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Full Length Research Paper

Assessment of length-weight relationship, sex ratio and condition factor of common carp (*Cyprinus carpio* Linnaeus, 1758) in Lake Ziway, Ethiopia

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Abstract

The present study some biometric measurements (length-weight relationship, condition factor and sex ratio) were examined from 1950 specimens of *Cyprinus carpio* L. 1758 (Common carp) collected from Lake Ziway from October 2012 to September 2014. The maximum fork length was observed to be 48 cm in female and 45 cm in male. The relation between fork lengths (13 to 48 cm) and total weight (57 to 2500 gm) was curvilinear and represented as TW = 0.026 $FL^{2.925}$, R^2 = 0.899, P < 0.05. Fulton condition factor values (mean ± SE) varied from 1.49 ± 0.05 to 1.82 ± 0.04 for females and from 1.28± 0.04 to 1.59 ± 0.04 for males. Mean FCF (± SE) was found to be 1.63 ± 0.04 for the females and 1.41 ± 0.03 for the males. The overall mean FCF was 1.52 ± 0.01. Sex ratio was significantly different in size classes between 35-39 cm (X^2 = 25.14) and the overall female to male ratio was 1.1:1 (X^2 = 4.154).

Keywords: Condition factor *Cyprinus carpio, Ethiopia,* Lake Ziway, length-weight relationship, sex ratio.

INTRODUCTION

The Common carp, *Cyprinus carpio* (L., 1758) is a freshwater cyprinid fish that is widely distributed in the world (Vostradovisky 1973; Economids 1991; Kottelat 1997). It occurs in shallow ponds, lakes rich in vegetation and slow moving rivers (Vostradovisky 1973). It burrows in mud in the dry season or winter and tolerates cold, organic pollutants and low oxygen concentration in water (Blazka, 1958; Vostradovisky 1973). Since it is a fast growing and hardy fish that can withstand adverse environmental conditions, it has been successfully introduced into fresh waters throughout the world (Welcomme, 1988; Seegers *et al*. 2003). It is an important food fish in the world that is available round the year. This is also a popular culture fish due to its hardy nature, omnivorous habit, fast growth rate and easy breeding in confined water (Ram *et.al* 2015). As a result, this exotic fish has now become common in natural and manmade water bodies and makes substantial proportion of the inland capture fishery in Ethiopia.

C. carpio was introduced in to Lake Ziway in late 1980's by the staff of Ministry of Agriculture with the intention of increasing fish production by introducing a macrophyte feeder into the system where the niche was not occupied by any of the indigenous fish (FAO, 1997). The ecological impact of such an introduction could be undesirable because the species is known to be a potential pest in many countries for which data are available (Mathewos Hailu 2013). At present *C. carpio* is one of the most commercially important fish species that often forms the basis of commercial

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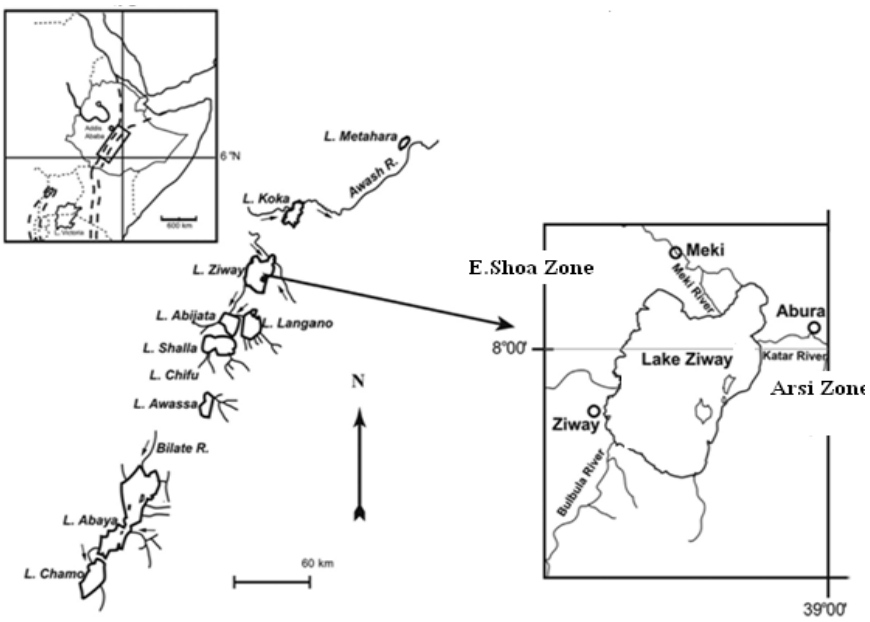

Figure 1: The Ethiopian Rift Valley lakes and map of Lake Ziway

fisheries and the most desired fish species by the local community among the commercially exploited fish species in the lake.

