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RESEARCH PAPER

Population parameters of African Carp, *Labeo victorianus* (Cyprinidae) in River Kuja-Migori, Kenya

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Abstract

Labeo victorianus is one of the fish species capable of sustaining commercial riverine fishing in the Lake Victoria basin. The present study was conducted to determine the growth, mortality rate, exploitation rate and recruitment pattern of *Labeo victorianus* in River Kuja-Migori, Kenya. Fish specimens were collected from January to December 2021 (12 months) using an electrofisher from five sampling stations along the River Kuja-Migori. The total length and total weight of fish samples were measured in centimeters and grams, respectively. Growth parameters, fishing mortality and natural mortality were determined using length frequency data. 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 0.91 yr^{-1}, 0.65 yr^{-1} and 1.56 yr^{-1}, respectively. The exploitation rate was estimated at 0.42 yr^{-1}. The asymptotic length (L_∞) was 36.89 cm TL. The instantaneous growth rate (K) was 0.31 yr^{-1}. There were two recruitment peaks where major recruitment occurred from March to June while a minor recruitment took place between September and November. Results revealed that *L. victorianus* exhibits a short lifespan of approximately 6 years. The present study contributes significantly to the development of management advice for the riverine fishery of *L. victorianus.*

Introduction

Labeo victorianus is a ray finned fish species belonging to the family Cyprinidae. Its spindle-shaped body is suitable for riverine habitat. It used to be a commercially important fish in the fishery of Lake Victoria basin during the 1960s (Njiru et al., 2005). African Cyprinids which belong to the genus *Labeo* are known to be vulnerable to overexploitation. For example, there was a collapse of the fisheries of *Labeo mesops* in Lake Malawi (Anteneh et al., 2012) and *Labeo altivelis* fisheries in Lake Mweru at the border of Democratic Republic of Congo and Zambia (Gordon, 2003). The reduction of *L. victorianus* stocks and other migratory fish within the Lake Victoria basin is well recorded in the Kenya, Uganda, and Tanzania sectors of Lake Victoria. For example, fish catches per net from the mouth of river Kagera decreased from 13.6 in 1954 to 0.5 in 1963 (Rutaisire & Booth, 2005). In Kenya, the yield of *L. victorianus* in Winam Gulf dropped from 44716 kg in 1995 to 4352 kg in 2009 (Omwoma et al., 2014).

L. victorianus and other riverine fish species were first sparingly exploited in the early twentieth century, primarily near the mouths of major rivers that flow into Lake Victoria. This necessitated the adoption of ancient fishing techniques like weirs, reed fences, and traps (FAO, 1988). As fish catches declined, fishermen moved to more effective gears, such as flax gill nets, in 1905 to increase catches. With further declining catches, fishermen switched to monofilament nylon gillnets, which were more efficient (Cadwalladr, 1965; Ogutu-Ohwayo, 1990). The use of these fishing gears nearly wiped-out *L. victorianus* and other migratory fish species in the Lake Victoria basin (FAO, 1988). Overfishing using unlawful small mesh gillnets and other gear including beach seines, mosquito nets, and traps has been shown to catch fish that are sexually mature just before spawning (Rutaisire & Booth, 2005).

Population parameter studies are critical for assessing the status of fish stocks. They are important tools for managing overfished fish populations (Sparre and Venema, 1999). Most species population parameters, including those of *L. victorianus*, in the Lake Victoria basin are unknown. Thus, the purpose of this work was to describe the growth, mortality, exploitation rate, and recruitment of *L. victorianus* in the River Kuja-Migori, Kenya.

