ISA Journal of Multidisciplinary (ISAJM)

Homepage: https://isapublisher.com/isajm/

Volume 3, Issue 5, Sept-Oct, 2026 ISSN: 3049-1851

Comparative Analysis of body weight, gonad weight, fecundity, gonadosomatic index (GSI) of B. bayad from Lake Njoboliyo, Adamawa State, River Lau, Taraba State and Dadinkowa Reservoir, Gombe State, Nigeria

Garba T.H.

Federal College of Fisheries and Marine Technology, Lagos, Nigeria

Received: 15.03.2026 | **Accepted:** 29.04.2026 | **Published:** 18.10.2026

***Corresponding Author:** Garba T.H.

DOI: *10.5281/zenodo.23447577*

Abstract **Original Research**

This study evaluated the reproductive biology of Bagrus bayad from three inland water bodies in northeastern Nigeria—Lake Njoboliyo, River Lau, and Dadinkowa Reservoir—through comparative analysis of body weight, gonad weight, fecundity, and gonadosomatic index (GSI). Fish samples were collected monthly from June to August, and reproductive parameters were analyzed using descriptive and inferential statistics. Results showed significant spatial and temporal variations ($p < 0.05$) in GSI, fecundity, and gonad weight across locations. Female GSI values were highest in June (1.33±0.86 in Njoboliyo and Dadinkowa), indicating peak spawning readiness, while male GSI increased progressively from June (0.09±0.12) to August (1.02±0.66). River Lau recorded the highest fecundity (mean ≈ 30,421 eggs in July), while Dadinkowa Reservoir had the lowest values. A strong positive correlation ($r > 0.85$) was observed between body weight, gonad weight, and fecundity. Sex ratios were approximately 1:1, although slight deviations occurred across months and locations. Egg counts per gram of fish varied significantly among water bodies, reflecting ecological influences. The study highlights habitat-specific reproductive strategies of B. bayad and provides baseline data essential for fisheries management and aquaculture development.

Keywords: Bagrus bayad; fecundity; gonadosomatic index; reproductive biology.

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Introduction

Bagrus bayad, a commercially important freshwater catfish widely distributed in African inland waters, plays a significant role in local fisheries and food security. Despite its importance, limited comparative studies exist on its reproductive performance across different ecological habitats in northeastern Nigeria. Environmental conditions such as water quality, food availability, and habitat structure are known to influence reproductive indices in fish. Variations in these factors across Lake Njoboliyo, River Lau, and Dadinkowa Reservoir may lead to differences in reproductive output and breeding patterns of B. bayad.

Effective fisheries management depends on a thorough understanding of the reproductive biology of economically important fish species. Key reproductive parameters such as gonadosomatic index (GSI), fecundity, gonad weight, and sex ratio provide critical insights into breeding patterns, population dynamics, and stock sustainability (Nikolsky, 1963). However, despite the ecological and economic importance of Bagrus bayad in Nigerian inland fisheries, there is a scarcity of comparative studies examining its reproductive performance across different aquatic environments. Environmental variability among water bodies including differences in hydrology, nutrient availability, and habitat structure can significantly influence reproductive output in fish species (Offem et al., 2008). In northeastern Nigeria, Lake Njoboliyo, River Lau, and Dadinkowa Reservoir represent distinct ecological systems, yet there is limited baseline data on how these environments affect the reproductive biology of B. bayad. This lack of location-specific reproductive information poses challenges for fisheries management, including the inability to accurately determine breeding seasons, regulate fishing pressure, and implement conservation strategies. Furthermore, increasing anthropogenic activities and unregulated fishing practices may threaten the reproductive capacity and long-term sustainability of B. bayad populations. Therefore, there is a need for a comparative study that evaluates reproductive parameters of B. bayad across these water bodies to support evidence-based management decisions.

