BIOMETRICS OF THE COMMON SMOOTH-HOUND SHARK, *MUSTELUS MUSTELUS* FROM LANDING SITES OF LAGOS AND ONDO COASTS (NIGERIA)

Omolara Opeyemi FOLA-MATTHEWS *, *Olufemi Olukolajo SOYINKA* **
and *Aderonke Omolara LAWAL-ARE* *** *(c.a.)*

* Nigerian Institute for Oceanography and Marine Research, P.M.B. 12729, V. I., Lagos, Nigeria, tunjimoruf@yahoo.com, ORCID: 0000/0002/7800/7558.
** University of Lagos, Department of Marine Sciences, University Road, Akoka, Lagos, Nigeria, awarushs@yahoo.com, ORCID: 0000-0002-5776-2757.
*** University of Lagos, Department of Marine Sciences, University Road, Akoka, Lagos, Nigeria, alawalare@gmail.com, ORCID: 0000-0001-7656-6930.

DOI: 10.2478/trser-2024-0006

KEYWORDS: biometrics, morphometrics, truss morphometrics, sharks, Nigeria.

ABSTRACT

This study investigates the biometrics of the common smooth-hound shark, *Mustelus mustelus*, from fish landing sites of the Lagos and Ondo Coasts. Morphometric measurements and meristic counts were used on 1,018 specimens to analyze morphometric differentiations. Significant sex-based differences were found across various morphometric traits, with phenotypically separable populations observed between locations. Bray-Curtis analysis categorized morphometrics into four groups based on similar characteristics. Principal component analysis identified three components, with PC1 dominated by chondrocranium and gill slit measurements, PC2 by gill slit and fin origin measurements, and PC3 by snout and fin origin measurements.

RÉSUMÉ: Biométrie de l’Émissole lisse, *Mustelus mustelus*, provenant des sites de débarquement au large des côtes de Lagos et d’Ondo (Nigeria).

Cette étude examine la biométrie de l’Émissole lisse, *Mustelus mustelus*, sur les sites de débarquement de poissons au large de Lagos et de la côte d’Ondo. Des mesures morphométriques et des comptages méristiques ont été effectués sur 1.018 spécimens pour analyser la différenciation morphométrique. Des différences significatives basées sur le sexe ont été constatées entre les traits morphométriques, avec des populations distinctes observées entre les différents sites. L’analyse de Bray-Curtis a permis de classer les caractéristiques morphométriques en quatre groupes sur la base de caractéristiques similaires. L’analyse en composantes principales a identifié trois composantes, la PC1 étant dominée par les mesures du chondrocrâne et de la fente branchiale, la PC2 par les mesures de la fente branchiale et de l’origine de la nageoire, et la PC3 par les mesures du museau et de l’origine de la nageoire.

REZUMAT: Biometria rechinului mustel, *Mustelus mustelus* din locurile de acostare costieră din Lagos și Ondo (Nigeria).

Aceast studiu investighează biometria rechinului mustel, *Mustelus mustelus*, din locurile de acostare a bărcilor pescărești de pe coastele Lagos și Ondo. Măsurătorile morfometrice și numărătorile meristice au fost utilizate pe 1.018 indivizi, pentru a se analiza diferențierile morfometrice. S-au găsit diferențe semnificative bazate pe sex în diferite trăsături morfometrice, cu populații separabile fenotipic observate între locații. Analiza Bray-Curtis a clasificat morfometria în patru grupuri pe baza unor caracteristici similare. Analiza componentelor principale a identificat trei componente, cu PC1 dominat de măsurătorile condrocraniului și a fantei branhiale, PC2 prin măsurarea originii fantei branhiale și a aripioarelor și PC3 prin măsurătorile originii botului și a aripioarelor.

INTRODUCTION

There are numerous approaches that can be taken into consideration to determine the stock or population structure of any fish species including among others genetic analyses, phenotype analyses to detail the growth rates, age composition, morphometrics, and micro constituents in calcified structures, together with parasite loads, and tagging returns. Biometrics is an old science concerning the documentation of the bio-measurements or identification characteristics of the targets which could be humans, animals, and even fossils. Biometric measurements include morphometrics and meristics which has various applications in taxonomy, species identifications, pollution monitoring, species abnormalities, environmental changes, growth variation, feeding behaviour, ecological strategies, stock management, and aquaculture.

Generally, fish demonstrate greater variances in morphological traits within and between populations than other vertebrates and are more susceptible to environmentally induced morphological variations. Meristic counts provide quantitative data and information about the number of certain specific structures in a fish’s body. Studies on meristic features are also important in fisheries because it is necessary to understand fish population dynamics and growth patterns in fish stocks (Najmudeen et al., 2019). According to Sidiq et al. (2021), information on meristic features can be valuable for various reasons, including taxonomy, ecological studies, and population assessments. Morphometrics helps to indicate differences in growth and maturity patterns which are sensitive to environmental fluctuations and show little variation in the gene pool. It also provides the relationship between body parts (Carpenter et al., 1996) and to know the origin of stock, separation of stocks, or identification of the commercially important species of fish (Narejo et al., 2000; Kohinoor et al., 1995; Devi et al., 1991).

Morphological relationships (based on descriptive assessment of individual characters, functional morphology, and multivariate analyses of multiple anatomical characters) is directly related to species life history and specific habitat use. Thus, fish morphometrics analysis represents an important tool for determining their systematic, growth variation, population parameters, and environmental relationships (Pathak et al., 2013; Sampaio et al, 2013). Despite the presence of molecular biology techniques, the study of morphometric traits is still one frequently employed by many biologists and taxonomists as it provides faster and cost-effective methods (Abbas et al., 2016; Farrag et al., 2015; Mekkawy and Mohammed, 2011; Nayman, 1965).

