ORIGINAL RESEARCH

Growth, mortality, exploitation, and recruitment patterns of *Labeobarbus altianalis* (Boulenger, 1900) in River Kuja-Migori, Kenya

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ABSTRACT. The Ripon barbel, *Labeobarbus altianalis*, a riverine fish found in the Lake Victoria Basin is regarded as species of less concern, but it is vulnerable to overfishing and population decline. This study aimed at determining growth, mortality, exploitation rate, and recruitment patterns of *L. altianalis* (Boulenger, 1900) in River Kuja-Migori. A total of 1,217 specimens with overall total lengths ranging from 9.5-41.5 cm (mean 28.5 ± 2.7) were collected monthly from January to December 2021. The fish were caught using an electrofisher in wadable areas and monofilament nets in deeper areas. Electronic length frequency analysis (ELEFAN) software in Fish Stock Assessment Tools (FiSAT II) program was used to analyze data. Natural mortality (M) Fishing mortality (F) and total mortality (Z) coefficients were 0.15 year^{-1}, 0.52 year^{-1} and 0.67 year^{-1} respectively. The asymptotic length (L_∞) was 44.94 cm TL while the instantaneous growth rate (K) was 0.15 year^{-1}. The exploitation rate was 0.44 year^{-1} and the length-based growth performance index (Ø') was 3.03. Results indicated that the longevity of *L. altianalis* was 9 years. Recruitment occurs throughout the year with bimodal annual recruitment peaks coinciding with the two rainy seasons in the region. This study provides important information for developing management advice for the *L. altianalis* riverine fishery.

Key words: Ripon barbel, riverine, fishery management, Lake Victoria basin.

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Patrones de crecimiento, mortalidad, explotación y reclutamiento de *Labeobarbus altianalis* (Boulenger, 1900) en el Río Kuja-Migori, Kenia

RESUMEN. El barbus, *Labeobarbus altianalis*, un pez ribereño que se encuentra en la cuenca del Lago Victoria, se considera una especie de menor preocupación, pero es vulnerable a la sobrepesca y al declive de la población. Este estudio tuvo como objetivo determinar el crecimiento, la mortalidad, la tasa de explotación y los patrones de reclutamiento de *L. altianalis* (Boulenger, 1900) en el Río Kuja-Migori. Se recolectó un total de 1.217 especímenes con longitudes totales generales que oscilaron entre 9,5 y 41,5 cm (media 28,5 ± 2,7) mensualmente de enero a diciembre de 2021. Los peces se capturaron utilizando un electropescador en áreas vadeables y redes de monofilamento en áreas más profundas. Se utilizó el *software* de análisis electrónico de frecuencia de longitud (ELEFAN) en el programa Fish Stock Assessment Tools (FiSAT II) para analizar los datos. Los coeficientes de mortalidad natural (M), mortalidad por pesca (F) y mortalidad total (Z) fueron 0,15 año^{-1}, 0,52 año^{-1} y 0,67 año^{-1} respectivamente. La longitud asintótica (L_∞) fue 44,94 cm TL mientras que la tasa de crecimiento instantáneo (K) fue 0,15 año^{-1}. La tasa de explotación fue 0,44 año^{-1} y el índice de desempeño de crecimiento basado en la longitud (Ø') fue 3,03. Los resultados indicaron que la longevidad de *L. altianalis* fue de 9 años. El reclutamiento ocurre durante todo el año con picos de reclutamiento anual bimodal que coinciden con las dos estaciones lluviosas en la región. Este estudio proporciona información importante para brindar asesoramiento de gestión para la pesquería fluvial de *L. altianalis*.

Palabras clave: Barbus, rivereño, gestión pesquera, cuenca del Lago Victoria.