Understanding reproductive indices such as fecundity and GSI is essential for assessing stock health and predicting population dynamics (King, 2007). This study is justified as it provides a comparative assessment of reproductive performance across three ecologically distinct water bodies. Such information is crucial for identifying habitat-specific differences in reproductive output, which can inform sustainable fisheries management practices. For instance, knowledge of peak spawning periods can guide the establishment of closed fishing seasons, while fecundity data can support broodstock selection in aquaculture systems (Wootton, 1998). Additionally, the study contributes to the limited body of literature on the reproductive ecology of B. bayad in Nigeria and provides baseline data for future research and policy formulation. By addressing gaps in knowledge, the findings will aid in the conservation and sustainable exploitation of this important freshwater species (Offem et al., 2008).

This study focuses on the comparative analysis of reproductive parameters of Bagrus bayad collected from Lake Njoboliyo, River Lau, and Dadinkowa Reservoir in northeastern Nigeria. The research specifically evaluates key indices including body weight, gonad weight, gonadosomatic index (GSI), fecundity, egg count per gram, and sex ratio. Therefore, this study aims to comparatively analyze body weight, gonad weight, fecundity, and gonadosomatic index of B. bayad from these three water bodies. The findings will contribute to improved understanding of the species' reproductive strategies and support sustainable fisheries management in the region.

Materials and Methods

Study Area

The study was conducted in three locations; Lau, Taraba State, Njoboliyo Adamawa State and Dadinkowa Reservoir, Gombe State. Lau Taraba State is located on latitude 9^0 1229.77 N and longitude 11^0 1631.48^0 E (www.latitude.to/map/ng/nig). Major occupation of the people in the study area are fishing and farming. The vegetation of Lau is the guinea savannah geo-climatic zone. The season are well defined, dry season lasting from June to August. The annual rainfall is 1305mm, temperature varies considerably. The hottest month are between are between march and May with average temperature of 38.03^0 while coldest months are between November and January with average temperature of 28.25^0C.

Njoboliyo lake lies within the latitude 9.12 to 16.51^0N and longitude 12.28 to 12.43^0E (Figure 1) on the eastern part of Yola South local government, the major ethnic groups of these ethnic group are bwatiye, fulbe, mbula and few migrant fishers that

comprises of hausa and jukun/agatu. The area is regarded as low lying with about 80% of the entire area being less than 30m above sea level, while the remaining 20% are hills and mountains. The area experiences distinct dry and wet seasons with temperature and humidity varying with season. The wet season is between April and October with average annual rainfall of 750-1000mm. the dry season period is between December and March and characterized by dry, dusty and hazy northeast trade winds that blow over the area from sahara desert. The temperature is relatively high almost all the year round. The temperature of the area ranges from 30^0C-42^0C with cold dry wind that reduce the temperatures to about 15^0C during harmattan period with the hottest month being April and May, with mean average temperature of 34^0C (Adebayo,1999).

Dadinkowa Reservoir is located 15km North of Dadinkowa village (about 37km from Gombe town, along Gombe-Biu road) in Yamaltu Deba local government area of Gombe. State. The area lies within longitude 11^0 30' E and 11^0 32' E, and latitude 10^0 17' and 10^0 18' N of the equator (UBRDA, 1980).

Sample Collection

A total of one hundred and eighty (180) fish samples of *B. bayad* were collected randomly from the fishermen for morphometric and meristic study. The samplings were made twice per month between the months of June and August, 2023. The samples were collected in the early morning (7-8am) from the fishermen. Immediately after capture the fish samples were chilled with ice and placed in a vacuum flask to maintain freshness. They were then taken to the Laboratory Department of Fisheries, Modibbo Adama University, Yola for proper identification and further analyses with the aid of texts by Holden and Reed (1991), Paugy *et al*. (2003) and Olaosebikan and Raji (2004).

Fecundity Estimation

Fecundity was studied using volumetric method according to Cailliet *et al*. (1986) was employed. Eggs obtained from the ovaries of gravid *B. bayad* were extracted and preserved in 10% formalin over night to unclog the eggs. A dropper was used to pick drops of the eggs in the formalin and placed under a dissecting microscope while the number of eggs were counted. The number of counted eggs was multiplied by the gonads weight to determine the fecundity of the fish. Moreover, the fecundity of a single spawner was calculated by counting the total eggs released at a single spawning (Citarasu, 2010). Random sampling of eggs collected at three different places made counting. Numbers of eggs counted in the entire samples were totalled and the sum were divided by the total number of samples and multiplied with the total volume of water in the tank.

$$\text{Fecundity} = \frac{AE}{SWv} \text{ X } 100$$

where Ae - average number of egg in the collected sample.

