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Original Article

Reproductive biology and condition factor of the African catfish, *Clarias gariepinus* (Burchell 1822) in Lake Koka, Ethiopia

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Abstract
The study was conducted to investigate the breeding season, sex ratio, size at maturation, fecundity and condition factor of African catfish *Clarias gariepinus* in Lake Koka. A total of 754 fish specimens were collected from October 2020 to August 2021. Total length and weight were measured and sexes were identified and gonad maturity levels were recorded. The sex ratio of African catfish in different size classes was similar to that of a hypothetical 1:1 ratio. The length at first maturity (L_{50}) was 51.8 cm in total length. The mean Fulton's condition factor of female African catfish ranged from 0.65 ± 0.05 – 0.71 ± 0.14, while the males ranged from 0.62 ± 0.04 – 0.7 ± 0.11. The Fulton's condition factor was significantly higher in August for females than in the rest of the sampling months. The highest ripe gonads were recorded in the rainy season and the lowest was in the dry season, with the percentage of ripe gonads being 27.5%, while the males showed similarly extended maturity patterns among seasons. Fisheries management for African catfish should therefore take into account the estimated L_{50} value and the main breeding season to sustain the fishery and benefits the fishermen.

Keywords: breeding season; fecundity; Fulton's condition factor; maturity; sex ratio

1 | INTRODUCTION

In Ethiopia, African catfish (*Clarias gariepinus*) is widely distributed in most water bodies both in major river basins and lakes (Golubstov and Mina 2003; Habteselassie 2012). African catfish is the second most important commercial fish species in Ethiopia's capture fishery next to the Nile tilapia, *Oreochromis niloticus* (Tesfaye and Wolff 2014). Generating information on the biology (reproductive, food and feeding habit) of freshwater fish species is important for proper decision making in developing appropriate management programme in the capture fishery as well as in the culture systems.

The food and feeding habits of African catfish has been documented by various scholars (Dadebo 2000, 2009; Dadebo *et al.* 2014; Admassu *et al.* 2015). However, the reproduction biology and condition factor of fish vary depending on location of the habitat and the climatic conditions (Dadebo 2000; Billard and Breton 1978). Therefore, generating baseline information on the reproductive biology of the African catfish would support the management efforts of this important resource in Lake Koka. Besides, since Lake Koka is serving as a source of parent African catfish brood stock and pituitary gland for captive breeding, proper understanding of the reproduc-

tive biology of this fish species at its natural habitat will be very much helpful for successful fish culture as the pituitary gland obtained during the peak breeding season is much potent than those in the other seasons.

Moreover, condition factor is an indicator of the well-being of fish (Bagenal and Tesch 1978). Since the condition of fish affects the reproductive potential of a given species, it is important to understand the factors that influence the condition of fish and to know when the African catfish has a good condition in Lake Koka. The present study aims to investigate some of the essential reproductive traits and condition factor of the African catfish in Lake Koka.

2 | METHODOLOGY

2.1 The study area

The Lake Koka is located in the Ethiopian Rift Valley (08°23′22″N 39°05′15″E) at an altitude of 1590 m.a.s.l. It has a surface area of about 255 km^2; the maximum and mean depth of the lake is 14 m and 9 m respectively (Tesfaye and Wolff 2015). It is 90 km far from the capital, Addis Ababa in the Southeast direction (Figure 1). The Awash River is the main water supplier all year round and Mojo River inflows during rainy season. According to Daniel Gamachu (1977) the area is characterised by four months of dry season (November – February) and eight months of rainy season (March – October). Lake Koka has a production potential of 1362 t year^{-1}. It contributes about 7% of the country's annual catch (Gashaw *et al.* 2015).