Standard morphometric measurements concentrate along the specific locus of the fish i.e., from the head/tip of the snout to the posterior end of the vertebral column, and it is largely dependent on the size of the fish and highly correlated with the total length of the fish. In advancement of this, the Truss Network morphometric system, a landmark-based technique system, can capture information about the shape of an organism with no restrictions on the direction of variation or localization of shape changes (Cavalcanti et al., 1999). The Truss Network technique is also important in species identification when more intensive measurements are required due to the loss of some biometric characters of the fish during fishing, sampling, and handling. A Truss Network measures a series of distances calculated between landmarks that form a regular pattern of connected quadrilaterals or cells across the body form (Strauss and Bookstein, 1982). The tope shark, *Galeorhinus galeus* and the common smooth-hound shark *Mustelus mustelus*, are the two representatives from the family Triakidae identified in Nigeria and the Gulf of Guinea (Tobor, 1993; FAO, 1990). There are presently no occurrences of any other species of the genus *Mustelus* recorded. The common smooth-hound shark, *Mustelus mustelus* represents an important fishery resource of the

Southwestern Nigerian Coast caught mainly as bycatches in both artisanal and industrial fleets while the tope shark was not observed throughout the study period at all sampling locations. In this study, observation on the biometric measurements of the common smooth-hound shark, *Mustelus mustelus* was taken to collect taxonomic data of the species that would serve as a guide to differentiate amongst other *Mustelus* species that may be sighted around the Southwestern coast of Nigeria. Variations in morphometric and sex-related characteristics were also compared between species of *Mustelus mustelus* collected around the Coast of Lagos and Ondo.

MATERIAL AND METHODS

Ethical statement

This study was carried out with strict commendations and approval of the Health Research Ethics Committee of the College of Medicine of the University of Lagos, Nigeria, Registration number: CMUL/ACUREC/09/21/1094.

Study area

Samples of *Mustelus mustelus* were collected randomly at landing sites off the Lagos Coast (OLC) and off the Ondo Coast (ONC) as well as two fish markets in Lagos state between March 2018 and September 2021. The landing sites were located between 5°57'N-6°27'N and 3°23'E-4°54'E.

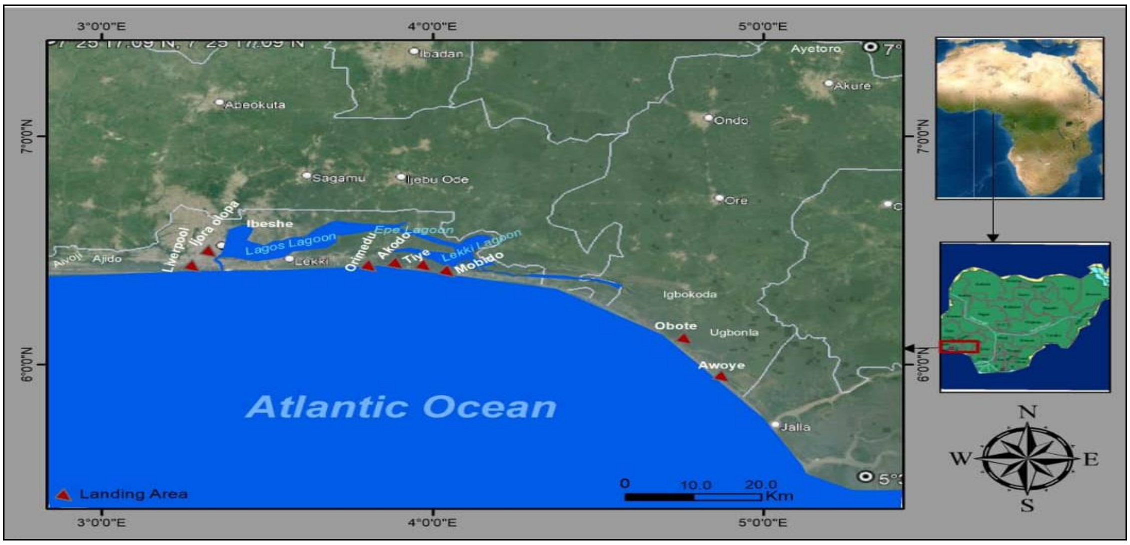

Figure 1: Map of the study area showing the location of fish landing sites of Lagos and Ondo Coasts, Nigeria (Google Earth Pro).

Sample collection

1,018 samples of *Mustelus mustelus* were collected in this study. All specimens were transported to the laboratory and persevered in an ice chest freezer. Length and weight measurements were taken after each specimen was properly thawed. Total Length (TL) was measured to the nearest centimeter with a tape measure; TL- distance from the tip of the snout to the end of the upper caudal lobe while the Total Weight (TW) was measured to the nearest gram on a digital balance.

Biometric measurements

The meristic features counted were the number of dorsal fins, gill slits, and vertebrae (monspondylous precaudal vertebrae, diplospondylous precaudal vertebrae, diplospondylous caudal vertebrae) (Fig. 2).

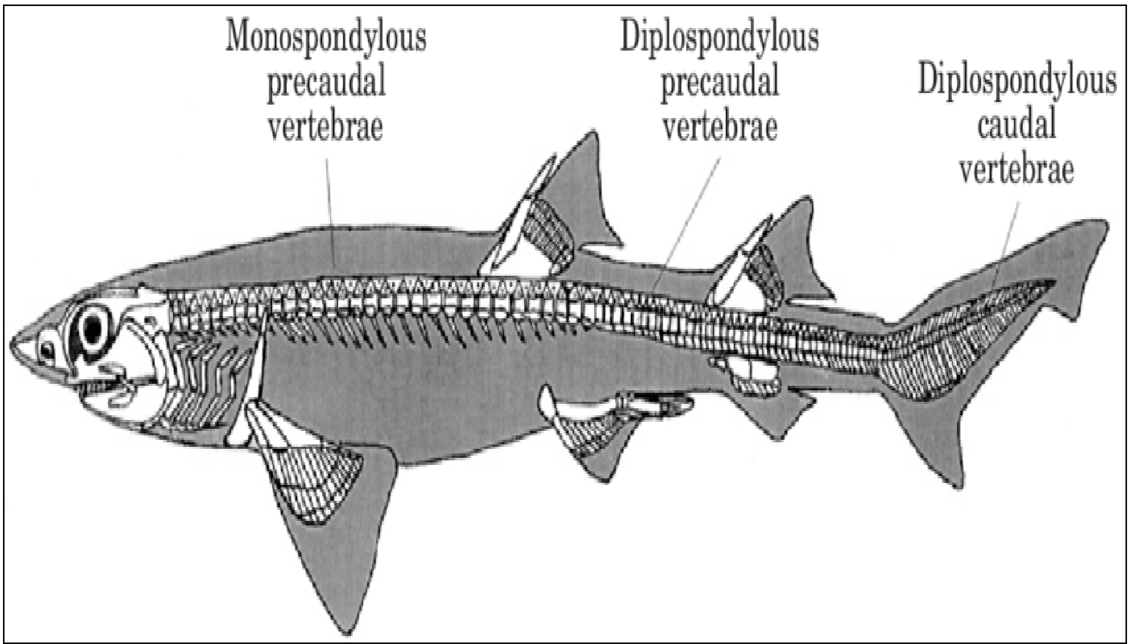

Figure 2: The location of caudal and precaudal vertebrates in sharks (Compagno, 1999).