INTRODUCTION

Ripon barbel *Labeobarbus altianalis* (Boulenger, 1900) is an interlacustrine-riverine cyprinid fish species that is widely spread in rivers and streams across the Lake Victoria Basin (LVB) (Aruho et al. 2018). *Labeobarbus altianalis* is considered a species of less concern but it suffers a major threat due to destruction of the habitats (Ondhoro et al. 2016). It is also found in Uganda's River Kagera and Lake Edward (Aruho et al. 2018), and in the Democratic Republic of Congo's Lake Kivu (Snoeks et al. 2012). In Kenya, *L. altianalis* is found in the rivers Nyando, Nzoia, Yala, Sondu-Miriu, Kuja-Migori, and Mara (Chemoiwa et al. 2017; Achieng et al. 2020) where it's regarded as a commercial fish (Ondhoro et al. 2016). It is considered a delicacy by fishing communities in Lake Victoria, Kenya, Uganda, and the eastern Democratic Republic of Congo (Anteneh et al. 2012). According to their life history, they move up rivers and streams to reproduce during the rainy season. They concentrate at river mouths during migration, making them an obvious target for overexploitation because they are easily caught during such times (Aruho et al. 2018).

Studies on population parameters are important in evaluating the status of fish stocks and they are vital means for management of exploited fish populations (Sparre and Venema 1998). Currently, there is a dearth of information on the population parameters of many species in the LVB including *L. altianalis.* Thus, the purpose of the present study was to determine growth, mortality, exploitation rate, and recruitment of *L. altianalis* in River Kuja-Migori, Kenya.

MATERIALS AND METHODS

Study area

River Kuja-Migori is situated in western part of Kenya, southwest of Lake Victoria, East Africa. The region has two main peak wet seasons, long rain season runs from March to June, while the short rain season runs from September to November (Kizza et al. 2009). The rivers Kuja and Migori converge at Sango area of Migori County, where they then flow into Lake Victoria. Activities occurring on the catchment, such as urbanization, industrial waste disposal, and agricultural, pose a threat to the river by degrading the water quality of the river. As a result, the distribution and abundance of fish communities around the LVB have been impacted. This study was conducted at five sampling points in River Kuja-Migori (Figure 1). The sampling points were chosen due to their ecological significance covering the headwaters, middle reaches and the lower reaches of the river.

Collection of fish specimen

Fish samples were collected from River Kuja-Migori every month from January to December 2021. The fish were captured using 400V 10Amps, electrofishing equipment (model Electra catch Wolvampton W.O 580 Winchester procurement limited). A Honda GX 240 8 HP petrol generator was used to power the electrofisher. The electro fisher's power was adjusted at each sampling site based on water conductivity (40-350 µS cm^{-1}). Fish were captured during the day in wadable regions, and the stunned fish were gathered with a 10 mm mesh