Materials and Methods

Study area

The present study was carried out on the River Kuja-Migori from five sampling stations selected along the river. A handheld global positioning system (GPS), model Garmin GPSMAP 78s was used to mark the coordinates of the five sampling stations (Figure 1). River Kuja Migori is located on the Southwestern part of Lake Victoria in western Kenya, East Africa. The basin experiences an equatorial climate that receives rain throughout the year. However, there are two major peak rainy seasons. The long rain season occurs in March to June while the short rain season occurs between September and November with an annual rainfall of approximately1800 mm (Kizza et al., 2009). The Kuja River and River Migori meet at a confluence at Sango area in Migori County and thereafter flow and pour its water into Lake Victoria.

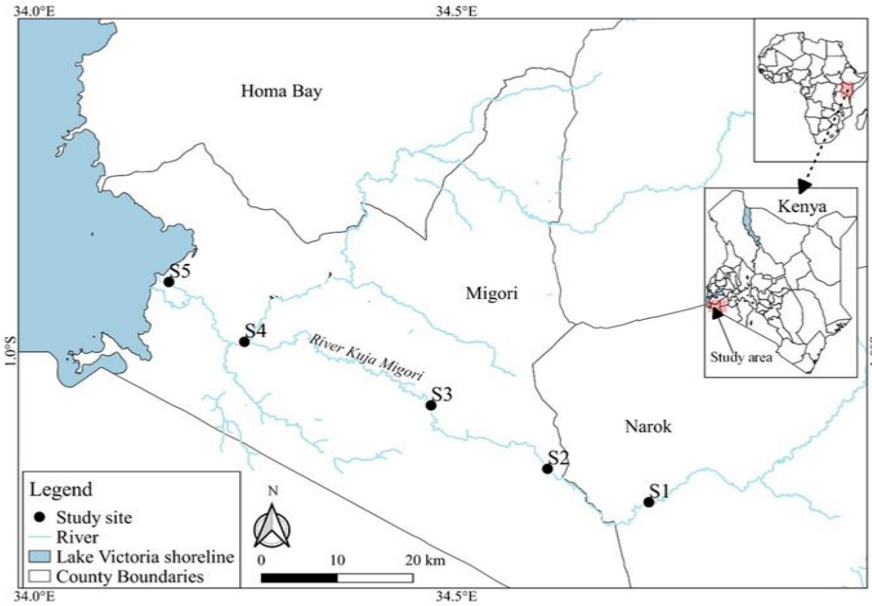

Figure 1. Map showing the sampling points along river Kuja-Migori, Lake Victoria basin, Kenya.

Description of sampling stations

The upper portions of the river (sampling stations S1 and S2) were narrower, small, and rocky with woodlands and livestock grazing areas notably for the pastoralist Maasai community. Sampling station S1 was situated at the most upstream location (34.72785 E, 1.186067 S), in Maasai land between Lolgorian trading center and Kilgoris town. This part of the river had a rocky bottom and water movement was sluggish forming several subsequent pools. There was some sparse emergent vegetation composed of papyrus. Otherwise, the sampling location was immediately exposed to sunlight. S2 sampling station (34.7106420 E, 1.20443630 S) was slightly behind the Lolgorian trading center on the way to Migori town. Station S2, like S1, had a stony bottom but no emergent or submerged vegetation. Because the slope was mild, the water flowed slowly. The bottom of sampling station S3 (34.4698870 E, 1.0663310 S) in the middle reach was made up of soft sediments. There was no emergent or submerged vegetation, therefore the station was exposed to direct sunlight. The station was located in Migori town and was affected by urban effluent from domestic, agricultural, and stormwater sources. In the lower reaches, stations S4 (34.2489590 E, 0.9878524 0 S) and S5 (34.1595180 E, 0.9139200 S) were located on the river Kuja-Migori just after the confluence of rivers Kuja and Migori before discharge into Lake Victoria. At station S4, the river widened and there was sub-emergent and emergent vegetation. The riverbed had a heterogeneous substrate composition, consisting primarily of sand, silt, and occasional rock out cropping. Maize, cassava, beans, sugarcane, arrow roots millet, peas, and traditional vegetables, were among the crops grown on the ground near to the sample station. Sampling station S5 adjacent to the river Kuja delta had a bottom constituting fine sand and some mud. The land surrounding the sampling place was used for agricultural purposes. The wetland was cleared to allow for crop cultivation. The wetland's size was shrinking as agricultural land expanded.

