Study on the Adaptability Status and Reproductive Success of Oreochromis niloticus L. (Pisces: Cichlidae) and Carp (Cyprinus carpio L., 1758) in a Tropic Reservoir (Fincha, Ethiopia)

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Abstract The adaptability status and reproductive success of the introduced fish Nile Tilapia (Oreochromis niloticus L.) and common carp (Cyprinus carpio L., 1758) in Fincha reservoir, Ethiopia were studied on monthly basis from July 2006 to August 2007. Gill nets of different mesh size (60 mm, 80 mm, 100 mm, 120 mm and 140 mm, stretched mesh size) and beich sein (50 m long) were used to harvest the fish (a total of 645 fishes). Total length (L) and body weight (W) of both species were measured to the nearest 0.1 cm and 1g respectively. The results of the study showed that both fish species are adapted and have established successful breeding population in the reservoir. The size at first sexual maturity (L50) for Oreochromis niloticus in Fincha reservoir was 21.8 cm for female and 24.5 cm for the male while L50 was 37.5cm and 24.5cm for female and male Cyprinus carpio respectively. It was found that Oreochromis niloticus breeds throughout the year showing a peak breeding season in January and July in Fincha reservoir while Cyprinus carpio showed a peak breeding season between March and June. The length-weight relationships, total length (L) in cm; total weight (W) in g were calculated for O. niloticus (W=0.8×10^-2L^3.20; n=87; r^2= 0.96) and C. carpio (W=1.4×10^-2L^2.97; n=558; r^2=0.99) and showed a curvilinear relationship signifying the fish grow nearly isometrically. A significant seasonal variation (ANOVA, P < 0.05) was observed in the condition (K) of the fish coupled with the peak breeding season in Fincha reservoir. The relatively low values in the condition of the fish during January, March and July seems to coincide with the peak breeding season of the fish, which probably drains high energy for spawning. However, no significant difference was observed between sexes (ANOVA, P>0.05). Apparently, length frequency distribution of both species indicated that the fish population is normal fish population with no apparent problems of over exploitation.

Keywords Breeding-season; Cyprinus carpio; Fincha; Oreochromis niloticus; Reservoir; Ethiopia

Abbreviations
ANOVA: Analysis of covariance; NFLARC: National Fisheries and Aquaculture Research Center; L50: The size at first sexual maturity; TW: Total weight of the fish; TL: Total length of the fish

1 Introduction
Due to their economic importance tilapia are among the most studied group of fish in African waters (Low-McConnel, 1982). In Ethiopia Nile tilapia, Oreochromis niloticus is commercially the most important and widely preferred and consumed fish. It is one of the most important fish species in the ecology and fisheries of almost all-Ethiopian inland waters (Tedla, 1973; Pauly and Gaynilo, 1997). Several investigators have studied the breeding season and maturity size of O. niloticus in some lakes in Ethiopia. For example, Oreochromis niloticus breed through out the year, but its breeding activity is intensive during the periods from January to April and July to September in Lake Awassa (Admasu 1990; 1994 and 1996) from December to March in Lake Ziway (Tadesse, 1988). However in Lake Tana, unlike the Rift Valley lakes, Oreochromis niloticus seems to have longer breeding season which lasts from March to August (Tadesse, 1997).

The main breeding activity of fish species in tropical waters has been associated with factors such as light intensity, temperature, rainfall and water level or seasonal
flooding (Tadesse, 1997). Abundance of food has also been considered as an important factor in timing of breeding in some species (Tadesse, 1997). Demeke Admasu (1996) has found the peak breeding activity of *Oreochromis niloticus* in Lake Awassa to be coincident with increasing in phytoplankton biomass. The size of first sexual maturity of tilapia (*Oreochromis niloticus*) is extremely variable, and depends on the species, growth rate and environment (Wootton, 1998). *Oreochromis niloticus* individuals, which are in poor body condition, mature at a small size than in good condition (Wootton, 1998). In contrast *Cyprinus carpio* exploit large and small man made and natural reservoirs and pools in low and fast moving streams. They prefer larger, slower-moving bodies of water with soft sediments, but they are tolerant and hardy fish that thrive in a wide variety of aquatic habitats (Dadebo and Tugie, 2009). Under tropical conditions carp breeds throughout the year, but it is a season spawner in temperate waters and breeds at a temperature range of 15°C to 20°C (Dadebo and Tugie, 2009).

The principal fish species found in Fincha reservoir is probably *Barbus pludunosis*, a fish species which has no commercial value in Ethiopia. Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus Carpio*) were introduced into the reservoir in late 1970-ies to fill an empty pelagic niche of planktivorous fish and to provide cheap protein to the local people (Tedla and Fisseha, 1981).