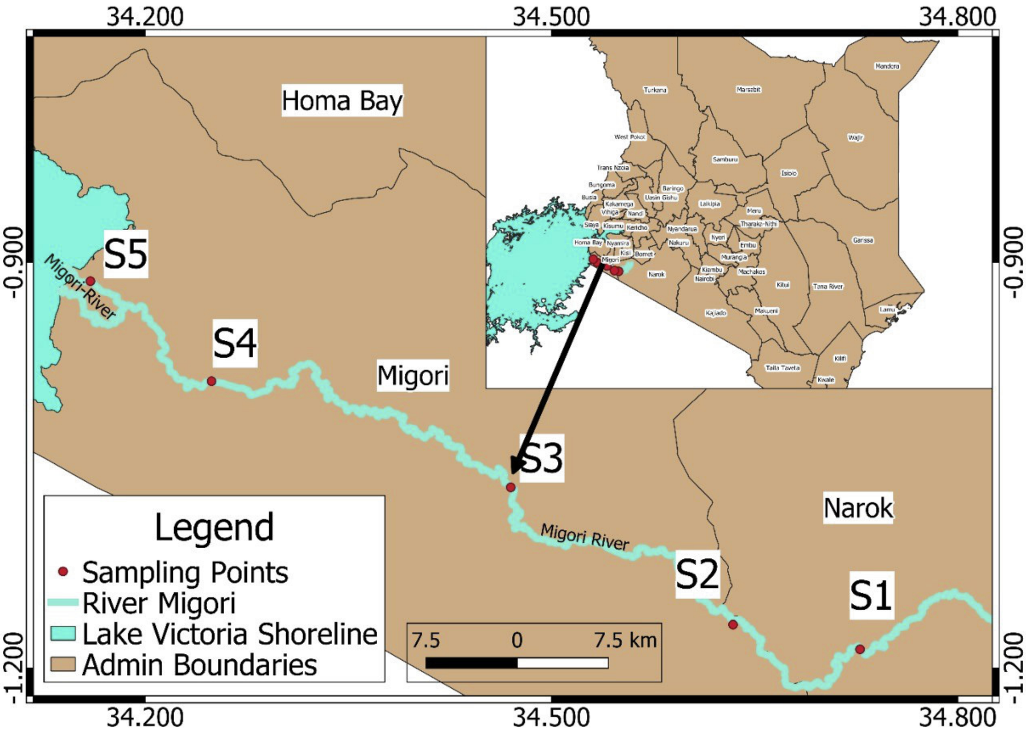

Figure 1. Map showing sampling points (S1-S5) in the River Kuja-Migori, Lake Victoria Basin, Kenya.

dip net. Monofilament nets were deployed in deeper areas and were set for 2 h per station during daytime. The fish specimens were preserved in a cool box of ice and transported to the laboratory. Identification of the species was done following the keys provided by Skelton (2016). The total length (TL) was measured to the nearest 0.1 cm using a measuring board, from the tip of the mouth to the end of the caudal fin.

Data analysis

Data analysis for the population parameters was based on length frequency distribution using the Electronic Length Frequency Analysis (ELEFAN 1) in Food and Agricultural organization (FAO) ICLRAM Stock Assessment Tool (FiSAT) (Gayanilo and Pauly 1997). The estimation of growth parameters was based on the Von Bertalanffy growth formula (VBGF) expressed as:

$$Lt = L_\infty (1-e^{-k(t - t_0)})$$

where L_∞ is asymptotic length or the mean sizes the fish attain if they were to grow indefinitely, k is the instantaneous growth constant, and t_0 is the age of the fish at zero length if they were to grow according to the growth function of Von Bertalanffy, while L_t is the predicted size at age t. The model assumes constant environmental conditions. Growth performance indices based on L_∞ (cm) and W_∞ (g) with the growth constant k were estimated as follows:

- Weight based growth performance:

$$Ø = (\log K + 2/3 \log W_\infty)$$

- Length based growth performance:

$$Ø' = (\log K + 2 \log L_\infty)$$

Natural mortality was estimated using the method of Gayanilo and Pauly (1997):

$$\text{Log (M)} = -0.0066 - 0.279 \log (L_\infty) + 0.6543 \log (K) + 0.4634 \log (T)$$

where L_∞ is the asymptotic length measured in total length; K is the VBGF growth constant, and T is the average surface temperature of the water.

Total mortality Z is the sum of the fishing mortality (F) and natural mortality (M) was calculated as:

$$Z = F + M \text{ and } F = Z - M$$

The exploitation rate was estimated as a ratio of fishing mortality and total mortality rates:

$$E = F/Z$$

where E = exploitation rate; F = fishing mortality and Z = total mortality.

RESULTS AND DISCUSSION

Length frequency distribution

A total of 1,217 specimen of *L. altianalis* with total lengths ranging from 9.5 cm TL to 41.5 cm TL (mean 28.5 ± 2.7) were collected from River Kuja-Migori during the study. The total lengths of *L. altianalis* increased gradually to a peak in class size of 27-29.9 cm TL and then decreased to length class size of 39-41.9 cm TL. Frequency distribution exhibited a unimodal distribution of total length for the species indicating that most fish in the river were between 21 cm TL and 33 cm TL (Figure 2).

Length weight relationship

According to the general formula that expresses the link between fish length and weight (Froese et al. 2013; Ogamba et al. 2014; Abobi 2015), the association between length and weight (Table 1) was linear. The value of *b* in both sexes fell between Bagenal and Tesch's suggested range of 2 to 4. For these fish species, the coefficient of determination values was greater, indicating a good linear regression prediction (Hossain et al. 2011). Consequently, future catches of this species in the river may be extrapolated for comparable fish size ranges. The fish grew allometrically, meaning that their body weight rose in proportion to their length (Lederoun et al. 2020). Aruho et al. (2018) obtained similar *b* value for *L. altianalis* from Lake Edward and Upper Victoria Nile in Uganda.

