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Population Dynamics of *Chrysichthys nigrodigitatus* (Lacépède, 1803) in a Tropical Man-Made Lake, Southwestern Nigeria

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ABSTRACT

Background and Objective: The concern over probable loss of biological diversity and ecosystem function informed the updating of information on *Chrysichthys nigrodigitatus* population dynamics for sustainable management. This study, thus, aims to determine the population parameters of *C. nigrodigitatus* in Asejire Lake, Oyo State, Nigeria. **Materials and Methods:** Samples of the *C. nigrodigitatus* were obtained bi-monthly from Asejire reservoir landing sites between February and July, 2024. Total length (TL), fork length, standard length, and body weight (BW) were taken to precision. Length-weight relationships, condition factors, and growth parameters were estimated following standard methods. Mortality rate, longevity, and exploitation rate were determined using FSAT software. Data were analysed using descriptive statistics, multiple linear regression, and ANOVA at $\alpha_{0.05}$. **Results:** The TL ranged from 13.55 to 40.30 cm with a mean at 24.41±0.31, while BW varied from 11.00 to 320.00 g. Length-weight relationships and condition factor were 2.93 and 0.51±0.13, respectively. The length at infinity ($L\infty$), growth coefficient (k), longevity, and exploitation status were 36.07 (cm), 0.38 ($year^{-1}$), 3.5 (years), and 0.75 (>0.5), respectively. The total mortality, Z, was 2.54 $year^{-1}$, while natural mortality and fishing mortality were 0.67 and 1.91 $year^{-1}$, respectively. **Conclusion:** The growth coefficient revealed that the *C. nigrodigitatus* in Asejire reservoir is a fast-growing and short-lived species with an isometric growth pattern but a low condition factor. There is a need to improve the condition of the lake and adopt more sustainable management strategies to enhance the stock of *C. nigrodigitatus* in Asejire Lake, Nigeria.

KEYWORDS

Chrysichthys nigrodigitatus, growth parameters, mortality, longevity, exploitation rate, Asejire Lake

INTRODUCTION

Silver catfish, *Chrysichthys nigrodigitatus*, is a widespread and economically important freshwater fish species for artisanal fishery in Nigeria. It provides good quality fish with white and very tasty flesh, serving as a delicacy for the teeming populace, especially in riverine communities[1]. Silver catfish is a vital resource for local communities, contributing to their economy, livelihoods, and nutritional needs. This carnivorous

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species is ecologically important for maintaining the freshwater ecosystem dynamics. Of recent stock of *C. nigrodigitatus* and many others are reducing in our waterbodies due to unscrupulous exploitation occasioned by population expansion and improved fishing technology[2]. The concern over foreseeable loss of biological diversity and ecosystem function, informed by updated information on population dynamics for sustainable management[3].

The surge in population and industries around the Asejire area has contributed to the depletion of fish stock in the Lake, where catches in recent times are mostly juvenile sizes and consequently exposed valuable resident species such as *C. nigrodigitatus* to the risk of extinction[4]. To achieve sustainable exploitation and effective management, data on fish biology and population dynamics are essential[5]. Understanding the growth, mortality, weight, and longevity of *C. nigrodigitatus* in Asejire Reservoir, Nigeria, is crucial for effective fisheries management and conservation in this environment. The growth patterns, biomass distributions, and survival rates of *C. nigrodigitatus* may differ significantly from those in natural habitats compared to constantly changing reservoir conditions[6]. Overall, this study is not only significant for the sustainable management of *C. nigrodigitatus* populations in Asejire Lake but will also contribute to broader efforts in managing fish resources in tropical man-made lakes across Nigeria and other regions with similar ecosystems[7].

Thus, this study aimed to provide information on the growth, mortality, and longevity of silver catfish inhabiting the Asejire Lake, Nigeria.

MATERIALS AND METHODS

Study area: Asejire Lake is an artificial depression approximately 30 km East of Ibadan, between Latitudes 7°21'30"-7°21'50"N, and Longitudes 4°07'30"-4°08'10"E, at an altitude of 137 m.a.s.l.[8]. The Asejire basin is inundated by floodwater from two main Rivers (i.e., Rivers Oshun and Oba), forming two unequal arms of a Y-shaped (Fig. 1). It is a freshwater Lake with a deepest point of 19 m and a surface area of 24 km^2. In addition to its role in irrigation, flood control, and potable water supply, artisanal fishing is remarkably prominent in the Lake.

