



Research Article

Assessment of Morphometric and Meristic Characterization of Silver Catfish (*Bagrus bayad*) from Northeast Nigeria

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ABSTRACT

Morpho-meristic analysis in fish provide crucial information on species differentiation, population structure and evolution. This research was carried out to study the morphological characteristics of *Bagrus bayad*, from three locations in the North-east Nigeria, using morphometric measurements and meristic counts. A total number of ninety (90) freshly caught samples of *B. bayad* were randomly selected and bought from commercial fishermen at the landing sites (Njoboliyo Reservoir, Lau Reservoir and Dadin Kowa Dam) between June and August, 2024. The results revealed that all the morphometric characters of *B. bayad* from the three locations varied, whereas some meristic counts including mean number of rays on pectoral fin (9.07 ± 0.94 , 8.83 ± 0.94 , 9.07 ± 0.94), anal fin ray (11.53 ± 1.11 , 11.08 ± 0.77 , 11.53 ± 1.11), caudal fin ray (19.63 ± 0.33 , 19.77 ± 0.30 , 19.58 ± 0.23) and pelvic fin ray 1 (6.00 ± 0.00 , 6.00 ± 0.00 , 6.00 ± 0.00) and pelvic ray count 2 (6.00 ± 0.00 , 6.00 ± 0.00 , 6.00 ± 0.00) respectively were constant. The principal component analysis revealed LAU reservoir had the highest average body weight (789.54g) in comparison to the other locations. The study highlights significant morphological characters and principal component analysis (PCA) confirmed that weight and length are the primary distinguishing factors among population.

Keywords: *Bagrus bayad*; Conservation; Fish Biology; Meristic; Morphometric; Reservoir

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INTRODUCTION

Bagrus bayad is one of the species of the family Bagridae identified from Nigerian Freshwaters especially in Rivers Kaduna, Niger, Benue and Lake Chad (Idam *et al*, 2020), The species have reputable growth size reaching 90cm in length and about 7kg in weight. The *Bagrus bayad* is found in rivers, lakes and wetlands (Idam *et al*, 2020). It avoids salt water, spends almost all of the daylight hours in rock crevices and is therefore seldom seen (El-Drawany and Elnagar, 2015). Males grow bigger than females under natural conditions (El-Drawany and Elnagar,

2015). *Bagrus bayad*, has high commercial value in Nigerian freshwater fish markets and have wide spread consumer acceptance. High production capacity of members of *Bagridae* family in the wild has prompted many attempts by fisheries scientists to culture them. Many catfishes do not readily breed under captivity because they are not able to exhibit their natural spawning behavior in artificial ponds and this constitutes a limiting factor to their culture and mass production (Rajts *et al.*, 2023). *Bagrus bayad*, also called bayad with Common name (Silver Catfish) is a member of Bagridae family which are commonly

referred to as a naked catfish. They are commercially important species found in Nigeria freshwaters especially in Rivers and Lakes such as Niger, Kaduna, Benue, Lake Chad, and other inland waters (Dienye, 2020; Abdulkarim *et al.*, 2022). *Bagrus bayad* has high growth rate and high production capacity Fakunmoju *et al.* (2014) many catfishes do not readily breed under capacity because they are not able to exhibit their natural spawning behavior in artificial pond this constitute a limiting factor to their culture and mass production. Morphometric and meristic characters are part of important rigorous tools used to differentiation closely related species of organisms having huge similarity indices of various parameter. The habitats and habits of *Bagrus* fish are fairly similar to those of the Nile perch. Both species are predacious, feeding on small fish, insects, crustaceans, molluscs and fish, some debris and vegetable matter may also be ingested (Okechi, 2022). *Bagrus bayad* lives and feeds on or near the bottom, while *B. docmac* is a benthopelagic species,

widespread in both shallow and deep water (Yakubu and Okunsebor 2011). The aim of the study is to investigate the morphomeristic characterization and some biology of silver catfish *Bagrus bayad* from the three locations. Morphological change and divergence within species are expected to take place when fishes are expose to new developmental and evolutionary factors that determine their body forms Mwanja *et al.*, (2011) a change could take place either through natural hybridization or effect.

MATERIALS AND METHODS

Study Area

This study was conducted on three locations of silver catfish (Njoboliyo reservoir is found in eastern part of Yola-south local government area in Adamawa state 9°12'N; 12°43'E Lau reservoir is located at 9° 82'N;11°0'E and Dadin kowa is located in Yamaltu Deba local Government area of Gombe state 10°11'N;11°01'E.