Growth performance indices and longevity

The growth performance index (Ø') of *L. altianalis* based on asymptotic length was 3.03 while that based on asymptotic weight (Ø) was 1.74. The projected asymptotic length (L_∞) was 44.94 cm TL (Figure 3) while the instantaneous rate of growth (K) was 0.15 year^{-1}. The species is a slow-growing freshwater fish, as demonstrated by its growth rate and a lifespan of nine years. If fish grow slowly with a modest mean length at a particular age, it could be because the density is too high in relation to the food supply or the habitat is insufficient to maintain an acceptable prey base (Abowei and Hart 2009). Rapid growth occurs during the larval and juvenile stages, but growth slows in adult fish as energy is redirected from somatic growth to gonadal development (Camargo et al. 2015). Fisheries managers are often most interested in the adult life stage because it is the stage at which fish can be harvested. Faster growth rates, on the other hand, are defensive strategies against predators that help to sustain fish populations in aquatic environments. Fast growth indicates that fish density is in equilibrium with food resources, and the habitat quality is appropriate (Dong et al. 2019).

This study found that the maximum length (L_∞) was significantly smaller than the previously documented 90 cm TL for this species (Froese and

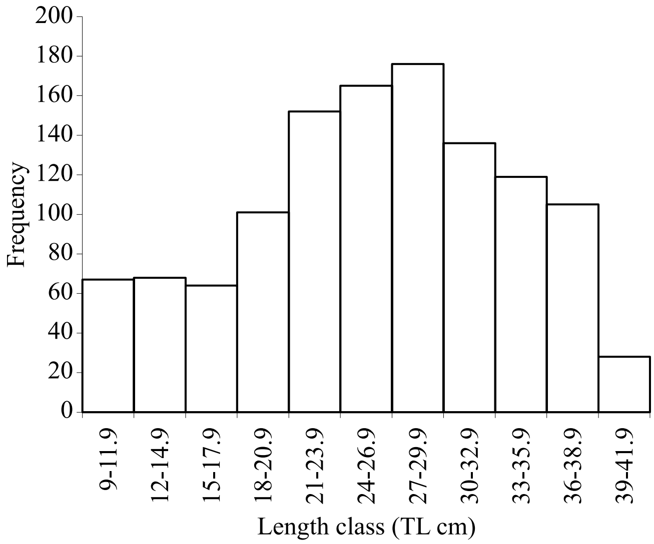

Figure 2. Length frequency distribution of *Labeobarbus altianalis* in River Kuja-Migori used for estimation of population parameters.

Table 1. Length weight relationship of *Labeobarbus altianalis* in River Kuja-Migori from January to December 2021.

Description	N	*a*	*b*	R^2	Equation
Males	656	-2.16	3.15	0.87	W = 3.15TL - 2.16
Females	561	-2.07	3.07	0.91	W = 3.07TL - 2.07
Both males and females	1,217	-2.11	3.11	0.89	W = 3.11TL - 2.11

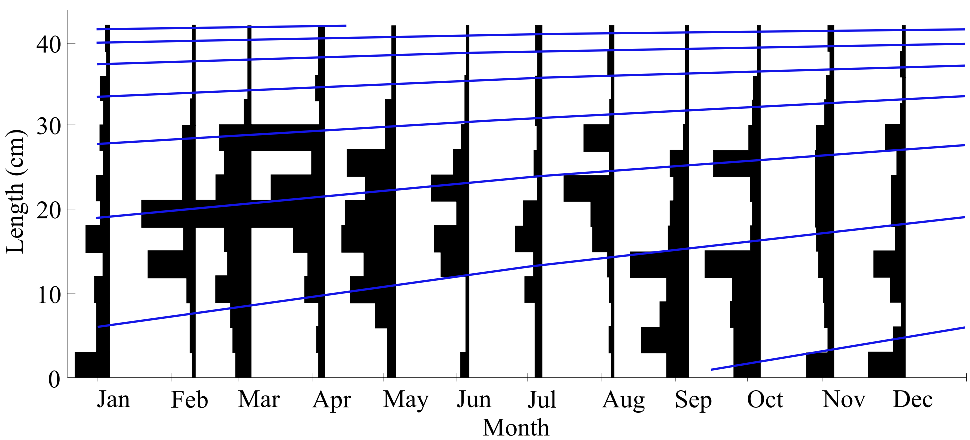

Figure 3. Estimation of the growth parameters of *Labeobarbus altianalis* using Electronic Length Frequency Analysis (ELEFAN 1) method. Von Bertalanffy growth curves superimposed on the restructured length-frequency histograms.