Various workers have studied the reproductive biology of *C. carpio* in some European and Asian water bodies (Vestradovsky, 1973; Laurila *et al*., 1987) and very little work has been done in Ethiopia, like some reproductive aspects of the fish in Amerti (Mathewos Hailu 2013). So far no work has been done on the biology and ecology of *C. carpio* in Lake Ziway. Hence, Length-weight relationship gives the condition and growth patterns of fish. It provides important information concerning the structure and function of fish populations (Lemma Abera 2013). The length-weight relationships of a particular species allow the inter-conversion of these parameters. Fish are said to be growing isometrically if the length increases with equal proportion to body weight for constant specific gravity (Olurin and Aderibigbe 2006) while allometric growth is assumed when the increase in any of the parameters (length or weight) is un proportional to the other. It is, therefore, possible to estimate the weight or length of fish from either of each parameter that is available from a formula that takes into account the growth pattern (whether isometric or allometric).

Condition factor refers to the well-being of the fish in question and by extension its health status (Blackwell *et al* 2000). It is, therefore, an index reflecting interactions between biotic and abiotic factors to the physiological condition of fish. Condition factor is estimated by comparing individual fish weight of a given length to a standard weight. It is assumed that heavier fish reflect a healthier physiological state. It is an important concept in fisheries management and can be used to assess the health and potential of any fishery to support the fishing pressure. This simple approach and interpretation can therefore aid in development of intervention measures which can easily be implemented by fishery managers especially with respect to maintaining a healthy fish population through controlling of the fishing effort. Therefore, the main focus of this paper is to investigate some aspects of the biology (Length-weight relationship, sex ratio and condition factor) of *C. carpio* in the lake with the aim of providing preliminary necessary scientific information for proper utilization and management of the stock.

METHODOLOGY

Lake Ziway: The Lake is found in the Ethiopian part of the Great East African Rift Valley. It has an open water area of 434 km^2, average depth of 2.5 m, and an elevation of 1636 m.a.s.l. (Wood and Talling, 1988). The Ziway watershed falls in between 7^{0}54'N to 8^{0}55'N latitude and 38^{0}14E to 38^{0}56'E longitude covering a total area of about 7300 km^2 (Figure 1). It is comprise of two main rivers, Meki from the north-west and Katar from the east flowing into the lake and it has an outflow through Bulbula River, draining into Lake Abijata (Figure1).

Data on mean monthly maximum and minimum air temperature, and monthly total rainfall for the year 2013 of the lake region were obtained from National Meteorology Agency of Ethiopia. According to the data, given in Figure 2, mean monthly minimum air temperature ranged from

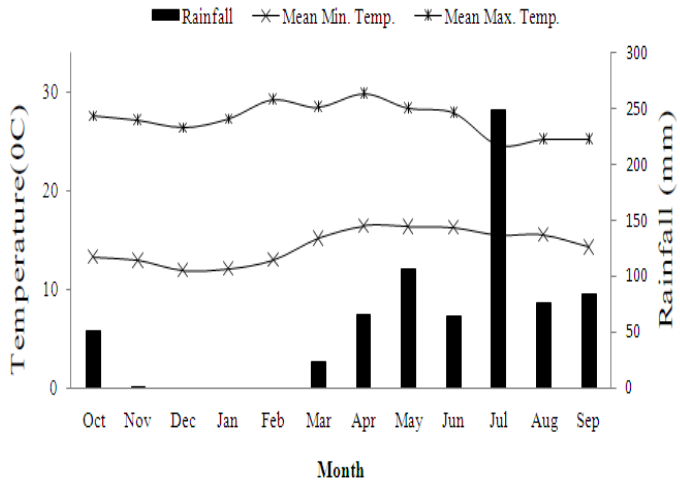

Figure 2: Monthly total rainfall, mean minimum and maximum air temperature of the lake region.

11.9 to 16.4 ^{0}C, while the maximum mean monthly air temperature varied from 24.6 to 29.8 ^{0}C. Monthly total rainfall varied from 1.9 mm (November 2013) to 249 mm (July 2013). Although the region was described as having two rainy periods (Amare Mazengia 2008), the minor one extending roughly from March to May and the major one between June and September, appreciable quantities of rainfall were recorded throughout from April to September, 2013, and peaking in July. Daniel Gamachu (1977) also documented that the lake area has moderate rainfall with the major peak occurring between July and August and a minor peak between February and May. The present meteorological data also show comparable trend (Figure.2).