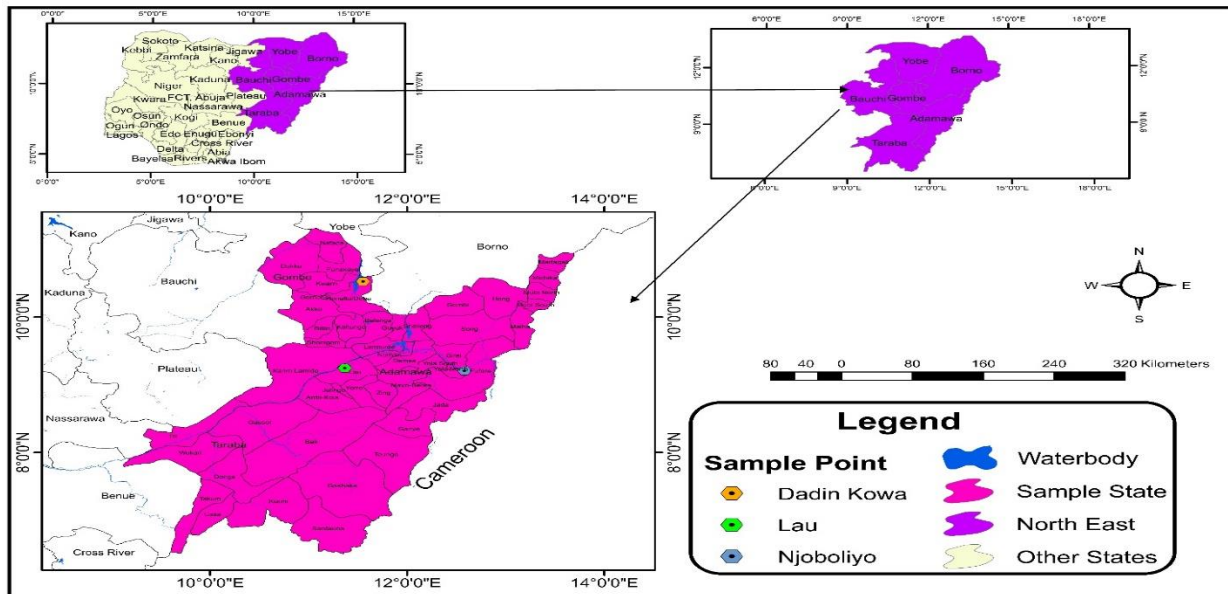


Figure 1: Map of the Study Area (Source: GIS, 2024)

Collection of Fish Samples

A total number of sixty (90) freshly caught samples of *B. bayad* were randomly selected and bought from commercial fishermen at the landing site from the three locations (Lakes Njoboliyo, and Lau and Dadin kowa dam) between June and August, 2024. The fishermen used a wide range of fishing gears to catch fish, and an outboard engine canoe to convey the fish to the landing site. Fish samples were immediately immersed in 10% formalin and transported to the laboratory of Department of Fisheries, Faculty of

Agriculture Moddibo Adama Universty Yola, where the fish samples were identified by using keys and works provided by (Olaosebikan and Raji, 1998).

Measurement of morphometric and meristic characteristics of *B. bayad*

Morphometric characters were obtained from each specimen using calibrated measuring board. The morphometric characters were measured to the nearest 0.1 cm. The Morphometric measurements taken from the fish include; Total length (TL), Standard length (SL), Head Length (HL), Body height

(BH), Pre-dorsal distance (Pre-D), Pre-anal distance (Pre-A), Pre-pectoral distance (Pre-PECT), Pectoral fin length (PFL), Dorsal fin base length (DBFL), Anal fin length (AFL), Inter-orbital distance (IOD), Eye diameter (ED), Snout length (SnL), Adipose Fin Length (ADFL), Maximum Babel length (MBL), Maximum caudal peduncle (MCP), Maximum Weight (MW) Five meristic characters were also counted which include Anal ray counts (ARC), Dorsal ray counts (DRC), Pectoral ray counts (PRC), Pelvic ray counts (PVRC1), Pelvic ray counts 2(PVRC2).

Data Analysis

Morphometric and meristic data were analyzed separately using Paleontological Statistical Test (PAST) software (Hammer *et al.* 2001) since the former is continuous and more susceptible to more environmentally induced variability while the latter is discrete and fixed early in the developmental stages (Samaradivakara *et al.*, 2012). The morphometric data meristic data were analyzed in the same way, Canonical variate analysis (CVA) was used to visualize relationships among populations while Principal Component Analysis was also carried out in order to illustrate the morphometric and meristic characters that differentiate populations through each component loadings of the PCA.