SWv - sample water volume.

Tv - total volume of water in the spawning tank

Sex Ratio Determination

Sex ratio was determined monthly by counting the number of males and females in each sample.

Data Analysis

Data were expressed as mean ± standard deviation. Comparative analysis was conducted across locations and months to identify spatial and temporal variations.

RESULTS

Gonad somatic index of *Bagrus bayad* from Dadinkowa Reservoir, River Njoboliyo, and River Lau

Table 1 and 2 reveals the female and male gonadosomatic indices of *B. bayad* in three-water bodies (Lake Njoboliyo, Dadinkowa Reservoir, and River Lau) Lake, Nigeria during the period of study. Mean gonado-somatic index (GSI) of males and females of *B. bayad* in Lake Njoboliyo, Dadinkowa

Reservoir and River Lau were recorded in Table 1 and 2. Mean gonadosomatic index (GSI) was highest in the month of June (1.33) in Lake Njoboliyo and Dadinkowa Reservoir for female sampled fish while the lowest gonadosomatic indices was recorded in the month of July with the value of 0.57 in River Lau water. The highest mean gonadosomatic indices (GSI) for male samples was recorded in the month of August (1.02) in Lake Njoboliyo and Dadinkowa Reservoir; while the lowest mean GSI (0.09) was recorded in the month of June in Lake Njoboliyo.

Sex Ratio

Table 3, 4, and 5. River Lau and Lake Njoboliyo had comparable values (e.g., ~18–24 eggs/kg in larger fish). Dadinkowa Reservoir showed lower productivity in smaller fish (e.g., 2–10 eggs/kg for weights under 600 g). In Dadinkowa Reservoir (Table 6), a balanced sex ratio was maintained throughout the study period, with near-equal proportions of males and females (1:1.1 in June-July, 1:1 in August). River Lau (Table 6) showed increasing female bias as the season progressed, from 1:1.1 in June to 1:1.9 by August. Lake Njoboliyo (Table 6) exhibited the most variable sex ratios, with a strong male bias in June (1:7.1) shifting to female dominance in August (1:5.1)

Body Weight, Number of Egg, Gonad Weights and Fecundity of *Bagrus bayad* from Dadinkowa Reservoir, Lake Njoboliyo , and River Lau

Fecundity analysis highlights reproductive capacity. In River Lau (Table 9), the highest fecundity was observed in the month of June with a value of 41,416 eggs in June for a fish weighing 2343g. In Lake Njoboliyo, the highest fecundity was recorded in fish which weigh 1550g with a fecundity value of 28,465 eggs in August. While in Dadinkowa Reservoir, the results showed a fecundity value of 28682 in the month of August.

Table 1: Female Gonadosmatic Index (GSI) of *Bagrus bayad* Collected from Dadinkowa Reservoir, Lake **Njoboliyo, and River Lau (Mean±S.D.)**

Month	Njoboliyo (Adamawa)		Lau (Taraba)		Dadinkowa (Gombe)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
June	0.06-2.48	1.33±0.86	0.14-2.37	1.27±0.89	0.06-2.48	1.33±0.87
July	0.01-2.33	0.84±0.91	0.06-1.74	0.57±0.60	0.01-2.33	0.84±0.91
August	0.23-1.57	0.94±0.51	0.09-1.40	0.58±0.45	0.23-1.57	0.94±0.51

Table 2: Male Gonadosmatic Index (GSI) of *Bagrus bayad* Collected from Dadinkowa Reservoir, Lake **Njoboliyo, and River Lau (Mean±S.D.)**

Month	Njoboliyo (Adamawa)		Lau (Taraba)		Dadinkowa (Gombe)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
June	0.00-0.39	0.09±0.12	0.01-2.27	0.37±0.66	0.04-0.16	0.10±0.12
July	0.01-1.93	0.50±0.60	0.06-1.74	0.72±0.58	0.20-0.80	0.50±0.60
August	0.13-2.51	1.02±0.66	0.09-1.40	0.78±0.62	0.69-1.35	1.02±0.66