The fish community found in Lake Ziway is composed of six indigenous fish species comprising *Barbus ethiopicus*, *Barbus paludinosus*, *Labeobarbus intermedius*, *Garra makiensis*, *Garra dembecha* and *Oreochromis niloticus* (Golubtsov *et al*. 2002; Eshete Dejen *et al*. 2010) . The lake also harbors four exotic fish species *Tilapia zillii*, *Carassius carassius, Clarias gariepinus* and *Cyprinus carpio* (Golubtsov *et al*. 2002).Of all these species *B.ethiopicus* is endemic to Ethiopia and unique to this lake.

Sample Collection and Measurements

Samples of *C.carpio* were collected monthly for 24 consecutive months between October, 2012 and September, 2014. Sampling sites were selected based on geographical proximity and/or habitat similarity (river mouths neighboring floodplains, depth and distance to shore). In each sampling site fishing was conducted using gill nets having different mesh sizes (6 cm, 8 cm, 10 cm, 12 cm and 14 cm stretched mesh). The gear was set parallel to the shoreline in the afternoon (05:00 pm) and lifted in the following morning (7.00 am). Immediately after capture the fish were serially tagged, the total length (TL), fork length (FL) and total weight (TW) of each specimen were measured to the nearest 0.1 cm and 0.1g, respectively. Each specimen was then dissected and its sex determined by inspecting the gonads.

Length-weight Relationship and Condition Factor

The relationship between fork length and total weight of *C. carpio* was calculated using least squares regression analysis (Bagenal and Tesch, 1978) as follows:

$TW = aFL^b$

Where: TW = Total weight (gm)

FL = Fork length (cm)

a = Intercept of the regression line, b = Slope of the regression line

An allometric coefficient *b* value larger or smaller than 3.0 shows an allometric growth, or isometric growth when it is equal to 3.0 (Bagenal and Tesch 1978). The determination coefficient (r^2) was used as an indicator of the quality of the regressions.

The well being of each species was studied by calculating Fulton Condition Factor (Bagenal and Tesch, 1978). Fulton Condition Factor (%) was calculated as:

$FCF = TW / FL^3 \times 100$

Where: FCF = Fulton condition factor,

TW = Total weight in grams

FL = Total length in centimeters.

Estimation of sex-ratio: Both female and male fish were recorded for each sampling occasion. Sex-ratio (female: male) was then calculated for the total sample. Chi-square test was employed to test if sex ratio varied from one - to - one in the total sample as in Demeke Admassu (1994).

RESULTS AND DISCUSSION

Size Composition of the Sample

A total of 1950 (1020 female and 930 male) *C. carpio* individuals were caught during the study. The fork length of the fish ranged from 15 to 48 cm for females and from 13 to 46 cm for males. The corresponding total weights ranged between 80 and 2500 grams for females and 57 to 2000 grams for males. The greater proportion of the sampled fish ranged in size class between 20 and 39 cm for both sexes, the peak being between 25 and 29 cm for females and 30 to 34 cm for males. This length group alone was about 27% for females and 29% for males in the total sample. Fish over 35 cm and below 24 cm FL were least represented and accounts less than 16% in the sample (Figure 3).

Length - weight Relationship and Condition Factor

Length-weight relationship of *C. carpio* in Lake Ziway was curvilinear and statistically highly significant ($P<0.05$) (Fig. 4). The equations separated by sex were as follows.

