Ethiop. J. Biol. Sci., 10(2): 153-166, 2011
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ADAPTABILITY, GROWTH AND REPRODUCTIVE SUCCESS OF THE NILE TILAPIA, *OREOCHROMIS NILOTICUS* L. (PISCES: CICHLIDAE) STOCKED IN LAKE SMALL ABAYA, SOUTH ETHIOPIA

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ABSTRACT: Despite the high contribution of the introduced *Oreochromis niloticus* as source of food and additional income to the local community, little has been documented on the adaptability and reproductive success of stocked fish in Ethiopia. This study was therefore, conducted to examine the adaptability and reproductive success of *O. niloticus* stocked in Lake Small Abaya in 1997. Monthly fish samples were collected from two sampling sites (open water and littoral area) between September, 2002 and August, 2003 using gillnets of different mesh size (60 mm, 80 mm, 100 mm and 120 mm stretched mesh size) and beach seine of 20 mm mesh size. The size of *O. niloticus* captured ranged between 4 and 33 cm TL (mean ± s.d., 17. 9±6.99 cm TL) and from 1 to 659 g TW (mean ± s.d.. 148.3±134.9 g TW). Males were more numerous than females (χ^2 = 5.61, p< 0.05) in total catch as well as in samples taken in February (χ^2 = 7.45, p< 0.05) and August (χ^2 = 6.64, p< 0.05), whereas females significantly dominated the catch in January (χ^2 = 4.13, p< 0.05). Individual *O. niloticus* with ripe gonads were caught throughout the year however; their frequency in the catch varied a great deal with season. Based on the proportion of ripe gonads and mean gonado-somatic indices (GSI) the main breeding season of *O. niloticus* in Lake Small Abaya occurred between December and May peaking in January, February and March. A minor peak was also observed in June, July and August. The mean monthly Fulton´s condition factor (FCF) of *O. niloticus* in Small Abaya also varied significantly between months (ANOVA, p<0.05). However there was no significant difference in FCF between sexes (ANOVA, p>0.05). Calculated length-weight relationship of the fish was found to be curvilinear ($TW = 0.0174TL^{2.99}$, R^2 = 0.99, n = 1676). Generally, *O. niloticus* in Lake Small Abaya has established a breeding stock which can serve as source of inexpensive fish protein and income for the local community.

Key words/phrases: Breeding season, Fulton's condition factor, Lake Small Abaya, Length-weight relationship, *O. niloticus,* Sex ratio.

INTRODUCTION

Food production in most part of the world is not on a par with the increasing human population. Therefore, in addition to increasing agricultural

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production, it is necessary to search for alternative food source. Exploitation of the aquatic resource, in particular the fishery is a well-developed activity in several part of the world. In countries like Ethiopia, where there is shortage of protein, the country should utilize its fishery resource. To fill the gap aquatic ecosystem can serve as inexpensive source of fish protein and needs to be fully exploited.

Aiming at increasing the productivities of water bodies, introduction of both exotic and indigenous freshwater fishes have been made to several man-made and natural water bodies in Ethiopia since the 1970s. In most cases the Nile tilapia (*Oreochromis niloticus*) has been stocked to several small water bodies because of its adaptability to wide environmental conditions as well as high demand of the fish by the local consumers (Fryer and Iles, 1972). Exotic fishes which have been introduced to the country from abroad include *Cyprinus carpio*, *Ctenopharyngodon idella*, *Tilapia zillii*, *Salmo gairdneri, Salmo trutta* etc. (Shibru Tedla, 1973; Shibru Tedla and Fisseha Haile Meskel, 1981). In spite of some ecological problems reported by conservationists (Zinabu Gebre-Mariam, 1998), there have been success stories which resulted in providing fish for the local communities and markets of major cities as evidenced in the cases of Lakes Small Abaya, Fincha, and Hashengie (FAO, 2003).