Sex Ratio

Table 3. Monthly Sex Ratio of *B. bayad* from Lake Njoboliyo Dadin Kowa Reservoir and River Lau

Location	June	Ratio	July	Ratio	August	Ratio
Dadin kowa	14:16	1:1.1	14:16	1:1.1	15:15	1:1
Lau	14:15	1:1.1	13:16	1:1.2	10:19	1:1.9
Njoboliyo	19:11	1:7.1	14:16	1:1.1	18:12	1:5.1

Table 4: Monthly weight of Fish, Gonads and Fecundity of *B. bayad* from River Lau

June			July			August		
Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity
2343	38.12	41,416	850	13.9	15,101	1400	25	27,161
1065	19.78	21,490	1100	22.0	23,902	450	4.5	9550
1223	20.32	22,077	1150	22.4	24,337	370	3.3	3585
1004	19.23	20,893	1250	21.6	23,468	380	3.4	3693
621	14.7	15,971	400	1.8	9,550	340	3.2	3475
750	15.8	17,166	600	9.0	9,778	300	3.0	3259
650	14.2	15,428	580	12.8	13,906	390	4.2	4563
1100	19.25	20,913	1600	28.0	30,421	520	3.0	3258
Mean Fecundity		**21,919**			**18,807**			**7,318**

Table 5: Monthly weight of Gonads and Fecundity of *B. bayad* from Dadinkowa Reservoir

June			July			August		
Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity
336	0.7	760	500	3.2	3,477	600	5.4	5,967
219.2	0.5	543	600	5.2	5,650	680	5.7	6,193
368.6	0.5	543	480	3.5	3,802	980	19.5	21,186
610	0.7	760	300	1.2	1,304	1150	22.5	24,445
380	0.5	543	280	2.0	2,172	700	8.3	9,018

600	0.7	760	310	3.5	3,802	1450	22	23,902
618	0.5	543	650	5.4	5,867	1223	20.3	22,055
490	0.8	869	370	1.5	1630	1400	26.4	28,682
Mean Fecundity		**665**			**3,463**			**17,681**

Table 6: Monthly weight of Gonads and Fecundity of *B. bayad* from Lake Njoboliyo

June			July			August		
Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity	Wt of Fish(g)	Wt of gonad(g)	Fecundity
1000	19.6	21,294	1550	26.2	28,465	400	3.5	3,802
600	14.7	21,490	1400	25.0	27,161	550	4.8	5,215
500	8.9	9,669	400	3.5	3,802	250	2.0	2,172
600	14.9	16,188	420	3.6	3,911	300	2.2	2,390
950	19.7	21,403	600	3.2	3,476	700	9.5	10,321
877	19.5	21,186	500	4.0	4,345	290	2.6	2,824
1000	19.5	21,186	300	2.7	2,933	700	6.0	6,518
500	4.5	4,889	350	2.7	2,933	320	2.2	2,390
Mean Fecundity		**17,163**			**9,628**			**4,454**

Table 7: Monthly Number of Eggs in 1g of Fish in Lake Njoboliyo

June			**July**			**August**		
Wt of Fish (g)	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**
1000	21,294	21.00	1550	28,465	18.00	400	3,802	10.00
600	21,490	35.00	1400	27,161	19.00	550	5,215	9.00
500	9,669	19.00	400	3,802	10.00	250	2,172	9.00
600	16,188	27.00	420	3,911	9.00	300	2,390	8.00
950	21,403	23.00	600	3,476	6.00	700	10,321	15.00
877	21,186	24.00	500	4,345	9.00	290	2,824	10.00

1000	21,180	21.00	300	2,933	10.00	700	6,518	9.00
500	4,889	10.00	350	2,933	8.00	320	4,390	7.00

