Biometric Characteristics and Condition Factors of *Clarias gariepinus* and *Hepsetus odoe* from Three Major Reservoirs of Ekiti-state, Southwest Nigeria

Tominwa. A. Akindele a*, Omotayo. Fagbuaro a and Mary. A. Adegbola a

a Department of Zoology and Environmental Biology, Faculty of Science, Ekiti State University
Ado-ekiti, Ekiti-state, P.M.B. 5363, Nigeria.

**Authors’ contributions**

This work was carried out in collaboration among all authors. TAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. OF managed the analyses of the study. MA A managed the literature searches. All authors read and approved the final manuscript.

**Article Information**

DOI: 10.9734/AJFAR/2022/v16i530383

**Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/83353

**Received 03 January 2022**

**Accepted 01 March 2022**

**Published 17 March 2022**

**ABSTRACT**

The study was carried out between July to October 2018. 50 *Clarias gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs and 66 *Hepsetus odoe* from Egbe and Ado-Ekiti reservoirs (not present in Ero-reservoir), Ekiti-State, Southwest, Nigeria, respectively. The fish samples were collected directly from fishermen at the bank of each reservoir. Analysis of variance (ANOVA) was used. The mean body weight and total length of *Clarias gariepinus* were 319.13± 152.18 a, 379.60 ± 268.40 b, 542.11 ± 159.38 c and 35.76 ± 7.64 a, 34.67 ± 9.55 a and 42.47 ± 4.02 b from Ero, Egbe and Ado respectively. The mean body weight and total length of *Hepsetus odoe* were 193.79±83.80 a, 192.87±80.62 a and 28.56±3.13 a, 28.81±6.09 a from Egbe and Ado respectively. The results recorded on the mean body weights and total lengths of *C. gariepinus* and *H. odoe* from the populations are statistically similar. There are morphologically similarities between and among the three populations. Principal component analyses and cluster analyses were further used to determine the closeness of the morphological characters using paleontological statistics (PAST) software. The condition factors (K) values for *C. gariepinus* are 0.7 ± 0.2, 0.9 ± 0.3 and 0.7 ± 0.2 from Ero, Egbe and Ado reservoirs respectively. The condition factors values are not significantly different from one another. And for *H. odoe* were 0.008 ± 0.002 and 0.74 ± 0.04 from Egbe and Ado-reservoirs respectively.

*Corresponding author: Email: tominwaakindele@gmail.com;*
Ado respectively. It showed that the populations are not well fed. There is need to determine the condition factor(s) which favours the growth and development of the fish from Ado (Ureje), Egbe and Ero reservoirs.

Keywords: Clarias gariepinus; Hepsetus odoe; morphometric; meristic traits; characteristics; reservoir; Nigeria.

1. INTRODUCTION

Dam is a structure or massive barriers built across stream, a river, or an estuary to confine and utilize the flow of water for human purposes. Reservoirs are man-made lakes which are formed by damming rivers to create an artificial impoundment for water storage, irrigation, hydropower electricity etc. This brings about lacustrine condition which can be conducive to the establishment and maintenance of fish stocks appropriate for exploitation through captured fisheries and aquaculture [1,2]. Claridae catfishes are air breathing fish naturally occurring in freshwater bodies in Africa, South-East Asia where they constitute significant component of catches. It was introduced all over the world in the year 1980s for aquaculture purpose and is found in countries for outside its natural habitat. Clarias gariepinus are readily recognized by their cylindrical body with scale less skin flattened bony head, small eyes elongated spineless dorsal fin and four pairs of barbells around the broad mouth. The anal, caudal and dorsal fins are not united. The Clarias gariepinus are of great importance as food and vital in the sustainable of the aquaculture with these attributes: ability to withstand handling stress especially low oxygen content, disease resistance, high growth rate, yield potential, fecundity and palatability. C. gariepinus is one of the most readily acceptable species of Clarias in Nigeria because they grow to a large size [3]. The African Pike Characin is a predator. Fresh water Characin belonging to the family Hepsetus. It was considered that there was a single species of Hepsetus. H. odoe is the West African representative of the group. It is an elongated fish with a Pike-body. However, the species is a Characin and the Pike resemblance is due to convergent evolution. This species can reach up to about 26cm (11inches) in length. H. odoe species are widely distributed around Western and Central Africa. It inhabits slow running and shallow waters of rivers in the plains as well as estuaries and a variety of other freshwater habits. H. odoe is piscivorous, feeding on several species of smaller fish by laying ambush in dense vegetation, and they feed primarily on Cichilds and Mormyrids. The African Pike (H. odoe) is a highly priced freshwater food fish species in Nigeria especially because of its availability all year round, affordability, and tasteful flesh, economic and nutritional value [4].

Morphometric and meristic studies of animals are part of the vigorous tools for measuring discreteness of the same species [5]. Morphometric studies of animals are not only essential to understand the taxonomy but also the health of species involved in the environment. These traits reveal the inter relations between various body parameters like length, weight, fecundity etc. Meristic traits are countable structures occurring in series (such as vertebral column, fin rays, number of gill filament, number of gill arch and racker, etc.) in fish. These characters are among those most commonly used for differentiation of species population [2]. Since morphometric characterization of fish is not only essential to the understanding of the classification of fish but also, the health of the species involved; the shape and structures are unique to the species and the variations in its features are related to the habit and habitat among the fish species. This study was therefore designed to assess the population of C. gariepinus and H. odoe collected from Ero, Egbe and Ado-Ekiti- reservoirs through their morphometric characteristics and meristic traits.

2. MATERIALS AND METHODS

2.1 Study Sites

Clarias gariepinus and Hepsetus odoe samples were collected from Ado- Ekiti reservoir in Ado- Ekiti, Egbe- reservoir in Egbe- Ekiti and Ero- reservoir in Ikun- Ekiti, Ekiti, Nigeria (Fig.1).