Fish collection: In all, 629 *C. nigrodigitatus* samples were obtained bimonthly from the lake between February to July, 2024. The fish were transported to the Wet laboratory, Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria, where lengths (FL and TL ±0.1 cm) and body weight, ±0.01 g) of each specimen were recorded.

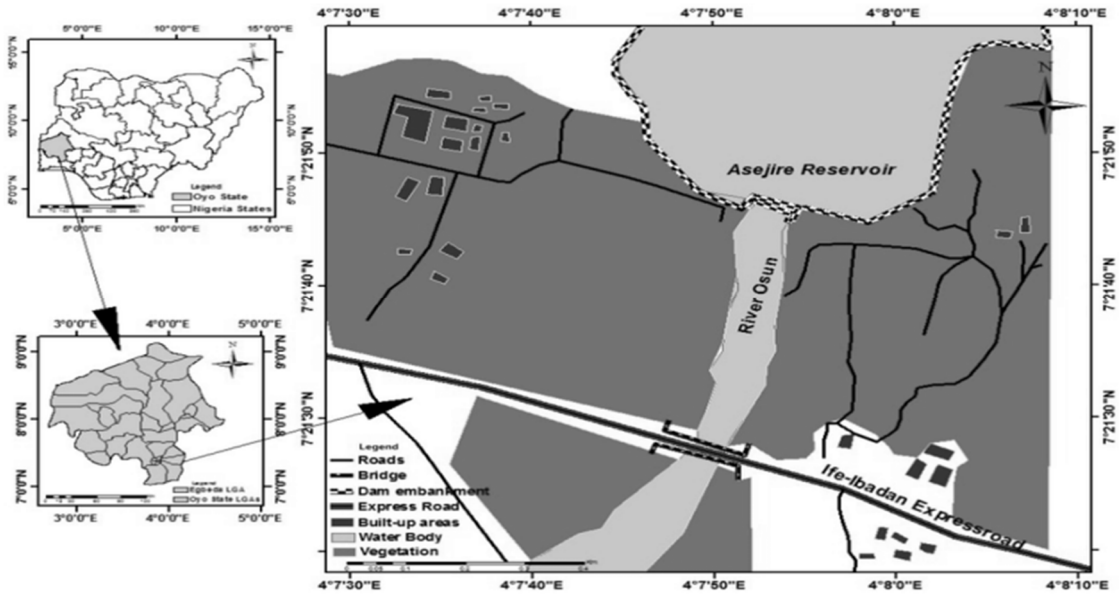

Fig. 1: Map of Asejire Lake, Ibadan, Nigeria

Length-weight relationship and condition factor: The relation between length and weight was computed using the formula[9]:

$$W = aL^b$$

where, W is the total weight in grams, L is the total length in cm, and a and b are the constants whose values were estimated by least squares regression analysis. The condition factor was estimated using the relationship:

$$W/L^3 \times 100$$

where, W is the fish weight (g), and L is the total length (cm)

Growth parameters: Growth parameters were estimated with Bertalanffy growth functions using the ELEFAN (Electronic Length Frequency Analysis) method[9]:

$$Lt = L\infty\ [1-exp(-K(t-t_0)]$$

where, Lt is the length at age t, $L\infty$ represents the asymptotic fish length, K is a relative growth coefficient, t is the fish age, and t_0 is the hypothetical time at which the length of the fish is zero.

The species longevity was estimated following[10] equation:

$$t_{max} = t_0+3/K$$

Where:
t_{max} = Species longevity
t_0 = Hypothetical time at which the length of the fish is zero
K = Growth coefficient

The total mortality (Z) was estimated using the length-converted catch curve method[11].

Then *et al.*[12] empirical formula was used to estimate natural mortality based on life history traits, size at maturity and environmental factors:

$$M = 4.118K^{0.73}L\infty^{-0.333}$$

Where:
M = Natural mortality
K = Relative growth coefficient
$L\infty$ = Asymptotic fish length

Fishing mortality was, however, calculated using the Qamar *et al.*[13] equation:

$$F = Z-M$$

Where:
F = Fishing mortality
Z = Total mortality
M = Natural mortality

The exploitation rate was calculated using the formula of Mudjirahayu *et al.*[14]:

$$E = Z/F$$

Where:

E = Exploitation rate
Z = Total mortality
F = Fishing mortality

Statistical analysis: The TropFishR package for fisheries analysis was used to analyse the data obtained for estimation of the growth and mortality parameters, exploitation rate, size, and composition of a fish stock utilizing virtual population analysis (VPA) and assessing stock status with yield prediction and production models.