Sampling

From January to December 2021, fish samples were caught from the River Kuja-Migori on a monthly basis. The fish were captured with 400 V and 10 A electrofishing equipment and a 50-meter electric wire, model Electra catch Wollaton W.O 580 Winchester procurement limited. Honda GX 240 8 horsepower petrol generator was used to power the electrofisher. The power of the electrofisher was adjusted at each sampling location based on water conductivity, which ranged from 40 to 350 µS cm^{-1}. Fish were captured during daytime in wadable areas, and stunned fish were scooped using a dip net with a mesh size of 10 mm. Every month for a year, a 100-meter river reach was sampled at each sampling point for 60 ± 5 minutes from downstream to upstream. Using a measuring board, the TL was measured to the nearest 0.1 cm from the tip of the mouth to the end of the caudal fin. Total fish weight was taken using an electronic balance model Shimadzu TX 4202 L to the nearest 0.01 g.

Data analysis

The population parameter data was analyzed using the Electronic Length Frequency Analysis (ELEFAN 1) in the Food and Agricultural Organization (FAO) ICLRAM Stock Assessment Tool (FiSAT) (Gayanilo et al., 1996). The growth parameters were estimated using the Von Bertalanffy growth formula (VBGF), which is represented as

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

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_o 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 further assumes that environmental conditions remain constant.

The growth performance indices based on L_∞ and W_∞ 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:

$$Ø' = (\log K + 2 \log L_\infty)$$

The L_∞ and W_∞ are in units of cm and grams, respectively, and the logarithms are in base 10.

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

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

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 which in this study was (18 ^{O}C).

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

$$Z = F + M$$

The exploitation rate was calculated as a ratio of fishing mortality to total mortality rates as

$$E = F/Z$$

Results

Composition of collected fish samples

A total of 553 fish were sampled from River Kuja-Migori, comprising 126 juveniles and 427 adults (Table 1).

Table 1. The number of fish per station collected in River Kuja Migori

Station	Juvenile	Male	Female	Total
S1	14	36	23	73
S2	37	47	38	122
S3	12	10	7	29
S4	45	72	41	158
S5	18	91	62	171
Total	**126**	**256**	**171**	**553**

Length frequency distribution

Fish sizes ranged from 7.5 to 35.7 cm total length (TL), with a mean (±SE) of 23 ± 1.88 cm TL (n = 553). The frequency peaked at a length of class 21-23.9 cm TL before steadily decreasing to length class 33-35.9 cm TL (Figure 2). The length distribution was unimodal, ranging from 15 cm to 27 cm TL. The modal length class ranged from 21.0 to 24 cm (TL).