2.2 Fish sampling

The fish specimens were collected at three different landing sites: Mojo Rive (MJ), Meto Aleka (MA) and Kentery (Kt) (Figure 1). A total of 754 fish specimens were bought from fish collectors at the landing sites. The fish specimens were collected from October 2020 to August 2021 at six sampling occasions. The total length (TL) and total weight (TW) were measured to the nearest 0.1 cm and 0.1 g respectively. Each fish specimen was dissected, sex and maturity stages determined by visual observation of the gonad using five maturity scales. The gonad maturity level was determined according to Bagenal and Braum (1978). The maturity level classified as immature (I); recovery spent or developing virgin (II); ripening (III); ripe (IV); and spent (V). The ripe ovaries were collected to determine fecundity, weighed to the nearest 0.1 g and preserved with Gilson's fluid.

2.3 Determination of fecundity and sex ratio

The fecundity of ripe ovaries was estimated using gravimetric methods (Bishail *et al.* 1974). All the ovaries' eggs were weighed and preserved in Gilson's fluid. Two subsamples of ovaries were weighed and the eggs were counted. The average number of eggs was calculated from the two sub-sample eggs that were taken from each gonad. A chi-square test was employed to determine if the sex ratio varied between months and with fish size. The total number of eggs per female was calculated as follows:

Fecundity = (Average No. of eggs in the sub sample × gonad weight) / (Average weight of two sub samples)

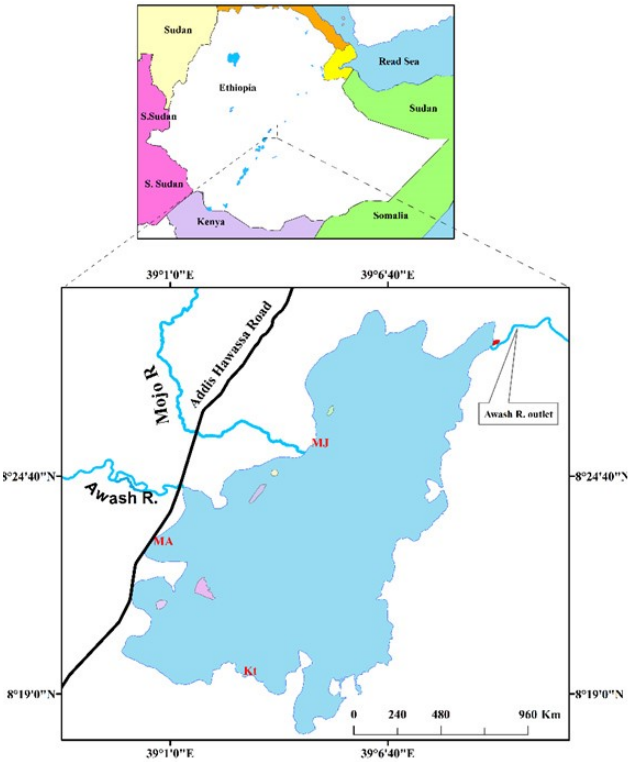

FIGURE 1 Map of Ethiopia and the geographical location of Lake Koka (source: Tesfaye 2016).

2.4 Length at first maturity and breeding season

The length at first maturity (L_{50}) commonly refer to as the length at which 50% of the total number of individuals of a length group reaches maturity (Willowughby and Tweddle 1978) was estimated using a logistic regression analysis following Gunderson *et al.* (1980):

$$P_x = \frac{1}{(1+\exp^{(bx+a)})}$$

The breeding season was determined by looking at the seasonal variation of the ripe gonads. As year-round sampling was not possible due to the Covid restriction and security problems during the main sampling periods, we have grouped the six sampling occasions as dry season, pre-rainy season (short rain) and rainy season. Sampling months of October, December and January represents dry season, March and April as pre-rainy season and August as rainy season.

2.5 Condition factor (K)

The wellbeing of AFrican catfish was determined using Fulton's condition factor (Bagenal and Tesch 1978). Fulton's condition factor (*K*) is calculated as follows. K = W / L^3 × 100, where, *W* is the total body weight and *L* is the total length.