RESULTS

Condition factor, lengths, and body weight characteristics: The condition factor, lengths, and body weight attributes of *Chrysichthys nigrodigitatus* samples in the study were given in Table 1. In all, 629 *C. nigrodigitatus* specimens were collected, which ranged from 10.4 to 31.6 cm (18.92±2.48 cm) in fork length and from 13.5 to 40.3 g in total length (24.41±0.13 cm). The weight distribution of all the specimens observed varied between 11.0 and 320.0 g with a mean of 76.44±30.6 g. The condition factor of *C. nigrodigitatus* population in Asejire Lake was 0.51±0.13. The scatter plot of length-weight relationship of *C. nigrodigitatus* in the Asejire Lake during the period of study was shown in Fig. 2. An exponential relationship as revealed between the fork length (FL) and body weight (W) of *C. nigrodigitatus* is expressed by the regression equation:

$$W = -1.8770^{2.9272} (r^2 = 0.9381)$$

The t-test conducted showed no significant difference ($p<0.05$) between the values of 'b' (2.9272) obtained and the expected value of isometric growth i.e., 3, which implies an isometric growth coefficient (Table 2). Also, fork-length is significant linear predictor of body weight ($p<0.01$) with a predictive ability of 94%.

Table 1: Condition factor, lengths, and body weight characteristics of *Chrysichthys nigrodigitatus* samples in Asejire Lake

Parameter	Values
Number of samples	629
Fork length range (cm)	10.40-31.60
Mean fork length (cm)	18.92±2.48
Total length range (cm)	13.50-40.30
Mean total length (cm)	24.41±0.13
Body weight range (g)	11.00-320.00
Mean body weight (g)	76.44±30.60
Mean condition factor (K)	0.51±0.13

Table 2: Regression coefficient of the transformed length-weight relationship of *Chrysichthys nigrodigitatus* collected from Asejire Lake

Coefficients	Estimate	Standard error	t value	Pr(>|t|)	2.5%	97.5%
Intercept	-1.8770	0.0383	-49.0544	8.2156e-217***	-1.9521	-1.8019
Log.FL	2.9272	0.0300	97.4965	0.0000***	2.8683	2.9862

Significance codes: 0'*** '0.001'** '0.01' *'0.05'. '0.1' '1

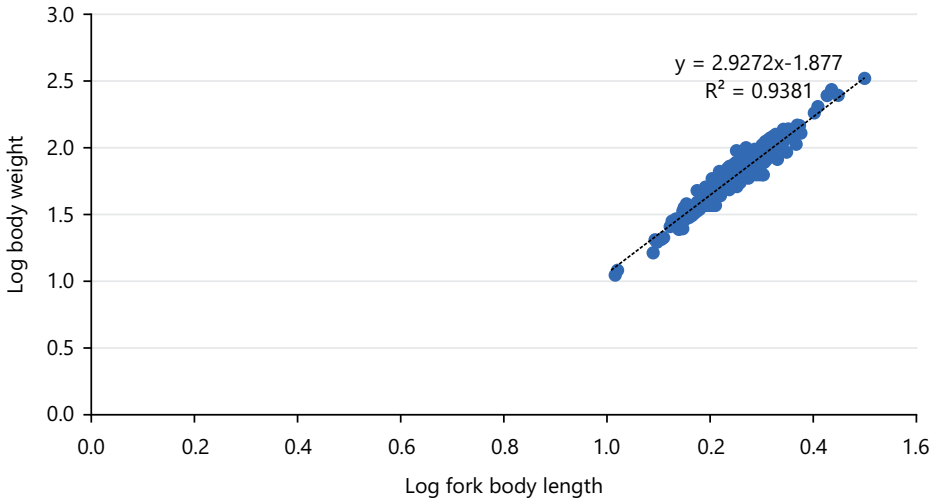

Fig. 2: Length-weight relationship curve of *Chrysichthys nigrodigitatus* from Asejire Lake