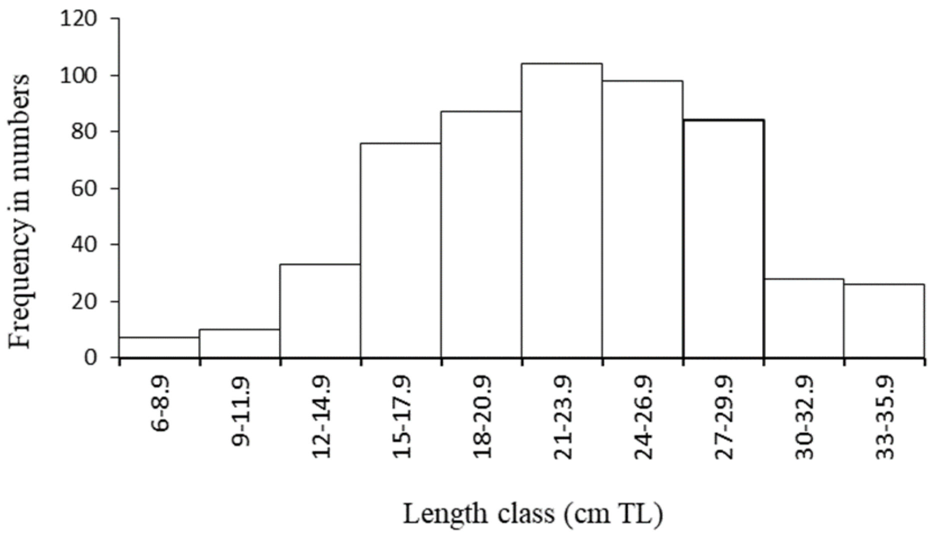

Figure 2. Length frequency distribution of *L. victorianus* in river Kuja - Migori, Kenya.

Mortality and exploitation rate

The estimated instantaneous total mortality rate (Z) of *L. victorianus* was 1.56 yr^{-1} (95% CI: 1.53–1.57). The longevity (t_{max}) of the species was estimated to be 6 years (Figure 3).

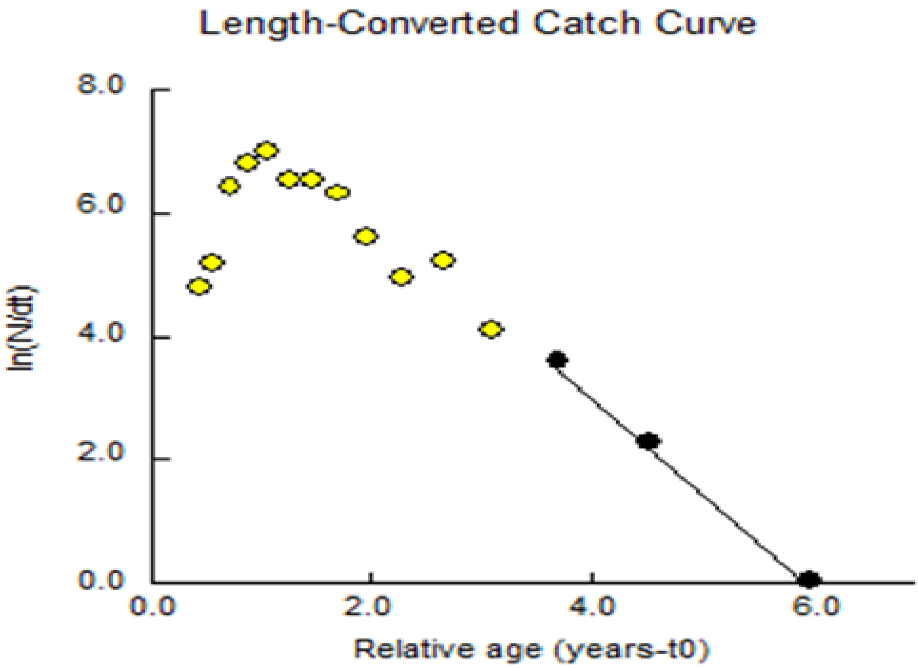

Figure 3. Estimation of total mortality rate of *L. victorianus* in river Kuja-Migori using length converted catch curve.

The fishing mortality rate (F = 0.65) exceeds the natural mortality rate (M = 0.15), suggesting potential fishing pressure on the population. The exploitation rate (E) for *L. victorianus* in River Kuja-Migori was estimated as E = 0.42 yr^{-1} (Figure 4).