Males: $TW = 0.029 \times FL^{2.88}$, $R^2 = 0.91$, $n = 930$

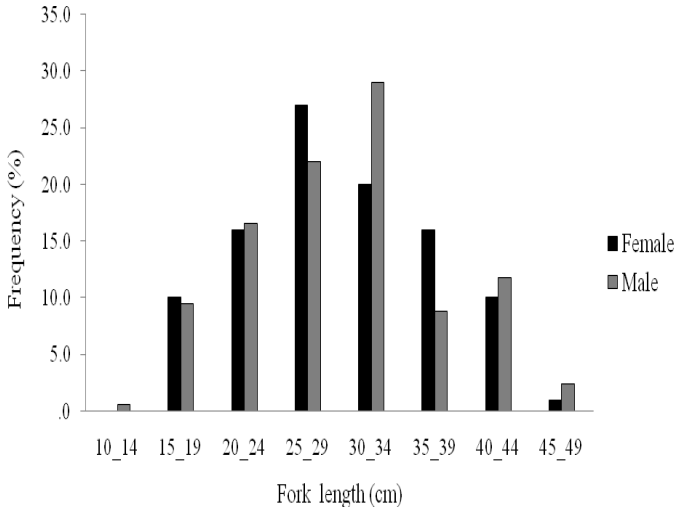

Figure 3: Length-frequency distribution of *C.carpio* from Lake Ziway

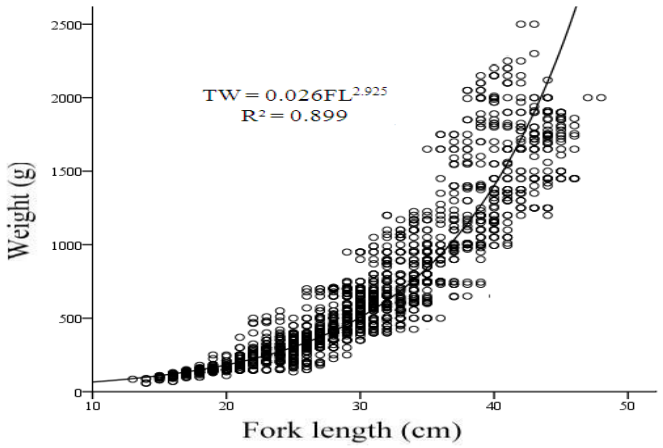

Figure 4: Pooled length-weight relationship of *C. carpio* in Lake Ziway (From Oct.2012 –Sep.2014)

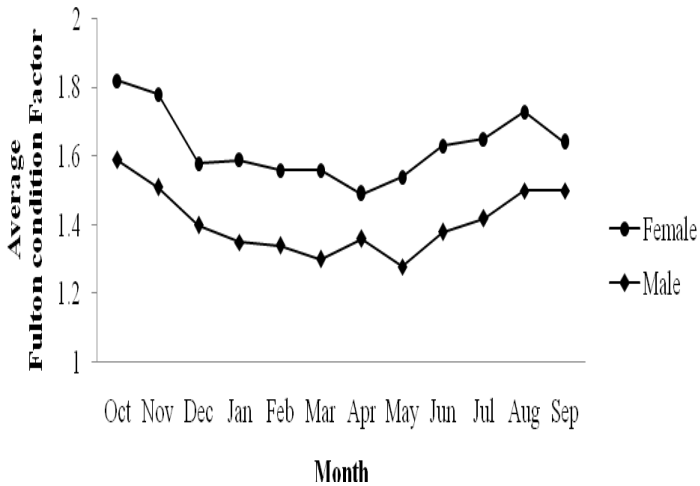

Figure 5: Pooled Monthly Average Fulton condition factor of female (□) and male (♦) *C. carpio* from Lake Ziway (From Oct.2012 – Sep.2014)

Females: $TW = 0.024 \times FL^{2.96}$, $R^2 = 0.90$, n = 1020

Therefore, an equation combined for fish ranging in length from 13 to 48 cm, and in total weight from 57 to 2500 g for both sexes was fitted and as shown in Fig. 4.

The largest *C. carpio* caught in the present study was a female with FL of 48 cm. This was found to be comparable to the largest size recorded for the species from Amerti Reservior (45 cm; Mathewos Hailu 2013) and from the country but smaller than that from the highland Lake Skadar (83 cm; Milosevic and Maric 2012). There was a curvilinear relationship between fork length and total weight of the fish in the lake (Figure 4). The parameter *b* value remained mostly within the expected range of 2.5 -3.5 (Froese 2006). Hence, the value of *b* in this study 2.88 (male), 2.96 (female) and 2.93 (for the population) was close to the theoretical value (*b* = 3), indicating isometric growth. This finding is in agreement with the principle of fish growth (Bagenel and Tesch, 1978), and comparable to the value of *b* calculated for the same species in Amerti (2.923) (Mathewos Hailu 2013).

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. Hence, average monthly Fulton condition factor (FCF) values (mean ± SE) of *C. carpio* ranged from 1.49 ± 0.05 (in April) to 1.82 ± 0.04 (in October) for females (Figure 5), and from 1.28± 0.04 (May) to 1.59 ± 0.04 (in October) for males (Figure 5). Mean FCF (± SE) was found to be 1.63 ± 0.04 for the females and 1.41 ± 0.03 for the males. The overall mean FCF was 1.52 ± 0.01.

