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Population Dynamics of *Bagrus bayad macropterus* from Dadin – Kowa Reservoir, Nigeria

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ABSTRACT

The population dynamic parameters of *Bagrus bayad macropterus* from Dadin-Kowa reservoir were studied. Population dynamic parameters such as growth, mortality and recruitment patterns were analyzed using length frequency data over 12-month period employing FiSAT II software. Findings revealed that K = 0.94^{-yr}., L∞ = 75.75 cm and T_{max} = 3.73 years. Mortality indices revealed that the fish is slightly above exploitation threshold (F > Eopt ≤ 0.5). However; the major source of population decay is associated with fishing factors (F = $2.56^{-yr.}$). Bimodal recruitment pulses were observed with Lm = 50.5 cm, Lc/ L∞ = 0.15. Restocking program is suitable to ensure its continuous existence as it seems to have low population, and experiencing recruitment overfishing.

Keywords: Fish population dynamics, *Bagrus bayad macropterus*, FiSAT II, Natural Mortality, Dadin-Kowa Reservoir.

INTRODUCTION

Fish and its resources has been an integral component of food security in many countries across the world, this is not limited to only coastal areas but also encompasses inland water bodies (Ahamed, Akter, Hasan, & Chakma, 2024). Human nutritional requirements depends also largely upon the resources obtained from fish such as lipids, high quality proteins (Nazeef, Ja'afaru, Ka, & Kabiru, 2021), and numerous minerals such as iodine and phosphorous (Ahamed *et al*., 2024).

Nigeria is one of the most populous country in the world with exponential population growth annually, a substantial part of this population lives around water confinements (Nazeef *et al*., 2021).

Globally 90% of inland fish stock are managed without less or no formal stock assessment (Dinh & Truong, 2023) indicates that only 10% or below of global fish species biological parameters were analyzed (Hommik, Fitzgerald, Kelly, & Shephard, 2020), this make it crucial to ensure sustainability of fish resources through appropriate management processes (Ahamed *et al*., 2024; Gabellini & Mariani, 2023).

The Bagrid *Bagrus bajad* is an omnivorous fish species found in Africa, especially in Northern Nigeria. The habitat of this species is confined to slow moving or stagnant impoundments such as lakes, wetlands and rivers (S Nazeef et al., 2021). Habitat destruction, overexploitation (Ahamed et al., 2024) and other factors of population decay such as flooding, stream-flow and predation (Bin, Hasan, Alam, & Mahfujul, 2021; Sheaves, Bradley, Lubitz, & Mattone, 2024) are forces that distort fish population. Despite its market value, the IUCN has rated this fish species as least concern (LC) (Dankwa et al., 2020).

Therefore successful management of fish resources is needed for maintaining equilibrium of the fish between additive and destructive forces acting on the population (Ara, Azadi, Nasiruddin, Hossain, & Mustafa, 2019; Renjithkumar, 2014). Therefore the

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advancement of fishery resources lies in the intimate utilization of fishery science, globally extensive studies were conducted by many researchers with regards to fish species population dynamics, this includes works of (Adite, Gbaguidi, & Ibikounle, 2017; Amponsah, Ofori-danson, Nunoo, & Ameyaw, 2016; Baset et al., 2020; Das, 2014; Fazli, Tavakoli, Khoshghalb, & Moghim, 2020; Garton, Wells, Baumgardt, & Connelly, 2015; Izquierdo-gomez, Bayle-sempere, Arreguín-sánchez, & Sánchez-jerez, 2016; Mehanna, El-gammal, Zaahkouk, Khalaf-ALLAH, & Makkey, 2017; Pesqueira et al., 2019; Sarker, Humayun, Atiar Rahman, & Sharif Uddin, 2017). In Nigeria, prominent researchers contributed to the development and understanding of fishery biology such as (Abowei, 2009; Ekundayo, Sogbesan, & Haruna, 2014; Essien-Ibok & Isemin, 2020; Famoofo & Abdul, 2020; Francis & Erondu, 2010; Udoh, Ekpo, & Essien, 2013; Udoh, Ukpatu, & Udoidiong, 2015; Vincent, 2015).