RESULTS

Length Morphometric characters of *Bagrus bayad* collected from Dadinkowa Reservoir, Lake Njoboliyo and River Lau

A total of ninety (90) *Bagrus bayad* were obtained from three locations, thirty (30) samples each from Njoboliyo reservoir, Dadinkowa Dam and Lau reservoir were used for morphometric studies. The total Length ranged from 39.30-60.00cm, 230.00-343.00cm and 39.10-62.00cm with the mean value of 49.17±5.39, 845.87±38.16 and 50.30±6.61. Standard Length ranged from 27.00-48.00cm, 35.00-71.00cm and 25.00-55.20cm with the mean value of 30.00±36.22, 53.96±6.49 and 37.09±8.40. Pre-dorsal Length ranged from 9.56-18.20cm, 6.20-16.50cm, and 9.30-16.80cm with the mean value of 13.80±1.80, 10.93±2.44 and 13.51±2.03. Head Length ranged from 6.20-11.20cm, 14.50-60.00cm and 2.00-14.50cm with the mean value of 8.70±1.19, 40.42±8.45 and 6.84±3.64 respectively. Results for other morphomeristic characters are presented in table 1.

Meristic characters of *Bagrus bayad* from three locations (Njoboliyo reservoir, Dadinkowa and Lau Reservoir)

The meristic characters of 90 *B.bayad* samples obtained from the three locations are shown in table 2. In all the characters counted mean number of Dorsal ray counts were 10.84±0.65, 11.07±0.75 and 10.83±0.65. Pectoral ray counts 9.07±0.94, 8.83±0.53 and 9.07±0.94. Anal ray counts 11.53±1.11, 11.80±0.77 and 11.53±1.11 and Caudal ray counts were 19.63±0.33, 19.77±0.30 and 19.50±0.23, Pelvic ray counts 1, 6.00±0.00, 6.00±0.00 and 6.00±0.00 and pelvic ray counts 2, 6.00±0.00, 6.00±0.00 and 6.00±0.00 respectively were constant.

PCA Loading plot of morphometric parameters for *B. bayad*

The PCA loading plot (Figure1:) of the first two principal components reveals clustering patterns among the three water bodies based on the fish morphological characteristics. PC1 is the horizontal axis and represents the largest source of variation among the fish populations. The following morphometric characters contributed significantly to PC1. And these are body weight, Total Length (TL), and Standard Length (SL). LAU reservoir had the highest average body weight (789.54g), followed by Njoboliyo reservoir (637.43g) and then Dadinkowa Dam (443.09g). This made fish LAU reservoir appear more distinct along PC1. Total Length (TL) and Standard Length (SL) were also higher in LAU reservoir (50.5cm and 37.95cm respectively), showing that fish from LAU reservoir were generally larger, which contributed to their separation along the PC1 axis. In PC2, this is the vertical axis and represent the second largest source of variation among the fish populations. Anal Fin Length (AFL), and Maximum Body Height (MBH) were morphometric characters which also had influential impact in differentiating populations along PC2. The fish from Dadinkowa Dam had the highest AFL (17.15cm), which contributed to their higher positioning along the PC2 axis compared to Njoboliyo reservoir and LAU reservoir, which had much smaller AFL measurements (10.15cm and 4.32cm respectively). Dadinkowa's fish had a higher Maximum Body Height (MBH) (9.39cm) compared to LAU reservoir (6.84cm) and Njoboliyo reservoir (4.11cm). This further influenced Dadinkowa's Dam separation along PC2.

Table 1: Morphometric measurements of *Bagrus bayad* from Dadinkowa Reservoir, Lake Njoboliyo, and River Lau (Mean±S.D.)

Range	Parameters	Njoboliyo (Adamawa)		Lau (Taraba)		Dadinkowa (Gombe)	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
1	Standard length (SL) (cm)	27.00-48.00	30.00±36.22	35.00-71.00	53.96±6.49	25.00-55.20	37.09±8.40
2	Total length (TL) (cm)	39.30-60.00	49.17±5.39	230.00-343.00	845.87±380.16	39.10-62.00	50.30±6.61
3	Pre-dorsal length (PDL) (cm)	9.50-18.20	13.80±1.84	6.20-16.50	10.93±2.44	9.30-16.80	13.51±2.03
4	Head length (HL) (cm)	6.20-11.20	8.70±1.19	14.50-60.00	40.42±8.45	2.00-14.50	6.84±3.64
5	PAL (cm)	18.00-34.00	23.69±4.50	10.50-25.90	15.22±2.67	17.00-29.20	20.66±2.75
6	PPvFL(cm)	8.90-21.20	5.29±0.91	6.60-33.49	6.09±2.75	5.50-10.80	7.57±1.39
7	PcFL(cm)	4.30-19.40	10.99±3.74	9.20-23.00	8.86±1.03	4.40-16.00	8.61±2.39
8	DFH (cm)	5.30-23.50	12.28±4.77	6.10-11.00	8.91±1.20	14.50-20.60	17.73±1.78
9	AFL (cm)	6.50-13.80	10.15±1.74	4.80-17.50	10.59±2.79	6.00-17.00	9.71±2.97
10	MBH (cm)	2.60-5.80	4.11±0.76	2.20-8.90	4.63±1.07	2.20-14.00	5.35±3.95
11	BL (cm)	2.20-4.00	3.24±0.56	1.60-5.50	3.64±1.02	2.00-5.20	3.05±0.72
12	ADFL (cm)	19.50-32.00	23.78±2.49	17.20-34.90	24.01±3.09	18.30-35.00	23.52±3.82