2.1.1 Ado- ekiti reservoir (Ureje reservoir)

It is situated on an undulating plane of an average height of about 440m above sea – level and surrounded by highlands. The reservoir lies between latitude 7° 37’ north and longitude 5° 13’
East of the Equator. The Ureje reservoir, Ado-Ekiti was constructed by putting a dam across Ureje River in Ado–Ekiti in 1958 for the supply of water for domestic uses and production of fish for Ado-Ekiti community and its environment. The full capacity of the reservoir was about 47 million gallons of water.

2.1.2 Egbe water reservoir

The reservoir is located in an undulating plane surrounded by highlands of which run–offs also feed the reservoir during raining periods. Egbe water reservoir was constructed by putting a dam across Osse River. The River takes its source from Kwara State, Nigeria and flows from the north to south of Ekiti through Ode–Ekiti to Egbe–Ekiti. The location of the reservoir is on latitude $7^\circ 36' - 8^\circ$ and longitude $5^\circ 36' - 5^\circ 45'$ East of the Equator; it was built in 1957 by damming this Osse River at Egbe–Ekiti. The reservoir was commissioned in 1989. And it covers an area of 26.5 hectares with the depth of about 64m. The capacity of the reservoir is about 144 million cubic meters.

2.1.3 Ero–reservoir

Ero reservoir is a tropical reservoir situated at Ikun–Ekiti. It is an earth filled embankment with a length of 662m and an impoundment area of 4.5km. It was commissioned in 1985. The water level is about 504 containing about 2009 million cubic meters. It lies between latitudes $7^\circ 15' - 8^\circ 5'$ and $4^\circ 45' - 5^\circ 45'$.

2.2 Samples Collection

Fish samples used in this study were collected from landing sites by artisanal fishermen at the bank of the water reservoirs on every Monday at Ero–reservoir, Wednesday at Egbe–reservoir and Friday at Ado–reservoir within a week for a period of twelve weeks from July to October, 2018. The fish were collected with the aid of cast netting of 2.5–3.5 mm mesh size, bamboos and hooks. The fish samples collected were counted and sorted into different species in the field and were transported to the Post Graduate Laboratory of Zoology and Environmental Biology Department, Ekiti State University, Ado–Ekiti for further practicals.

2.3 Identification of Fish Samples

$C.\ gariepinus$ and $H.\ odoe$ was identified by following the method of [6] and [7].

Fig. 1. Map of Ado, Egbe and Ero reservoirs
2.4 Data Collection

Twenty four [24] morphometric characters and Eleven [11] meristic traits were taken on each fish specimen. The parts were measured following the standard anatomical reference [8]. The specimen weights (measurement of the fish mass) were first measured using the electronic Citizen weighing balance (MP-3000 with a max from -3000g and a min of -5g). Standard Length (SL), Total Length (TL), Dorsal Fin Length (DFL), Anal Fin Length (AFL), Pectoral Fin Length (PFL), Spine Length (AFL), Pectoral Fin Length (PFL), Spine Length (SPL), Head Length (HL), Snout Length (SNL) Length of occipital fontanelle (OFL), Pre-Anal Distance (PAD), Pre-Ventral Distance (PVD), Pre-Pectoral Distance (PPP), Pre-dorsal distance (PDD), Distance between Dorsal and Caudal fin (DDCF), Distance between Occipital process and Dorsal fin (DODF), Caudal peduncle Depth (CPD), Body Depth (BD) (Width), Head Width (HW), Interorbital Distance (ID), Eye Diameter (ED), Occipital fontanelle Width (OFW), Distance between snout and Occipital process (DSO) and Mouth Length (NL). All these lengths was measured using thread, compass and meter rule.

Eleven [11] meristic traits counted include: number of barbells (nB), numbers of Gills (nG), number of Spines (nS), number of Gill Arch (nGA), Number of Gill Filaments(nGF), number of Gill rakers (nGR), Dorsal fin rays (DFR), Anal Fin rays (AFR), Pectoral Fin Rays(PFR), Pelvic Fin rays (PvFR), Number of vertebrae Colum (nVC) were counted.

2.5 Condition Factor

The condition factor (K) which is defined as the well-being of the fish was calculated. K is a useful index for monitoring of feeding intensity, age and growth rates. The K value was determined by using

\[ K = \frac{W}{L^3} \]

Where, \( W \) = weight of fish in grammes and \( L \) = length of fish in centimetres

2.6 Data Analysis

One way analysis of variance (ANOVA) was carried out on morphometric measurements to test the degree of variation among the fish species from the three location at \( P = 0.05 \) probability.

Morphometric measurements were standardized to fish size (SL) in accordance with [5, 8] to alleviate errors due to allometric growth using percentage standard length as it follows Mn = (Mo/SL) %, where, Mn is the corrected size.

Mo is the original measurement (total length); and SL is the standard length. The measurements of each of the meristic traits were not standardized because the meristic characters are fixed early in development and less susceptible to environmental variables.

The data obtained from the morphometric characteristics and meristic traits were then analysed with Principal Component Analysis (PCA) and Cluster Analysis (CA). PCA and CA on morphometric and meristic data were evaluated using Paleontological Statistics (PAST) software. Population centroids with 95% ellipses obtained from the PCA scatter diagram were used to observe the relationships among populations [5]. PCA loading method was used to show the traits with the highest variation within the population and CA was used to show the relationship in their Clustering patterns [9] using the unweight Pair Group Method with arithmetic mean for dendrogram grouping.