2.6 Statistical analysis

All data were analysed using one-way analysis of variance (ANOVA) SPSS version 25 (IBM, SPSS) with the results represented as Chi-square. Sigma Plot (version 12) was incorporated to determine L_{50}.

3 | RESULTS

A total of 754 fish specimens of African catfish ranging in size from 20 – 110 cm were bought from fishermen, of which 368 (48.8%) were females, while the remaining 387 (51.2%) were males. The largest female caught was 105 cm and weighed 8853 g. While the largest male caught was 110 cm and weighed 9118 g. The total female to male ratio was 1:1 which was quite similar to the hypothetical sex ratio in the natural environment (Table 1). There was no significant difference in sex ratio of fish caught in all length classes (Chi-square test, $p > 0.05$). The number of eggs in the ripe ovaries varied from 3966 to 444880 eggs per female and the mean fecundity was 70085 eggs per female. The lowest fecundity was 3966 eggs in the fish that weighed only 352 g that had an ovary weight of 6 g (1.7% body weight). Whereas the highest fecundity was counted from the fish measured 98 cm length and 8306 g total body weight with ovary weight of 855 g (10.3% their body weight).

TABLE 1 The number of females, males and sex ratio of *Clarias gariepinus* caught from the Lake Koka.

Month	Female	Male	Sex ratio (F : M)	Chi-square value	*p*-values
Jan	89	102	1 : 1.15	0.88	0.970
Mar	85	99	1 : 1.16	1.07	0.960
Apr	41	51	1 : 1.24	1.09	0.950
Aug	71	55	1 : 0.77	2.03	0.850
Oct	44	43	1 : 0.98	0.01	1.000
Dec	38	36	1 : 0.95	0.05	1.000
Total	368	386	1 : 1.05	0.43	0.990

3.1 Length at first maturity

The percentage of female and male African catfish having a gonad stage of III, IV and V were considered matured fish. In Lake Koka, the length at which 50% of African catfish fish first maturity was computed as 51.8 cm TL and its 95% confidence interval ranges from 50.2 to 53.3 cm (Figure 2).

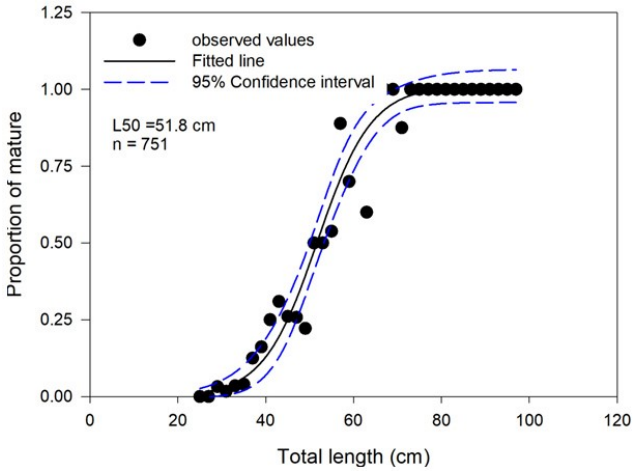

Figure 2 Length at first maturity (L_{50}) of *Clarias gariepinus* in the Lake Koka.

3.2 Fulton's Condition factor (*K*)

The Fulton's condition factor (Mean ± SE) of female African catfish ranged from 0.65 ± 0.05 – 0.71 ± 0.14 while that of males ranged from 0.62 ± 0.04 – 0.7 ± 0.11 (Figure 3). The smallest condition factor was recorded in December for males; October and December for females. The Fulton's condition factor was significantly higher in August for female African catfish. The reproductive period of African catfish was determined from the percentage of fish with ripe gonads taken in different seasons. Even if there were maturity eggs and milts existed in different seasons, the highest ripe gonad percentages were found during the rainy seasons with a 90.3% for females. On the other hand, lower percentages of ripe gonads were recorded during the dry season with only 27.5% ripe gonad in female. The males have shown similar maturity patterns at different seasons with ripe gonads ranging from 57.4- 63.0% ripe gonads in each season (Figure 4).