Key: TL: Total Length, SL: Standard Length, PAL: Preanal Length, PPvL: Prepelvic Length, PDL: Predorsal Length, AFL: Anal Fin Length ADFL: Adipose Fin Length, PcFL: Pectoral Fin Length, MBI: Maximum Body Height, HL: Head Length, BL: Barbel Length, DFH: Dorsal Fin Height

Table 3: Meristic Count of *Bagrus bayad* from Dadinkowa dam, Njoboliyo reservoir, and River Lau (Mean±S.D.)

Parameters	Lake Njoboliyo (Adamawa)		River Lau (Taraba)		Dadinkowa Reservoir (Gombe)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
DRC (cm)	10.04-12.00	10.84±0.65	11.00-12.00	11.07±0.25	10.00-12.00	10.83±0.65
PRC (cm)	7.10-11.00	9.07±0.94	7.50-11.05	8.83±0.53	7.00-11.00	9.07±0.94
PvRC1 (cm)	6.00-6.00	6.00±0.00	6.00-6.00	6.00±0.00	6.00-6.00	6.00±0.00
PvRC2 (cm)	6.00-6.00	6.00±0.00	6.00-6.00	6.00±0.00	6.00-6.00	6.00±0.00
ARC (cm)	10.50-13.00	11.53±1.11	11.00-13.00	11.80±0.77	10.00-11.00	11.53±1.11
CRC (cm)	18.00-20.00	19.63±0.33	18.00-20.00	19.77±0.30	18.00-20.00	19.58±0.23

Key: Dorsal fin ray (DFR), Anal fin ray (AFR), Caudal fin ray (CFR), Pectoral fin ray (PcFR), Pelvic fin ray 1 (PvFR1), Pelvic fin ray 2 (PvFR2), Caudal ray count (CRC) count, Dorsal ray count (DRC)

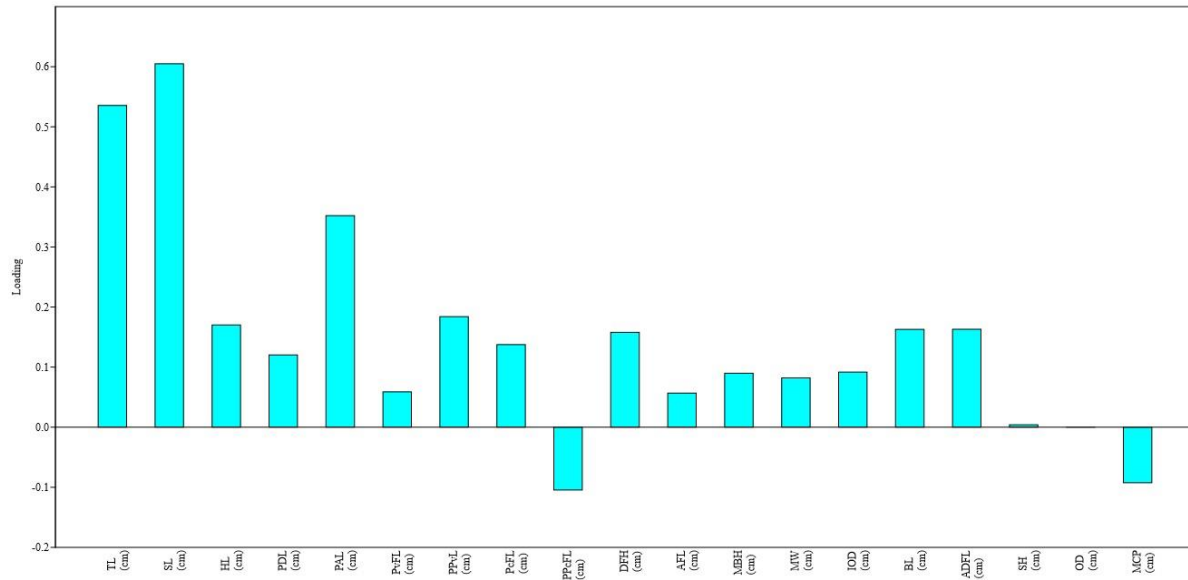


Figure 1: PCA loading plot for morphometric characters of *B. bayad* from the three locations

