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CONGENERIC DISCRIMINATION OF MORPHOMETRIC CHARACTERS AMONG MEMBERS OF THE PISCES GENUS *CLARIAS* (CLARIIDAE) IN ANAMBRA RIVER, NIGERIA

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Abstract

Congeneric variations in fifty-four morphometric characters among four *Clarias* Scopoli, 1777 were studied. Samples of *C. ebriensis* and *C. albopunctatus* as well as *C. gariepinus and C. anguillaris* have overlapping morphometric character ranges. Congeneric differences among the clariids occurred both in untransformed (raw) and transformed morphometric characters data. The pectoral fin base length (PFBL) and frontal fontanel width (FFW) were the only 2 raw morphometric characters exhibiting congeneric differences. Similarly, the ratios of standard length to 9 morphometric characters (pelvic fin base length (PeFBL), pectoral spine height (PSH), dorsal fin height (DFH), maxillary teeth band width (MTBW), premaxillary teeth band depth (PmTBD), frontal fontenelle length (FFL), internasal space (INS), pelvic fin – anal fin space (PeAS) and prenasal barbel length (PNBL)) exhibited congeneric differences. On the other hand, congeneric differences were not easily detected in 6 residual morphometric characters. These characters were total length (TOL), prepectoral length (PPL), pectoral fin base length (PFBL), Dorsal fin base length (DFBL), outer mandibular barbel space (OMBS) and eye diameter (EDIA) morphometric characters. These characters are recommended as key characters and their ecological and taxonomic implications reassessed.

Keywords: Congeneric, Morphometrics, Clariidae, Ecological, Taxonomic

Introduction

Homogeneity visible in outward appearance (external morphology) among different species of fish may probably be conveniently considered as similarities in shapes as function of sizes. The reverse is true for heterogeneity in external morphology among different fish species. The heterogeneity in external morphology is difficult to understand because fish of the same size are not necessarily of the same age or at the same developmental stage especially if their mean adult size differ. According to Cock (1966), heterogeneity in shape can occur through: (I) differences in the relative growth of different body parts during a given growth stanza (ii) differences in shape generated during the egg and larvae stages and (iii) differences in the size at which the transition from one set of growth rates to another occurs. This indicates that shape and size different can occur as a result of generic or environmental factors, thus, the ever existing interest in the genetic basis of morphological variation is still the stimulus behind any attempt to quantify morphology. The application of multivariate statistic (principal component and path analysis) to morphometric data prompted by the interest of defining a general factor that influences overall body size and allometric growth of different body parts is taxonomically inconclusive. Equally the transformation of raw data into ratios, logarithms, allometrics, and residuals in order to separate differences in size from differences in shape is critique prone and inconclusive (Atchley *et al.*, 1976; Humphries *et al.*, 1 981; McGlade, 1981; Thorpe and Leamy, 1983 and Reist 1985). Both untransformed (raw),

and ratio morphometric character data have often been employed by *Clarias* taxonomist (Sydenham, 1978, 1980; Sydenham and Olawoye, 1981; Ezenwaji, 1986, 1989; Teugels, 1990, 1982, a, b, c, and Teugels and Roberts, 1987). The genus *Clarias* has one of the highest specific diversity among all the fish genera in Anambra River. At present, seven species have been identified. They are *Clarias agboyiensis* Sydenham, 1980; *C. albopunctatus* Nichols and LaMonte, 1953; *C. anguillaris* Linnaeus, 1758; *C. buthupogon* Sauvage, 1879; *C. ebriensis* Pellegrin, 1920; *C. gariepinus* Burchell, 1822 and *C. macromytax* Gunther, 1864. These *Clarias* were established on the basis of their fixed morphological features that are usually considered in fish taxonomy.

The description of *Clarias* species based on univariate methods along with the use of several unquantitative morphological features needs to be seriously reviewed and improved upon. This is because of the frequent overlapping range values of the variables (characteristic morphological features) often noticed within and between species. Furthermore, most of these variates differ widely especially those associated with growth and or ecological changes. It is probably that the variability of *Clarias* species may be due to "speciation", possibly through high degree of hybridization, a tendency that produces specimens with intermediate morphological features. Consequently, the true taxonomic position of the *Clarias* species and also the diagnostic validity of various morphological characters traditionally used to distinguish these species have been studied in the last three decades with little agreement on their taxonomic position. The reliance on selected few variables and relatively small sample size has largely contributed to the problem of definition and delineation of species. The present studies aim at identifying specific differences in 54 morphometric characters treated either as raw, ratio and residual as a means of establishing key (diagnostic) morphometric characters for the clariids.

