Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer-Reviewed International Journal

Article Code: 0377/2022/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 9, No. 2, August 2022: 221-228.

REPRODUCTIVE BIOLOGY OF RIPON BARBEL (*Labeobarbus altianalis*) IN RIVER KUJA-MIGORI BASIN, KENYA

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ARTICLE INFO

Received
25 May, 2022

Revised
19 July, 2022

Accepted
18 August, 2022

Online
31 August, 2022

Key words:
Fecundity
Length
Ripon barbel
Gonadosomatic index
Kenya

ABSTRACT

The present study aimed to investigate the reproductive biology of *Labeobarbus altianalis* from River Kuja-Migori basin, Kenya. This fish species is distributed in most water bodies in the Lake Victoria basin and effluent rivers. *Labeobarbus altianalis* is susceptible to fishing due to aggregation at the river mouths during reproduction seasons. We conducted a study for 18 months with an objective of determining length at 50% sexual maturity, fecundity, gonadosomatic index, egg size, sex ratio and breeding season of *L. altianalis.* The results showed that breeding of this fish occurred from March to August and September to November coinciding with longer and shorter rain seasons. Fecundity ranged from 1320-2382 eggs (mean 1552 ± 23.3). There was a strong correlation between fecundity and total length (R^2 = 0.994). The mean egg diameter was 1.2 ± 0.007 mm. Mean gonado-somatic index was 5.63 ± 0.34 and 2.24 ± 0.21 for females and males respectively. The length at 50% sexual maturity was estimated to be 16.3 cm and 18 cm total length for males and females respectively. There was no significant difference in sex ratio from the hypothetical 1:1 (χ^2, $p > 0.05$). Females had low fecundity and males attain sexual maturity earlier than females. Results from this study provide important information for managing riverine fishery in the Lake Victoria basin.

To cite this article: Kembenya E., A. Getabu, J. Njiru and R. Omondi, 2022. Reproductive biology of Ripon barbel (*Labeobarbus altianalis*) in River Kuja-Migori basin, Kenya. Res. Agric. Livest. Fish., 9 (2): 221-228.

INTRODUCTION

Ripon barbel, *Labeobarbus altianalis* belongs to the family Cyprinidae and is distributed in most water bodies of the Lake Victoria basin and effluent rivers (Rutaisire *et al*., 2015). It is among fish species that can sustain commercial riverine fishery in the basin (Masese *et al*., 2020). In Kenya it's found in rivers Nzoia, Nyando, Yala, Sondu, Kuja-Migori and Mara among others (Achieng *et al*., 2021; Chemoiwa *et al*., 2017). Although, *L. altianalis* is considered a species of less concern, the indigenous stocks face a serious threat due to degradation of their habitats (Ondhoro *et al*., 2017; Chemoiwa *et al*., 2013). This fish species is susceptible to fishing as a result of aggregation at the river mouths during spawning (Ogutu-Ohwayo, 1990). Most fish species in the family Cyprinidae inhabit riverine environments but have also adapted to live in lake environment. *Labeobabus altianalis* exploits the lacustrine-riverine interconnectivity for migration up the rivers to breed (Rutaisire *et al*., 2015; Gebremedhin, 2012). Migration among fish communities between the rivers and Lake Victoria is a common feature in the basin (Manyala *et al*., 2012). Besides *L. altianalis,* other potamodromous fish include; *Schilbe intermedius*, *Synodontis victoriae, Bagrus docmak*, and *Clarias gariepinus* (Masese *et al*., 2020). Commercial fishery in major rivers in Kenya was once lucrative but has declined over time (Balirwa *et al*., 2003). The decline in commercial riverine fishery is attributable to pollution, degradation of fish habitats (Achieng *et al*., 2021), use of illegal gears which target egg laden females at the river mouths at the time of reproduction and introduction of alien species into Lake Victoria basin (Ogutu-Ohwayo, 1990). Most studies have focused on Lake Victoria fish communities but little has been done on riverine fish species. Earlier studies indicate a decline in biomass of riverine migratory fish, where exotic species are dominating with few indigenous species (Ochumba and Manyala, 1992).