Despite the high contribution of the introduced *O. niloticus* to the local community in supplying food and additional income, little has been documented on the adaptability and reproductive status of the introduced fish in the country. So far most studies conducted focused on the biology of commercially important fish species in major lakes of the Ethiopian Rift Valley and Lake Tana (Reyntjens and Tesfaye Wudneh, 1998; Tudoranceae *et al.,* 1999). Most studies conducted earlier dealt with the reproductive biology (Zenebe Tadesse, 1988, 1997; Demeke Admassu, 1994), age and growth (Demeke Admassu, 1990, 1994, 1996), food and feeding habits (Getachew Teferra, 1987; Getachew Teferra and Fernando, 1989; Eyualem Abebe and Getachew Teferra, 1992; Zenebe Tadesse, 1999), as well as on condition factor and length-weight relationship of *O. niloticus* in naturally occurring water bodies of Ethiopia (Demeke Admassu, 1990; Zenebe Tadesse, 1997; Yirgaw Teferi and Demeke Admassu, 2002). These studies provided vital information on the biology of *O. niloticus* stock occurring in major Rift Valley and other lakes of Ethiopia. Based on the results of earlier studies, important recommendations and guidelines were developed for proper management of the capture fishery. However, there are very limited studies done on the biology of introduced *O. niloticus* in natural and

artificial water bodies (Kebede Alemu, 1995; Kassahun Asaminew, 2005).

Hence, based on the request of the Silte Woreda Bureau of Agriculture, NFALRC did some preliminary survey in Lake Small Abaya and confirmed the absence of any fish of commercial importance except *Barbus* sp. Soon after the survey, *O. niloticus* and *Tilapia zilli* fry were stocked into the lake in 1997 with the aim of enhancing fishery and availing inexpensive fish protein to the local community. Thus, the present study was conducted to examine the adaptability and reproductive status of *O. niloticus* stocked in Lake Small Abaya.

MATERIALS AND METHODS

Study area

This study was conducted at Lake Small Abaya ($7^0$29´03.65´´N latitude and $38^0$03`17.79´´E longitude), which is located about 210 km south of Addis Ababa, at an altitude of 1835 m above sea level (Fig. 1). The lake covers a total area of 1253 ha and it is a shallow lake with a maximum depth of 9 m. The mean monthly minimum and maximum temperature varied between 10.8^0C to 14.1^0C and 22.5^0C to 28.7^0C, respectively throughout the sampling period. The monthly total rainfall, monthly maximum and minimum temperature for the period from September, 2002 to August, 2003 are shown in Figure 3a. October and November are the driest months in the region. Before stocking, there were no commercially important fish species in the lake except for the naturally occurring *Barbus sp*. In 1997 NFALRC stocked *O. niloticus* and *Tilapia zilli* fry into Lake Small Abaya.

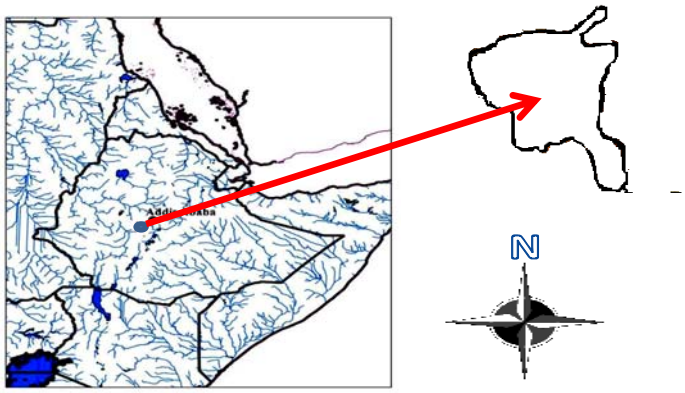

Fig. 1. Map of Ethiopia showing the location of Lake small Abaya..
Source: (www.earth.google.com and www.d-maps.com)

Sample collection

Monthly fish samples were collected from two sampling sites (open water and littoral area) between September 2002 and August 2003 using gillnets of 60 mm, 80 mm, 100 mm and 120 mm stretched mesh sizes and beach seine of 20 mm mesh size. Immediately after collection, 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 a sensitive balance, respectively.