Materials and Methods

Collection and care of fish specimen

Catfish specimens, *Clarias* species were collected from the Anambra River, Nigeria between May 1990 to April 1993. The fish was captured using set nets (mesh sizes 70 mm – 120 mm) and long line baited with ripe palm fruits. Specimens were also bought from the major landing river port at Otuocha. The multiple sampling methods were employed to eliminate gear selectivity and ensure good representation of all sizes of the catfish. Individuals required for morphometric and meristic studies were iced and transported to the Pure and Applied project laboratory, Department of Zoology, University of Nigeria, where they were kept under refrigeration until used.

Identification and classification of catfish

The Clariids were properly identified and classified to their subgeneric level using Teugels (1982a) key. The "large" *Clarias* were identified to the species level using key to some of the fishes of River Niger (After Dr. R. H. Lowe-McConnell 1992) and "key to the genus *Clarias* in Nigeria (After Dr. D. H. J. Sydenham, 1983). The "small" *Clarias* were identified using "key to the "small" *Clarias* species of Anambra river basin, Nigeria (After Dr. H. M. G. Ezenwaji, 1989). The keys relevant to taxonomy of the Anambra river catfish of the genus *Clarias* have been catalogued (Eyo, 1997). A total of 52 *Clarias gariepinus*, 56 *C. anguillaris*, 60 *C. ebriensis* and 90 *C. albopunctatus* were analyzed.

Morphometric characters distribution measured among *Clarias* species of Anambra River, Nigeria

Prior to the measurement of the morphometric characters, the frozen specimen was allowed to thaw completely and the fresh weight taken to the nearest 0.01 gram using a Mettler PC 2000 electronic balance. Fifty-four morphometric characters were measured per individual. All measurements were taken on the left side of the fish using a vernier caliper or a pair of dividers or a piece of thread or a scaled fish measuring board, in centimeters to the nearest 0.5 mm. The schematic representations of morphometric characters measured are shown (Fig 1, 2 and 3). The characters were:

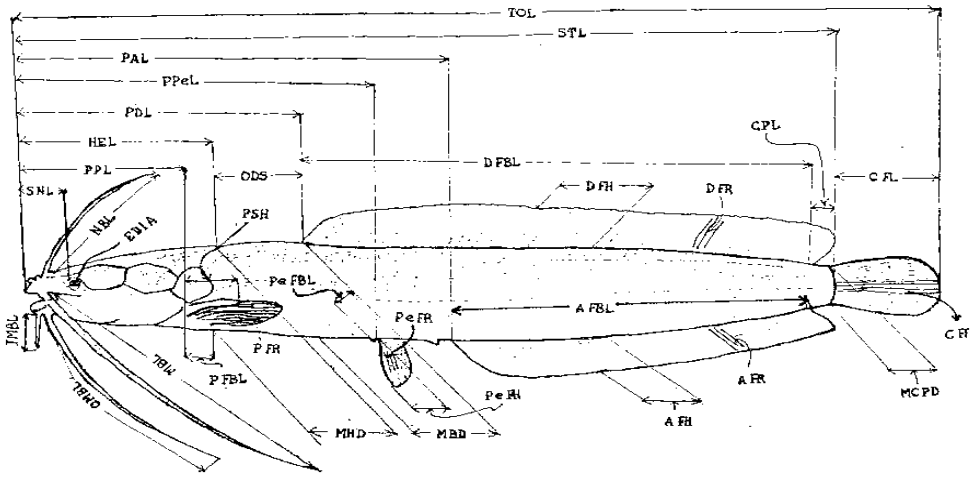

Fig. 1. Schematic representation of morphometric character measurements for *Clarias* species of Anambra River, Nigeria. Lateral view. Codes are explained in the text.

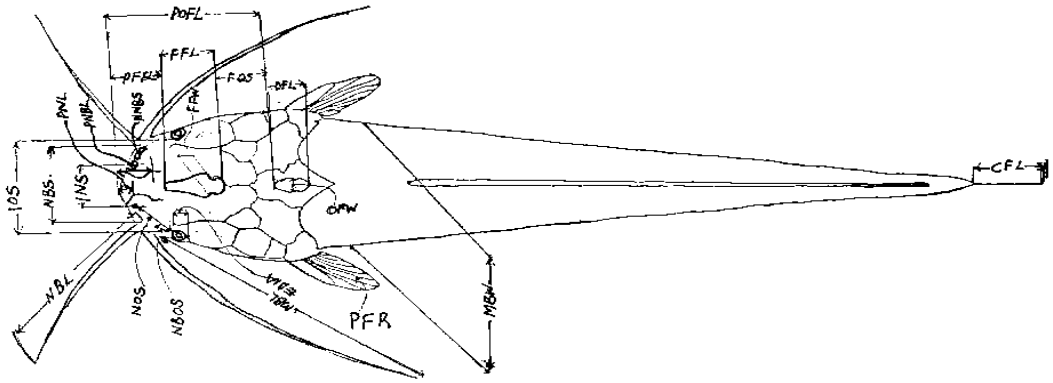

Fig. 2. Schematic representation of morphometric character measurements for *Clarias* species of Anambra River, Nigeria. Dorsal view. Codes are explained in the text.