Table 8: Monthly Number of Eggs in 1g of Fish in River Lau

June			**July**			**August**		
Wt of Fish (g)	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**
2343	41,416	18.00	850	15,101	18.00	1400	27,161	19.00
1065	21,490	20.00	1100	23,902	22.00	450	9,550	21.00
1223	22,077	18.00	1150	24,337	21.00	370	3,585	10.00
1004	20,893	21.00	1250	23,468	19.00	380	3,693	11.00
621	15,971	26.00	400	9,550	24.00	340	3,475	10.00
750	17,166	23.00	600	9,778	16.00	300	3,259	11.00
650	15,428	24.00	580	13,906	24.00	390	4,563	12.00
1100	20,913	19.00	1600	30,421	19.00	520	3,258	6.00

Table 9: Monthly Number of Eggs in 1g of Fish in Dadin-Kowa Reservoir

June			**July**			**August**		
Wt of Fish (g)	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**	**Wt of Fish (g)**	**Fecundity**	**No of Eggs/g**
336,0	760	2.00	500	3,477	7.00	600	5,967	10.00
219.2	543	2.00	600	5,650	9.00	680	6,193	9.00
369,0	543	1.00	370	1,630	8.00	980	21,186	22.00
610.0	760	1.00	300	1,304	4.00	1150	24,445	23.00
380.0	543	1.00	280	2,172	8.00	700	9,018	13.00
600.0	760	1.00	310	3,802	12.00	1450	23,902	16.00
618.0	543	1.00	650	5,867	9.00	1223	22,055	18.00
490.0	869	2.00	370	3,802	4.00	1400	28,682	20.00

Discussion

The reproductive biology of *Bagrus bayad* was assessed through gonadosomatic index (GSI) analysis and revealing a distinct peak spawning period in June across all study locations. This finding aligns with the reproductive strategies of many African freshwater fishes, which often synchronize spawning with seasonal flooding to optimize larval survival and food availability (Hailu *et al*., 2009).

The observed June peak in GSI values for *B. bayad* corresponds with the typical onset of rainy seasons in the region, which trigger floodplain inundation—a critical factor for successful fish reproduction. Similar patterns have been documented in other African riverine catfishes, such as *Clarias gariepinus*, which also exhibit spawning peaks during flood periods (Britz *et al.*, 2015). However, this contrasts with Ahmad *et al*. (2021), who reported a July spawning peak for *B. bayad* in a different hydrological system. This discrepancy may stem from regional climatic variations, as spawning timing in tropical fishes is often influenced by local rainfall patterns and water temperature fluctuations (Lowe-McConnell, 1987).

Interestingly, closely related species like *Bagrus docmak* exhibit multiple spawning peaks (March–May and September) in East African lakes (Mwanja *et al*., 2011; Anja *et al*., 2009). This divergence highlighted how reproductive strategies can vary even within the same genus, likely due to differences in habitat stability and prey dynamics. For instance, *B. docmak* inhabits deeper lacustrine environments where seasonal floods are less pronounced, possibly favoring bimodal spawning to exploit periodic resource pulses.

The single annual spawning peak in *B. bayad* mirrors findings for other large African *bagrids*, such as *Chrysichthys nigrodigitatus*, which also relies on floodplain ecosystems (Olurin and Aderibigbe, 2006). This strategy maximizes offspring survival by aligning larval emergence with plankton blooms in inundated floodplains. In contrast, species like *Synodontis schall* in the same habitats may spawn multiple times annually, reflecting adaptations to more variable food webs (Omondi *et al.*, 2014).

The strict seasonal spawning of *B. bayad* underscores the need for targeted conservation measures during the June peak period. Protecting critical floodplain habitats and regulating fishing activities during this window could enhance recruitment, as demonstrated for similar species in the Niger Delta (Abobi *et al*., 2019). Future studies should explore how climate-induced shifts in rainfall timing might affect spawning synchrony, given the species' reliance on environmental cues.

The gonadosomatic index (GSI) serves as a critical indicator of reproductive investment in fish, reflecting the energetic allocation towards gamete production (Lambert *et al*., 2000). In *Bagrus bayad*, the observed monthly GSI fluctuations revealed pronounced sexual dimorphism, with females exhibiting substantially higher values than males—a pattern consistent with the greater metabolic demands of oogenesis compared to spermatogenesis (Wootton, 1990).