Maturity level, gonado-somatic index (GSI) and sex ratio

After dissection the sex and maturity stage of each fish were determined following standard methods (Holden and Raitt, 1974; Siddiqui, 1977; Babiker and Ibrahim, 1979). The maturity level of each gonad was rated as immature (I), recovering spent or developing virgin (II), ripening (III), ripe (IV) and spent (V).

Each gonad was then removed and weighed to the nearest 0.1 g. GSI of each fish was calculated using the following formula (1).

$$GSI = \frac{\text{Gonad weight}}{\text{Body weight}} \times 100 \quad \text{---------- (1)}$$

The mean monthly GSI values were calculated separately for each sex. The sex ratio (Male: Female) of fish samples collected in each month as well as for the total sample size was determined and the level of significance was estimated using the Chi-square test.

Length-weight relationship, body condition and length frequency distribution

Length-weight relationship was calculated using least squares regression as indicated below (2).

$$TW = aTL^b \quad \text{---------- (2)}$$

Where TW, total weight in gram, TL, total length in centimetre, a and b are intercept and slope of the length-weight regression equation, respectively.

The frequency distribution of the different length class of sampled fish was also plotted using sigma plot. FCF for each fish of both sexes and average values for each month were calculated using the formula below (Le Cren, 1951; Bagenal and Tesch, 1978).

$$FCF = (TW/TL^3) \times 100 \quad \text{----------(3)}$$

Where, TW is in grams and TL is in centimetres.

Statistical analysis

A chi-square test was employed to determine if the sex-ratio varied between months (Sokal and Rohlf, 1981). One-way ANOVA was also used to determine variations between the monthly GSI and FCF values.

RESULTS

Sex ratio, maturity level and gonado-somatic index

A total of 1676 *O. niloticus* specimens were examined in twelve sampling occasions. Males were more numerous than females ($\chi^2 = 5.61$, $p < 0.05$) in total catch as well as in samples collected in February and August. On the contrary, females were significantly more numerous than males ($\chi^2 = 4.13$, $p < 0.05$) in January (Table 1). The size of *O. niloticus* captured in Lake Small Abaya averaged 17. 9±6.99 cm (SD) TL and 148.3±134.9 g (SD) TW and ranged between 4 and 33 cm TL and 1 to 659 g TW (Fig. 2).

Table 1. Number of males, females and sex-ratio in monthly samples of *O. niloticus* in Lake Small Abaya.

Month	Male	Female	Sex-ratio (Male-female)	Chi-square
September, 2002	70	62	1:0.89	0.48
October	66	47	1:0.71	3.18
November	98	76	1:0.78	2.78
December	63	67	1:1.06	0.12
January, 2003	108	140	1:1.30	4.13*
February	54	29	1:0.54	7.45*
March	58	65	1:1.12	0.40
April	18	15	1:0.83	0.29
May	59	52	1:0.88	0.45
June	69	51	1:0.74	2.70
July	19	16	1:0.84	0.28
August	68	41	1:0.60	6.64*
Total	750	661	1:0.88	5.61*

The last column shows chi- square values. * Significant ($p<0.05$).

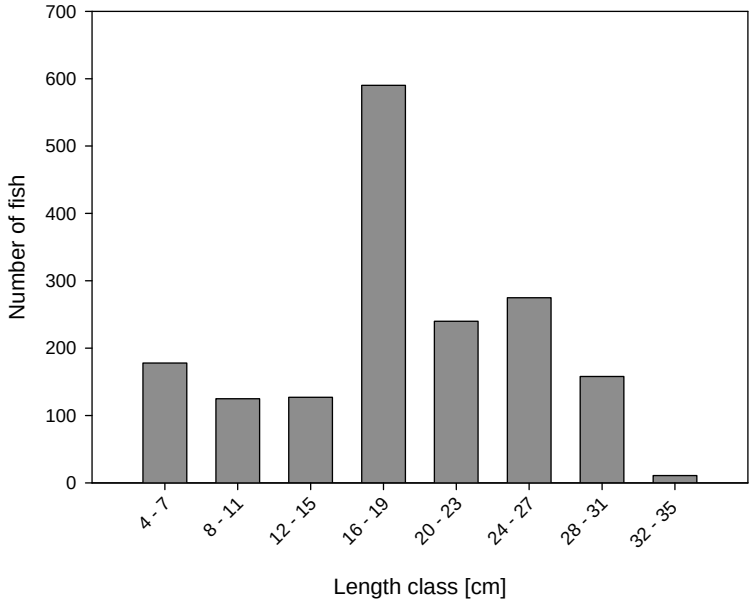

Fig. 2. Length frequency distribution of *O. niloticus* in Lake Small Abaya.