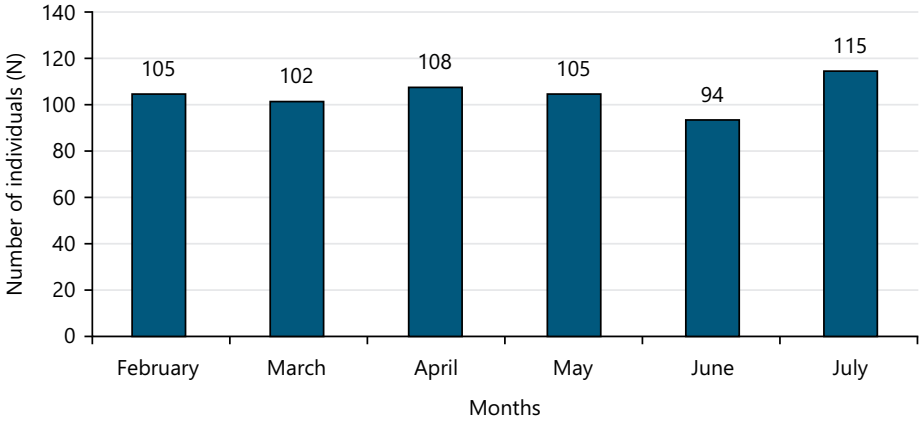

Fig. 3: Sampling distribution of *Chrysichthys nigrodigitatus* collected from Asejire Lake

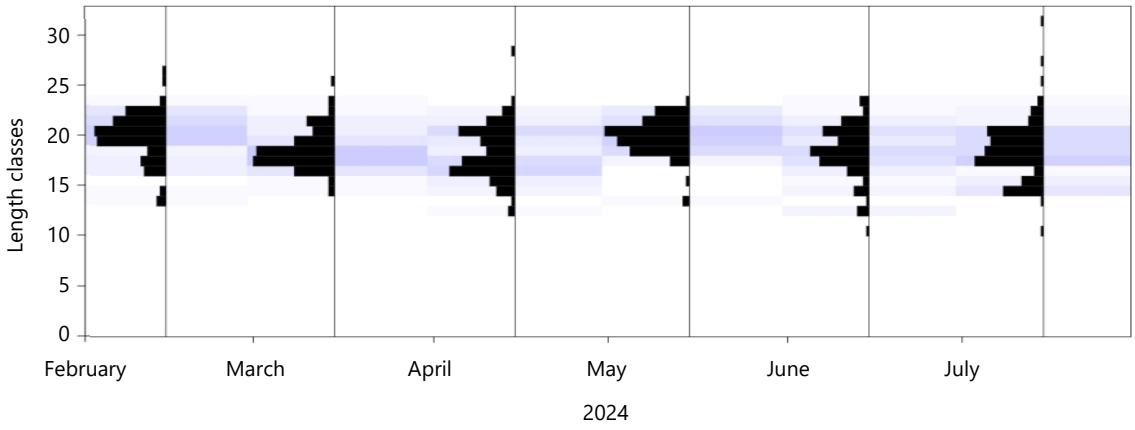

Fig. 4: Von Bertalanffy growth function curve of *C. nigrodigitatus* in Asejire Lake

The distribution of data from the study showed strong monthly variability in the number of individuals (unbalanced data), ranging from 105 in February to 115 in July (Fig. 3). It was also observed that the length frequency distribution exhibited the greatest variability in April, June, and July. Meanwhile, the extremely small and large individuals encountered during the study suggested June and July as the spawning period (Fig. 4 and 5). The density plot of the length frequency distribution exhibited three modes corresponding to mean length at age 0^+(13.1 cm), 1^+ (18.8 cm), and 2^+ (27.5 cm), respectively (Fig. 6).