Sexual maturation, a process of fish becoming capable of sexual reproduction occurs once in life, when an individual fish moves to adult stage (Domínguez-Petit *et al*., 2017). Knowledge on reproduction in fish is important for proper management of fisheries. This is so because most fisheries resource regulators rely on size at which fish attain sexual maturity, the commencement and spawning duration for management (Trindade-Santos and Freire, 2015). In addition, some fish management measures are completely based on reproductive characteristics of fish stocks (Morgan, 2008). However, when there is no information on reproduction, overexploitation of natural fish stocks is likely to occur. Late sexual maturation may result into larger fish with increased fecundity at the time of spawning (Nunes *et al*., 2011). The aim of the present work was to study breeding season, sexual maturity, fecundity, gonadosomatic index, and sex ratio of *L. altianalis* from River Kuja-Migori.

MATERIALS AND METHODS

Study area

Fish samples were collected from January 2018 to June 2019 in five sampling points (S1-S5) on the River Kuja-Migori (Figure 1). The River Kuja - Migori basin is located on the western part of Lake Victoria, Kenya.The basin receives rain almost throughout the year, with two major peak seasons. The long rains occur in March to August while short rains commence from September to November with an annual rainfall of 1800 mm per year (Kizza *et al*., 2009). The river basin supports an artisanal fishery and is also used for irrigation, generation of hydroelectric power, livestock and domestic use. However, the basin is threatened by anthropogenic activities on the catchment such as encroachment into wetlands, urban developments and poor management of wastes.

Sampling

The fish were caught using a 400 V (10 A) electrofishing equipment with 50 m long electric cable. Sampling was done on wadable areas of the river and the stunned fish (n =1217) were collected by a dip net (10 mm mesh-size). A river reach of 50 m at each sampling station was sampled starting from downstream. The total lengths (TL cm) of randomly selected fish from each sampling site were measured using a measuring board to the nearest 0.1 cm. The fish were weighed using an electronic balance model Shimadzu AUW 320 to the nearest 0.1 g.

Breeding season

Macroscopic examination of maturity stages was done in the laboratory soon after capture. Only females whose oocytes were free in the lumen of the ovaries (ovulated eggs) which were easily released by gentle pressing of the abdomen were used. An estimation of the breeding season, relies on accurate determination of various stages of maturation. Given that this is usually determined for female fish, we considered the female fish only as suggested by (Núñez & Duponchelle, 2009).

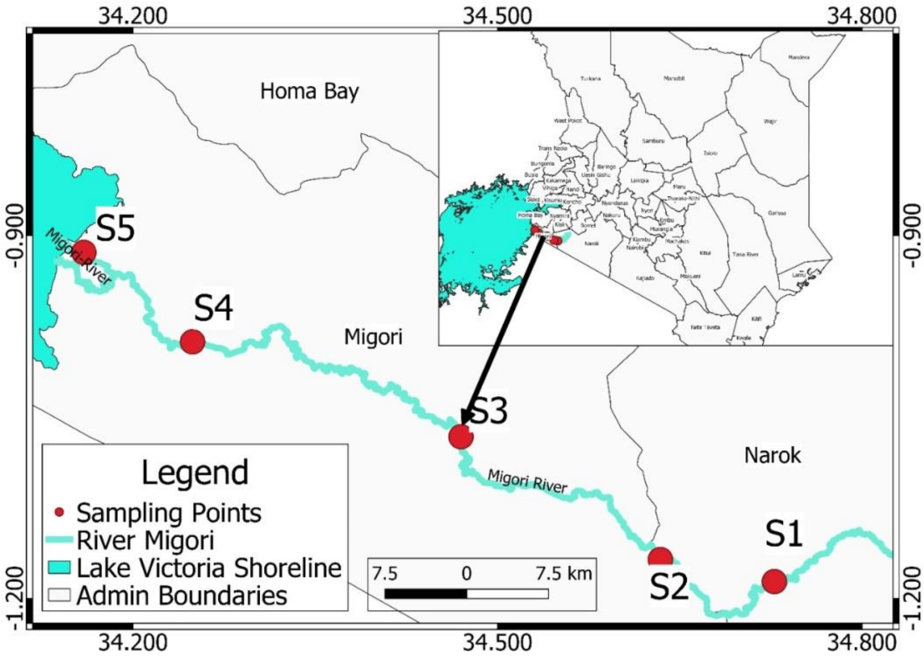

Figure 1. Map showing the sampling points in the River Kuja-Migori, Lake Victoria basin, Kenya

Length at 50% maturity and sex ratio

The length at which 50% of the fish were mature was determined by fitting frequency of mature fish by total length to a logistic curve for both males and females. Sex was determined through visual examination of the genital papillae and confirmed later by dissection. Sex ratio was calculated by determining the total number of males and females in the samples.