Pauly 2024). This can probably be attributed to the fishing season, the geographical location of fishing operations and the predominant fish size at the time of sampling (Rehatta et al. 2021).

Mortality and exploitation rates

Population parameters are useful for assessing the status of fish stocks and are critical tools for managing exploited fish populations (Pauly 1983; Sparre and Venema 1998). The predicted overall mortality Z for *L. altianalis* in River Kuja-Migori was 0.67 $year^{-1}$ while natural mortality rate was 0.15 $year^{-1}$ and a fishing mortality of 0.52 $year^{-1}$. Natural mortality rates were lower than fishing mortality rates, showing that fishing activities contributed to *L. altianalis* mortality in the river (Mannini et al. 2020). High fishing mortality and low natural mortality could suggest the presence of growth overfishing, in which more juvenile fish were caught than old fish (Abowei and Hart 2009).

Relatively high mortality rates may result in changes of size at maturity, lower survivability of juveniles due to predation and a subsequent reduction in abundance (Rehatta et al. 2021). The exploitation rate of *L. altianalis* in River Kuja-Migori was 0.44. This was lower than the optimum level proposed by Beverton and Holt (1966), that when natural mortality and fishing mortality are equal (i.e. exploitation rate (E) = 0.5), the stock was in good health and being fished optimally. Therefore, the present exploitation rate of 0.44 for *L. altianalis* in this study was optimal.

Recruitment patterns

Determination of fish recruitment is vital in assessing fish stocks and it can vary from year to year thus influencing population abundance, age structure, number of fishable stocks and fish growth rates (Camargo et al. 2015). Understanding recruitment variation is an important consideration when evaluating fish harvest policies (Quist 2007). The recruitment pattern of *L. altianalis* in River Kuja-Migori showed that recruitment occurs throughout the year with bimodal annual recruitment peaks (Figure 4). The recruitment pattern was similar with the breeding seasons of this species in River Kuja-Migori reported by Kembenya et al. (2022). The first recruitment peak was observed in February (11%) while the second peak occurred in the month of September (18%). The second peak was more pronounced than the first and both recruitment peaks coincided with the two rainy seasons occurring in the region. The size of the recruits is governed by the quantity of brood stock ready to spawn as well as the mortality rate between spawning periods (Nunn et al. 2003; Rehatta et al. 2021). Furthermore, environmental conditions during the post-larval cohort on the nursery grounds may have influenced the recruitment success.

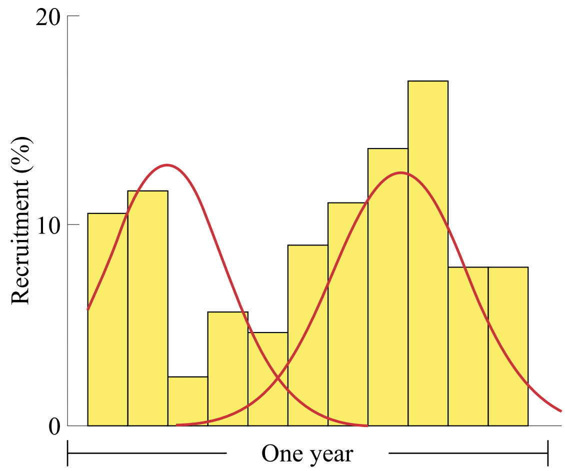

Figure 4. The recruitment pattern of *Labeobarbus altianalis* in River Kuja-Migori, Lake Victoria Basin, Kenya.

CONCLUSION

Results from this study showed that *L. altianalis* has a slow growth rate, attaining an asymptotic length of 44.94 cm TL at the age of 9 years. Natural mortality rate was lower than the fishing mortality rate for *L. altianalis* in River Kuja-Migori. Recruitment occurred throughout the year, with two peaks occurring in February and September. Though the exploitation rate fell within the parameters of rational and sustainable use there is need for monitoring. The findings of this study provide useful information for the management of *L. altianalis* in the River Kuja-Migori.

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Author contributions

Elijah Kembenya: collection; analysis and drafting the manuscript. Albert Getabu: supervision; conceptualizing and editing. James Njiru: supervision; conceptualizing and editing. Reuben Omondi: supervision; conceptualizing and editing.

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