One hundred and one selected conventional morphometric characters were measured for each studied specimen. The samples were measured using a measuring board and a measure tape to the nearest centimeter. The measurements of all the body parts were made first with the head of each specimen pointed to the left on the measuring board. The weight (g) of each specimen was measured using an electronic weighing balance (Satorius-Werke GMBH model).

The following conventional morphometric characters were measured for each fish: Total Length (TOT), Pre-pelvic Length (PP2), Fork Length (FOR), Snout-Vent Length (SVL) Precaudal Length (PRC), Preanal Length (PAL), Pre-Second Dorsal Length (PD2), Interdorsal Space (IDS), Pre-First Dorsal Length (PD1), Dorsal-Caudal Space (DCS), Head Length (HDL), Pectoral-Pelvic Space (PPS), Peribranchial Length (PG1), Pelvic-Anal Space (PAS), Prespiracular Length (PSP), Anal-Caudal Space (ACS), Preorbital Length (POB), Pelvic-Caudal Space (PCA), Prepectoral Length (PPL), Vent-Caudal Length (VCL), Prenarial Length (PRN), Por Preoral Length (POR), Eye Length (EYL) Eye Height (EYH), Intergill Length (ING), First Gill Slit Height (GS1), GS2 Second Gill Slit Height (GS2), Third Gill Slit Height (GS3), Fourth Gill Slit Height (GS4), Fifth Gill Slit Height (GS5), Sixth Gill Slit Height (GS6), Seventh Gill Slit Height (GS7), Pectoral Anterior Margin Pectoral Radial Length (PLR), Pectoral Base (PLB), Pectoral Inner Margin (PLI), Pectoral Posterior Margin (PIP), Pectoral Height (PIH), Subocular Pocket Depth (SOD), Dorsal Caudal Margin (DCM) Preventral Caudal Margin (CPV), Upper Postventral Caudal Margin (CPU), Lower Postventral Caudal Margin (CPL), Caudal Fork Width (CFW), Caudal Fork Length (CFL), Subterminal Caudal Margin (CST), Subterminal Caudal Margin (CSW), Terminal Caudal Margin (CTR), Terminal Caudal Lobe (CTL), First Dorsal Length (D1A), First Dorsal Anterior Margin (D1B), First Dorsal Base (D1H), First Dorsal Height (DLI), First Dorsal Inner Margin (DIP), First Dorsal Posterior Margin (D2L), Second Dorsal Length (D2A), Second Dorsal Anterior Margin (D2B), Second Dorsal Base (D2H), Second Dorsal Height (D2I), Second Dorsal Inner Margin (D2P), Second Dorsal Posterior Margin (P2L), Pelvic Length (P2A), Pelvic Anterior Margin (P2A), Pelvic Base (P2B), Pelvic Height (P2H), Pelvic Inner Margin Length (P2I), Pelvic Posterior Margin Length (P2P), Anal Length (ANL), Anal Anterior Margin (ANA), Anal Base (ANB), Anal Height (ANH), Anal Inner Margin (ANI), Anal Posterior Margin (ANP), Head Height (HDH), Trunk Height (TRH), Abdomen Height (ABH), Tail Height (TAH), Caudal Peduncle Height (CPH), First Dorsal Midpoint-Pelvic Origin (DPO), Pelvic Midpoint-First Dorsal Insertion (PDI), Pelvic Midpoint-Second Dorsal Origin (PDO), Second Dorsal Origin-Anal Origin (DAO), Second Dorsal Insertion-Anal Insertion (DAI), Mouth Length (MOL), Mouth Width (MOW), Upper Labial Furrow Length, Lower Labial Furrow Length (LLA), Nostril Width (NOW), Internarial Space (INW), Anterior Nasal Flap Length (ANF), Clasper Outer Length (CLO), Clasper Inner Length (CLI), and Clasper Base Width (CLB).

The Truss Network illustrated by Bookstein (2018), Bookstein et al. (1985), Strauss and Bookstein (1982), for fish morphometrics was applied to construct a network of measurements on *Mustelus mustelus* species studied specimens. Fourteen selected anatomical landmarks were taken for two hundred and fifty randomly selected specimens from the fish samples.

Points of these fourteen selected landmarks used on the specimens for constructing the truss system on *Mustelus mustelus* are explicitelly shown in figure 1. The number of distances on the body described by and Bookstein et al., (1985) and Strauss and Bookstein (1982) were:

$$N = (\frac{5n}{2}) - 4$$

where: N = number of distances on the body;
n = number of homologous anatomical landmarks.

The fourteen landmarks (n) compared to thirty-one distances (N) determined on the samples are shown in table 1. The fish were positioned on their side with the head to the left on water-resistant graph sheets, the body positioned with the fins spread into a natural state. Measurements of all the thirty-one distances were taken on one side with a measuring tape for each fish specimen. Moreover, to avoid likely bias generated from size results on the morphometric features, all the morphometric character data were standardized using the ratio transformation method (i.e., Log ratio) by Turan (1999) and Reist (1985) which is efficient in eliminating such size-dependent disparity as:

$$\mathrm{M}_{adj} = ({}^{\mathrm{logM}}/_{\mathrm{logSL}})$$

where: M_{adj} = size adjusted truss measurement;
M = original truss measurement;
SL= standard length of fish based on size -djusted morphological and landmark distance data.

Table 1: 31 distances measured on the body of each sampled shark; dist. – distance.