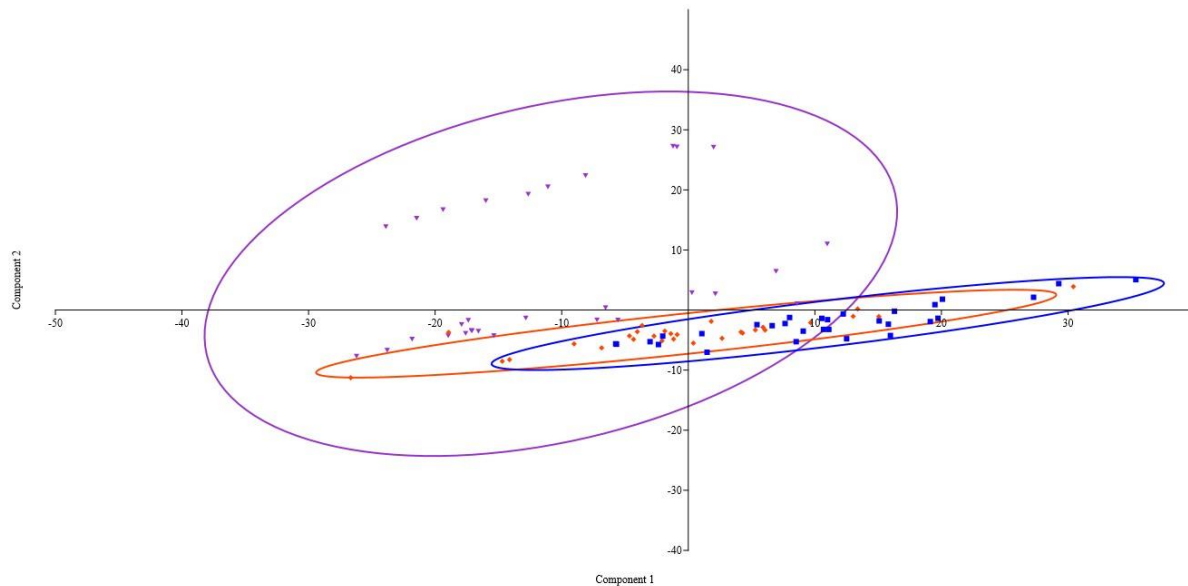


Figure 2: PCA Scatter Plot for Morphometric variables of *B. bayad* from the three locations

Keys: Purple = Dadinkowa Dam Blue= Njoboliyo Reservoir, Yellow = Lau Reservoir

Hierarchical clustering of morphometric parameters of *B. bayad*

Figure 3 presents the results on hierarchical clustering of morphometric parameters of *Bagrus bayad* in the studied waterbodies (Njoboliyo Reservoir, LAU Reservoir and Dadinkowa Dam). The figure 3 indicated that fish in LAU Reservoir and Njoboliyo Reservoir may be more similar than fish in Dadinkowa

Dam in several parameters. This could be as a result of fish in LAU Reservoir and Njoboliyo Reservoir have closer values in Total Length (TL) (50.5cm and 49.17cm respectively), Standard Length (SL) (37.95cm and 36.22cm respectively), and PAL (23.54cm and 23.69cm respectively), indicating possible clustering together. Similarly, the figure displayed a form of

divergence, as fish in Dadinkowa Dam displayed distinct values in parameters.

PCA biplot of meristic parameter

The PCA biplot (Figure 5) showed that Dorsal Fin Ray Count (DRC), Pectoral Fin Ray Count (PRC), Pelvic Fin Ray Count 1 and 2 (PvRC1 and PvRC2), Caudal Fin Ray Count (CRC), and Anal Fin Ray Count (ARC). DRC numbers ranged from 10.69 to 10.93. Fish in Dadinkowa dam had the highest DRC (10.93) followed by fish in Njoboliyo reservoir (10.83) and LAU reservoir (10.69). The highest value of DRC in Dadinkowa Reservoir indicated that fish in Dadinkowa dam had distinct morphological characteristic compared to fish in LAU reservoir and Njoboliyo reservoir. In PRC, fish in Dadinkowa dam had the highest (9.97) while fish in Njoboliyo reservoir had the lowest value of PRC (9.07). PvRC1 was highest in Dadinkowa dam waterbody (6.43) and the lowest value of 6 was recorded in Njoboliyo reservoir. PvRC2 was the same across the three locations with a value of 6. The value of CRC ranges from 11.53 to 18.4. The highest value of 18.4 cm was recorded in Dadinkowa dam while the lowest value of 11.53 was in Njoboliyo reservoir waterbody. In Dadinkowa dam also ARC was highest (12.08) and the lowest (11.41) was recorded in Lau reservoir water.