MATERIALS AND METHODS

The study Area

The Dadin-Kowa is located in Yamaltu-Deba Local Government area, Gombe State in the north east of Nigeria. Dadin-kowa town is located between Latitudes 10°19′19″N and 10.32194°N; Longitude 11°28′54″E and 11.48167°E. It shares common boundary with Akko Local Government area, to the South and West, Yamaltu-Deba to the East and Kwami to the North. Dadin-kowa has an altitude of about 370 meters above sea level (Nazeef & Yerima, 2023; Nazeef & Abubakar, 2013)

Data Collection

Fish samples were collected from three prominent landing sites on a monthly basis for the period of 12 months (January - December, 2020) from the catches of artisanal fishermen. The three landing sites were: *Almakashi*: 10°44’40.584’’N, 11°30’32.574’’E, *Dadin-Kowa*: 10°92’14.142’’N, 11°28’43.956’’E and *Malleri*: 10°18’ 38.539’’N, 11°9’13.582’’E. The study area has bordered three local government areas of Gombe State each with at least a town having intensive fishing activities, therefore, the aforementioned landing sites were selected reflecting the entire Reservoir coverage, and the local government areas includes Funakaye (Almakashi); Yamaltu-Deba (Dadin-Kowa) and Kwami (Malleri) accordingly.

Fish samples were sampled from the population and their morphometric measurements (Standard length & weight) were measured using a measuring tape and a digital weighing balance (Sartorius) to the nearest 0.1cm and 0.1g respectively. The standard lengths of each of the fish species measured from the three landing sites was pooled monthly (Ahmad, Yola, & Nazeef, 2018) and grouped into classes of 2-cm constant class sizes using the FiSAT_II software for subsequent analyses.

Fish Species Length-Weight relationship (*LWR*) Determination

Using MS Excel, the incurred morphometric data (length and weight precisely) from the fish species studied was transformed into their natural logarithm numbers using the “*LN*” function. Thereafter, “*Regression*” function of the same MS Excel was employed to determine the length-weight relationship ($W=aL^b$) (Ahmad, Yola, & Suleiman, 2018; Somy, 2014). Equations of the graph was generated thereafter. These gave the functions and the constants of the intercepts and slopes (*a & b*) of the corresponding graphs (Arame, Adite, Adjibade, Imorou, & Sonon, 2020).

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Fish Species Growth Parameter Determination

The length frequency data was used to plot *Powell-Wetherall Plot* (Dong, Xiang, Ju, Li, & Ye, 2019) which was then used to obtain the initial asymptotic length ($L\infty$) – Which is the hypothetical length a fish will reach if it were to grow forever - and Z/K. The value of asymptotic length was then fitted into ELEFAN 1 to obtain growth coefficient (K) of Von Bertalanffy Growth Formula (VBGF) and the best growth curve for better estimation of asymptotic length. Also the length frequency distribution was obtained using ELEFAN I (Vicentin, Tondato, Ferreira, Costa, & Suarez, 2018).

Where:

$L\infty$ = Asymptotic length

Z/K = the ratio between total mortality and growth speed towards $L\infty$

Also, fish species hypothetical longevity or T_{max} was determined for each species using the function Longevity (T_{max}) = 3/(K)……….(1)

(Achmad, Gani, Ardiansyah, & Mokoginta, 2022; Gosavi, Kharat, Kumkar, & Tapkir, 2019; A. Wehye & Amponsah, 2017)

Where

K = VBGF growth constant, or coefficient of growth.

Growth Performance index was calculated as explained by Ahmad *et al*, (2018) using the function

$ø' = \log10(K) + 2\log10(L\infty)$…………….... (2)

Where:

K is the VBGF growth constant and $L\infty$ is the asymptotic length.

Fish Species Recruitment Patterns Determination

The recruitment rate of the fish species was estimated by backward projection, as illustrated in the FiSAT routine, along a trajectory defined by the VBGF; of the length-frequencies onto the time axis of a time-series of samples using the original data, as described in the FiSAT II routine. Inputs for the recruitment determination includes growth parameters such $L\infty$, K and t_0 (if available). Recruitment pulses were obtained, which is/are the month(s) with the highest percentages of recruitment as an output (Asriyana, Halili, & Irawati, 2020; Chowdury, Nasiruddin, Azadi, & Mustafa, 2023).

Where;

$L\infty$ = Asymptotic length

K = Growth speed

t_0 = growth of fish at age zero

Also, the length at first maturity (Lm) was determined employing the function:

$Lm = L\infty * 2/3$, (Wehye *et al*., 2017) ……....(3)

Where,

$L\infty$ = Asymptotic length.