3. RESULTS

In this study, a total number of 116 fish species was collected. The numbers of collections were made up of 50 Clarias gariepinus (43.1%) across the three reservoirs and 66 Hepsestus odoe (56.9%) from Egbe and Ado-Ekiti reservoirs because H. odoe were not found in Ero reservoir (i.e H. odoe is not available at Ero reservoir).

3.1 Morphometric Characteristics and Meristic Traits

The mean values for morphometric characters and meristic traits of Clarias gariepinus from Ero, Egbe and Ado-Ekiti reservoirs are listed in Table 1. The result shows that the mean body weight of Clarias gariepinus populations ranged from 319.13 ± 152.18 in the Ero-reservoir to 542.11 ± 159.38 in the Ado-Ekiti reservoir respectively. The mean weight of C. gariepinus samples was significantly different (\( P = 0.05 \)) across the three populations. The mean total lengths ranged from 34.67 ± 9.55cm in the Egbe population to 42.47 ± 4.02cm from the Ado-Ekiti reservoir respectively. The mean total length of the Clarias gariepinus sample from the Ero-reservoir was not statistically different from the Egbe fish.
population, but significantly different from the Ado-Ekiti population (P = 0.05).

The mean values of other morphometric characters of *C. gariepinus* were significantly different across the three populations except in SNL, OFL, DDCF, DODF, ID and ED which were similar in the three population samples (p > 0.05).

The mean value for meristic characters of *C. gariepinus* showed the number of gill filaments of *C. gariepinus* from the three populations ranged from 1152.00 ±162.38 in Ero- reservoir to 1683.11±33.68 in the Ado-Ekiti reservoir respectively. The mean number of gill filaments of *C. gariepinus* was significantly difference across the three populations (p= 0.05). The mean values on other meristic characters of *C. gariepinus* were significantly different across the three populations except in nG, AFR and PvFR.

The mean morphometric traits of *H. odoe* from the Egbe and Ado-Ekiti reservoirs, Ekiti- State, Nigeria are listed in Table 2. The result shows that the mean body weights of *H. odoe* from the two populations are 192.87±80.62 from Ado-Ekiti reservoir and 193.79 ± 83.80 from the Egbe-reservoir respectively. The means were not statistically different from each other at the 95% level of significance. All other morphometric characters of *H. odoe* from the Egbe population were not significantly different from those from the Ado-Ekiti population (p> 0.05).

### Table 1. Mean values of the morphometric and meristic traits of *Clarias gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs, Ekiti- State, Nigeria

| Characteristics | ERO MEAN±SD | EGBE MEAN±SD | Ado-Ekiti MEAN±SD |
|-----------------|-------------|--------------|--------------------|
| SL              | 32.31±4.23a | 29.80±9.29a  | 36.56±3.61a        |
| TL              | 35.76±7.64a | 34.67±9.55a  | 42.47±4.02b        |
| W               | 319.13±152.18a | 379.60±268.40b | 542.11±159.38c     |
| DFL             | 20.93±3.56a | 20.18±4.46a  | 24.06±2.57         |
| APL             | 3.91±0.72a  | 3.07±0.65a   | 3.36±0.53a         |
| HL              | 2.86±0.69a  | 2.14±0.35a   | 2.06±0.34a         |
| PAD             | 17.81±2.59a | 16.64±5.92a  | 21.42±1.62a        |
| PvP             | 15.59±1.70a | 13.79±4.79a  | 17.78±1.76         |
| PPB             | 6.99±0.69a  | 6.35±2.11a   | 8.57±1.12a         |
| PDD             | 11.21±1.56b | 9.58±2.89a   | 11.61±1.17         |
| DDCF            | 1.03±0.24a  | 1.51±0.94a   | 1.63±0.32a         |
| DODF            | 1.94±0.28a  | 1.76±0.33a   | 1.78±0.34a         |
| CD + D           | 2.24±0.36a  | 1.80±0.66a   | 2.79±1.12a         |
| BD              | 4.24±0.66a  | 5.06±1.67a   | 5.58±1.05a         |
| HW              | 2.19±0.29a  | 2.58±0.92a   | 3.33±0.66a         |
| ID              | 3.60±0.47a  | 3.00±1.10a   | 3.76±0.67a         |
| ED              | 0.53±0.07a  | 0.48±0.12a   | 0.55±0.06a         |
| OFW             | 2.93±0.70b  | 2.64±0.98a   | 3.53±0.28a         |
| DSO             | 6.73±0.68a  | 7.60±13.47b  | 5.90±2.17a         |
| NL              | 3.00±0.70a  | 2.89±0.74a   | 3.72±0.26a         |
| nB              | 8.00±0.00a  | 11.33±16.33b | 8.00±0.00a         |
| nG              | 4.00±0.00a  | 4.00±0.00a   | 4.00±0.00a         |
| nGA             | 8.00±0.00a  | 11.33±16.33b | 8.00±0.00a         |
| nGF             | 1152.00±162.38a | 1351.00±95.26b | 1683.11±33.68c    |
| AFR             | 48.75±2.82a | 52.54±4.53b  | 48.28±2.42         |
| PFR             | 9.63±0.92a  | 8.88±0.85a   | 8.56±1.25a         |
| PvFR            | 5.75±0.46a  | 6.00±0.00a   | 5.89±0.32a         |
| DFR             | 67.50±4.38b | 63.33±5.50a  | 63.94±3.24         |
| nVC             | 55.75±3.06a | 56.42±1.72b  | 56.44±1.85         |