Apparently there exist comparatively very few scientific investigations on the reproductive biology of carp species in Ethiopia (Dadebo and Tugie, 2009; Tedla and Fisseha, 1981). It is not know also if these introduced fish species established breeding populations in the reservoir. Hence, this paper is the first attempt to investigate the adaptability status and reproductive success of introduced fish species, *Oreochromis niloticus* and *Cyprinus carpio* in Fincha reservoir.

2 Results

2.1 Length-weight relationships

The Length-Weight relationship of *O. niloticus* and *Cyprinus carpio* in Fincha reservoir was curvilinear (Figure 1). Length-Weight relationships were calculated for all tilapia (W=0.8×10^-0.32; n=87; r^2=0.96) and carp (W=1.4×10^-2.99; n=558; r^2=0.99) collected. The relationship was first determined separately for male and female *O. niloticus* and carp respectively, however when an analysis of covariance indicated no apparent difference in the length-weight regression coefficients and adjusted means for either sex, the data for both sexes were pooled.

![Figure 1](image)

2.2 Fulton’s condition factors (k)

The average K value of *O. niloticus* in Fincha reservoir was 1.82 for female and 1.74 for the male while mean K value was 1.97 and 1.88 for female and male *Cyprinus carpio* respectively. The values were found to be significantly different between months (ANOVA, P<0.05). Lower values were observed during January, March and July (Figure 2) which seem to coincide with the peak breeding season of the fish. However, no significant difference was observed between sexes (ANOVA, P>0.05).
2.3 Length frequency distribution
A total of 645 *O. niloticus* (n=87) and *Cyprinus carpio* (n=558) individuals were caught during the study period. The total length (TL) of the fish ranged from 10 to 42 cm and 8 to 60 cm for *O. niloticus* and *Cyprinus carpio* respectively (Figure 3). The greater proportion of the sampled fish for both species was in the size range between 16 and 24 cm. Generally the length frequency distribution of both species indicated that the fish population is normal fish population with no apparent problems of over exploitation (Figure 3).

2.4 Length at first maturity (L\(_{50}\))
The size at first sexual maturity (L\(_{50}\)) for *Oreochromis niloticus* in Fincha reservoir was 21.80 cm for female and 24.50 cm TL for the male while L\(_{50}\) was 37.50 cm and 24.50 cm TL for female and male *Cyprinus carpio* respectively (Figure 4). Thus, female *O. niloticus* matured at smaller size than males whilst male *Cyprinus carpio* matured at smaller size than females in Fincha reservoir.
2.5 Breeding season
The breeding season of *Oreochromis niloticus* and *Cyprinus carpio* was determined from percentages of fish with ripe gonads taken monthly from July 2006 to August 2007. Accordingly, *Oreochromis niloticus* and *Cyprinus carpio* with ripe gonads were caught throughout the years; however the most intense breeding activity occurred in January and July for *O. niloticus* and between March and June for *C. carpio* (Figure 5).

Figure 5 The breeding season of *Oreochromis niloticus* (top) and *Cyprinus carpio* (bottom) in Fincha reservoir as indicated by the frequency of ripe gonads.

3 Discussions
This study demonstrates that there is a curvilinear relationship between total length and total weight of both fish species in Fincha reservoir. This agrees with other studies in tropical lakes and reservoirs (Teferi and Admasu, 2002). The regression coefficient (b) in the relation $W=aL^b$ obtained in this study was not significantly different from the cube value ($b=3.2$ and 2.97 for *Oreochromis niloticus* and *Cyprinus carpio* respectively) signifying isometric growth of the fish (Chaudhuri, 1973; Naeem et al., 2010). Usually the coefficient is expected to be close to three, since growth in weight signifies an increase in three dimensions while length measurements are taken in one dimension (Tadesse, 1997). Therefore, the relatively high value of the coefficients might be attributed to adequate food available for the fish in Fincha reservoir (algal biomass 15.6 µg/L and zooplankton density 457 individual per litter). The Fulton’s condition factor (K) expresses the relative plumpness or degree of well-being of the fish. The average K value of *O. niloticus* (1.82) and *C. carpio* (1.97) in Fincha reservoir is slightly lower than values reported for the same fish species from Ethiopian rift valley lakes (Abebe and Tefera, 1992). Generally k value varied significantly (ANOVA, P<0.05) between months (Figure 2). Lower values were observed during January, March and July which seem to coincide with the peak breeding season of the fish. In Fincha reservoir, *O. niloticus* breeds throughout the year showing a peak breeding season in January and July while *C. carpio* breeds intensely between March and June. The low K value during these periods is attributed to the fact that breeding drains energy profusely for the production of sperm and eggs (Tadesse, 1997; Abebe and Tefera, 1992). In a mouth brooder fish species like *O. niloticus* females fast during the early stages and probably throughout the brooding period while the males are also actively engaged in building and guarding nests and fertilizing females (Tadesse, 1997; Tesfaye and Tadesse, 2008). Also, decreased condition of *O. niloticus* during the peak breeding season in two Ethiopian Rift Valley lakes (Ziway and Awassa) was documented with increased reproductive activity of the fish which causes inconsistent feeding and subsequently affects the body condition (Admasu, 1994; Tadesse, 1988).