O. niloticus individuals with ripe gonads were caught throughout the year. However, the frequency of ripe male and female varied considerably between months. The proportion of ripe gonads increased in the dry season between December and May peaking in January, February and March (Fig. 3c). We also observed a minor peak in the percentage of ripe gonads in June to August.

The monthly mean GSI values of both sexes also varied significantly between months (ANOVA, $p<0.05$). The monthly mean gonado-somatic indices of males varied between 0.11 and 0.36 with highest value in July. In females, the mean gondo-somatic indices ranged between 0.43 and 1.05 with higher values in February and March. Minor peak was also recorded in June to August (Fig. 3b).

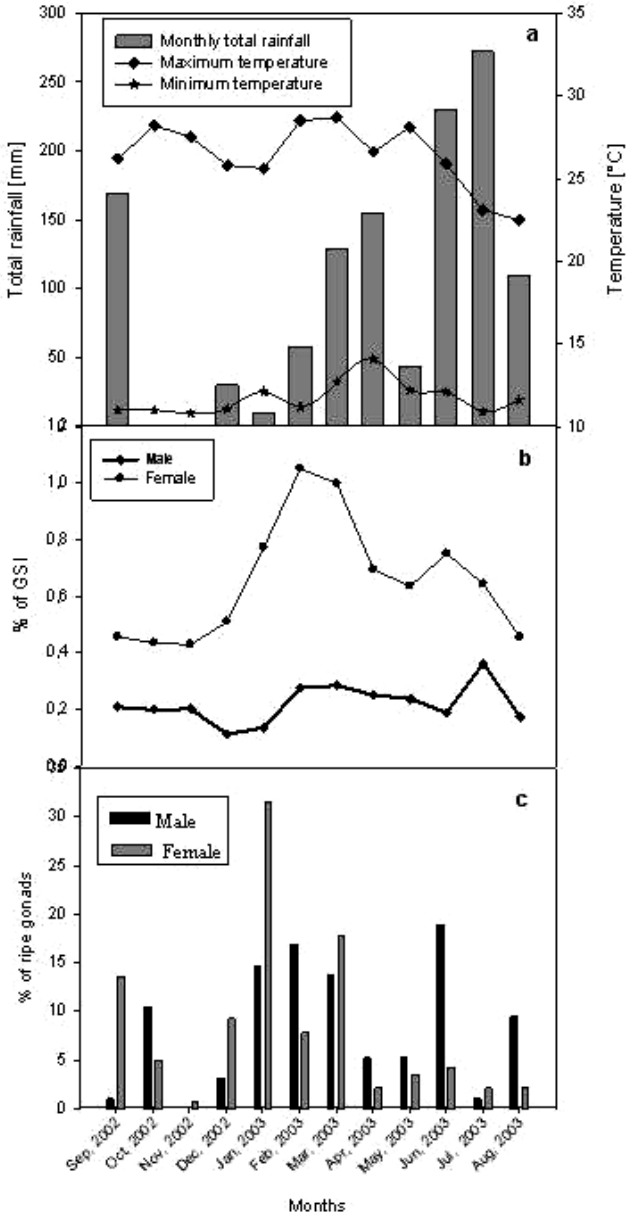

Fig 3. Monthly total rainfall, minimum and maximum temperature around Lake Small Abaya (a) monthly mean gonado-somatic index (b) and seasonal variations in percentage ripe gonads (c) of *O. niloticus* in Lake Small Abaya.