S/N	Distance	Truss morphometric measurements
1.	1_2	Dist. between anterior tip of snout on upper jaw and chondrocranium end point
2.	1_3	Dist. between the anterior tip of snout on upper jaw and the first gill slit
3.	1_4	Dist. between the anterior tip of snout on upper jaw and pectoral fin origin
4.	2_3	Dist. between the chondrocranium and the first gill slit
5.	2_4	Dist. between the chondrocranium and the pectoral fin origin
6.	2_5	Dist. between the chondrocranium and the first dorsal fin origin
7.	3_4	Dist. between the first gill slit and the pectoral fin origin
8.	3_5	Dist. between the first gill slit and the first dorsal fin origin
9.	4_5	Dist. between pectoral fin origin and first dorsal fin origin
10.	4_6	Dist. between pectoral fin origin and the pectoral fin insertion
11.	4_7	Dist. between pectoral fin origin and the first dorsal fin insertion
12.	5_6	Dist. between first dorsal fin origin and the pectoral fin insertion
13.	5_7	Dist. between first dorsal fin origin and the first dorsal fin insertion
14.	6_7	Dist. between pectoral fin insertion and the first dorsal fin insertion
15.	6_8	Dist. between the pectoral fin insertion and the pelvic fin origin
16.	6_9	Dist. between the pectoral fin insertion and second dorsal fin origin
17.	7_8	Dist. between the first dorsal fin insertion and the pelvic fin origin
18.	7_9	Dist. between the first dorsal fin insertion and the second dorsal fin origin
19.	8_9	Dist. between the pelvic fin origin and the second dorsal fin origin
20.	8_10	Dist. between the pelvic fin origin and the anal fin origin
21.	9_10	Dist. between the second dorsal fin origin and the anal fin origin
22.	9_11	Dist. between the second dorsal fin origin and second dorsal fin insertion
23.	10_11	Dist. between the anal fin origin and the second dorsal fin insertion
24.	10_12	Dist. between the anal fin origin and the lower precaudal pit
25.	10_13	Dist. between the anal fin origin and the upper precaudal pit
26.	11_12	Dist. between the second dorsal fin insertion and the lower precaudal pit
27.	11_13	Dist. between the second dorsal fin insertion and the upper precaudal pit
28.	11_14	Distance between the second dorsal fin insertion and the terminal lobe
29.	12_13	Dist. between the lower precaudal pit and the upper precaudal pit
30.	12_14	Dist. between the lower precaudal pit and the terminal lobe
31.	13-14	Dist. between the upper precaudal pit and terminal lobe

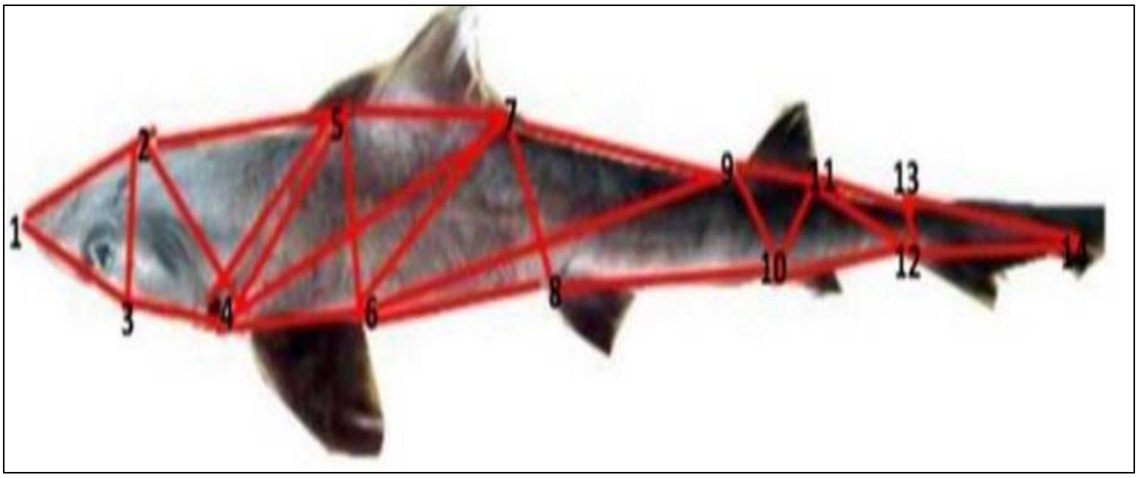

Figure 3: Location of the 14 anatomical landmarks used for Truss morphometrics on *Mustelus mustelus*; 1. anterior tip of the snout on the upper jaw; 2. most posterior aspects of chondrocranium; 3. first gill slit; 4. origin of pectoral fin; 5. origin of first dorsal fin; 6. insertion of pectoral fin; 7. insertion of first dorsal fin; 8. origin of pelvic fin; 9. origin of second dorsal fin; 10. origin of anal fin; 11. insertion of second dorsal fin; 12. lower precaudal pit; 13. upper precaudal pit; 14. terminal lobe.

RESULTS AND DISCUSSION

Meristic features

The meristic counts for *Mustelus mustelus* recorded are dorsal fins counts (first dorsal fin and second dorsal fin). Gill slits counts were five. There were variations in the number of vertebrae. Monospondylous, pre-caudal centra ranged from 24-30, diplospondylous pre-caudal centra ranged from 40-65 and diplospondylous caudal vertebrae ranged from 43-68. Meristic counts for *Mustelus mustelus* recorded in this present study showed variations in the number of vertebrae. The range of the diplospondylous pre-caudal centra was higher than the range of the monospondylous, pre-caudal centra. The result of meristic features consolidates the report of Cordova and Ebert (2021) on *Apristurus manocheriani*, a new species of catshark from the Southwest Indian Ocean.

Standard morphometrics

The result of the standard morphometrics using ANOVA revealed significant differences ($p < 0.05$) across the morphometric traits in the sexes of *Mustelus mustelus*, except for the Eye Height (EYH) which showed no significant difference. For location, ANOVA revealed significant differences ($p > 0.05$) in weight (WT), fork length (FOR), pre-pelvic length (PP2), pectoral inner margin (P1I), first dorsal length (D1L), first dorsal height (D1H), second dorsal length (D2L), second dorsal anterior margin (D2A), pelvic base (P2B), Anal height (ANL), abdomen height (ABH), and girth (GIR) of *Mustelus mustelus* from both sampling stations (OLC and ONC). This result is similar to the study from Grunow et al., (2022) on the morphological characters of the Small-Spotted Catshark, *Scyliorhinus canicula* with an optimal model organism. The maximum lengths of the same species were reported as 162 cm from the North-Eastern Mediterranean Sea (Ozcan and Başusta, 2018). Morphometric variations for female and male *Mustelus mustelus* from OLC and ONC are illustrated in figures 3 and 4.