The Size at first sexual maturity ($L_{50}$) of *O. niloticus* (21.80 cm for females and 24.50 cm TL for the males) was slightly higher than those reported by other investigators in tropical water bodies (Trewavas, 1983; Wudneh, 1998). Apparently $L_{50}$ of *C. carpio* in Fincha reservoir (37.50 cm for females and 24.50 cm TL for
males) is comparable to *C. carassius* fish in Lake Ziway, 30.50 cm for females and 26.80 cm for males (Dadebo and Tugie, 2009). Size at first maturity is inversely correlated to the degree of fishing mortality. Several investigators have noted that $L_{50}$ was related with the condition of the fish; and the fish individuals that are in poor condition tend to breed at smaller sizes than those in good condition (Wootton, 1998; Teferi and Admasu, 2002).

### 4 Conclusions and Recommendations

In summary, *O. niloticus* and *C. carpio* showed isometric growth in Fincha reservoir, however, the body condition of the fish was found to be different between months but not between the sexes. Both fish species in Fincha Reservoir followed the general pattern of breeding activities in tropical water bodies where comparatively higher proportions of fish were in breeding condition during the onset of the rainy season. In Fincha reservoir female *O. niloticus* matured at smaller size than males whilst male *Cyprinus carpio* matured at smaller size than females. Therefore, capture size of the stock should be determined taking into account the $L_{50}$ of females, which may otherwise remove the spawning fish during their peak breeding season. Generally the length frequency distribution of both species in Fincha reservoir indicated that the fish population is normal fish population with no apparent problems of over exploitation. However, we recommend the fishermen have to use a fishing gear greater than 8 cm stretched mesh size for sustainable utilization of the stock in Fincha reservoir. Thus, the gill net being used at the reservoir may not remove the juveniles before replacing the next generation to sustain the yield.

### 5 Material and Methods

#### 5.1 Study area

Fincha Reservoir (09°54′N, 37°27′E) is located in west-central Ethiopia some 150 km from the capital Addis Ababa, at an altitude of 2 200 m a.s.l. (Figure 6).

![Figure 6 Map of Ethiopia showing the location of Fincha reservoir together with its swampy area (Mesfin et al., 1988).](image-url)
Fincha reservoir was built date back into the 1972s by the construction of a rock-fill dam on the Mita stream, shortly above the point where it plunges into the gorge of the Fincha River, a tributary of the Blue Nile River (Mesfin et al., 1988). It has a surface area of 170 km$^2$ and an average depth of 9 m. The reservoir area is characterized by a sub-humid type of climate with an annual precipitation of 1,824 mm and the monthly mean air temperature varies from $15^\circ$C to $18^\circ$C (Table 1).

Fish were introduced into Fincha Reservoir in late 1970-ies to provide cheap protein source to the riparian community (Mesfin et al., 1988).

Table 1 Some chemical features of Fincha Reservoir (Mesfin et al., 1988).

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5.2 Sampling
Fish samples were collected monthly using gill nets of different mesh size (60 mm, 80 mm, 100 mm, 120 mm and 140 mm stretched mesh) set overnight. The total length (TL) and total weight (TW) of fresh fish samples were measured to the nearest 0.1 cm and 0.1 g, respectively. Subsequently length-weight relationship was calculated using power function (Lager, 1956):

$$W = aL^b$$

Where, “a” is the intercept, “b” is the slope of length-weight regression, W is total weight and L is total length. Fulton’s condition factor (k), an indicator of the “well-being” of an individual fish was calculated using the following formula (Lager, 1956):

$$K = \frac{[\text{Weight}/(\text{Length})^3]}{100}$$

After dissection, the sexes were identified and maturity stage (S) of each fish was measured using a five scale maturity index: immature (S1), developing (S2), ripening (S3), ripe and running (S4) and spent (S5). The relationship between the percentage of mature fish (P) per length class and fish length ($X$ in cm) was described with a logistic curve:

$$P_X = \frac{1}{[1+e^{(bX+a)}]}$$

The length at first sexual maturity (L$_{50}$) was then derived from the relationship of a and b:

$$L_{50} = -\frac{a}{b}$$

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Author’s contributions
GT and FT contributed considerably during data collection, analysis of the result and write-up of the manuscript. GT contributes to plot the L$_{50}$ graph was instrumental during the preparation of this manuscript.

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