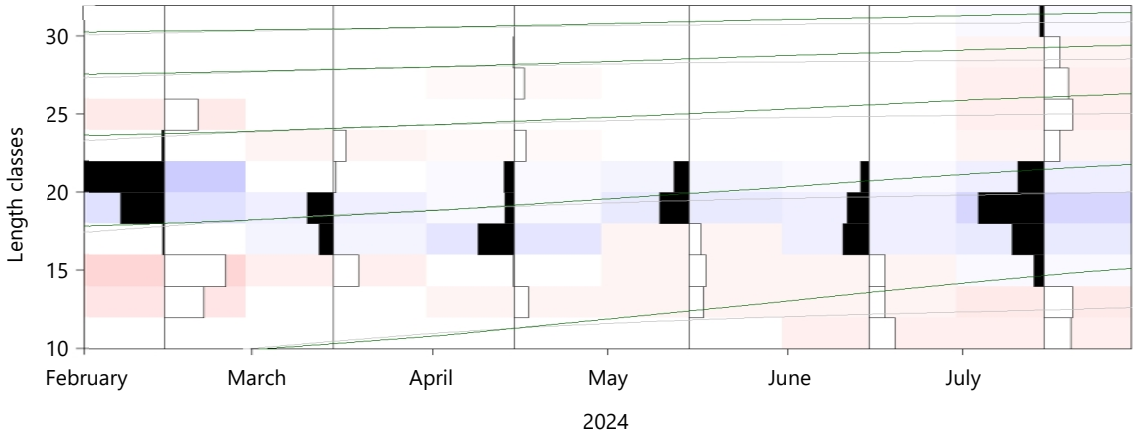

Fig. 5: Age cohorts (dashed lines) estimated by the VBGF model
A maximum age of 5 years was estimated for the species

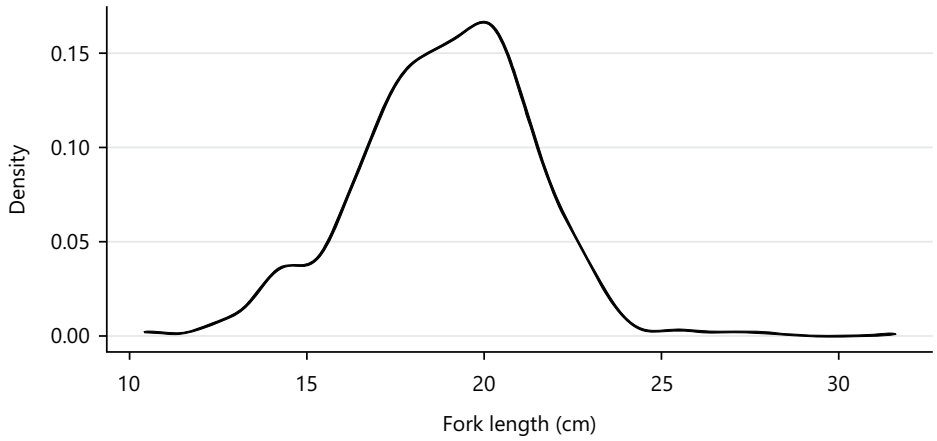

Fig. 6: Length frequency distribution exhibited three modes; mean-length at age 0^+(13.1 cm), 1^+ (18.8 cm), and 2^+ (27.5 cm)

The length attained at infinity ($L\infty$) and growth coefficient (K) values were 36.07 cm and 0.38 y, respectively. The estimated $L\infty$ (36.07 cm) is greater than the observed maximum size of 31.60 cm, an indication that *Chrysichthys nigrodigitatus* does not attain full size potential in the Asejire Reservoir. The estimated life span for the species in the habitat was 3.5 years. The length-converted catch curve of *C. nigrodigitatus* is shown in Fig. 7a-b. Instantaneous total mortality (Z) was estimated as 2.54 $year^{-1}$. The natural and fishing mortality rates were estimated at M = 0.67 and F = 1.91 $year^{-1}$, respectively. The current exploitation rate (E) was obtained at 0.75.

DISCUSSION

In the present study, the average weight of the sampled fish varied from 11 to 320 g. Most of the specimens encountered have an average weight of about 80 to 100 g, which implies excessive exploitation of the fish and degradation of ecological conditions[15]. Though these results are somewhat comparable to those recorded (25.0-546 g) by Nurudeen and Kareem[16] for *Chrysichthys nigrodigitatus* in the same Lake. Silga *et al.*[17], also noted that these low catch weights signify non-compliance with the regulations concerning the size of the mesh of the nets. The linear relationship between the fork length and body weight of *C. nigrodigitatus* in the study reflects an isometric growth pattern where the length increased proportionately to weight. This indicates that the fish maintains dimensional equality. This result is consistent with the growth pattern reported in a population of *C. nigrodigitatus* from Lake Akata (2.95) in Benue State, Nigeria[18], and Lake Ahozon (2.99) in Ouidah City in Southern Benin[19]. However, this result is in contrast with Nurudeen and Kareem[16] and Kareem *et al.*[1], who reported a negative allometric growth