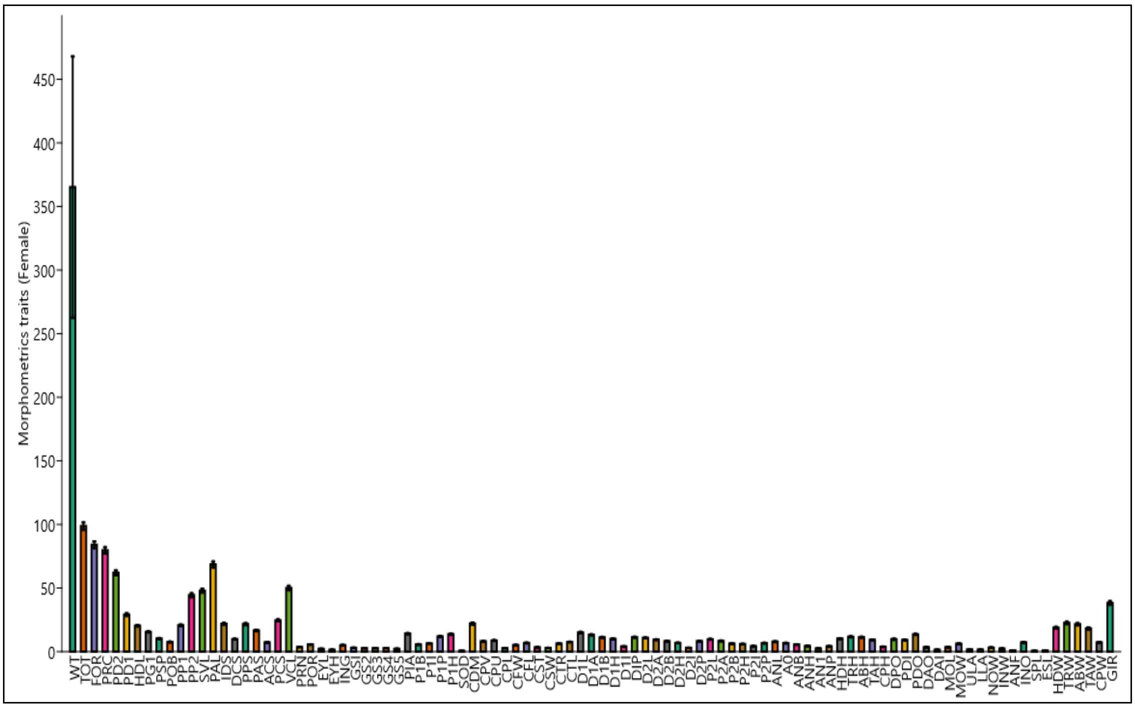

Figure 4: Morphometric variations for female *Mustelus mustelus*.

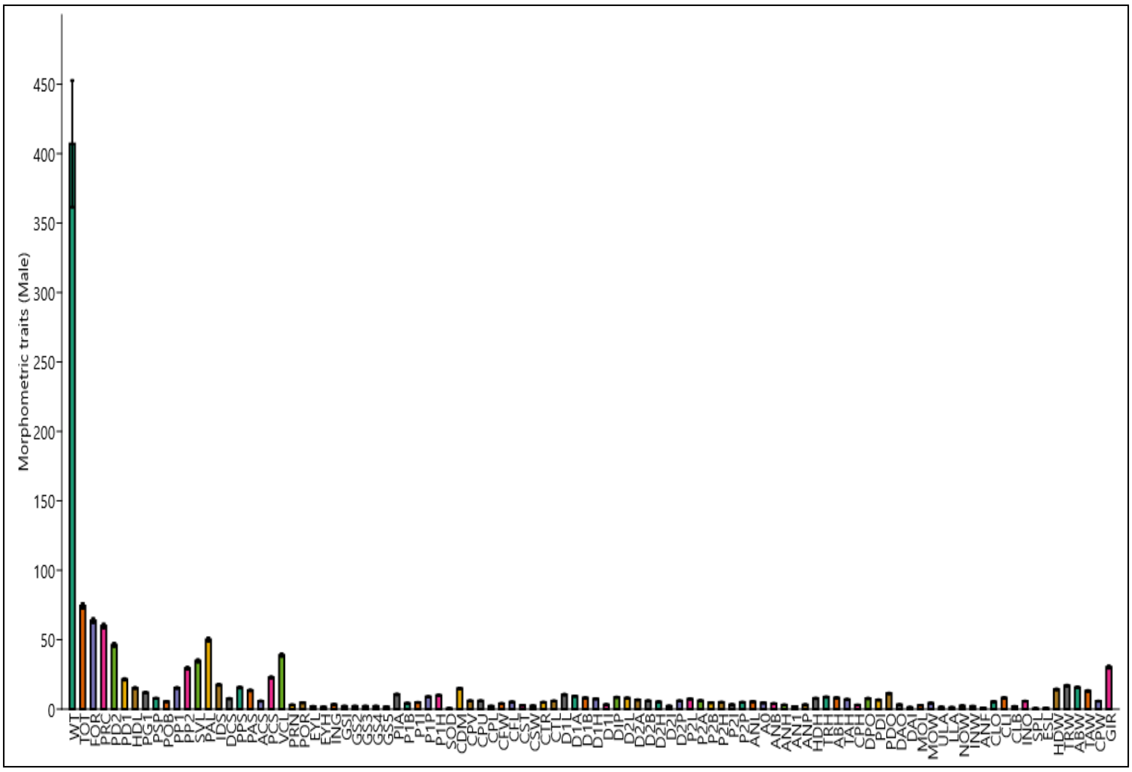

Figure 5: Morphometric variations for male *Mustelus mustelus*.