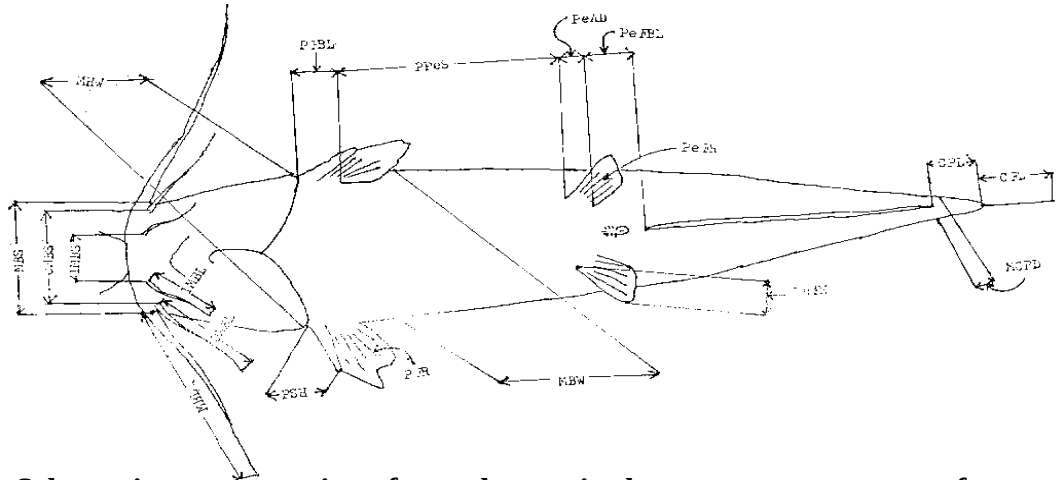

Fig. 3. Schematic representation of morphometric character measurements for *Clarias* species of Anambra River, Nigeria. Ventral view. Codes are explained in the text.

Standard length (STL); the length measured from the tip of the snout to the end of the root of the caudal peduncle.

Total length (TOL); the length taken from the tip of the snout to the end of caudal fin.

Predorsal length (PDL); length measured from the tip of the snout to the anterior base of the first ray of the dorsal fin.

Prepectoral length (PPL); length taken from the tip of he snout to the anterior base of the pectoral spine.

Prepelvic length (PPel); length measured from the tip of the snout to the anterior base of the first pelvic fin ray.

Preanal length (PAL); length taken from the tip of the snout to the anterior base of the first anal fin ray.

Preorbital length (POL) or Snout length (SNL); the length taken from the tip of the snout to the anterior margin of the eye.

Caudal peduncle length (CPL); the length taken from the posterior base of the last anal fin ray to the root of the caudal fin.

Head length (HEL); the length taken from the tip of the snout to the posterior edge of the occipital bone.

Maximum head depth (MHD); taken as the dorso-ventral distance in centimeters at the posterior end of the occipital bone.

Maximum body depth (MBD); taken as the dorso-ventral distance at the anterior base of the first dorsal fin ray.

Maximum caudal peduncle depth (MCPD); taken as the dorso-ventral distance at the end of the caudal peduncle.

Maximum Head Width (MHW); taken as the ventral distance between the lateral sides at the operculum, discounting lateral projections and the branchiostegal membranes.

Pelvic fin height (PeFH); taken as the length of the tallest pelvic fin ray.

Pelvic fin bas length (PeFBL); taken as the basal length of the pelvic fin, i.e. the distance between the anterior base of the first pelvic fin ray to the posterior base of the last pelvic fin ray.

Pectoral spine height (PSH); taken as the length of the pectoral spine.

Pectoral fin base length (PFBL); the basal length of the pectoral fin, i.e. the distance between the anterior base of the pectoral spine to the posterior base of the last pectoral fin ray.

Anal fin base length (AFBL); the basal length of the anal fin i.e. the distance between the anterior base of the first anal fin ray to the posterior base of the last anal fin ray.

Anal fin height (AFH); taken as the length of the tallest anal fin ray.

Dorsal fin base length (DFBL); the basal length of the dorsal fin measured as the distance between the anterior base of the first dorsal fin ray to the posterior base of the last dorsal fin ray.

Inner mandibular barbel length (IMBL); measured as the length of the inner mandibular barbel from the base of the mandibular bone to the tip of the inner mandibular barbel.

Outer mandibular barbel length (OMBL); measured as the length of the outer mandibular barbel from the base of the mandibular bone to the tip of he outer mandibular barbel.

Nasal barbel length (NBL); taken as the length of the nasal barbel from the base of he nasal bone to the tip of he nasal barbel.