Mean values in the same column with the same superscripts are not significantly different from each other (P> 0.05).
Table 2. Mean values of the morphometric and meristic traits of *Hepsetus odoe* from Egbe and Ado-Ekiti reservoirs, Ekiti State, Nigeria

| Characteristics | Egbe- reservoir MEAN±SD | Ado-Ekiti- reservoir MEAN±SD |
|-----------------|--------------------------|-----------------------------|
| SL              | 23.37±2.93\(^{a}\)       | 23.74±3.61\(^{a}\)          |
| TL              | 28.56±3.13\(^{a}\)       | 28.81±6.09\(^{a}\)         |
| W               | 193.79±83.80\(^{a}\)     | 192.87±80.62\(^{a}\)       |
| DFL             | 2.71±0.47\(^{a}\)        | 2.68±0.44\(^{a}\)          |
| AFL             | 2.46±0.40\(^{a}\)        | 2.24±0.32\(^{a}\)          |
| PFL             | 3.67±0.66\(^{a}\)        | 3.93±0.72\(^{a}\)          |
| HL              | 7.05±0.65\(^{a}\)        | 7.54±1.08\(^{a}\)          |
| SNL             | 3.29±0.54\(^{a}\)        | 2.93±0.67\(^{a}\)          |
| OFL             | 3.14±0.70\(^{a}\)        | 3.57±0.73\(^{a}\)          |
| PAD             | 19.20±2.39\(^{a}\)       | 19.46±3.18\(^{a}\)         |
| PVD             | 13.85±1.96\(^{a}\)       | 13.44±2.35\(^{a}\)         |
| PPD             | 6.69±0.85\(^{a}\)        | 6.80±0.90\(^{a}\)          |
| DDD             | 14.80±2.02\(^{a}\)       | 14.83±1.85\(^{a}\)         |
| DDCF            | 5.14±0.94\(^{a}\)        | 5.51±0.81\(^{a}\)          |
| DODF            | 5.57±0.96\(^{a}\)        | 5.99±0.87\(^{a}\)          |
| CPD             | 2.44±0.43\(^{a}\)        | 2.40±0.35\(^{a}\)          |
| BD              | 4.67±0.79\(^{a}\)        | 4.83±0.63\(^{a}\)          |
| HW              | 3.06±0.51\(^{a}\)        | 2.97±0.81\(^{a}\)          |
| ED              | 2.20±0.28\(^{a}\)        | 2.17±0.26\(^{a}\)          |
| OFW             | 0.97±0.11\(^{a}\)        | 0.97±0.10\(^{a}\)          |
| DSO             | 2.11±0.27\(^{a}\)        | 2.33±0.36\(^{a}\)          |
| NL              | 3.61±0.66\(^{a}\)        | 3.62±0.56\(^{a}\)          |
| nG              | 1.83±0.33\(^{a}\)        | 1.82±0.33\(^{a}\)          |
| nG               | 4.00±0.00\(^{a}\)        | 4.00±0.00\(^{a}\)          |
| nG               | 8.00±0.00\(^{a}\)        | 8.00±0.00\(^{a}\)          |
| nG               | 1090.97±57.53\(^{a}\)     | 1057.80±87.44\(^{a}\)      |
| nGR             | 189.89±12.45\(^{a}\)     | 192.33±9.68\(^{a}\)        |
| AFR             | 11.11±0.93\(^{a}\)       | 12.13±0.57\(^{a}\)         |
| PFR             | 12.11±0.93\(^{a}\)       | 12.13±0.57\(^{a}\)         |
| PvFR            | 8.94±0.24\(^{a}\)        | 8.70±0.47\(^{a}\)          |
| DFR             | 8.94±0.24\(^{a}\)        | 8.70±0.47\(^{a}\)          |
| nVC             | 39.17±5.10\(^{a}\)       | 41.77±2.91\(^{a}\)         |

*Mean values in the same column with the same superscripts are not significantly different from each other (P> 0.05)*

Table 2 also shows that all meristic character values of Hepsetus odoe such as number of gill (nG), number of gill filaments (nGF), number of gills arches (nGA), number of gill rakers (nGR), anal fin rays (AFR), pectoral fin rays (PFR), pelvic fin rays (PvFR), dorsal fin rays (DFR) and number of vertebral column (nVC) were not varied among the two populations (P= 0.05).

### 3.2 Meristic Frequency

**Clarias gariepinus**

*Clarias gariepinus* are usually with dark black colouration on the back, fading to a white belly. It has no scale, 8 barbells, 4 gills, no dorsal spine, 4 pairs of gill arches (upper and lower), 976-1500 gill filaments, 180-380 gill rakers, 45-60 anal fin rays, 7-10 pectoral fin rays, 6 pelvic fin rays, 55-70 dorsal fin rays (soft) and 50-70 vertebral columns depending on the geographical location (Table 3).

**Hepsetus odoe**

Hepsetus odoe is ovoid or oviform with a short and wide body surface, silvery colouration with black stripes or bands, has scales all over its body, no barbell, 4 gills, 14-17 dorsal spines, 13-15 dorsal soft rays, 27-29 dorsal fin rays, 4 pairs of gill arch (upper and lower), 1040-1240 gill filaments, 180-280 gill rakers, 10-14 anal fin rays, 11-12 pectoral fin rays, 6 pelvic fin rays and 25-38 vertebral columns depending on the habitat (Table 3).
Table 3. Meristic traits frequency for *Clarias gariepinus* and *Hepsetus odoe* across the three main reservoirs (Ero, Egbe and reservoirs)

| Name of species | Name of reservoir | nB | nG | nS | nGA | nGF | nGR | AFR | PFR | PvFR | DFR | nVC |
|-----------------|-------------------|----|----|----|-----|-----|-----|-----|-----|------|-----|-----|
| *C. gariepinus* | Ero               | 8  | 4  | -8 | 976 | 180 | 45  | 7-10| 6   | 25-50| 50-50|     |
|                 | Egbe              | 8  | 4  | -8 | 1040| 510 | 52  | 9-10| 6   | 27-55| 60-60|     |
|                 | Ado-Ekiti         | 8  | 4  | -8 | 1650| 325 | 47  | 9-10| 6   | 27-53| 30-30|     |
| *H. odoe*       | Egbe              | -  | 4  | -8 | 1000| 184 | 10  | 9   | 9   | 30-30|      |     |
|                 | Ado-Ekiti         | -  | 4  | -8 | 880 | 184 | 10  | 9-10| 9-10| 40-40|      |     |

nB= number of barbells, nG= number of gills, nS= number of spine, nGA= number of gill arches, nGF= number of gill filaments, nGR= number of gill rackers, AFR= anal fin rays, PFR= pectoral fin rays, PvFR= pelvic fin rays, DFR=dorsal fin rays, nVC= number of vertebral column.