Using Bray-Curtis analysis, the interrelationships of the morphometric characteristics in relation to the sexes of the sharks across two locations are categorized into two subsets from the biplots; the sex of sharks was grouped into two (2): group 1 (male of OLC and male of ONC) and group 2 (female of OLC and female of ONC). Bray-Curtis analysis statistically grouped the morphometrics into four (4) categories based on similar characteristics; category 1 (Total weight of the OLC- male and female, ONC- male and female); category 2 (SOD, SPI, ANF and ESL); category 3a (PRN, CPH, CST, MOL, DAO, D1I, ANP, P2I, ANH, EYI, GS5, GS1, GS2. GS3, GS4, CPI, CSW, D2I, AN1, INW, NOW, EYH, ULA, DAI, LLA, and CLB); category 3b (CLO and CLI); category 3c (POB, ANL, ACS, INO, CPW, CTL, CPV, D2B, D2P, P2A, CPU); category 3d (POR, P2H, P1I, CTR, P2P, ANA, P2B, MOW, CFL, D2H, ING, P1B, ANB, and CFW); category 3e (PG1, PIA, D1I, PDO, P1H, D1A); category 3f (PSP, HDH, DCS, DPO, D1H, P2L, D2A, PDI, TAH, P1P, TRH, D1B, ABH, DIP, and DLL); category 3g (HDL, PP1, PPS, ABW, CDM, IDS, TEW, PAS, HDW, and TAW), category 3h (PD1 and PCS); and category 4a (TL, FOR, PRC, PD2 and PP2), category 4b (PP2, GIR, SVL, and VCL); figure 1 indicating that morphometric parameters clustered in the same category showing similar characteristics (Notarbartolo di Sciara et al., 2020) on biological notes and records and conservation of the long horned pygmy devil ray, *Mobula eregoodoo*.

The T-Test analysis on standard morphometrics showed that there were significant differences ($p < 0.05$) between the morphometric variables of the male and female *Mustelus mustelus* across the sampling period. As for location; the T-Test indicated that there were no significant differences ($p < 0.05$) between the morphometric variables acquired off Lagos and Ondo Coast of the sampled *Mustelus mustelus* sharks across the sampling period. Kousteni (2021) also recorded significant differences among the morphometric characters in the description and biological notes of the rare kitefin shark *Dalatias licha*.

Truss morphometrics

In this study, the contribution of the three principal components generated from truss morphometric data with the eigenvalues accounted for approximately 94% of the variation. There was very little difference in the percentage of variance of PC 1, PC 2, and PC 3, with low scores occurring. Negative and positive loading of morphometric measurements with different magnitudes in all the PCs signified that the size effect on the morphometric measurements had been totally removed before analysis (Tab. 2).

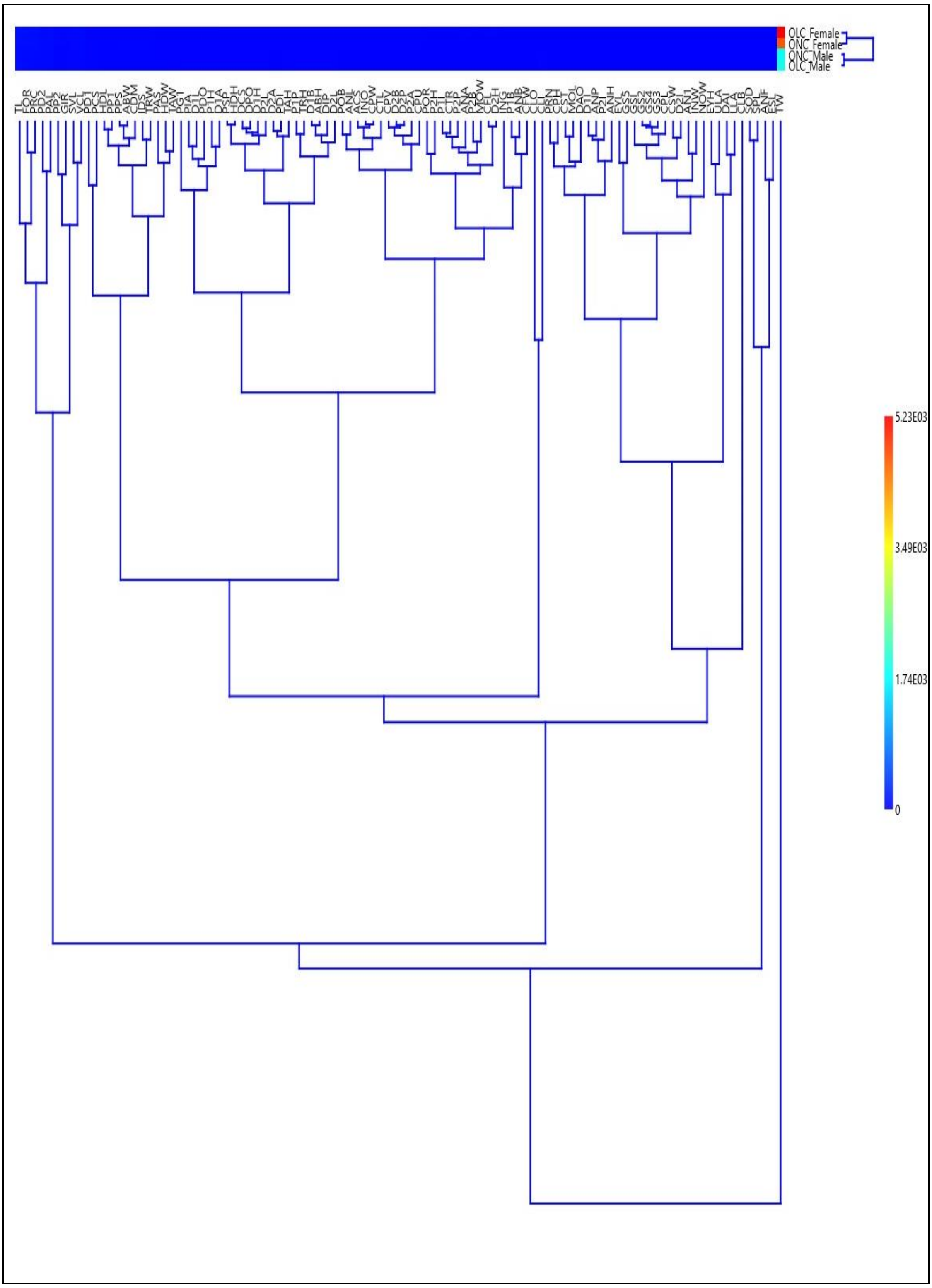

Figure 6: Hierarchical clustering (Bray-Curtis Similarities Index) of the sex-related morphometric characteristics of *Mustelus mustelus* across Lagos and Ondo Coasts.