Hierarchical clustering showing similarities of individuals of *B.bayad* from Njoboliyo Reservoir, Lau Reservoir and Dadinkowa dam

Figure 6 shows the hierarchical clustering of the study locations (Lake Njoboliyo, River LAU and Dadinkowa Reservoir). This figure identifies the clusters and branch lengths. Njoboliyo reservoir and LAU reservoir forms the first cluster since their meristic variables are quite similar to each other, this can be observed in DRC, PRC, PvRC1, PvRC2, and ARC. The Euclidean distance between them is relatively small, indicating a high degree of similarity. On the other hand, Dadinkowa dam forms its own cluster and joined to the Njoboliyo reservoir - Lau reservoir cluster at a much later stage. This indicates more distinct, especially in terms of CRC (18.40 compared to 11.53 and 12.00) and PRC (9.97 compared to 9.07 and 9.31). The length of the branches in the dendrogram indicates the level of dissimilarity between clusters. Longer branches between Dadinkowa dam and the Njoboliyo reservoir - Lau reservoir cluster suggest that Dadinkowa's fish population is morphologically distinct, and most likely adapted to different environmental conditions or evolutionary pressures. The short branch between Njoboliyo reservoir and LAU reservoir indicates a high degree of similarity, suggesting that these two populations may be more closely related or share similar environmental factors. Fish in Njoboliyo reservoir and LAU reservoir cluster together first due to their similar meristic parameters. Fish in Dadinkowa dam joins this cluster at a greater height in the dendrogram, indicating a higher degree of morphological difference.

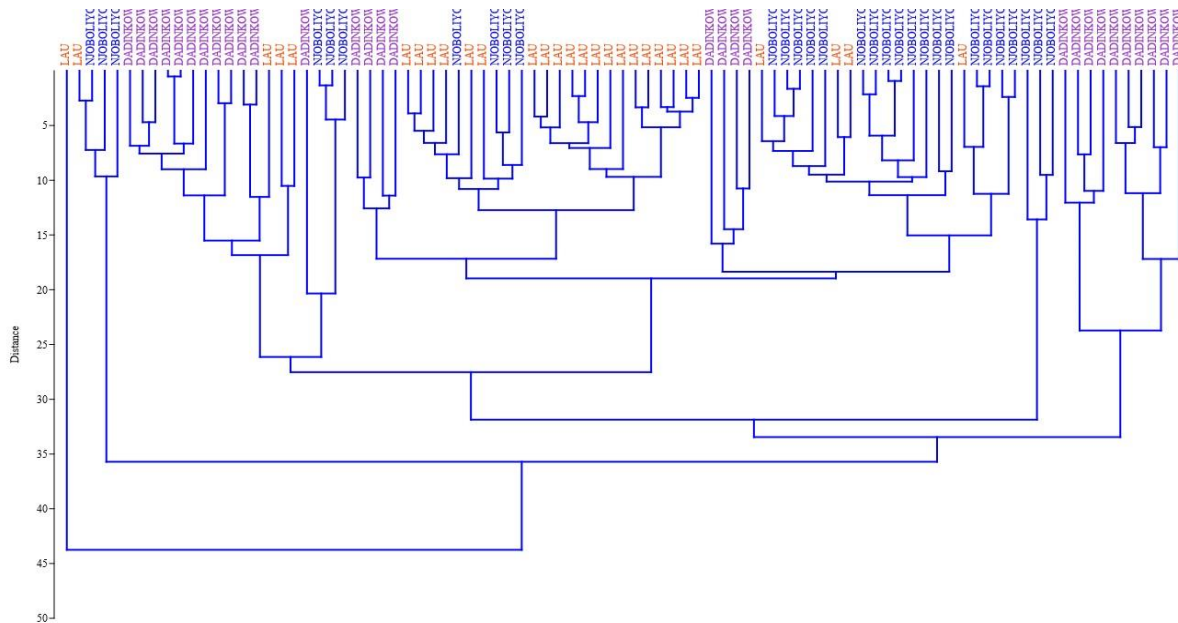


Figure 3: Hierarchical Clustering of Morphometric Parameters in Njoboliyo, Lau and Dadinkowa Waterbody
Keys: Purple = Dadinkowa Dam Blue =Njoboliyo Reservoir, Yellow = Lau Reservoir