Fig. 2. PCA scatter diagram for morphometric of *C. gariepinus* from all the reservoirs using 95% ellipses Ero (red), Egbe (blue) and Ado-Ekiti (pink)

3.3 Analysis of *C. gariepinus* across the Three Reservoirs (Ero, Egbe and Ado-Ekiti)

The PCA for morphometric and meristic characters of *Clarias gariepinus*, the PCA scatter diagram using 95% ellipses for the morphometric characters of *C. gariepinus* species obtained from the three populations of study showed that there is an overlap of data between populations from Ero-Reservoir (red) and Ado-Ekiti - Reservoir (pink), and a big overlap between Egbe-Reservoir (blue) and the other reservoirs, which revealed a great homogeneity of *C. gariepinus* from the populations (Fig. 2). The cluster Analysis (dendrogram) *C. gariepinus* from all the reservoirs using Rho similarity measure showed Ero-Reservoir (red) especially Egbe-Reservoir (blue) and Ado-Ekiti Reservoir (pink) were mixed and has a single homogeneity of the *C. gariepinus* from the three populations (reservoirs) Fig. 3. The principal component Analysis (PCA) Scatter diagram using 95% of ellipses for meristic traits or characters of *C.
gariepinus form the three populations of study showed that, the circle representing the data in the population of Egbe-Reservoir (blue) are inside circle representing the data in the population of Ero-Reservoir (red) and it also overlapped and there is a clear separation between population of Ado-Ekiti Reservoir (pink) and the other two reservoirs, which indicate that the C. gariepinus from Egbe-reservoir and Ero-reservoir have meristic characters (traits) in common and are homogeneity. And also that C. gariepinus from Ado-Ekiti -Reservoir were significantly different i.e varies from the two reservoirs in meristic characters Fig. 4. The PCA loading for morphometric characters for C. gariepinus showed that there were no significant differences of variations (homogeneity) among the characters of C. gariepinus from the studied populations shows ‘number of gill filament' (loading 0.9993) as the meristic character that varied most among the three C. gariepinus populations Fig.9 and Table 4b.

The Eigen values and corresponding percentage variance from principal component analysis PCA of the morphometric and meristic characters of C. gariepinus respectively across the three studied populations as shown in Tables 6a and 6b respectively. These components are showing the distribution of variation among the components in the CA for morphometric characters, PCI accounted for 99.7% of the variation, PC XVII for 6.4% and PC XXIII for 6.1% Table 6a, for meristic characters, PCI 60.6% of the variation, PC II for 39.1% and PC VIII for 7.1% (Table 6b).

3.4 Analysis of H. odoe across the Two Reservoirs (Egbe and Ado-Ekiti-reservoir)

The principal component analysis of morphometric and meristic characters of Hepsetus odoe was found in two reservoirs. The PCA scatter diagram using 95% ellipses for the morphometric characters of H. odoe species obtained from the two populations showed that there is an overlap of data between populations from Egbe-Reservoir (blue) and Ado-Ekiti Reservoir (pink), which revealed a great homogeneity of H. odoe from the populations Fig.5. The cluster Analysis (Dendrogram) of H. odoe from two reservoirs using Rho similarity measure showed Egbe-Reservoir (blue) and Ado-Ekiti Reservoir (pink), the two colour were mixed and can be trace to a single Origin (Ancestors) which also confirm the great homogeneity of the H. odoe from the two populations Fig 6. The principal component analysis (PCA) scatter diagram using 95% of ellipses for meristic characters of H. odoe from the two populations showed that, there is an overlap of data between populations from Egbe-Reservoir (blue) and Ado-Ekiti Reservoir (pink). It revealed a great homogeneity in meristic characters of H. odoe from the two populations Fig. 7.

Fig. 3. Cluster analysis (dendrogram) for morphometric of C. gariepinus from Ero, Egbe and Ado-Ekiti- Ekiti reservoirs using Rho similarity measure
Fig. 4. PCA scatter diagram for meristic of *C. gariepinus* from all the reservoirs using 95% ellipses Ero (red), Egbe (blue), Ado-Ekiti (pink)

Fig. 5. PCA scatter diagram for morphometric of *Hepsetus odoe* for two reservoirs Egbe (blue), Ado-Ekiti (pink)
Fig. 6. Cluster analysis (dendrogram) for morphometric of *H. odoe* from Ero and Egbe-reservoirs using Rho Similarity measure.

Fig. 7. PCA scatter diagram for meristic characters of *H. odoe* from the two reservoirs, Egbe (blue) and Ado-Ekiti (pink).