Fish Species Mortality Rates Determination

Employing the *Pauly M's Equation*; the Total mortality rate (Z) of the fish species was estimated using *Length-Converted Catch Analysis* taking 25°C as the mean annual surface temperature of the Reservoir. The Natural mortality rates (M) were estimated using Pauly M's equation. Outputs of the process besides **Z** and **M**; includes the Fishing mortality (F) and Exploitation ratio (E).

$$\ln(M) = -0.0152 - 0.279 \ln(L\infty) + 0.6543 \ln(K) + 0.463 \ln(T)............(4)$$

(Ghofar *et al*., 2021; Purnama, Yusuf, & Didiharyono, 2023)

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Where;

L∞ = Asymptotic length

K = VBGF growth constant

T = Mean annual surface temperature (Temperature measurements were taken in-situ using Hanna portable thermometer)

Also, Optimum fishing (F_{opt}) which is directly related to the natural mortality (M) was calculated for the selected fish species using the expression below:

$F_{opt} = 0.4*(M)$........……….……………....(5)

But (M) is coefficient of natural mortality(Paschoal & Zara, 2024; A. Wehye, Ofori-danson, & Lamptey, 2017).

Fish Species Virtual Population Analysis (VPA)

This is where the population of the species is reconstructed to obtain the estimated catches, biomass/kg, the exploitation level of the various length classes and the assumed total population. Inputs for the computation of VPA were; Length-weight relationship constants, *a* and *b*, Fishing mortality (F), Natural mortality (M), Fishing mortality (Ft) and growth parameters – asymptotic length (L∞) and growth rate (K). *Length-structured option* of the VPA was used (Beaune et al., 2020; Simon & Buzevych, 2024).

RESULTS

Growth Parameters

Data obtained for the parameters of growth for *Bagrus bajad* indicated that asymptotic length (L∞) = 75.75 cm, growth speed (K) is $0.94^{-yr.}$, growth performance index (ø') = 3.73 and potential longevity (T_{max}) is 3.19 years accordingly (Figure 1).

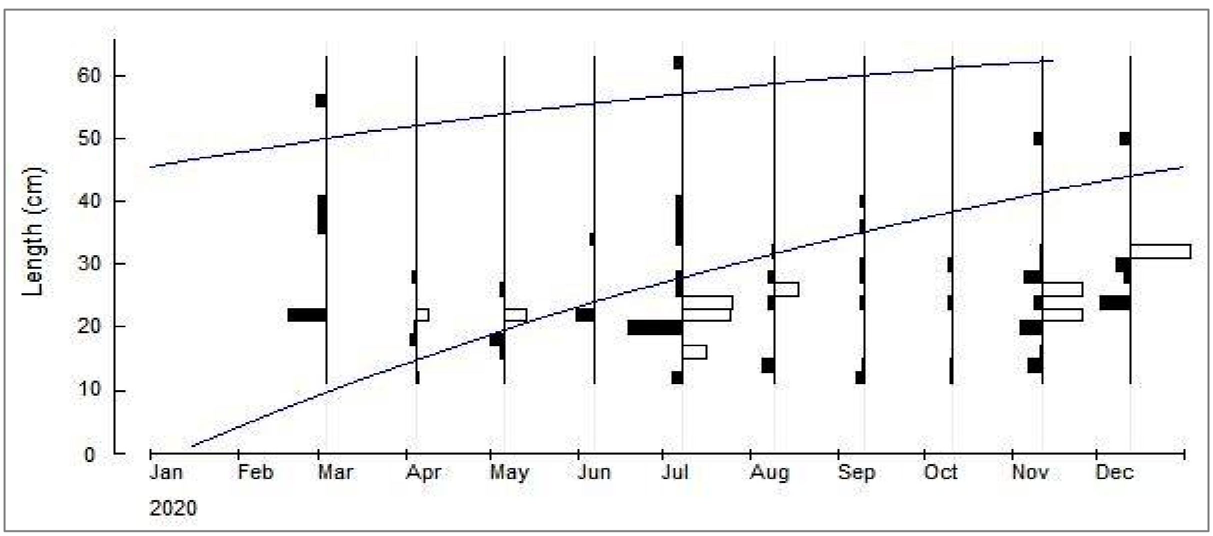

Figure 1: Length frequency histograms superimposed with growth curve of *Bagrus bayad macropterus.*

Mortality Parameters

The parameters of mortality with respect to the said fish species revealed that Total mortality (Z) stood at 3.85^{-yr}, Natural mortality (M) is 1.26^{-yr} and Fishing mortality (F) is 2.56^{-yr}. However, the Exploitation ratio (E) is 0.67^{-yr} L_{opt} = 52.4 cm, L_{50} = 12 cm, and Lc/L∞ = 0.15 (Figures 2 and 3).