Fecundity and egg size

To estimate fecundity, both ovaries were extracted, dissected and the eggs emptied into a petri dish. Gilson's fluid was added to the ovaries to harden and dissolve the ovarian tissue for easy counting. To determine the relationship between fecundity and fish size, the number of eggs from each female fish was regressed with TL to produce a model of $F = a L^b$ where F is fecundity; *a* is the y intercept of the regression; L is the total length in cm and *b* is the slope of the regression. Egg diameter (mm) of fully developed ovaries was measured using digital micrometer gauge.

Gonadosomatic index

Fish specimen were dissected, their gonads extracted and weighed. The gonadosomatic index (GSI) for each fish was calculated as:

$$GSI\ (\%) = GW / W*100;$$

where, GW is the weight of gonads and W is the weight of fish in grams respectively.

Statistical analyses

Simple linear regression was used to determine the relationship between fecundity and total length. To test whether there was a deviation from the theoretical sex ratio of 1:1, chi square was used. The analyses were performed using Statgraphics version 19.1.1 software. The differences were considered significant at $p < 0.05$.

RESULTS

The breeding season of *L. altianalis* depicts an extended period in which most of the fish in the river became mature from March to May and September to November (Figure 2). The length at which 50% of the fish were mature was estimated at 16.3 cm TL for males and 18 cm TL for females (Figure 3). At 24 cm TL the fish had already attained 100% maturity. A total of 105 female ranging from 24.0 - 41.5 cm TL with a mean of 28.09 ± 0.39 cm TL were analyzed for fecundity and its relationships with total length. Fecundity ranged from 1320 eggs in a female fish of size 24 cm TL to 2382 in a fish of 41.5 cm TL. The mean fecundity was 1552 ± 23.3. The relationship of fecundity versus body length of *L. altianalis* is depicted in Figure 4. Fecundity and body size was positively correlated; $R^2 = 0.994$.

The GSI in males ranged from 1.3 to 3.1 with a mean of 2.24 ± 0.21. In females it ranged from 1.70 to 8.55 with a mean of 5.63 ± 0.34. There was a variation in egg size where diameter ranged from 0.89 mm to 1.27 mm in female fish of 24 cm TL and 41.5 cm TL, respectively. The mean egg diameter was 1.22 ± 0.007 mm. The total number of female and male fish analyzed for sex ratio was 356 and 417 respectively giving an overall female to male ratio of 1:1.17. This did not deviate significantly from the hypothesized ratio of 1:1 (χ^2, $p < 0.05$).

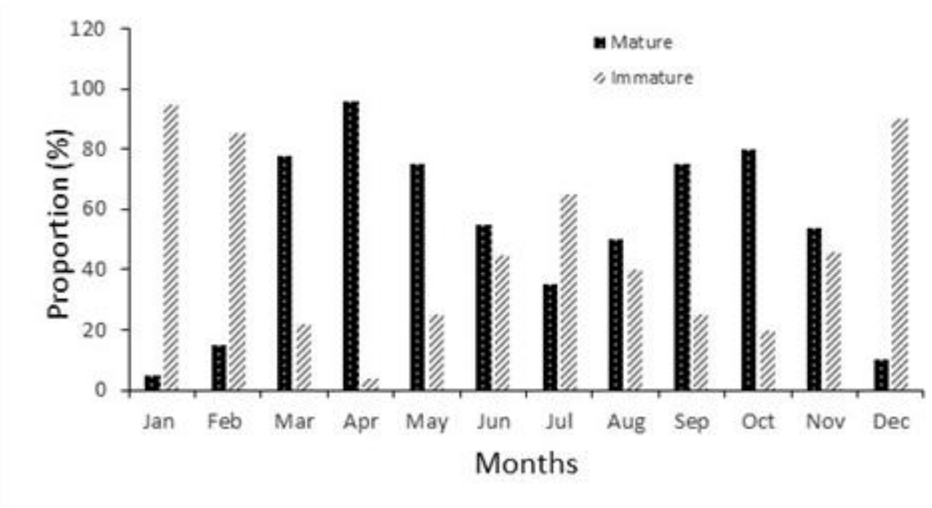

Figure 2. Breeding season of *Labeobarbus altianalis* in River Kuja - Migori from January to December 2018