Fig. 8. PCA loadings for morphometric of *C. gariepinus* in Ero, Egbe and Ado-Ekiti-reservoirs.
Fig. 9. PCA Loadings for meristic characters of *C. gariepinus* from all the reservoirs

Table 4a. PCA loadings for morphometric of *C. gariepinus* from Ero, Egbe and Ado-Ekiti-reservoirs

| Traits (cm) | Loadings |
|-------------|----------|
| TL          | -0.003322|
| W           | -0.9999  |
| DFL         | 0.005304 |
| AFL         | 0.002774 |
| PFL         | 0.002238 |
| SPL         | 0        |
| HL          | -0.005269|
| SNL         | 0.001523 |
| OFL         | 0.004    |
| PAD         | -0.006762|
| PVD         | -0.005012|
| PPD         | -0.002511|
| PDD         | -0.0006479|
| DDCF        | -0.001007|
| DODF        | 0.001143 |
| CPD         | -0.001677|
| BD          | -0.001345|
| HW          | -0.001734|
| ID          | -0.001236|
| ED          | 0.0001636|
| OFW         | -0.0009802|
| DSO         | -0.006863|
| NL          | 0.0004559|

The PCA loadings for morphometric characters for *H. odoe* showed that there were no significant differences (variations), indicating the level of similarity among the characters of *H. odoe* from the studied populations Fig. 10 and Table 5a. The PCA loadings for meristic characters of *H. odoe* from the two populations showed a little variation in the “number of Vertebrate Column” (Loadings 0.01078) as the meristic character that varied most the among meristic characters of two populations of *H. odoe* Fig 11 and Table 5b.
Table 4b. PCA Loadings for meristic characters of *C. gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs

| Traits (cm) | Loadings |
|------------|----------|
| nB         | 0        |
| nG         | 0        |
| nS         | 0        |
| nGA        | -0.004808|
| nGF        | 0.9993   |
| nGR        | 0.0371   |
| AFR        | -0.003449|
| PFR        | -0.001271|
| PvFR       | 0.0001868|
| DFR        | 0.002262 |
| nVC        | 0.001773 |

Table 5a. PCA loading for morphometric characters of *H. odoe* from two reservoirs

| Traits (cm) | Loadings |
|------------|----------|
| TL         | 0.002682 |
| W          | -0.9999  |
| DFL        | -0.0001895|
| AFL        | 0.00067  |
| PFL        | -0.001481|
| SPL        | 0        |
| HL         | 0.004237 |
| SNL        | -0.0002295|
| OFL        | 0.002217 |
| PAD        | -0.002123|
| PVD        | -0.005366|
| PPD        | 0.0003334|
| PDD        | 0.001077 |
| DDCF       | -0.001033|
| DODF       | 0.002758 |
| CPD        | -0.0002034|
| BD         | 0.0008222|
| HW         | -0.002745|
| ID         | 0.0008179|
| ED         | 0.0005649|
| OFW        | 0.00164  |
| DSO        | 0.005738 |
| NL         | 0.00154  |

The Eigen values and corresponding percentage variance from principal component analysis PCA of the morphometric and meristic characters for *H. odoe* respectively across the two populations as shown in tables 6a and 6b respectively. These components are showing the distribution of variation among the components in the PCA. For morphometric characters, PC I accounted for 99.4% of the variation, PC XXII for 5.4% and PC XXIII for 2.2% (Table 7a). For meristic characters, PC I accounted for 97.4% of the variation, and PCII for 2.2% (Table 7b).

### 3.5 Condition Factor

The condition factor (K) values for *C. gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs are 0.7 ± 0.2, 0.9 ± 0.3 and 0.7 ± 0.2 respectively. The values are not significantly different from one another.

The condition factor (K) values for *H. odoe* from Egbe and Ado-Ekiti reservoirs are 0.008 ± 0.002 and 0.74 ± 0.04 respectively. The values are significantly different from each other.
Fig. 10. PCA loadings for the morphometric of H. odoe from two reservoirs

Fig. 11. PCA Loadings for meristic characters of H. odoe from two reservoirs

Table 5b. PCA Loadings for meristic characters of H. odoe from two reservoirs

| Traits (cm) | Loadings  |
|-------------|-----------|
| nB          | 0         |
| nG          | 0         |
| nS          | 0         |
| nGA         | 0         |
| nGF         | -0.9998   |
| nGR         | -0.01564  |
| AFR         | -0.00444  |
| PFR         | 0.0009066 |
| PvFR        | 0.0007821 |
| DFR         | -0.001832 |
| nVC         | 0.01078   |
Table 6a. Distribution of variation of morphometric data for *C. gariepinus* among the principal components

| PC | Eigen Values | % Variance |
|----|--------------|-------------|
| 1  | 264431       | 99.701      |
| 2  | 644.606      | 0.24304     |
| 3  | 66.0935      | 0.02492     |
| 4  | 36.5261      | 0.013772    |
| 5  | 16.8341      | 0.006347    |
| 6  | 7.69913      | 0.0029029   |
| 7  | 6.25831      | 0.0023596   |
| 8  | 3.81471      | 0.0014383   |
| 9  | 2.29167      | 0.00086405  |
| 10 | 2.19764      | 0.0008286   |
| 11 | 1.57804      | 0.00059499  |
| 12 | 1.26942      | 0.00047862  |
| 13 | 0.900055     | 0.00033936  |
| 14 | 0.867731     | 0.00032717  |
| 15 | 0.496435     | 0.00018718  |
| 16 | 0.297644     | 0.00011222  |
| 17 | 0.170835     | 6.4412E-5   |
| 18 | 0.117212     | 4.4194E-5   |
| 19 | 0.062789     | 2.3674E-5   |
| 20 | 0.0480277    | 1.8108E-5   |
| 21 | 0.0298724    | 1.1263E-5   |
| 22 | 0.0127403    | 4.8036E-6   |
| 23 | 1.6424E-17   | 6.1925E-21  |