Fulton's condition factor (FCF)

The mean monthly FCF value of *O. niloticus* significantly varies between months (ANOVA, $p<0.05$). However, no significant difference was observed between sexes (ANOVA, $p>0.05$). Monthly FCF (mean ± SD) value of *O. niloticus* in Lake Small Abaya ranged from 1.5±0.38 in March to 1.9±0.18 in April for males and from 1.5 ±0.34 in March to 1.9±0.22 in July for females. Lowest monthly FCF were recorded in March in both sexes (Fig. 4).

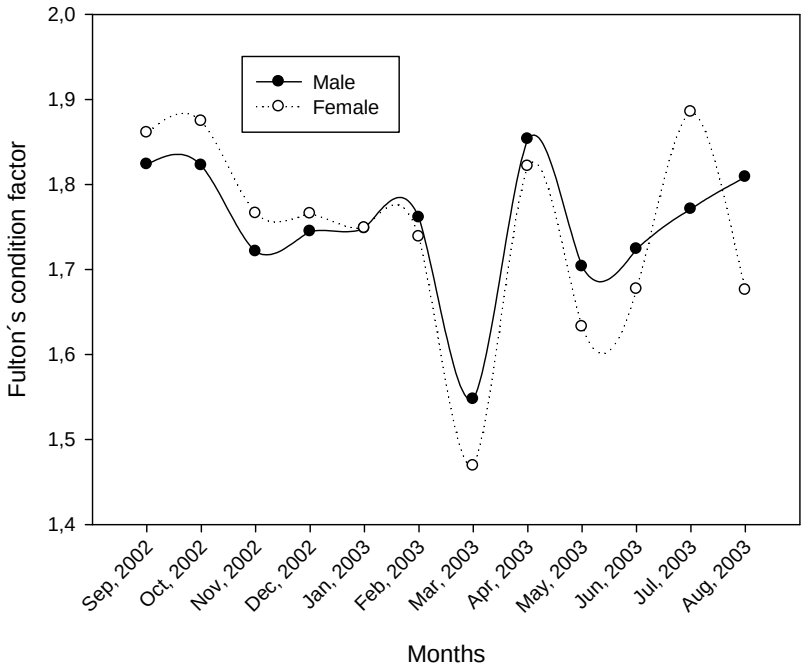

Fig. 4. Seasonal variations on monthly Fulton's condition factor of *O. niloticus* in Lake Small Abaya.

Length-weight relationship

The length-weight relationship of female and male *O. niloticus* in Lake Small Abaya was curvilinear and described best by the following regression equations.

Female: $TW = 0.0187TL^{2.9686}$, $R^2 = 0.9542$, $n = 661$

Male: $TW = 0.0173TL^{2.9988}$, $R^2 = 0.9662$, $n = 751$

Sex and age combined $TW= 0.0174TL^{2.9947}$, $R^2 = 0.9871$, $n = 1676$

Comparisons of the two equations showed no significant difference in length-weight relationship between sexes ($p > 0.05$). Therefore, an equation common to both sexes and age groups were fitted to total length ranging between 4 cm and 33 cm and total weight ranging between 1 g and 659 g. The relationship between TL and TW of combined sexes and age was curvilinear. The slope of the equation is very close to the theoretical value b=3.