The peak female GSI in June (1.33 ± 0.87 in Dadinkowa Reservoir) aligns with the typical spawning period of many African riverine catfishes, which capitalizes on seasonal floods to enhance larval dispersal and survival (Hailu *et al*., 2009). The subsequent decline in July (0.84 ± 0.91 in Lake Njoboliyo) signifies post-spawning regression, while the slight August rebound (0.94 ± 0.51) may indicate residual spawning activity or asynchronous maturation within the population, as documented in other batch-spawning teleosts (Murua and Saborido-Rey, 2003).

Male GSI patterns diverged notably, with values remaining low during peak female spawning (0.09–0.37) but rising in July (0.50 ± 0.60). This lag suggests prolonged spermatogenic activity, possibly to ensure fertilization success across the extended female spawning window—a strategy observed in other *bagrids* like *Chrysichthys nigrodigitatus* (Olurin and Aderibigbe, 2006).

The June GSI peak corroborates Idodo's (2003) findings for West African *B. bayad*, reinforcing the species' adaptation to regional flood cycles. However, Emam *et al*. (2015) reported an earlier peak (March–April) in River Nile populations, likely

driven by differing hydrological regimes. The River Nile's predictable annual inundation, influenced by the Aswan Dam, may advance spawning cues compared to rain-fed West African systems (Dudgeon, 2019). Such plasticity highlights the species' ability to adjust reproductive timing to local environmental signals, though the single annual peak remains a conserved trait across its range.

The sustained male GSI elevation post-spawning contrasts with the rapid regression seen in semelparous species but mirrors iteroparous strategists like *Clarias gariepinus* (Britz *et al*., 2015). This aligns with *B. bayad*'s life-history strategy, which favoured repeated spawning events over a lifetime to maximize fitness in variable floodplain environments (Lowe-McConnell, 1987).

The gonadosomatic index (GSI) has been widely recognized as a reliable indicator of reproductive activity in fish populations (Mahboob and Sheri, 1997; Offem *et al*., 2008). This study's findings on *Bagrus bayad* demonstrated significant sexual dimorphism in GSI values, with females consistently exhibiting higher indices than males - a pattern commonly observed in oviparous teleosts where females allocate substantial energy resources to egg production (Wootton, 1990).

The observed peak in female GSI during June aligned with reproductive patterns documented in other African freshwater species. Similar seasonal spawning synchrony has been reported by Offem *et al*., (2008) for *Chrysichthys nigrodigitatus* and various tilapiine species by Adebayo and Fagbenro, (2004), suggesting convergent evolutionary strategies among tropical floodplain-adapted fishes. This June peak corresponded with the onset of rainy seasons in the region, when increased water levels and food availability create optimal conditions for larval survival (Lowe-McConnell, 1987).

The significant positive correlation between female body weight and GSI supports findings by Okera (1974) but contraste with Mann's (1976b) observations. This discrepancy may reflect species-specific reproductive strategies or methodological differences in sampling. The stronger weight-GSI relationship in females (higher 'r' values) likely indicated their greater proportional investment in gonadal development compared to males, as documented in other species with similar mating systems (Murua and Saborido-Rey, 2003).

Comparative analysis revealed that while the absolute GSI values in *B. bayad* (1.33 ± 0.86 in June) are lower than those reported for *C. nigrodigitatus* (4.78 ± 3.21) as found by Offem *et al*., (2008), the relative difference between sexes followed the same trend. This suggest that while reproductive investment varies among species, the fundamental pattern of female-biased energy allocation is conserved across African catfishes.

The study's implications for fisheries management are significant. The clear June spawning peak indicated that this period should be prioritized for conservation measures, including temporal fishing bans or habitat protection. Such strategies have proven effective for maintaining stocks of other commercially important species in African waters (Welcomme, 2016). Future research should investigate how climate variability might affect the timing and intensity of these reproductive peaks, particularly given increasing unpredictability of rainy seasons in tropical regions (Dudgeon, 2019).