Generally, the females had higher FCF values than the males. However, sex by month interaction was insignificant (ANOVA, P>0.05) suggesting that temporal variation in FCF was similar for both sexes (Figure 5). Thus, FCF of both sexes was high during June to November, but relatively low during the rest of the months (Figure 5). Hence, relatively low condition factor was characterized by poor environmental conditions and the period of reproduction of the fish. This study coincided with the seasons that cause the decreased metabolism of the fish, so dropping the somatic overweight (Laurila *et al*. 1980). According to Mathewos Hailu (2013) the corresponding values Fulton's condition factor of *C. carpio* for both sexes was 1.22 ± 0.14. The value varied from 1.22 to 1.46 for males and 1.23 to 1.77 for females. Thus, *C.carpio* in Lake Ziway show a relatively better well-being than that in Amerti,

Additional evidence can also be obtained by using length-weight equations fitted in the present study such as the work by Mathewos Hailu (2013). In other words, a 17 cm fish fork length *C. carpio* would weigh 86.9 g in Amerti reservoir, and 120 g in Lake Ziway. Hence, it can be concluded that the *C. carpio* population grows relatively faster in Lake Ziway than that in Amerti. The reason for this difference may be related to the differences in productivity of the two water bodies and those factors that enhance productivity such as higher temperature, less competition in Lake Ziway, including food quality and quantity.

Table 1. Pooled monthly number of females and males and sex ratio of *C. carpio* in Lake Ziway (From Oct.2012 –Sep.2014) (* means significant at 5% level).

Month	Female	Male	Sex- ratio	X^2
Oct.	53	54	0.93:1	0.009
Nov.	59	55	1.07:1	1.4
Dec.	60	56	1.07:1	1.38
Jan	75	72	1.06:1	0.061
Feb.	86	82	1.07:1	0.095
Mar.	87	76	1.15:1	0.742
Apr.	88	94	0.94:1	0.198
May.	87	83	1.05:1	0.024
Jun.	97	86	1.13:1	0.661
Jul.	115	86	1.29:1	3.591
Aug.	104	93	1.12:1	0.614
Sep.	109	91	1.2:1	1.620
Total	**1020**	**930**	**1.1:1**	**4.154***

Table 2. Pooled number of female and male and sex ratio of *C. carpio* in various size classes in Lake Ziway(From Oct.2012 –Sep.2014) (* means significant at 5% level).

Size class	Female	Male	Sex- ratio	X^2
10-14	0	5	0.0:1	-
15-19	97	88	1.1:1	0.438
20-24	161	154	1.05:1	0.079
25-29	245	269	0.91:1	1.121
30-34	238	201	1.18:1	3.118
35-39	160	82	1.95:1	25.14*
40-44	107	109	0.98:1	0.019
45-49	12	22	0.55:1	2.941
Total	**1020**	**930**	**1.1:1**	**4.154***

However, a detailed study is required to confirm this conclusion.

Results of FCF of *C. carpio* in Lake Ziway suggest that females are in relatively better condition than males. Our finding agrees with sex-biased difference in FCF reported for other fish species in the country (Elias Dadebo, 1988; Leul Teka, 2001; Lemma Abera 2007). It is also common to find populations whose female members grow superiorly and have better condition than the males (Fryer and Iles, 1972).

Sex Ratio

Sex ratio results are presented in Tables 1 and 2. The ratio was not significantly different from the hypothetical distribution of 1:1 ($P > 0.05$) for all sampling months (Table. 1). While, this indicates that the sex ratio found in the carp population from the lake was very close to 1:1, which suggests a well balanced population; the overall sex ratio (1.1:1) was significantly different ($X^2 = 4.154$) from 1:1 showing a preponderance of the females (Table 1 and 2). In addition, sex ratio of the fish was also similar to 1:1 for length classes, except in length interval between 35 to39 cm when there was preponderance of females over males (Table. 2).

Preponderance of females over males in this study had been recorded in the populations of the same species (1 M: 1.5 F) (Mathewos Hailu 2013) and other species in Ethiopia (Elias Dadebo, 1988; Leul Teka, 2001; Lemma Abera 2007). The authors suggested that sex disparity could be a result of the differential survival potentials of the species against certain environmental conditions of a water body. Offem *et al* (2007) and (2009) described it as a mechanism for regulations or sex related behaviors in fishes, such as female emigrate between and feeding grounds exposing them to the possibility of better opportunities for better quality and quantity of food. Finally, it is recommended that as this is the first study on *C.carpio* in Lake Ziway, it may be necessary to conduct the same experiment for a long period covering all season and various parts of the lake in comparison with the performance of other competing species of the lake.

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