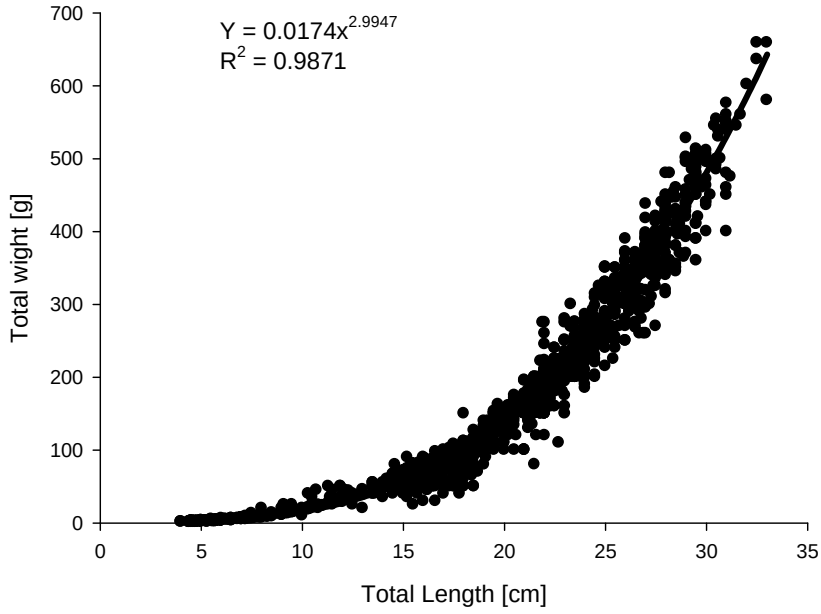

Fig. 5. Length-Weight relationships of *O. niloticus* in Lake Small Abaya.

DISCUSSION

In the present study the overall sex ratio for *O. niloticus* in Lake Small Abaya was found to be 1:0.88 (Male:Female) and deviated significantly from the expected 1:1 ratio ($\chi^2 = 5.61$, $p < 0.05$). In general males dominated the catch in nearly all months except in January and March. The dominance of males in the catch might be attributed to the active movement of males for search of mates and building nests for courtship which makes them more vulnerable for gill nets. Earlier study on the same species in Lake Tana also indicated the preponderance of males over females and this has been attributed to the reproductive behaviour of the fish (Zenebe Tadesse, 1997).

Similar results were also reported for *O. niloticus* in Emiliano Zapata Dam in Mexico (Peña-Mendoza, *et al*., 2005). Fryer and Iles (1972) also pointed out that in the African lakes; it is commonly observed that males dominate over females in the cichlid population. However, studies conducted on the same species in some water bodies in Ethiopia and elsewhere in the world (Babiker and Ibrahim, 1979; Demeke Admassu, 1996; Gómez-Márquez *et al.,* 2003) revealed that females are more numerous than males. However, Nikolsky (1963) described that the sex ratio could vary considerably from species to species, and from year to year in the same population, but in the majority of cases it is close to one to one.

In Lake Small Abaya, *O. niloticus* spawned all year round. However, a bi-modal breeding season was observed; the main breeding season occurred between December and May followed by a minor one between June and August. Similar studies conducted on *O. niloticus* in the nearby Rift Valley Lakes Ziway and Hawassa (Zenebe Tadesse 1988; Demeke Admassu 1996) also revealed bi-modal breeding patters which are in agreement with our finding. In Lake Ziway the breeding season of *O. niloticus* was between December and March (Zenebe Tadesse, 1988) and in Lake Awasa between January and March (Demeke Admassu, 1996) and a minor one between June and July. Several studies indicated that the peak breeding season of *O. niloticus* could be triggered by increase in temperatures, solar radiation or rainy period of the region (El Zarka *et al*., 1970; Lowe-McConnell, 1982; Trewavas, 1983; Stewart, 1988). Thus the main breeding season of *O. niloticus* in Lake Small Abaya might be triggered by high temperature and solar radiation occurring during December to March. The minor breeding period in June to August could be associated with the onset of the main rainy period of the region which triggers the availability of food (phytoplankton) for the fingerlings.

The average FCF values of *O. niloticus* for male (1.8) and female (1.7) in this study was found to be comparable to values reported for both sexes of the same species from Lakes Koka (1.87), Ziway (1.81) and Langano (1.84) (Gashaw Tesfaye and Zenebe Tadesse 2008), but comparatively higher values were reported for the same species from Lakes Hawassa (2.03) and Chamo (2.35) (Eyualem Abebe and Getachew Teferra, 1992; Yirgaw Teferi and Demeke Admassu, 2002). The difference in FCF value in different Lakes might be attributed to the differences in food availability between Lakes. There was no significant difference in FCF between females and males ($p>0.05$) in Lake Small Abaya. However, we found significant difference in FCF values between months ($p<0.05$) indicating differences in