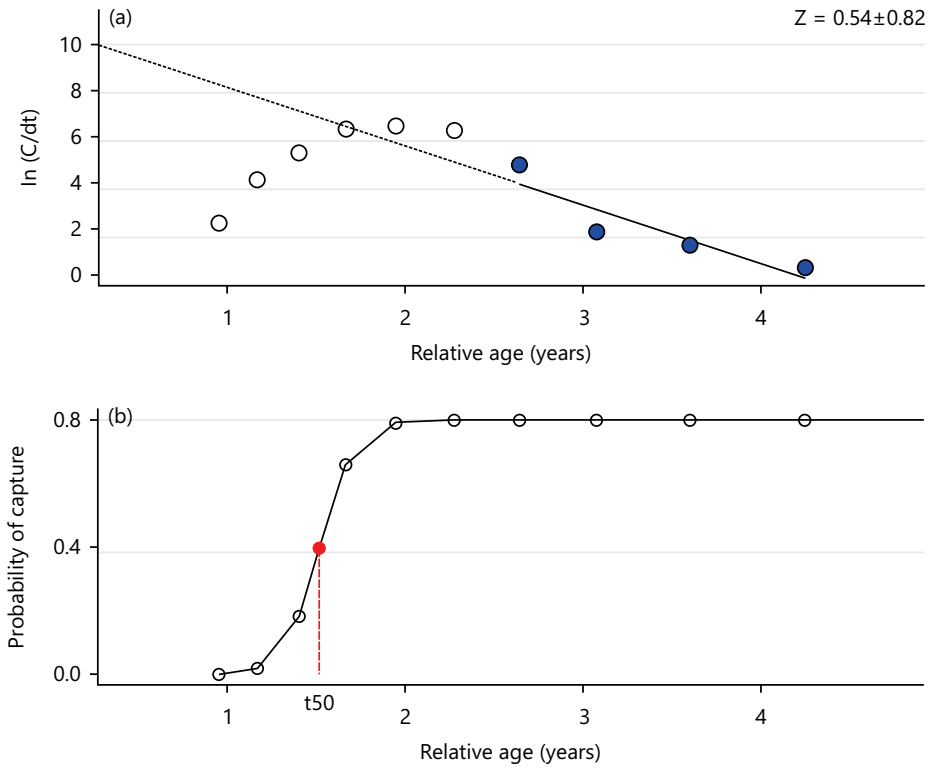

Fig. 7(a-b): Length-converted catch curve for *Chrysichthys nigrodigitatus* from Asejire Lake, (a) Total mortality coefficient (Z) of *C. nigrodigitatus* and (b) Length at first capture of *C. nigrodigitatus* from Asejire Lake

for *C. nigrodigitatus* in Asejire and Erelu Lakes, Oyo State, Nigeria. These results agree with the view of Abdul *et al.*[20], who reported that fish do not retain the same shape throughout their lifespan. Some of the factors responsible for the fluctuation in LWR and growth patterns of fish species as observed by Oboh and Olowo[21] include gear selectivity, time of the year, sex, and differences in seasons. The correlation coefficient obtained in this study (0.93) is close to unity (1) which signifies a strong relationship between the length and weight of *C. nigrodigitatus*. This result coincides with the findings of Nurudeen and Kareem[16] on *C. nigrodigitatus* from the same water body.

