

Full Length Research Paper

Reproductive aspects of common carp (*Cyprinus carpio* L, 1758) in a tropical reservoir (Amerti: Ethiopia)

Mathewos Hailu

Ziway Fisheries Resources Research Center, Ethiopia.

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The reproductive aspect of common carp (*Cyprinus carpio* L, 1758) in the Amerti reservoir (9°.63 N, 37°.23' E) was studied monthly between August 2011 and July 2012. A total of 496 specimens, comprising 231 males and 265 females were captured during the sampling period. There were no significant differences between the sex ratio ($\chi^2 = 2.33$; $P = 0.126$). The mean \pm SD of Fulton's condition factor was 1.22 ± 0.14 for both sexes. The size at first sexual maturity (L_{50}) for male *Cyprinus carpio* was 27.2 cm fork length (F_L) while the females attained L_{50} at 28.3 cm F_L . Absolute fecundity (F) varied between 36955 and 318584 with a mean \pm SD of 170937 ± 13084 for the length group (270-470 mm F_L). The relationship between F and F_L were significant ($F = 0.224 * F_L^{3.708}$, $R^2 = 0.933$; $p < 0.001$). The mean monthly water temperature that ranged from 18.9 to 23.1°C during the study period appears to favor year round spawning of common carp in the reservoir.

Key words: Breeding season, fecundity, maturity, species introduction.

INTRODUCTION

The rising demand for electric power, potable water and irrigation has led to the construction of different dams in Ethiopia (Kloos and Legesse, 2010). Furthermore, these reservoirs are sources of income and enhanced nutritional health by supplying fish protein for the adjacent community. Most of these reservoirs are stocked with *Oreochromis niloticus* and *Cyprinus carpio* or sustained themselves with the riverine fish (Tariku et al., 2009; Tigabu, 2010).

The common carp (*C. carpio* L, 1758) is native to coastal areas of the Caspian and Aral Seas (Balon, 1995). The ability of common carp to withstand various environments has made it one of the major exotic species to spread throughout the world (Britton et al., 2007; Sivakumaran et al., 2003). Despite its benefit in commercial fishery *C. carpio* is regarded as a pest fish because of its tendency to destroy vegetation (Miller and Crowl, 2006; Zambrano et al., 2001) increase water turbidity (Lougheed et al., 1998) and decrease habitat

heterogeneity for native species (Perrow et al., 1999). Natural spawning of *C. carpio* varies according to environmental factors. In tropical and subtropical regions carp usually mature during their first year and may spawn several times within a given year (Sivakumaran et al., 2003). Female gonad development is continuous when temperatures are above 16°C (Crivelli, 1981).

C. carpio was introduced in Ethiopia in 1936 for aquaculture (Welcome, 1988); it has been stocked in various reservoirs and natural lakes to enhance fish yield by filling the available niche (Dagne and Degefu, 2007; Tedla and Haile-Meskel, 1981). Even though *C. carpio* is wide spread in Ethiopia little is known about its reproductive biology. The aim of this study was to assess the adaptability status and reproductive pattern of *C. carpio* in a tropical highland reservoir, including its size at sexual maturation and seasons of spawning to enable sustainable fishery exploitation.