the condition of the fish with seasons. Relatively the lowest value was recorded in March and coincided with or shortly after the main spawning period of the fish. The poor condition of the fish might be attributed to the stress resulting from intense breeding activities which cost high energy of the fish. This has also been confirmed in earlier studies from Lakes Ziway, Tana and Turkana (Stewart, 1988; Zenebe Tadesse, 1988, 1997). The males were also busy in building and guarding nests and fertilizing many females which mobilizes energy from their body reserve (Zenebe Tadesse, 1997; Demeke Admassu and Casselman, 2000). Other environmental factors such as availability of food and food quality, feeding rate, degree of parasitism (Getachew Teferra, 1987; Teshima *et al*., 1987; Stewart, 1988) and pollution are also reported to affect the condition factors of *O. niloticus* in Lake Mariut, and Shanawan drainage canal in Egypt (Bakhoum, 1994; Khallaf *et al*., 2003). Maternal mouth brooders like *O. niloticus* fast or take less food during the early stages and probably throughout the brooding period (Fryer and Iles, 1972).

The relationship between total length and total weight of *O. niloticus* in Lake Small Abaya was found to be curvilinear. Similar relationships have been reported for the same species in Lakes Tana, Hawassa, Chamo, Koka, Langano and Ziway (Zenebe Tadesse, 1988, 1997; Demeke Admassu, 1990; Yirgaw Teferi and Demeke Admassu, 2002; Gashaw Tesfaye and Zenebe Tadesse, 2008). The exponent 'b' of the length-weight relationship obtained in this study was close to the cube value (b=2.99) indicating isometric growth of the fish. This means that the fish grew well and gained weight proportional to their lengths (Bagenal and Tesch, 1978). Similar to our result, 'b' values close to cube have been reported for *O. niloticus* from Lakes Ziway (b=3.03 and 3.19), Chamo (b=2.98) and Koka (b=3.04) (Zenebe Tadesse, 1988; Yirgaw Teferi and Demeke Admassu, 2002; Gashaw Tesfaye and Zenebe Tadesse, 2008). On the other hand, lower values were also reported for the same species from Lakes Hawassa (b=2.9), Langano (b=2.89) and Tana (b=2.74) (Demeke Admassu, 1990; Zenebe Tadesse, 1999; Yirgaw Teferi and Demeke Admassu, 2002; Gashaw Tesfaye and Zenebe Tadesse, 2008).

CONCLUSION

O. niloticus stocked in Lake Small Abaya has adapted and established a breeding population which can be used as source of protein for the local community. This has been confirmed by the presence of year-round breeding and good body condition of the fish. Generally, males were

numerous than females as indicated in sex ratio of the total sample. *O. niloticus* breeds throughout the year in the lake, but the main breeding period occurred between December and May peaking in January to March and the minor one in June to August. The main breeding period coincided with the increase in environmental temperature and sunshine whereas the minor spawning of the fish might be triggered by the onset of the rainy period. Hence, fishermen in Lake Small Abaya should take care not to capture the spawning fish mainly during the main breeding period which coincides with the fasting period of the Orthodox Christians where the demand for fish increases significantly. Thus, the spawning population in the shallow littoral part of the lake should be protected from intensive fishing during this period. *O. niloticus* shows isometric growth in Lake Small Abaya indicating the well-being of the fish. However, the body condition of the fish was found to vary between months but not between sexes. The lowest FCF value in March could be associated with the main breeding season of the fish.

ACKNOWLEDGEMENTS

The authors are grateful to the support and cooperation of all NFLARC staff members, particularly Dr. Redeat Habtesselasse, Dr. Adamneh Dagne, Ato Aschalew Lakew, Ato Gashaw Tesefay, W/o Abeba W/Gebreal, Ato Mulugeta Jovani, Ato Niguse Ergetie, Ato Kebede Bereda and Ato Ashenafi Azage who were helpful during the field work. We also appreciate the valuable support from Ziway Fishery Research Centre and Silte Zone Bureau of Agricultural and Rural Development. The study was financed by the Ethiopian Institute of Agricultural research (EIAR).

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