Table 6b. Distribution of variation of meristic data for *C. gariepinus* among the principal components

| PC | Eigen Value | % Variance |
|----|-------------|------------|
| 1  | 47576.4     | 60.633     |
| 2  | 30722.5     | 39.154     |
| 3  | 126.852     | 0.16166    |
| 4  | 23.0733     | 0.16166    |
| 5  | 13.3345     | 0.016994   |
| 6  | 3.14119     | 0.0040032  |
| 7  | 0.803213    | 0.0010236  |
| 8  | 0.0560874   | 7.148E-5   |
| 9  | 0           | 0          |
| 10 | 0           | 0          |
| 11 | 0           | 0          |

4. DISCUSSION

4.1 *Clarias gariepinus* from the three reservoirs

*Clarias* has a wide spread distribution and adapted to Nigeria and Africa. The cat fishes from the *Clariidae* are used as important economic species and as invasive species due to their high predatory nature along with Omni-voracity and prolificacy, the species used to impose a great threat to the nature fishes. The used of predatory fish species such as *Clarias gariepinus* in controlling the population of fish species at lower tropic level such as *Tilapia* species, *Orechromis niloticus* through culturing method has been acceptable method worldwide. Results of the biometric characterization in the present study revealed that *C. gariepinus* obtained from three populations are exhibited morphologically similar, although the level of similarity between them varies across the three populations. The PCA scatter diagram for
morphometric characters of *Clarias gariepinus* showed distinct similarity and relationship. The ANOVA illustrated incomplete homogeneity. The overlap of data between population of *Clarias gariepinus* from Ero-reservoir (red), Ado-Ekiti reservoir (pink) and Egbe (blue) as observed on the PCA scatter diagram (Fig.2) implies that these populations are phenotypically inseparable (i.e. homogeneity) based on the morphometric characters.

The cluster analysis (dendrogram) using Rho similarity measure for *Clarias gariepinus* in the three reservoirs Fig.3, which has a single origin of ancestor, also illustrated the level of homogeneity of *Clarias gariepinus* from the three populations.

[3] Reported similarities in the morphological composition of *Clarias gariepinus* collected from a fish pond in Emure - Ekiti (controlled population) and Ogbese-River (Uncontrolled population). However, the data obtained in the present study conforms to [10], discussed in their report that PCA scatter diagram using 95% ellipses for the morphometric of wild (Ero-reservoir) and cultured (pond) *Clarias gariepinus* of both genders, illustrated incomplete homogeneity. Despite the level of similarities that exist between *Clarias gariepinus* from the three reservoirs, some little variation still exist. Variations in body form have important fitness consequent on fish, both in cultured and wild populations [11]. The fish, *Clarias gariepinus* from the three reservoirs also showed colour differences which might be caused by environmental factors. Specimens obtained from Ero-reservoir were darker than Ado-Ekiti reservoir. Similarly, those obtained from Egbe reservoir were darker than those from Ero-reservoir. This may also suggest that the fish specimens examined had made morphological variation to better adjust to their environmental conditions. This variation was also noticed by [12]. They reported that fish specimens obtained from Omo-Reservoir were darker than that of Ogbese - Reservoir, and those obtained from Oluwa-Reservoir were darker than those from Owena-Reservoir.

PCA scatter diagram for meristic characters of *Clarias gariepinus* from the three populations using 95% ellipses (Fig. 4) revealed that *C. gariepinus* from Ero-reservoir (red) and Egbe- reservoir (blue) have homogeneity, while those from Ado-Ekiti reservoir (pink) were morphologically not related. The PCA loadings for the morphometric characters of *Clarias gariepinus* from the three reservoirs also illustrated the homogeneity with little variations existed in these populations and indicated the precise trait or character with highest morphometric variation – DFL (0.005304) and gill filament (0.9993) for meristic character (Fig. 8 and 9), this gives detailed information of ANOVA. All the studied populations are the strains with more gene flow had occurred among them in their locations. This is the evidenced in the high level of homogeneity reported in this study.

Furthermore, this paper also revealed that, *H. odoe* obtained from two populations (reservoirs) showed homogeneity which is phenotypically similar. The PCA scatter diagram for morphometric characters of *H. odoe* (Fig.5) showed a distinct similarity and relationship. The complete overlap of data between populations of *H. odoe* from Egbe (blue) and Ado-Ekiti (pink) as observed on the PCA scatter diagram implies that these populations have phenotypically homogeneity based on their morphometric characters. The cluster analysis (dendrogram) using Rho similarity measure for *H. odoe* in the two reservoirs (Fig.6), which has a single origin of ancestor, also confirmed the level of homogeneity of *H. odoe* from the two populations. Likewise the PCA scatter diagram for meristic characters of *H. odoe* from the two populations using 95% ellipses also confirmed that *H. odoe* from Egbe (blue) and Ado-Ekiti (pink) have homogeneity as indicated by the overlapping of data (Fig.7). The PCA loadings for the morphometric characters and meristic characters of *H. odoe* from the two reservoirs also support that, they exhibited homogeneity with a little variations in these populations and indicated the precise character with the variation DSO (0.005738) loadings and nVC (0.01078) loadings for meristic characters. The two studied populations for *H. odoe* are the same species with more gene flow occurring among them in their locations (Fig. 8 and Table 5a, Fig. 9 and Table 5b).

### 4.2 Condition Factor

The mean condition factor (K) of the fish which strongly depend on fish length for *Clarias gariepinus* from Egbe was slightly higher than that of Ero and Ado-Ekiti reservoirs populations’ sample. The condition factor of *H. odoe* from Ado-Ekiti population is higher than that of Egbe- population sample. When there is variation in the condition factor from three or two different populations, it suggests that the fish under this study are not
from the same source, except *C. gariepinus* from Ado-Ekiti reservoir and Ero-population sample that has the same values.