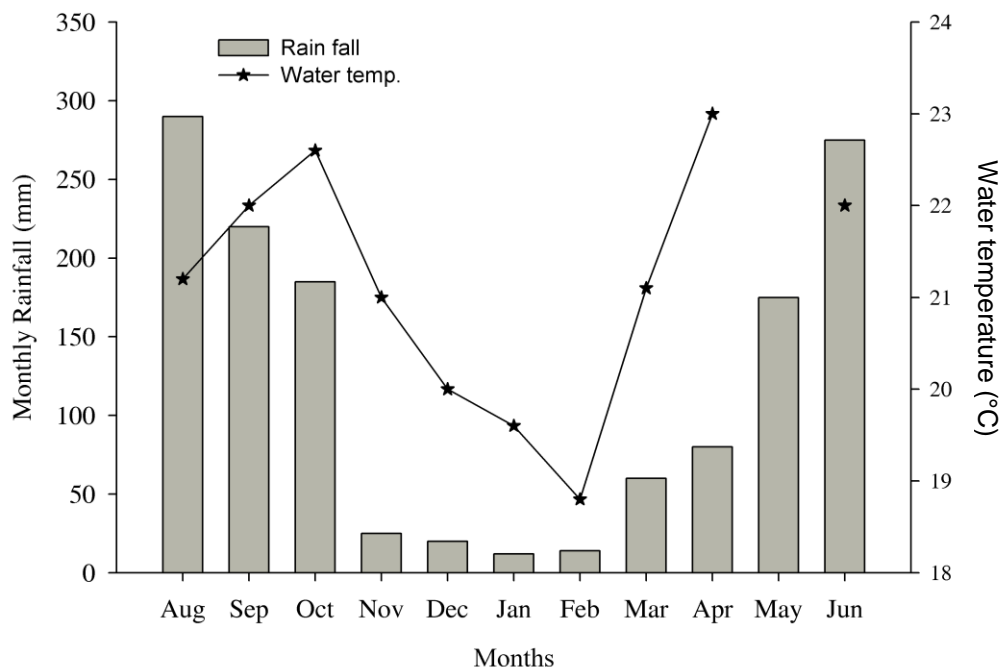


Figure 1. Monthly variation in water temperature and rainfall around Amerti Reservoir (2011-2012).

MATERIALS AND METHODS

Study area

Amerti reservoir (9° 63' N, 37° 23' E) is located at an altitude of 2243 m above sea level. The reservoir was built to supply water to the adjacent Fincha reservoir through a tunnel for hydroelectric power generation (OADB, 1996). The reservoir was stocked with *C. carpio*, *O. niloticus* and *Tilapia zilli*. The water temperature of the reservoir ranges between 18.9 and 23.1°C (Figure 1). The area has annual rainfall of 1823 mm with long rains occurring from May to August and the short rains from November to February (Figure 1).

Sample collection

Fish samples were collected monthly between August 2011 and June 2012 using multifilament gill net having 60, 80, 100 and 120 mm stretched mesh size. The panel length of each mesh size was 25 m and the depth was 3 m. Immediately after capture, the fork length (F_L) and total weight (T_w) were measured and weighted to the nearest 1 mm and 0.1 g, respectively. Sex was determined from gonads of the specimens. The sex ratio was computed and Chi-square (χ^2) test was used to determine if it varied from 1:1 (Zar, 1999).

The length-weight relationship was determined using the following equation:

$$W = aF_L^b$$

Where, W: weight in grams; F_L : fork length in centimeter.

While, Fulton's condition factor (F_C) (King, 1995) was computed using the following equation:

$$F_C = W/T_L^3$$

Where, W: total weight in g; T_L : total length in cm

Maturity estimation

Length at which 50% of both sexes reached maturity (L_{50}) was determined from the percentages of mature fish that were grouped in 1 cm length classes and fitted to the logistic equation described by Echeverria (1987). The breeding season was determined from the percentages of fish with ripe gonads taken each month. The absolute fecundity (F) of individual females was determined gravimetrically (Bagenal and Braum, 1987), with the number of ripe oocytes counted from triplicates of 1 g sub-sample of the ovary. The relative fecundity was also estimated from the number of oocytes per unit body weight of a matured *C. carpio* (Sivakumaran et al., 2003). The relationship between absolute fecundity and fork length was determined using least squares regression.

RESULTS

A total of 496 *C. carpio* comprising 231 (47%) males and 265 (53%) females were captured during the sampling period. The sex ratio between females and males 1:1.15 did not differ significantly from 1:1 ($\chi^2 = 2.33$; $P = 0.126$). The fork length of the specimens ranged from 14.0 to 45 cm (Figure 2), while the weight ranged between 56.9 and 1535.8 g. The length-weight relationships was curvilinear (Figure 3) and statistically significant with $W = 0.022 L_F^{2.923}$ ($R^2 = 0.977$, $P < 0.001$).

The Fulton's condition factor (Mean \pm SD) of *C. carpio* for both sexes was 1.22 ± 0.14 . The value varied from

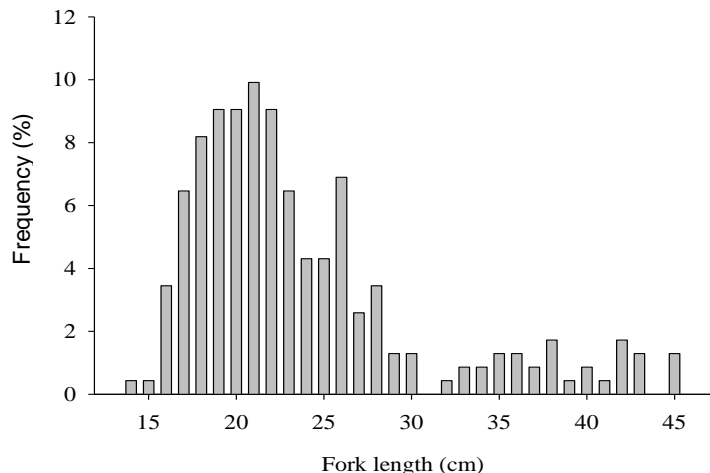


Figure 2. Length frequency distribution of sampled *C. carpio* in Amerti reservoir.