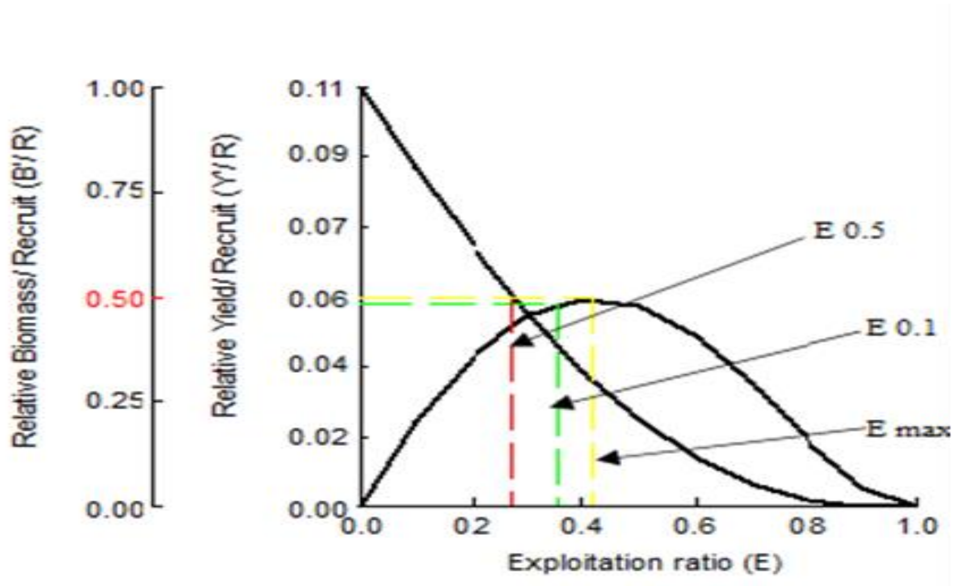

Figure 4. Exploitation model of *L. victorianus* in river Kuja-Migori, Lake Victoria basin, Kenya.

Recruitment pattern of L. victorianus in River Kuja – Migori

The trend is bimodal, implying that there are two recruitment seasons every year (Figure 5). The first major recruitment takes place between March and August, while the second occurs between September and November.

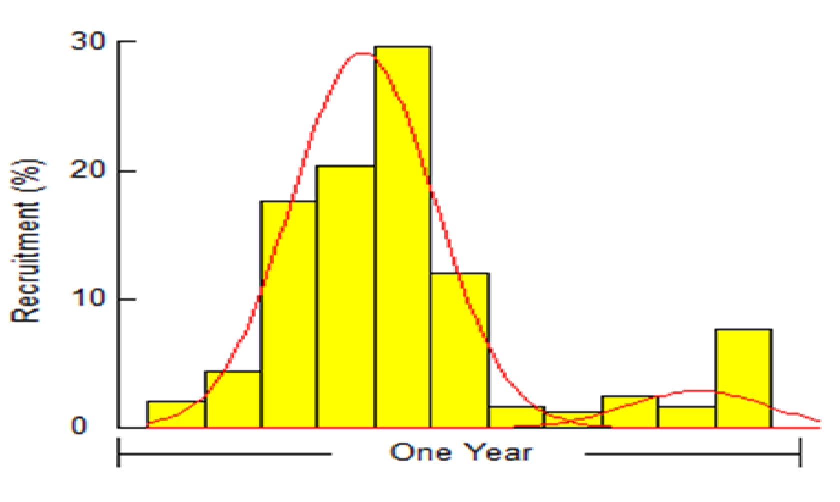

Figure 5. The recruitment pattern of *L. victorianus* in river Kuja-Migori, Lake Victoria basin, Kenya

Discussion

Mortality rate is used to describe the rate at which fish are lost from a population hence critical in formulation of sustainable fisheries regulations (Xianghong et al., 2019). Fishing mortality is a critical metric for understanding the dynamics of an exploited stock (Bousseba et al., 2021). It represents the number of fish caught by fishing activities in a given year. Natural mortality is typically caused by aging, predation, illnesses, cannibalism, pollution, and other natural adverse environmental events (Mannini et al., 2020; Froese and Pauly 2019). The river Kuja-Migori's low natural death rate and high fishing mortality rate may suggest species overexploitation (Sparre and Venema 1999).