The condition factor defines the well-being of the fish in a particular environment at a time. Fish with higher K values are in a better condition than the fish with lower K values with respect to their lengths [13,2]. A value of K for *C. gariepinus* from Ero, Egbe and Ado-Ekiti populations, and *H. odoe* from Egbe and Ado-Ekiti populations are lesser than 1. This means that the feeding of *C. gariepinus* from Ero, Egbe and Ado-Ekiti populations and *H. odoe* from Egbe and Ado-Ekiti populations may be inadequate. And this implies that these fish populations may not have been fed to the required level or caught from not well naturally fertilised ecological niche or there is more competition for available food substances in the ecological niche. So, there is need to determine the reasons for better growth and development of:

(i) *C. gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs and

(ii) *H. odoe* collected from Egbe and Ado-Ekiti reservoirs, Ekiti-state, Nigeria.

Fish sufficiently fed had ‘K’ values equals or greater than 1 while undernourished fish had ‘K’ less than 1. These results suggest similarity in the morphological composition and the condition factor of both *C. gariepinus* from Ero, Egbe and Ado-Ekiti reservoirs and *H. odoe* from Egbe and Ado-Ekiti populations [14,2].

**5. CONCLUSION**

The results obtained in this study established morphologically homogeneity in both morphometric and meristic characters of *Clarias gariepinus* inhabiting the three different reservoirs of study based on multivariate analysis. Except the meristic characters of *Clarias gariepinus* from Ado-Ekiti reservoir that somehow differ from other two reservoirs. Hence, there should be further genetic tests on this fish species to detect the level of differences from the three reservoirs. These results also established homogeneity phenotypically in both morphometric and meristic characters of *H. odoe* inhabiting two different reservoirs based on multivariable analysis of the morphometric and meristic characters.

Lastly, these results obtained also revealed similarities in the morphological composition and the condition factors of *Clarias gariepinus* and *H. odoe*. There is need to determine the favourable factors of the growth and development of *Clarias gariepinus* and *H. odoe* in the subsequent studies on Ero, Egbe and Ado-Ekiti reservoirs, Ekiti State, Nigeria.

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

**REFERENCES**

1. Ita EO. Reservoir lakes and Fisheries Management and investment opportunity in proceeding of the 5th Annual Conference of Fisheries Society of Nigeria. K.L.R.I. Publication;1986.

2. Akindele TA, Fagbuaro O. The Morphometric characteristics and meristic traits and condition factors of *Sarotherodon galilaeus* from three major reservoirs of Ekiti-State, Nigeria. Asian Journal of Advances in Research. 2022;12(1):1-11.

3. Fagbuaro O, Oso JA, Ola-Oladimeji FA, Olafusi TO. Comparative biometric variation of two *Cichlidae*. *Oreochromis niloticus* and *Tilapia zillii* from a reservoir in southern Nigeria. American Journal of Research Communication. 2016;4(5):119 – 129.

4. Kareem C, Alp A, Gurlex ME, Morphological variations of the trouts (*Salmo trutta* and *Salmo platycephalus*). In the rivers of Ceyhan, Sehan and Euphrates, Turkey. Turkish Journal of Fisheries and Aquatic Sci. 2011;11:77-85.

5. Oladimeji TE, Awodiran MO, Ola-oladimeji FA. Morphological characterization of natural populations of *Sarotherodon galilaeus* (*Linnaeus 1758*) from three selected reservoirs in south western, Nigeria. Ife Journal of Science. 2022;22:3.

6. Mutaseem KA, Ismadi IA. A survey on fish classification techniques; 2020. Available:https://doi.org/10.1016/j.jksuci.2020.07.005.

7. Hanano M, Takahiro J, Tatsuhito H. Fish Species Identification Using a CNN-based Multimodal Learning Method IVSP ‘20: Proceedings of the 2020 2nd International Conference on Image, Video and Signal Processing. 2020;15–19. Available:https://doi.org/10.1145/3388818.3389164.

8. Hassan AH, Mahmoud ZN, Elhg AA, Hagar EL SA, Hamid M.M. Meristic and
Morphometric of Sarotherodon galilaeus from the Nile and its Tributaries, Sudan. IAR J Agri Res Life Sci. 2020;1(5):121-129.

9. Majolagbe FA, Awodiran MO, Awopetu JI. Electrophoretic studies of Clarias gariepinus (Burchell 1822) and Heterobranchus bidorsalis (Geoffroy Saint-Hilaire 1809) and their hybrids. Ife Journal of Science. 2012;14(1):167-176.

10. Fagbauer O, Oso JA, Olurotimi MB, Akinyemi O. Morphometric and meristic characteristics of Clarias gariepinus from controlled and uncontrolled population from South Western Nigeria. Journal of Agriculture and Ecology Research International. 2(1):39-45. Article no:JAER. 2015.005, 2015.

11. Guillet JM, Han DC, Hood CS. The effects of phylogeny on interspecific body shape variation in data (Pisces: Percidae). Systematic Biology. 2003;52:488-500.

Ola-Oladimeji FA, Awodiran MO, Fagbauer O, Akomolafe AO. Morphological Characterization of wild and culture Clarias gariepinus (Buchell 1822) using principal component and cluster analyses. Notulae Scientia Biologicae. 2016;8(4):603-607.

13. Nikos D. 2005 The farming of Arctic charr, condition factor:2004. Available:www.holar/s/aquafarmer/node101.html.

14. Sadaghat S, Hosseini SA, Fazel AA. Morphometric and meristic characteristic studies of Loach, Paracobitis malapterurus in the Zarringol, River, East of the Elburz Mountains (Northern Iran). American – Eurasian Jour. Agric and Envtal. Sci. 2021;12(10):1282-1287.

© 2022 Akindele et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/83353