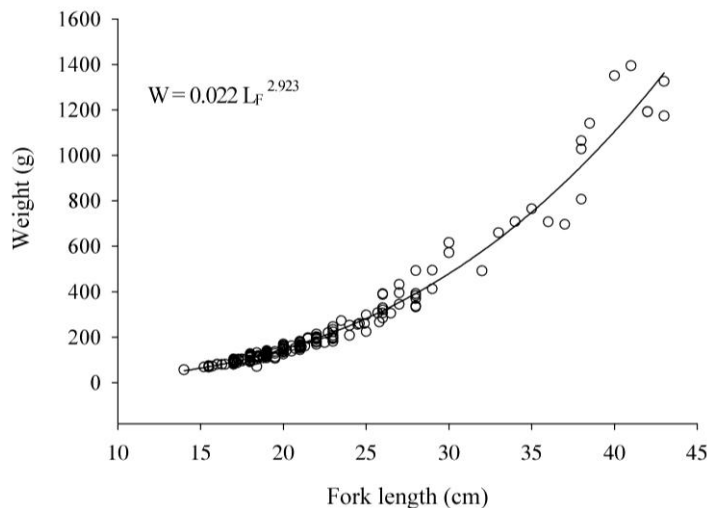


Figure 3. Length-weight relationship of *C. carpio* in Amerti Reservoir.

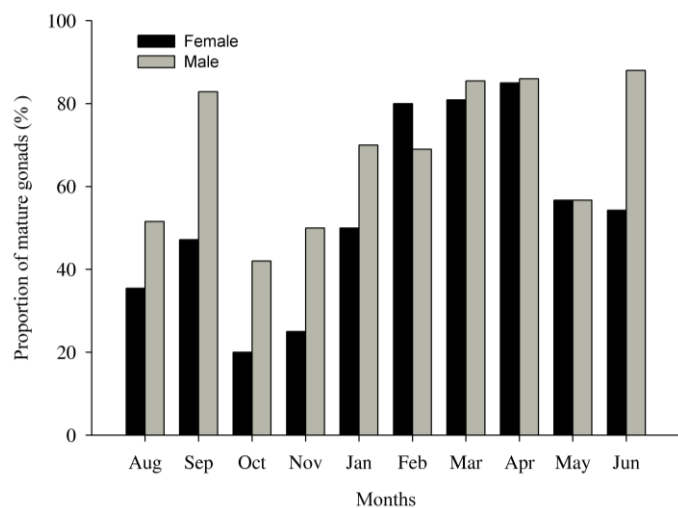


Figure 4. Breeding pattern of *C. carpio* in Amerti Reservoir (August 2011 to June 2012).

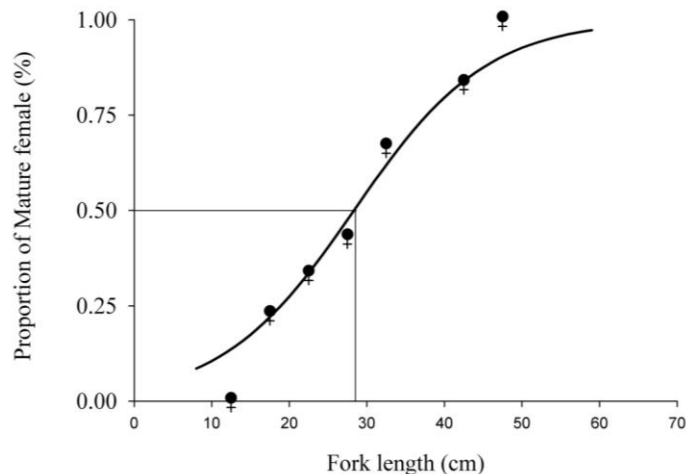


Figure 5. Size at first sexual maturity (L_{50}) for female *C. carpio* in Amerti Reservoir.

1.22 to 1.46 for males and 1.23 to 1.77 for females.

The breeding season of *C. carpio* was determined from percentages of fish with ripe gonads taken monthly from August 2011 to June 2012. Breeding was continuous throughout the year; however the most intense breeding activity was from February to April 2012 (Figure 4). During high breeding time, 69 - 86% of the males and 80 - 85% of the females were found with ripe gonads (Figure 4). The proportion of fish with ripe gonads was relatively low during the months of October and November.

