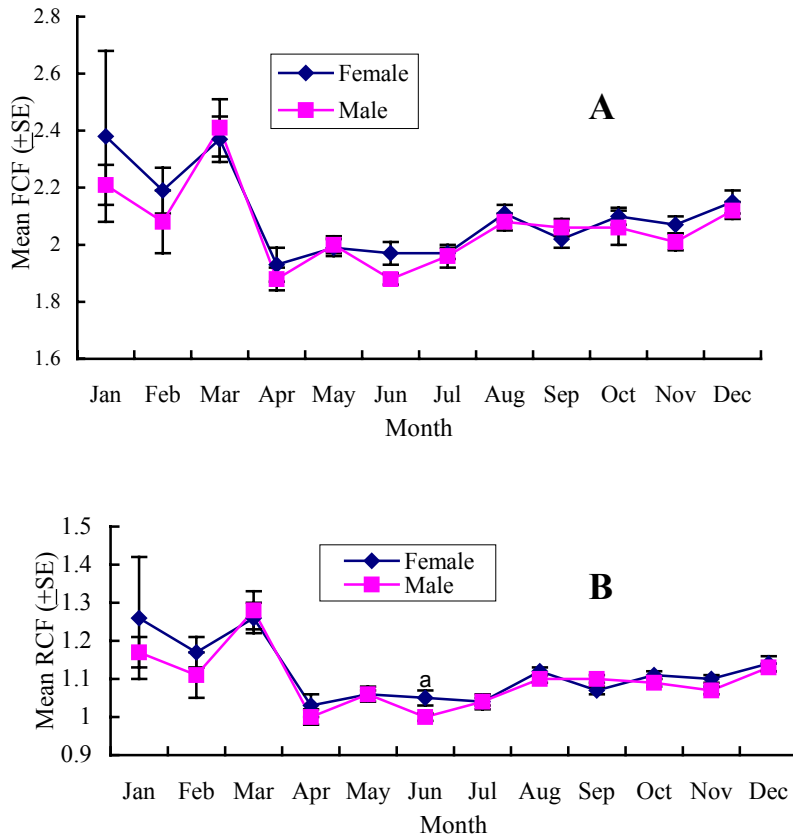**Fig. 3. Comparison of length-weight curves of *T.zillii* populations from Ethiopia and Nigeria.**

Fig. 4. Monthly Fulton's (A) and Relative (B) condition factor (mean ± SE) of female and male *T. zillii* in Lake Zwai for the year 2001.

Mean FCF of the fish in Lake Zwai was 2.08 for females, 2.05 for males and 2.06 for the population in general. FCF of *T. zillii* population in Lake Victoria, another area of introduction, was found to be 1.9 and reported to be better than that in its native lakes, Rudolf and Albert (Welcomme, 1967). Thus, *T. zillii* in Lake Zwai was relatively in better condition than that in lakes Victoria, Rudolf and Albert.

In conclusion, in Lake Zwai *T. zillii* breeds all year round with a high peak of activity between April and September and poor body conditions coincided with peak breeding months. Thus, better exploitation of the fish may be made when breeding is not at its climax during which the fish has better body condition and the capture of breeding ones is minimal.

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