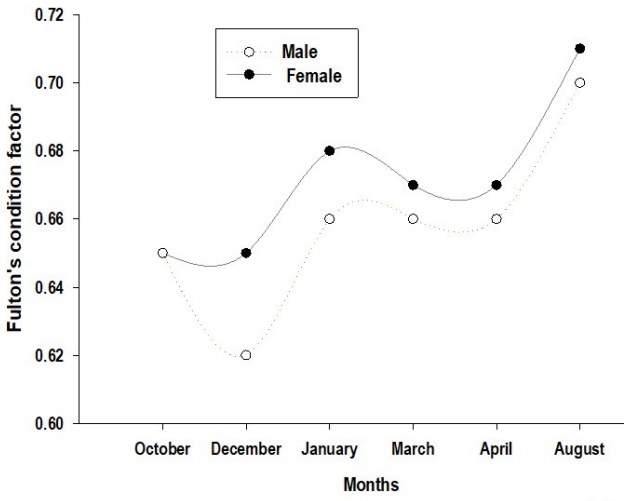

FIGURE 3 The mean Fulton's condition factory of *Clarias gariepinus* in the Lake Koka.

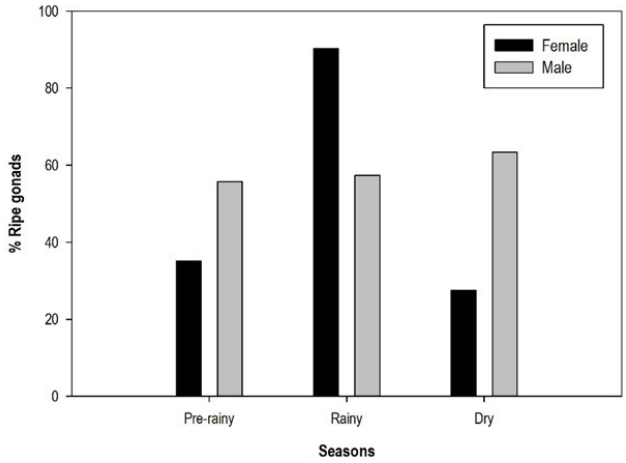

FIGURE 4 Seasonal variation of ripe gonads in *Clarias gariepinus* in the Lake Koka.

4| DISCUSSION

The study indicates that the overall number of females to male ratio in different length classes was close to the expected hypothetical 1:1 ratio. This might be due to the inclusion of all fish, samples caught using beach seine, monofilament and multifilament gill nets and the representative random specimen was taken from this aggregate catch from fish collectors. Similar studies showed different sex ratios in Lake Hawassa and Lake Chamo (Dadebo 2000; Dadebo *et al*. 2011). The sex ratio in fish could vary from species to species and from year to year with the same population (Nikolsky 1963). In the wild population, however, sex ratio is close to one to one unless there is a bias in the sampling process.

4.1 Length at first maturity

The size of African catfish at first maturity was slightly smaller than previously reported value (53.4 cm) (Tesfaye *et al.* 2016), but similar to the upper limit of our estimated 95% CI of L_{50} value. Fishing mortality is negatively correlated with fish size at maturity. An increase in the mortality rate of fish causes a change in the population's reproductive pattern to compensate for the losses caused by fishing activities (Wootton 1998). The fishing pressure on African catfish is higher because of its high demand as food fish as a result the length at first maturity becomes smaller compared to previous studies in the same lake. The size at first maturity in the Lake Chamo shows that it was 58 cm for female catfish and 52 cm for male African catfish (Dadebo *et al.* 2011). This implies that African catfish matured at larger size in Lake Chamo than in Lake Koka. However, the first length at maturity of African catfish in Lake Tana was 43.2 cm for males and 57.7 cm for females (Tewabe 2013). These results clearly indicated that the L_{50} of African catfish varies between stocks and/or water bodies.