The size at first sexual maturity for male *C. carpio* was 27.2 cm F_L while the females attained first sexual maturity at 28.3 cm F_L (Figure 5). The smallest male found with ripe gonads was 15.5 cm F_L and weighed 74.3 g while the corresponding female was 17 cm F_L and weighed

86.9 g.

The estimated absolute fecundity of female *C. carpio* varied between 36955 and 318584 oocytes per specimen with a mean \pm SD fecundity of 170937 ± 13084 . The relationship between F and F_L were significant ($F = 0.224 * F_L^{3.708}$, $R^2 = 0.933$; $p < 0.001$). Relative fecundity varied between 98 284 and 310 964 oocytes kg^{-1} total body weight, with a mean of $177 786 \pm 48 427$ oocytes kg^{-1} total body weight.

DISCUSSION

Reservoirs can result in productive fisheries based on

their location and management status (Marmulla, 2001). Stocking of exotic species can enhance yields, as long as they are not influencing the indigenous species which are preferred by the community. *C. carpio* has adapted well in the Amerti reservoir with its reproductive trait.

The reproductive cycle and pattern of gonad development of *C. carpio* in natural ecosystems greatly depends on the ambient water temperature (Smith and Walker, 2004; Tempero et al., 2006). Spawning in *C. carpio* occurs at a water temperature of around 18°C (Fernández-Delgado, 1990). The mean monthly water temperature that ranged from 18.9 to 23.1°C during the study period appears to favor year round spawning of common carp in the reservoir. Year round breeding pattern for *C. carpio* has been reported in other tropical lake (Oyugi et al., 2011).

Length at first maturity is variable, ranging from 90 to 430 mm L_T for both males and females in wild *C. carpio* population (Fernández-Delgado, 1990; Prochelle and Campos, 1985). The first maturity for male and female which were 155 mm F_L 170 F_L respectively did not vary from other studies. However, the length at first maturity (27.2 cm F_L for female and 28.3 cm F_L for male) is lower than Lake Naivasha where it is 340 mm for male and 420 mm (L_T) for females (Oyugi et al., 2011).

Length and age at maturity in common carp are related to latitude and sex; males often mature before females, and fish mature earlier at low latitudes when compared with higher latitudes (Tempero et al., 2006). In Amerti Reservoir, males matured at smaller sizes (27.2.6 cm F_L) than females (28.3 cm F_L). This may be related to the preparation of females to sustain large number of eggs. Males attaining maturity at a smaller size than females are also reported in both temperate and tropical aquatic ecosystems (Britton et al., 2007; Tempero et al., 2006).

Determination of fecundity and spawning season are indispensable in understanding the population dynamics of fish species (Sivakumaran et al., 2003). Fecundity also explains the degree of invasiveness and ecosystem impacts (Bajer and Sorensen, 2010). The mean relative fecundity in Amerti reservoir 177 786 kg^{-1} is larger than 97 200 oocytes kg^{-1} reported in Newzeland (Tempero et al., 2006); but comparable with 163 000 eggs kg^{-1} total body weight (Sivakumaran et al., 2003). Females *C. carpio* can carry >1000000 oocytes for length groups >60 cm (Bajer and Sorensen, 2010).

Maturing at small size with large number of oocytes is one of the physiological advantages of the traits of the carp which appear to have provided their population with resilience to the exploitation by providing rapid growth to maturity and the opportunity for early life reproduction prior to their capture.

The establishment and year round reproduction of *C. carpio* in a tropical environment with high fecundity has shown that introducing the species to other natural lakes with prior indigenous fish can threaten their ecology. Indigenous species are expected to have a competitive advantage over newly arriving species adapted to different

species and resource availability (Vermeij and Dudley, 2000). However, physiological advantages of displacement by *C. carpio* have been well documented (Jia et al., 2008). Once *C. carpio* is established in a system, eradication is extremely expensive and in many cases impossible (Zambrano et al., 2006).

In conclusion, *C. carpio* introduced in Amerti Reservoir has adapted successfully. The long spawning period and multiple spawning characteristics of common carp were favored by the ambient temperature of the reservoir. Care should be taken in introduction of *C. carpio* to natural lakes in similar habitats, as it can disrupt native species. Successful fisheries in Amerti reservoir from common carp could be established with a minimum catch size of 28 cm F_L , which could be achieved by using gillnet with a mesh size of 80 mm and above.

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