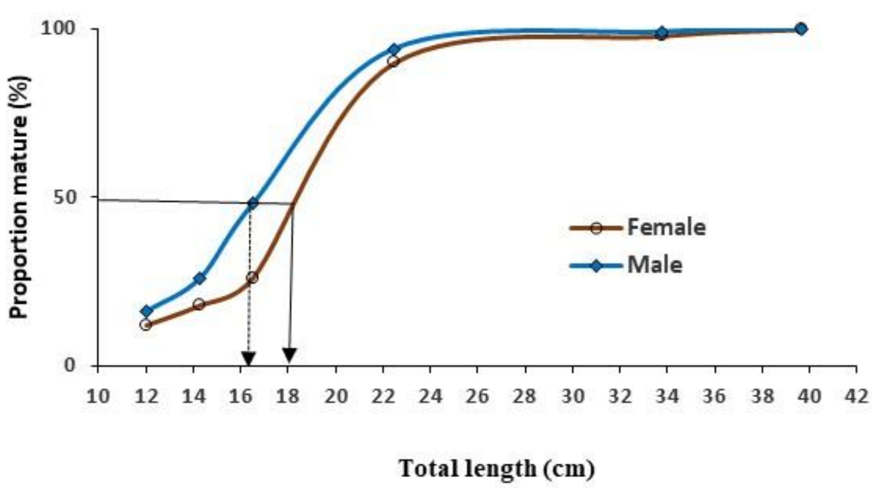

Figure 3. Maturity ogives for female and male *Labeobarbus altianalis* in River Kuja-Migori

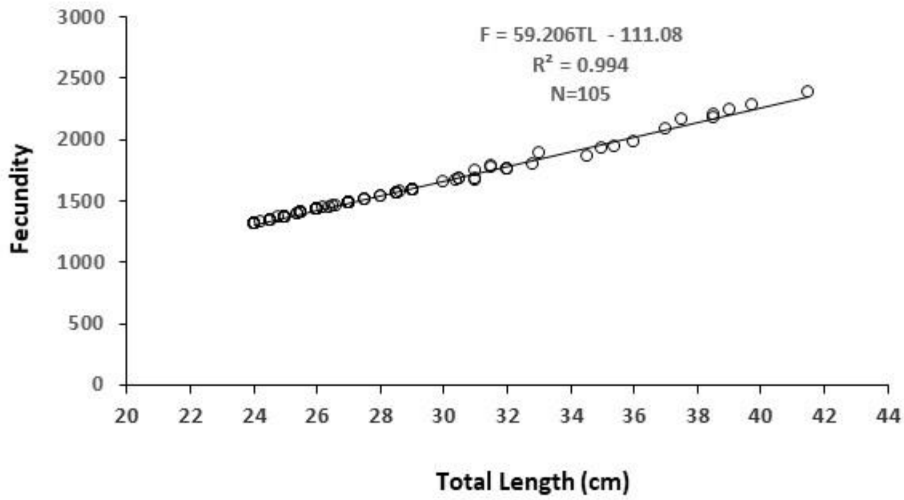

Figure 4. Regression of fecundity and total length of *Labeobarbus altianalis*, in River Kuja-Migori, Lake Victoria basin, Kenya

DISCUSSION

The findings of the present study on breeding seasons for this species concur with those of Ochumba and Manyala, (1992) in *L. altianalis* from River Sondu - Miriu. For reproductive activities to succeed, there has to be a match between spawning period and good conditions for survival of the offspring (Lowerre-Barbieri *et al*., 2011). This is because the spawning event in fish is temporal, with most fish exhibiting one or more breeding seasons yearly (Trindade-Santos & Freire, 2015). The reason for the two breeding seasons seen in this study may be related to the annual precipitation cycle whereby the prolonged breeding period corresponds to the long rain period starting from March to August every year. On the other hand, the shorter period of breeding happening from October to December is due to shorter rains occurring later every year (Kizza *et al*., 2009). Whereas breeding for this species follows specific pattern, there are chances that this is affected by anthropogenic activities on the river catchments such as direct disposal of organic and inorganic wastes particularly from agriculture and other development activities (Achieng *et al*., 2021; Aura *et al*., 2020).