4.2 Fulton's Condition factor

The Fulton's condition factor is an indicative of better physiological condition or wellbeing of a fish (Bagenal and Tesh 1978). In the presented study, the African catfish showed a better body condition during the rainy season than the pre- rainy and dry seasons. This could be due to the high number of matured fish that contain the highest number of eggs in their ripe gonads. This is clearly shown by their computed value of gonado-somatic index (GSI). In August, the GSI of African catfish was 1.9, while it was 1.6 in March and 0.9 in October. The pre-spawning fish showed a higher GSI than spawned fish with ripe ovaries. Studies indicate that the oocytes of 20 µm diameter contribute over 65% of ovaries weight in the fish (Latif and Rashid 1972). The present study showed that the mean ovary weight contributes 10.3% of the total fish body weight and supports suggestion of Latif and Rashid (1972) on ovary contribution to fish body weight. Another possible reason is that they have a high level of fat deposition in their body and the optimal water temperature may have encouraged the African catfish to feed actively throughout the wet months. The zooplankton abundance variation in lakes will have an impact on the condition factor fluctuation across seasons. Previous study showed that rainfall boosts phytoplankton and zooplankton productivity in the Rift Valley lakes, which is associated with increased nutrient loads from the watersheds (Elizabeth Kebede *et al*. 1994). However, further research should be conducted to determine the precise environmental factor that was responsible for the seasonal variation in condition factor of the fish in the Lake Koka.

In Lake Koka, the highest number of ripe gonads in African catfish was recorded during the rainy season, even though the other season's ripe gonads were available, but their proportion was less in number. Male African catfish showed a uniform ripe gonad in a different season, which implies that, it has a prolonged spawning period compared to females in different seasons. An earlier study indicated that the spawning period of African catfish occurred from February to August in Lake Hawassa and from March to June in Lake Chamo (Dadebo 2000). The present study indicates that the African catfish showed a similar peak breeding season to that of the Lake Hawassa and Chamo. Several environmental factors could be responsible for high spawning activities. The main trigger factors associated with spawning period include rainfall and water temperature. The peak breeding period of African catfish is correlated with the maximum rainfall, a rise in water level and flooded ponds and river margins stimulate the fish to spawn (Haylor and Muir 1998). Maturity stages of African catfish are influenced by water temperature change in the lake and spawning is triggered by rainfall (De Graaf *et al.* 1995). Even in the same region, gonad development may vary because of differences in environmental conditions. African catfish do not take care

of their laid eggs and young; rather, they select a suitable spawning site with a rich food supply so that the larvae can use after hatching (Payne 1986).

5 | CONCLUSIONS

In this study, the highest body condition factor of African catfish was recorded in the rainy season, which shows the wellbeing of the fish in the lake. Even though the African catfish breeding period varies with location, most of the breeding has been associated with rainy seasons. The current study showed that 90.3% of the catfish carried matured eggs in August, which is the peak rainy season in the area. The rise in water volume and water temperature in the surrounding area and short rain of the area appear to be important triggering factor for the spawning of the fish. Therefore, for artificial propagation purposes of this fish, the parents should be collected from the wild in July and August since they carry ripe eggs and it is possible to breed them artificially under a hatchery set up. Even the pituitary collection should be collected in the potency period, which is mainly in the rainy seasons, mostly in August. The current finding of African catfish length at first maturity was slightly lower than previous investigations in the same lake. This suggests that the lake fishery management was not proper in the last decade. Currently, fishermen use monofilament gillnets that are known to be destructive fishing gear in Ethiopia and many other African countries. So, proper management should be introduced to sustain the African catfish fishery in Lake Koka.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

AW conceptualisation, formal analysis, investigation; AD software, writing original draft, writing review & editing; GT data curation, writing original draft, writing review & editing; GT formal analysis, mapping the study area, writing review & editing; DAT formal analysis, writing original draft, writing review & editing.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request to the corresponding author.

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