Table 2: Relative contribution of the first three Principal Components (PC 1-3) generated from the truss morphometric data of *Mustelus mustelus*.

S/N	Distances	PC1	PC2	PC3
1.	1–2	0.1872	–0.1045	–0.00961
2.	1–3	0.177	0.04924	0.1035
3.	1–4	0.1709	0.08453	0.05093
4.	2–3	0.1624	0.09291	–0.01289
5.	2–4	0.1373	0.09861	0.02013
6.	2–5	0.2627	–0.1257	0.09192
7.	3–4	0.1107	0.5713	–0.03607
8.	3–5	0.1534	0.06837	0.05274
9.	4–5	0.1866	0.04342	–0.0403
10.	4–6	0.1549	0.06939	0.00774
11.	4–7	0.207	–0.1956	0.05386
12.	5–6	0.1796	0.05917	–0.04456
13.	5–7	0.1772	0.009683	0.1322
14.	6–7	0.2197	–0.1406	0.04204
15.	6–8	0.1931	0.1267	–0.0236
16.	6–9	0.254	–0.1405	0.03003
17.	7–8	0.1989	0.08497	–0.05471
18.	7–9	0.1654	0.1267	0.008822
19.	8–9	0.215	–0.02711	–0.9367
20.	8–10	0.1699	0.02255	0.04684
21.	9–10	0.1896	0.09933	0.1026
22.	9–11	0.1705	–0.01468	0.09519
23.	10–11	0.1827	0.1937	0.1292
24.	10–12	0.04635	0.383	–0.00818
25.	10–13	0.2113	0.09006	0.07337

The first PC which accounted for 66.17% of the total variability had the largest contributions from mainly the chondrocranium and first gill slit (0.2627), pectoral fin insertion, and pelvic fin origin (0.254). Principal Component 2 which accounted for 26.32% of the variability had high contributions from the first gill slit and pectoral fin origin (0.5713) and the distance between anal fin origin and lower precaudal pit (0.383). Principal component 3 accounted for 1.43% of the variability with high contributions from the anterior tip of the snout and the pectoral fin origin (0.1035). Rasheeq et al. (2023) investigated the stock structure of the white-spotted spine foot fish (*Siganus canaliculatus*) along the Indian coast using Truss morphometry. The PCA results demonstrated that the first two components (PC1 and PC2) accounted for over 52.6% of the total morphometric variance (PC1%-37% and PC2%-14%). PC1 and PC2 represented the posterior abdomen and the caudal peduncle region of the fish, and both components exhibited a positive correlation. Standard morphometric traits and truss measurements could both justify the differentiation among the stocks, as well as the ultimate scenario of the *M. mustelus* stock structure. The statistical analysis of this study is sufficient to distinguish among the stocks. Furthermore, if a large enough sample size is used, this study recommends that standard and truss morphometric characters can be a trustworthy method for stock-identification research (Mahfuj et al., 2023, 2022). Research projects on fish stocks conducted in the Bay of Bengal and the Arabian Sea revealed significant alterations due to environmental differences (Bostancı and Yedier, 2018). According to a different study conducted by Ramya et al. (2021), geographic segregation and gene-pool interchange resulted in the segregation of horse mackerel stocks. Another concern is abiotic influence, which plays a vital role in stock adjustment (Kern and Langerhans, 2018). The morphological characteristics of various stocks or populations belonging to the same species may also vary widely. Based on the body depth of *N. japonicus*, a distinction was presented between the east and west coasts by Bostancı and Yedier (2018).

REFERENCES

1. Abbas E. M., Abdelsalam K. M., Geba K. M., Ahmed H. O. and Kato M., 2016 – Genetic and morphological identification of some crabs from the Gulf of Suez, Northern Red Sea, Egypt, *Egyptian Journal of Aquatic Research,* 42, 319-329.
2. Bookstein F. L., 2018 – A course in morphometrics for biologists; Geometry and statistics for studies of organismal form, Cambridge, Cambridge University Press, 556.
3. Bookstein F. L., Chernoff B. C., Elder R. L., Humphries, J. M., Smith, G. R. and Strauss, R.E., 1985 – Morphometrics in evolutionary biology, *Academy of Natural sciences of Philadelphia Special Publication*, 15, 277-289.
4. Bostancı D. and Yedier S., 2018 – Discrimination of invasive fish Atherina boyeri (Pisces: Atherinidae) populations by evaluating the performance of otolith morphometrics in several lentic habitats, *Fresenius Environmental Bulletin*, 27, 6, 4493-4501.
5. Carpenter K., Sommer E. H. J. and Marcus L. F, 1996 – Converting truss interlandmark distances to Cartesian Coordinates, in Marcus L. F., Corti Loy A., Naylor G. and Slice D. E., (eds), Advances in Morphometrics, New York Plenum Publications, 103-111, 284.
6. Cavalcanti M. J., Monteiro L. R and Lopez P. R. D, 1999 – Landmark based morphometric analysis in selected species of Serranid fishes (Perciformes: Teleostei), *Zoological Studies*, 38, 287-294.
7. Compagno L. J. V., 1999 – Endoskeleton, in Hamlett W. C. (ed.), Sharks, Skates, and Rays: The Biology of Elasmobranch Fishes. Baltimore: Johns Hopkins University Press, 69-92.
8. Cordova J. A. and Ebert D. A., 2021 – Apristurus manocheriani (Carcharhiniformes: Pentanchidae), a new species of catshark from the Southwest Indian Ocean, *Journal of the Ocean Science Foundation*, 38, 13-26
9. Devi N. T., Khumar F and Siddiqui M. S, 1991 – Observations on the morphometric characters of the catfish Rita rita (Ham.) of the river Yamuna, *Journal of Inland Fisheries Society of India*, 23, 52-58.
10. FAO, 1990 – FAO species identification sheets for fishery purposes, Field guide to the commercial marine resources of the Gulf of Guinea, 268.
11. Farrag M. M. S., Soliman T. B. H, Akel E. K. A., Elhaweet A. A. K. and Moustafa M. A., 2015 – Molecular phylogeny and biometrics of lessepsian puffer fish Lagocephalus sceleratus (Gmelin, 1789) from Mediterranean and Red Seas, Egypt, *Egyptian Journal of Aquatic Research*, 41, 323-335.
12. Grunow B., Reismann T. and Moritz T., 2022 – Pre-hatching ontogenetic changes of morphological characters of Small-Spotted Catshark (Scyliorhinus canicula), *Fishes*, 7, 3, 100.
13. Kern E. M. and Langerhans R. B., 2018 – Urbanization drives contemporary evolution in stream fish, *Global Change Biology*, 24, 8, 3791-3803.
14. Kohinoor A. H. M, Saha N. C., Akhteruzzaman M., Shah M. C. and Mahata S. C., 1995 – Morphometric characters and their relationship in red tilapia (mutant Oreochromis mossumbicus x Oreochromis niloticus), *Bangladesh Journal of Fish*, 15-18, 19-24.