The assessment and management of fish populations is achieved by using size at sexual maturity and data on fecundity to estimate the biomass of spawning stocks (Nunes *et al*., 2011; Sabrah *et al*., 2017). Knowledge of the size at sexual maturity of fish is important in fishery management because it helps to avoid removal of fish that are smaller than sexually mature ones. Size at sexual maturity is also used to predict harvestable size of fish (Rahman & Samat, 2021). This could ensure sustainability, since the number of fish that join adult population will increase and are able to breed for future harvests (Gaspare & Bryceson, 2013). *Labeobarbus altianalis* from Kuja-Migori reached sexual maturity earlier than those from river Kagera and river Sio in Uganda (Aruho *et al*., 2018). This may be attributed to the geographical location of the rivers and variation in environmental conditions (Rutaisire *et al*., 2015). Further, males matured earlier than females, a similar finding that was also reported by Aruho *et al*., (2018). The early maturation of male fish may be regarded as a reproduction strategy which ensures that eggs released by female fish during spawning period are fertilized.

Fecundity is used to measure the potential of a fish to reproduce by the number of eggs in the ovaries before spawning event (Nunes *et al*., 2011). The increase of fecundity with increase in size in this study implies that larger individuals produce more eggs compared to smaller individuals (Gaspare & Bryceson, 2013). Knowledge on fecundity is essential to determine spawning potentials and its success. Fecundity in fish varies due to several factors such as size, age, fish species in question, season and food availability (Rahman & Samat, 2021). The low fecundity observed in this fish species may be attributed to the frequency of yearly spawning.

Gonadosomatic index is used to describe the maturity status of fish by expressing weight of gonads as a percentage of fish weight. GSI is expected to increase as the development of fish gonads approaches full maturity then it starts to decline as the fish starts to spawn (Shoko *et al*., 2015). Therefore, the onset of the spawning season is usually defined by GSI (Sabrah *et al*., 2017). In this study, female fish had higher values of GSI than males. This was comparable with the studies of Trindade-Santos and Freire (2015), who found that females had higher GSI values compared to males in 35 out of 36 fish species. The higher GSI in females may be associated with increased weight of the ovaries during spawning (Maskill *et al*., 2017).

Fish egg size is crucial in determining the quantity of viable eggs and larvae, a factor positively correlated with both growth and survival of the larvae (Nunes *et al*., 2011). Egg size is directly related with the number of eggs, fertilization success, size of larvae and duration of development. Larger eggs take a shorter time to develop and may act as a suitable target for sperms thus enhancing success of fertilization activity. In addition, bigger eggs give rise to bigger offspring which increase the chances of survival during the early days of the development of fish larvae (Reid and Chaput, 1979).

Information on sex ratio is important as it provides an indication about relative survival of females and males, assessing variation in population structure and future breeding potential (Sabrah *et al*., 2017). Sex ratio may vary during the life history of a fish as a result of events acting differently on fish of either sex. However, in the present study sex ratio did not deviate from the expected 1:1. Skewed sex ratios could suggest migration activity associated with breeding periods, a shorter life span for one sex, distribution range, and environmental variations (Aruho *et al*., 2018; Trindade-Santos & Freire, 2015). It was also established by Manal *et al*., (2016) that in some fish species unbalanced sex ratio may be due to vulnerability to fishing. Bias in sex ratio may bring changes to the biology, physiology, and behavior among fish, which may hinder reproduction success (Clark and Grant, 2010; Sabrah *et al*., 2017; Weir *et al*., 2011).

CONCLUSION

Results from the present study show that *L. altianalis* exhibit a negative allometric growth and has a good condition in its riverine environment as established from the length weight relationships. This fish has a low fecundity and the sex ratio did not deviate from the expected. It was also found that males attain sexual maturity earlier than females. This study recommends related studies for other riverine fishes of the Lake Victoria basin.

COMPETING INTERESTS

The authors declare that they have no competing interests

ACKNOWLEDGEMENTS

This work was funded by the National Research Fund (NRF), Kenya [Post Graduate Grant: 2016/2017 FY]; the Germany Academic Exchange (DAAD) In-Country/In-Region Scholarship Programme [grant number: 91637312]. We thank technical staff from Kenya Marine and Fisheries Research Institute, Kisumu Centre, for their help during sampling.

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