Fecundity metrics have been established as critical indicators of reproductive potential in fish populations, with egg production per unit weight serving as a reliable measure of reproductive efficiency (Bagenal and Braum, 1978). The current study revealed significant spatial variation in the reproductive output of *Bagrus bayad*, demonstrating how environmental conditions can profoundly influence fish fecundity.

The highest egg production (18-24 eggs/g) observed in River Lau aligns with findings by Welcomme (2016) in other African river systems, where optimal flow conditions and nutrient availability typically enhanced fish reproductive capacity. This superior performance suggested River Lau maintained particularly favorable conditions for *B. bayad* maturation and spawning. The intermediate values recorded in Lake Njoboliyo (9-15 eggs/g) corresponded with observations by Dudgeon (2019) in similar lacustrine environments, where

moderately productive conditions support average reproductive outputs.

The significantly reduced fecundity in Dadinkowa Reservoir (2-10 eggs/g) mirrored patterns reported by Offem *et al.* (2008) in impounded systems, where restricted habitat complexity and altered food webs often limit reproductive potential. These findings collectively support the habitat quality-fecundity relationship proposed by Bagenal and Braum (1978), confirming that egg production serves as a sensitive bioindicator of ecosystem health.

The fecundity range observed in River Lau exceeds values reported for related species like *Chrysichthys nigrodigitatus* (12-18 eggs/g; Adebayo and Fagbenro, 2004), suggesting *B. bayad* may possess superior reproductive efficiency in optimal habitats. However, the depressed values in Dadinkowa Reservoir fall below even the minimum ranges documented for other African catfishes in suboptimal conditions (5-8 eggs/g; Lowe-McConnell, 1987), indicating particularly severe environmental constraints.

The positive size-fecundity relationship observed across all locations corroborated findings by Murua and Saborido-Rey (2003) for multiple teleost species, where larger females demonstrated proportionally greater reproductive investment. This pattern was most pronounced in River Lau, where environmental conditions apparently allowed full expression of size-dependent fecundity potential

The sex ratio of *Bagrus bayad* displayed notable variation across the three study locations (Dadinkowa Reservoir, River Lau, and Lake Njoboliyo) and the months under investigation. The sex ratio patterns observed in *Bagrus bayad* populations aligned with and expand upon previous findings in African freshwater fish ecology. The stability of sex ratios in certain habitats corresponds with Bagenal and Braum's (1978) observations on balanced population structures in undisturbed environments, while the observed variations provide new insights into species-specific reproductive strategies.

The progressive female bias documented in riverine systems supports Welcomme's (2016) findings on sex-specific habitat use in African floodplain fishes. However, the degree of bias observed in this study exceeded that reported for related species like *Chrysichthys nigrodigitatus* (Offem *et al*., 2008), suggesting unique behavioral adaptations in *B. bayad*. This difference may reflect the species' specialized rheophilic nature compared to more generalist catfishes.

The dramatic fluctuations in lacustrine environments mirror Nikolsky's (1963) classic descriptions of reproductive aggregations but show more extreme sexual segregation than documented in other African bagrids (Britz *et al*., 2015). These patterns contrast with Ekanem's (2000) findings on more stable sex ratios in reservoir-dwelling catfishes, highlighting how *B. bayad* may respond differently to lentic environments compared to congeners.

The management implications of these findings both confirm and challenge existing paradigms. While the importance of temporal considerations aligns with Lowe-McConnell's (1987) framework for tropical fisheries management, the degree of spatial variability observed suggests that standard approaches may need modification for this species.

Conclusion

This study provides a comprehensive comparative assessment of the reproductive biology of Bagrus bayad across three distinct inland water bodies—Lake Njoboliyo, River Lau, and Dadinkowa Reservoir in northeastern Nigeria. The findings revealed significant spatial and temporal variations in key reproductive parameters, including gonadosomatic index (GSI), fecundity, gonad weight, and sex ratio. Overall, this study underscores the influence of environmental conditions on the reproductive performance of B. bayad and highlights the need for location-specific fisheries management strategies. The results provide essential baseline data for sustainable exploitation, conservation planning, and aquaculture development. Implementing measures such as seasonal fishing restrictions during peak spawning periods and habitat protection will be critical for maintaining viable populations of this economically important species.

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