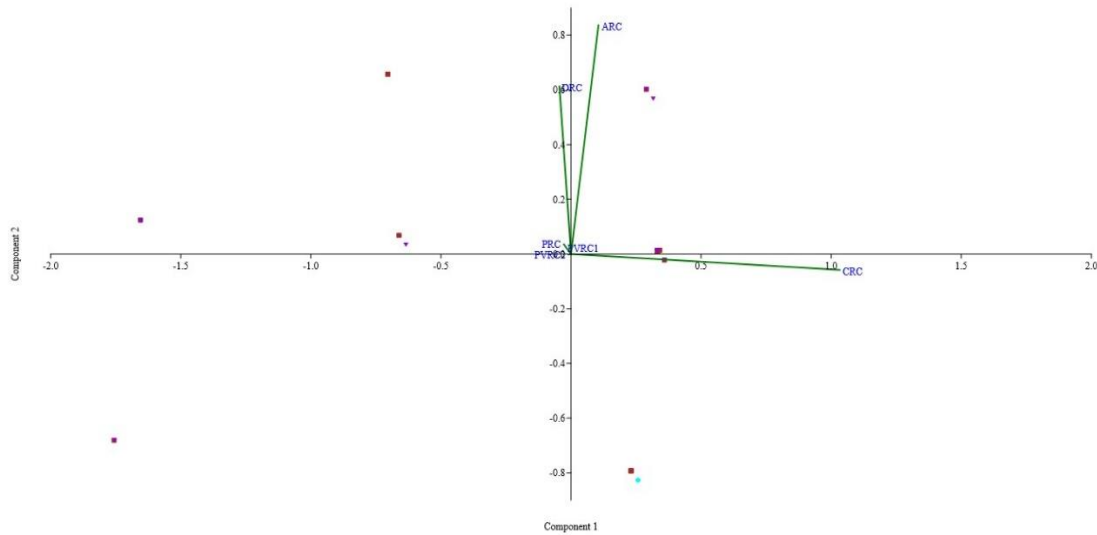


Figure 5: PCA Biplot of Meristic counts of *B. bayad* from three different waterbodies

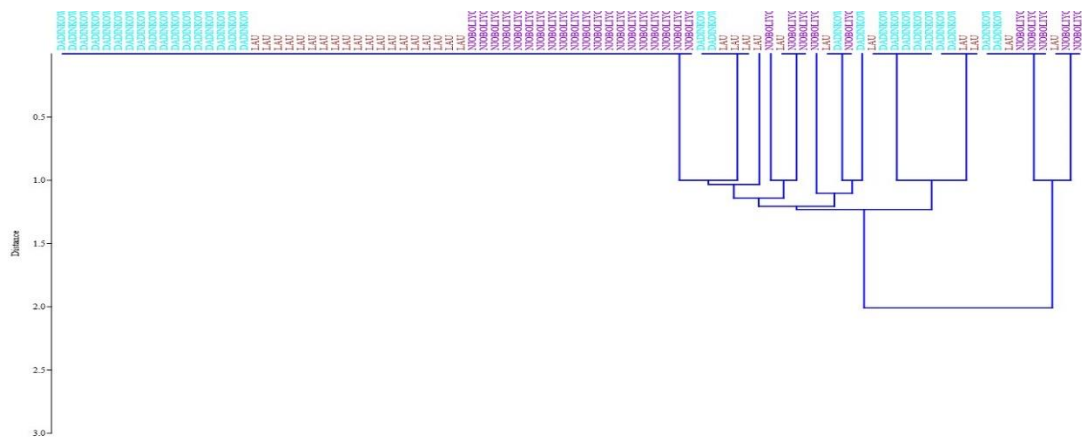


Figure 6: Hierarchical Clustering of meristic counts of *Bagrus bayad* in Study Locations

Key: Purple = Dadinkowa dam Blue = Njoboliyo reservoir Brown = Lau reservoir

DISCUSSION

Morphometric and meristic analyses are essential tools for differentiating closely related fish species, particularly when phenotypic similarities complicate identification (Behera *et al.*, 2015; Popoola, 2024). These methods are widely used in field studies to characterize fish populations, as morphological traits often exhibit plasticity in response to environmental factors such as food availability, temperature, and habitat structure (Ezeafulukwe *et al.*, 2015; Eze *et al.*, 2021). The morphometric relationships observed in *Bagrus bayad* align with findings from previous studies on related species. Onyia *et al.* (2018) reported proportional growth in catfish species, where increases in standard length (SL) correlated with snout height (SH) and head length (HL),

consistent with the trends in this study. Similarly, Bake *et al.* (2015) documented a strong positive relationship between head length and body weight in *Clarias gariepinus*, supporting the principle of allometric growth observed in *B. bayad*. These similarities suggested that growth proportionality in *B. bayad* follows general patterns seen in other *bagrid* catfishes. However, some variations were noted when compared to other studies. For instance, Fapohunda and Godstates (2007) reported a mean head length of 7.0 cm for *Chrysichthys nigrodigitatus*, whereas this study recorded slightly higher values (6.53–9.81 cm). Such discrepancies may stem from differences in sampling locations, environmental conditions, or population genetics, as noted by Adepo-Gourene *et al.* (1997), who found that