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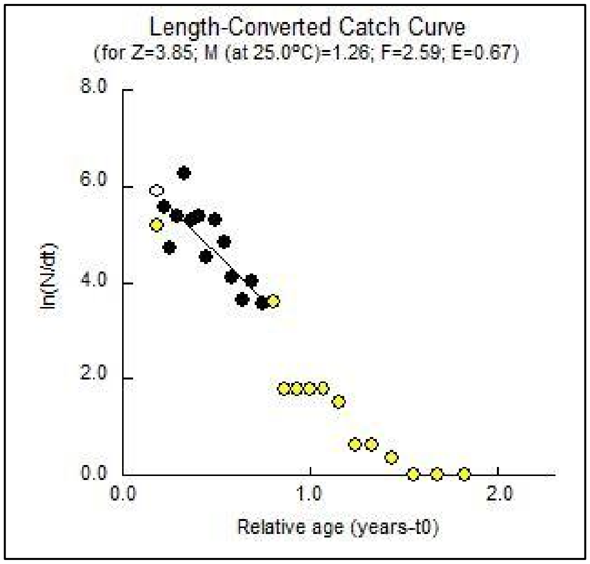

Figure 2: Mortality parameters of *Bagrus bayad.*

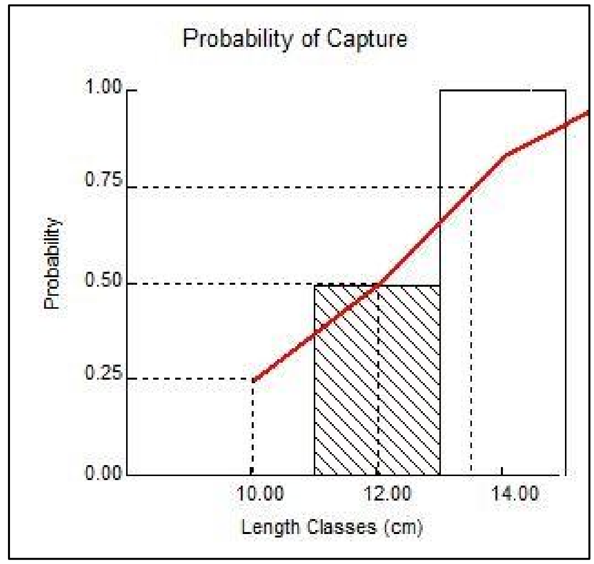

Figure 3: Probability of capture of *Bagrus bayad.*

Recruitment Patterns

Reflecting on the recruitment pattern of the said fish indicates a bimodal recruitment peaks occurring in March (14.9%) and June (20.5%), whereas the month of November recorded the least recruitment output with 2.24% of the fish's population. However, the **Lm** obtained was 50.5 cm accordingly (Figure 4).