The mean condition factor (K) estimated in this study was 0.51±0.13, which was comparatively low to the results of Abidemi-Iromini and Bello-Olusoji[22], who reported 1.64 for *C. nigrodigitatus* in Asejire Lake. Also, Abdul *et al.*[20] and Ikongbeh *et al.*[18] recorded 0.83-0.97 and 1.62±0.02 for *C. nigrodigitatus* in Lekki Lagoon, Lagos, and Lake Akata, Benue, respectively. According to Ricker[23], the estimation of the condition factor of fish species from length and weight relationship is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. This result implies that the fish in this study lack good general environmental conditions as predicated by le Cren[24]. The values of L_∞ (cm FL) and K (year) of the von Bertalanffy growth parameter for the study were, respectively estimated to be 36.07 and 0.38. The asymptotic length (L_∞) estimated in this study was above 25.70 cm, reported by Antigha *et al.*[25] in the Cross River estuary, Southeastern Nigeria. This L_∞ value is also generally close to the value (37.28 cm) observed by Ikongbeh *et al.*[18] from Lake Akata, Benue State, Nigeria. These results could imply that the stock of *C. nigrodigitatus* being exploited was mostly the medium-sized individuals as larger *C. nigrodigitatus* with L_∞ of 60.90 and 120.20 cm have been reported in Ajagbe *et al.*[26] and lower Cross River, Nigeria[27], respectively. However, Frota *et al.*[28] reported that the maximum size attainable in fishes is location-specific. Further, the K value in the present study was lower than 0.96 and 0.53 year^{-1} reported by Ikongbeh *et al.*[18] and Ajagbe *et al.*[26], respectively. However, Branstetter[29] noted that fish species with a growth coefficient in the range of K (0.20-0.50 year^{-1} and above) would be characterized by rapid growth.

The instantaneous total mortality (Z) of 2.54 year^{-1} in this study is low compared to 3.29 year^{-1} recorded for *C. nigrodigitatus* in Ikere-Gorge, Southwestern Nigeria[27], but slightly higher than 2.72 year^{-1} reported by Antigha *et al*.[25] in Mid Cross River Flood System, Southeastern Nigeria. The variations in results have been attributed to differences in environmental parameters and the level of fishing effort[30]. The estimated natural mortality (0.67 year^{-1}) and fishing mortality (1.91 year^{-1}) recorded in the present study were lower than M = 1.58 and F = 2.73 year^{-1} reported by Udoh *et al*.[27] in the lower Cross River, Nigeria. The current study indicates that (M) was lower than (F), which implies overfishing. The size at which the youngest individuals are captured corresponds to 15.90 cm at ages 1.5 years. The exploitation status of 0.75 (>0.5 threshold) suggests imminent collapse of the fish due to an unsustainable level of fishing, causing growth overfishing (excessive harvesting of young immature fish). With an estimated lifespan of 3.5 years for *C. nigrodigitatus* in Asejire Lake, the species has a relatively short life cycle, making it particularly vulnerable to fishing pressures. Short-lived species often struggle to recover from overfishing, especially if younger individuals are targeted. This implies that they are normally caught before they have had the chance to grow enough to contribute substantially to the stock biomass, which indicates over-fishing. Ajagbe *et al*.[26] obtained a similar longevity of 3.13 years for *C. nigrodigitatus* in Ikere-gorge, Iseyin, Nigeria. In contrast, Udoh *et al*.[27] reported 2 2-year potential longevity for *C. nigrodigitatus* from the lower Cross River, Nigeria.

The potential limitation of this study is essentially the paucity of funds to drive the research, which is responsible for the limited duration and sample size of the research. This study ought to cover two seasons, i.e., twelve months, to show seasonality with more samples covered if there is adequate funding. Further studies are, however, recommended to explore the seasonality effect on the fish stock. This will ensure more robust data to formulate a reliable and sustainable management policy for the fish stock in this Lake.

CONCLUSION

The research concluded that *C. nigrodigitatus* in Asejire reservoir, Nigeria, growth was isometric with a low condition factor, indicating the poor state of well-being. The length at infinity of this species indicates that the stock was being exploited using a net of an inappropriate mesh size. However, the growth coefficient revealed that the species is fast-growing and short-lived. Mortality parameters indicated an over-exploitation of the stock of *C. nigrodigitatus* in Asejire Lake. There is, thus, the need to improve the condition of the lake and adopt sustainable management strategies for the species in Asejire Lake.

SIGNIFICANCE STATEMENT

This study gives critical data on the dynamics of the *Chrysichthys nigrodigitatus* population in Asejire Lake, Oyo State, Nigeria. Current findings revealed that all the estimated parameters were within an acceptable range, however, the exploitation of *C. nigrodigitatus* is not sustainable on the Lake. The results suggest that the values of fishing mortality and exploitation rate is high, and dangerous for *Chrysichthys nigrodigitatus* population in Asejire Lake.

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