geographical separation can lead to morphological differentiation in *C. nigrodigitatus*. The strong correlation between body weight and gonad weight in this study, particularly in larger individuals from Lau reservoir and Njoboliyo reservoir supports Wootton's (1990) assertion that body size influences reproductive success. This finding underscores the ecological importance of conserving larger fish to maintain population viability. Meristic counts in *B. bayad*, including dorsal ray count (DRC) and caudal ray count (CRC), exhibited minimal variation across study sites, suggesting genetic stability among populations. This aligns with Bagenal and Braum's (1978) observation that meristic traits are generally conserved within species. However, slight variations in fin ray counts (e.g., dorsal and anal fin rays) were noted, possibly due to environmental factors such as water flow or habitat differences, as suggested by Kapuscinski and Miller (2007). Comparisons with other studies reveal both consistencies and contrasts. For example, Paugy *et al.* (2003) reported 6–12 anal fin rays in *C. nigrodigitatus*, overlapping with the range (8–11) observed in this study. However, Fapohunda and Godstates (2007) recorded higher dorsal fin rays of 9 as regards 6 to 7 in this study, which may reflect regional adaptations. Such variations highlight the influence of environmental plasticity on meristic traits, as noted by Jawad *et al.*, (2020). The inability to delineate *B. bayad* into subspecies based on meristic counts—due to overlapping ranges—echoes findings by Samaradivakara *et al.* (2012) and Chuhila (2015), who reported similar challenges in tilapia populations. Jawad *et al.* (2020) argued that meristic counts often overlap broadly, limiting their utility in population differentiation, a view that contrasts with some earlier studies but aligns with the present findings. Multivariate statistical methods, such as factor analysis and principal component analysis (PCA), are widely used in fisheries biology to reduce the dimensionality of morphometric and meristic datasets, identifying key variables that influence fish growth and distribution Kocer and Sen, 2014). These techniques help distinguish between correlated and non-correlated traits, summarizing them into principal components that explain phenotypic variations across populations (Garate-Lizarraga and Beltrones, 1998).

PCA has been extensively applied in fish morphometric to assess growth patterns and environmental adaptations (Popoola and Ebiwonjumi 2021). In this study, body weight (BW) and total length (TL) emerged as the most influential

morphometric parameters, consistent with findings by Dochin *et al.* (2015) in Kardzhali Reservoir, where these traits were key determinants of fish distribution. Turan *et al.* (2006) similarly noted that nutrient availability in water bodies significantly influences weight and length development, supporting the observed trends in *Bagrus bayad*. However, contrasts exist with studies on other species. For example, Muchlisin *et al.* (2015) found that head length (HL) and body depth were more critical than total length in *Clarias batrachus*, suggesting species-specific variation in trait importance. This discrepancy may stem from differences in feeding ecology, as *B. bayad* is a benthic predator, whereas *C. batrachus* exhibits more generalized feeding habits. Hierarchical clustering revealed distinct groupings of *B. bayad* populations across the study sites, with lower branch heights indicating higher similarity between clusters. This aligned with Popoola (2024), who reported that morphometric divergence in fish populations often reflects habitat-specific adaptations. For instance, River Lau's *B. bayad* exhibited larger body sizes, possibly due to richer food resources, mirroring observations by Fakunmoju *et al.* (2014) in Nigerian floodplains. Conversely, Dadinkowa dam populations showed smaller morphometric values, likely due to suboptimal growth conditions, as noted in other reservoir-dwelling species (Kosai *et al.*, 2014). Meristic traits, such as dorsal ray count (DRC) and pectoral ray count (PRC), displayed minimal variation, reinforcing their reliability for species identification (Huda *et al.*, 2022). The consistency in pelvic ray counts (PvRC1, PvRC2) across sites supports Ikpeme *et al.*, (2017) assertion that certain meristic traits are genetically conserved. However, caudal ray count (CRC) was higher in Dadinkowa dam, possibly an adaptation to stronger currents, as suggested by Idowu *et al.* (2019) for hemophilic species. Notably, anal ray count (ARC) showed slight variability, contrasting with Jawad *et al.* (2020) findings in *Lates niloticus*, where ARC varied significantly with substrate complexity. This difference may reflect *B. bayad* benthic lifestyle, which reduces selective pressure on anal fin morphology compared to pelagic species.

CONCLUSION

This study provides the first integrated dataset on *B. bayad*'s biology in the Northeast, Nigeria bridging gaps in morphometries, and highlighted significant morphological and the Principal component analysis

(PCA) of the specimens of silver catfish *B. bayad* confirmed that weight and length are the primary distinguishing factors among population and it revealed distinct clustering patterns among fish from different locations, suggesting subtle genetic or environmental influences on their morphology. This enhances knowledge of intraspecific variation in *Bagrus bayad* supporting future taxonomic classification and biodiversity conservation. Policy and management protocols should be established to hence size-limit regulations prohibited of juveniles (<1kg) to ensure reproductive condition.

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