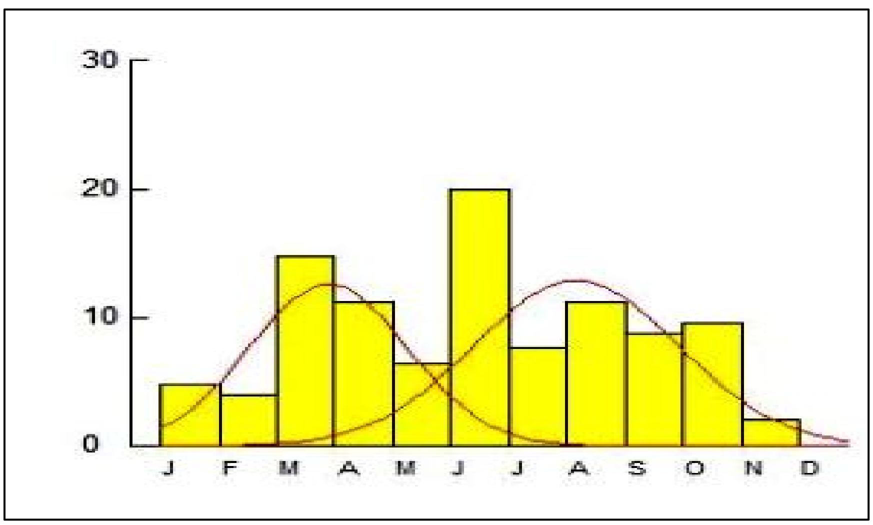

Figure 4: Recruitment pulses of *Bagrus bayad.*

DISCUSSION

Growth Parameters

Bagrus bayad macropterus

In this study; this fish species indicated asymptotic length 75.75cm, growth coefficient (K = 0.94), ideal length at first capture ($L\text{-}L^{I}$ = 31cm) potential longevity of 3.19 years and growth performance index of 3.75. Being the most important determining factor in stock assessment; the asymptotic length agreed with that of Nozha hydrodrome, Egypt

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(fishbase.org) and not in conformity to 87cm on *Bagrus bayad macropterus* from Sharkia Province, Egypt (El-drawany and Elnagar, 2015). Differences in genetic constitution, environmental factors such as water quality, predation and harvest intensity can influence asymptotic length of fish (Mohd and Zain, 2019). While growth performance index (3.73) is slightly larger than 3.26 (fishbase.org), and exceeds that of *Mormyrus rume* (Stephen Olubusoye Ajagbe and Folashade, 2020) and *Auchenoglanis occidentalis* (2.96) from Northern Ghana (Abobi, Oyiadzo, and Wolff, 2019). Growth performance index is species specific; and tropical fishes with high scores are characterized with short lifespan (Amponsah, Abdulhakim, Ofori-danson, & Anyan, 2017). Growth coefficient (K) exceed the ones documented at fishbase.org repository and higher than 0.159 (El-drawany and Elnagar, 2015). However, in terms of longevity; eight years was recorded for the said fish species which is comparably larger than that of this study. Growth performance index is inversely proportional to longevity; this is the possible outcome for such difference. Also; food availability, favorable aquatic environmental conditions for this species could have supported the fast growth of the fish species (Mudjirahayu *et al.*, 2017).

Mortality and Recruitment Indices

Bagrus bayad macropterus

Findings emanating from natural mortality indicates that *Bagrus bayad macropterus* has the score ($M^{-yr.}$ = 1.26) which aligned to that of *C. nigrodigitatus* from Ikere gorge (Ajagbe *et al.,* 2021) and exceeds $0.68^{-yr.}$ against *Thunnus albacares* (India) by (Ghofar *et al*., 2021). The recorded natural mortality (M) is however lower than 2.87^{-yr} for *Hydrocynus brevis* from Dadin-Kowa reservoir (Nazeef & Yerima, 2023), lesser than 1.44^{-yr} against *Brachydeuterus auritus* reported from Ghana (Amponsah *et al*., 2017). But however it exceeds 0.371^{-yr} documented against *Oreochromis mossambicus* of Limboto lake (Purnama *et al*., 2023).

Recorded length at first capture (L_C) is less than length at first maturity (Lm = 50 cm) and length at optimum exploitation (L_{opt} = 52.4cm) indicating growth and recruitment overfishing characterized by small-sized fishes in the landings. This L_C value agreed with that of Ahmed *et al.,* (2018). The aforementioned statement was strengthened by low value of $L_C/L\infty$ (0.15), this is also similar to that of Ahmed *et al.,* (2018). The fish species is one of the most sought for; because Z/K > 1, indicating mortality domination and exploitation rate is above the threshold of 0.5. These findings conformed to that of Ahmed *et al.,* (2018). Exploitation rates of fish is associated with harvest intensity, factors influencing natural population decay, and public demand (Langangen *et al*., 2023).

Bimodal recruitment present with peak pulse occurring in June (20.5%). Double recruitment peaks is characteristics of most tropical fishes which have short lifespan as observed from the works of the following scientists (Wehye & Amponsah, 2017) on *Galeoides decadactylus*, and *Schilbe mandibularis* (Assi *et al*., 2018).

Bimodal recruitment pattern is assumed to be plasticity of tropical fishes with diverse ecological flexibility (Musel *et al*., 2022).

CONCLUSION

The current findings revealed that *Bagrus bayad macropterus* from Dadin-Kowa Reservoir had good growth coefficient, but bears setbacks resulting from low lifespan and greatly ravaged by overexploitation.

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