The low value of K obtained in this study indicates that *L. victorianus* has a low growth rate and according to Sparre and Venema (1999) slow growth is depicted by K values greater or equal to 1. This value describes the time required for a fish to achieve maximum length (L_∞). The higher the K value the faster the growth of a fish. Earlier studies indicate that *L. victorianus* could attain a maximum of 41 cm TL (Reid, 1985) the maximum total length attained in this study were relatively small (36.89 cm TL). The results of this study are comparable with other studies on African cyprinids which belong to the genus *Labeo* (Table 2). The table shows that many African cyprinids, particularly those in the genus *Labeo*, do not grow past 40 cm TL and have a lifespan of no more than ten years. *Labeo capensis* and *Labeo parvus* have a length-based performance index of roughly 2.5, comparable to *L. victorianus* in this study.

Table 2. Comparison of population parameters of different African cyprinids

Species name	Locality	L_∞	K	Longevity	Ø'	Reference
Labeo capensis	Lake Gariep	38.8 cm FL	0.25 yr^{-1}	9 years	2.58	Winker et al., 2012
Labeo parvus	Ouémé River	30.5 cm TL	0.4 yr^{-1}	2 years	2.57	Montchowui et al., 2009
Labeo cylindricus	Lake Chicamba	22.4 cm FL	0.66 yr^{-1}	-	2.52	Weyl & Booth, 1999
Labeo niloticus	River Nile	72.99 cm TL	1.03 yr^{-1}	6 years	3.73	Midhat et al., 2007
Labeo victorianus	River Kuja-Migori	36.89 cm TL	0.31 yr^{-1}	6 years	2.10	This study

L_∞ = Maximum length; K = instantaneous growth rate; Ø'= Length based performance index; FL-Fork length; TL= Total length

The longevity of *L. victorianus* was like that observed by Midhat et al. (2007) in *Labeo niloticus* from River Nile in Egypt.

The exploitation ratio of 0.42 yr^{-1} for *L. victorianus* was lower than the optimum exploitation level. Gulland (1983) suggested that the optimum exploitation level of a fishery resource is 0.5 while Sparre and Venema (1999) argued that exploitation rate also known as overfishing is high when the value is greater than 0.5 and low (underfishing) if it is less than 0.5 and at optimal utilization when equal to 0.5. The exploitation rate (E = 0.42) falls below the ideal threshold (E = 0.5), indicating that overexploitation is not yet crucial.

Recruitment is an important feature of fisheries that can provide insight into a fish population's future feasible harvests (Xianghong et al., 2019). The two recruitment patterns observed in this study correspond to the annual precipitation cycle in the region. The first recruitment corresponds with the long rainy season starting from March to June each year, while the second recruitment happens between September and November corresponding to the short rain occurring later in the year (Kizza et al., 2009). While recruitment follows a precise pattern as observed, there is a probability that it is influenced by anthropogenic activities in the river watershed.

These activities include the direct disposal of organic and inorganic waste, primarily from agriculture, development, and gold mining. Encroachment in deltaic and riverine wetlands reduces fish habitats, particularly breeding zones (Orwa et al., 2012; Raburu et al., 2009).

Conclusion

This study revealed that *Labeo victorianus* is a small-bodied fish with a slow growth constant, growing to a maximum length of 36.89 cm TL. This species is short lived with a longevity of about 6 years. *Labeo victorianus* has two recruitment peaks in the River Kuja - Migori, which coincide with short and long rainfall. Given the slow growth rate, short lifespan, and potential overexploitation observed in *L. victorianus*, targeted conservation strategies such as regulated fishing efforts and habitat restoration are critical for sustaining this species.

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Ethical Approval

The author declares that this study complies with research and publication ethics.

Informed Consent

Not available

Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data supporting the findings of this investigation are accessible upon request from the corresponding author.

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Authors' Contribution

EMK participated in conceptualizing, data collection and drafting the manuscript. AMG participated in experimental design. JMN performed data analysis and editing while RO did final review. All the authors contributed to the submitted version.

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