15. Kousteni V., 2021 – Morphometric description and biological notes on the rare kitefin shark Dalatias licha (Chondrichthyes: Dalatidae) from the Hellenic waters, *Journal of Fish Biology*, 99, 1, 258-263.
16. Mahfuj M. S., Ahmed F. F., Hossain M. F., Islam S. I., Islam M. J., Alam M. A. and Nadia Z. M., 2022 – Stock structure analysis of the endangered Queen Loach, Botia dario (Hamilton 1822) from Five Rivers of Northern Bangladesh by using morphometrics: implications for conservation, *Fishes*, 7, 1, 41-50.
17. Mahfuj S., Islam S. I., Jinia S. S., Hossain M. F. and Atique U., 2023 – Stock identification of Congaturi halfbeak (Hyporhamphus limbatus): insight into conventional and truss-based morphometrics, *The Journal of Basic and Applied Zoology*, 84, 1, 10-19.
18. Mekkawy I. A. A. and Mohammed A. S., 2011 – Morphometrics and meristics of the three Epinepheline species*:* Cephalopholis argus (Bloch and Schneider, 1801), Cephalopholis miniata (Forskal, 1775) and Vardiola louti (Forskal, 1775) from the Red Sea, Egypt, *Journal of Biological Sciences*, 11, 1, 10-21.
19. Najmudeen T. M., Zacharia P. U., Seetha P. K., Sunil K. T. S., Radhakrishnan M., Akhildev S. and Sipson A., 2019 – Length-weight relationships of three species of pelagic sharks from southeastern Arabian Sea, *Regional Studies in Marine Science*, 29, 100647.
20. Narejo N. T., Jafri S. I. H and Shaikh S. A., 2000 – Studies on the age and growth of Palri, Gudusia chapra (Clupeidae: Teleostei) from the Keenjhar Lake (District Thatta) Sindhu, Pakistan, *Pakistan Journal of Zoology*, 32, 307-312.
21. Nayman, 1965 – Growth and ecology of fish population, *Journal of Animal Ecology*, 20, 201-219.
22. Notarbartolo di Sciara G., Adnet S., Bennett M., Broadhurst M. K., Fernando D., Jabado R. W. and Stevens G., 2020 – Taxonomic status, biological notes, and conservation of the longhorned pygmy devil ray Mobula eregoodoo (Cantor, 1849), *Aquatic Conservation*: *Marine and Freshwater Ecosystems*, 30, 1, 104-122.
23. Ozcan E. I. and Başusta N., 2018 – Preliminary study on age, growth and reproduction of Mustelus mustelus (Elasmobranchii: Carcharhiniformes: Triakidae) inhabiting the Gulf of Iskenderun, North-Eastern Mediterranean Sea, *Acta Ichthyologica et Piscatoria*, 48, 1, 27-36.
24. Pathak N. B., Parikh A. N. and Mankodi P. C., 2013 – Morphometric analysis of fish population from two different ponds of Vadodara city, Gujarat, India, *Journal of Animal Veterinary Fishery Science*, 1, 6, 6-9
25. Ramya V. L., Behera B. K., Das B. K., Krishna G., Pavankumar A. and Pathan M. K., 2021 – Stock structure analysis of the endemic fish, Barbodes carnaticus (Jerdon, 1849), for conservation in a biodiversity hotspot, *Environmental Science and Pollution Research*, 28, 55277-55289.
26. Rasheeq A. A., Rajesh M., Kumar T. A., Rajesh K. M., Kathirvelpandian A., Kumar S. and Singh P. K., 2023 – Stock structure analysis of the white-spotted spine foot fish (Siganus canaliculatus) along the Indian coast using Truss morphometry, *Regional Studies in Marine Science*, 65, 103072.
27. Reist J. D., 1985 – An empirical evaluation of several univariate methods that adjust for size variation in morphometric variation, *Canadian Journal of Zoology*, 63, 1429-1439.
28. Sampaio A. L. A., Pagotto J. P. A. and Goulart E., 2013 – Relationships between morphology, diet and spatial distribution: Testing the effects of intra and interspecific morphological variations on the patterns of resource use in two Neotropical cichlids, *Neotropical Ichthyology*, 11, 2, 351-360
29. Sidiq M., Ahmed I. and Bakhtiyar Y., 2021 – Length-weight relationship, morphometric characters, and meristic counts of the cold-water fish Crossocheilus diplochilus (Heckel) from Dal Lake, *Fisheries & Aquatic Life*, 29, 1, 29-34.

30. Pathak N. B., Parikh A. N. and Mankodi P. C., 2013 – Morphometric analysis of fish population from two different ponds of Vadodara city, Gujarat, India, *Journal of Animal Veterinary Fishery Science,* 1, 6, 6-9.
31. Ramya V. L., Behera B. K., Das B. K., Krishna G., Pavankumar A. and Pathan M. K., 2021 – Stock structure analysis of the endemic fish, Barbodes carnaticus (Jerdon, 1849), for conservation in a biodiversity hotspot, *Environmental Science and Pollution Research*, 28, 55277-55289.
32. Turan C., 1999 – A note on the examination of morphometric differentiation among fish populations: The Truss system, *Turkish Journal of Zoology*, 23, 259-263.