Maxillary barbel length (MBL); measured as the length of the maxillary barbel from the base of the maxillary bone to the tip of the maxillary barbel.

Inner mandibular barbels space (IMBS); measured as the ventro-basal distance between the left and right outer mandibular barbels.

Nasal barbel space (NBS); the dorso-basal distance between the left and right nasal barbels.

Maxillary barbel space (MBS); the dorso-basal distance between the left and right maxillary barbels.

Premaxillary teeth band width (PmTBW); the transverse length of the premaxillary teeth band.

Premaxillary teeth band depth (PmTBD); the anterior-posterior distance at the centre of the premaxillary teeth band.

Vomerine teeth band width (VTBW); the transverse length of the vomerine teeth band.

Vomerine teeth band depth (VTBD); the anterior-distance at the centre of the vomerine teeth band.

Mouth width (MOW); measured as the greatest width of the aperture of the open mouth.

Eye diameter (EDIA); taken as the anterior-posterior distance across the black aperture in the centre of the eye.

Prefrontal fontanelle length (PFEL); taken as the distance from the tip of the snout to the anterior point of the frontal fontenelle.

Frontal fontanelle length (FEL); measured as the anterior-posterior length of the frontal fontanelle.

Frontal fontanelle width (FFW); taken as the transverse length at the widest point of the frontal fontanelle.

Preoccipital fontanelle length (POFL)); the distance from the tip of the snout to the anterior point of the occipital fontanelle.

Occipital fontanelle width (OFW); the transverse length at the widest point of the occipital fontanelle.

Occipital fontanelle length (OFL); the anterior-posterior length of the occipital fontanelle.

Frontal fontanelle-occipital fontanelle space (FOS); the posterior-anterior length from the posterior end of the frontal fontanelle to the anterior end of the occipital fontanelle.

Internasal space (INS); the dorso-basal distance between the left and right nasal openings.

Interorbital space (IOS); the dorso-basal distance between the left and right eyes.

Maximum body width (MBW); the ventral distance between the lateral body sides at the region of the first dorsal fin ray.

Caudal fin length (CFL); the lateral distance between the posterior end of the caudal peduncle to the furthest ray of the caudal fin.

Pectoral-Pelvic fin space (PPeS); the ventro-basal distance between the posterior end of the pectoral fin and the anterior end of the pelvic fin.

Pelvic-Anal fin space (PeAS); the ventro-basal distance between the posterior end of the pelvic fin and the anterior end of the anal fin.

Occipital-Dorsal fin space (ODS); the dorso-basal distance from the posterior end of the occipital fontanelle to the anterior base of the first dorsal fin ray.

Preanal length (PAL); measured from the tip of the snout to the nasal opening.

Prenasal barbel length (PNBL); the dorso-basal distance from the tip of he snout to the base of the nasal barbel.

Nasal-Nasal barbel space (NNBS); the dorso-basal distance between the nasal opening and the nasal barbel.

Nasal barbel-Orbital space (NBOS); the dorso-basal distance between the nasal barbel and the eye.

Morphometric character data analysis

As a general rule in fish with allometric growth, measurements other than standard length are often transformed in to relative measurements. Raw, ratio (percentage standard length) and residual data were computed from their means, standard deviations, variances and range values. The residual was computed from the regression equation $X = Y - a/b$ (X = mean measurement for each character, Y = mean standard length, a = intercept, b = slope of the relationship). The residual was represented by $e = X - X$, where X is the original untransformed (raw) measurement of the character. The coefficient of skewness and the coefficient of kurtosis were computed for in the analysis of normality. Homogeneity of variance among the *Clarias* was examined using Bartlett's test. These analyses were perquisite for further testing involving F-LSD. F-LSD was used to detect differences between more than two means (Sokal and Rohlf, 1981).

Results

Specific differences in raw, ratio and residual morphometric data among the four *Clarias* species

The specific difference at $p = 0.05$ in raw, ratio and residual morophometric data between *C. ebriensis*, *C. albopunctatus*, *C. gariepinus* and *C. anguillaris* considering the 54 morphometric characters have been illustrated in table 1, 2 and 3. The standard length raw data were heterogeneously different in all species with exception of he standard lengths of *C. ebriensis* and *C. albopunctatus*. There were no standard length (STL) values for the ratio and the residual data, because the bases for both transformations were the standard lengths.

Table 1: Congeneric Differences in Raw Morphometric Data among *Clarias* Species of Anambra River, Nigeria Employing F-LSD

MORPHOMETRIC CHARACTERS	RAW DATA				
	F-LSD Values	*Clarias ebriensis*	*Clarias albopunctatus*	*Clarias gariepinus*	*Clarias anguillaris*
1. Standard length (STL)	2.0155	12.7816 a	13.1866 ab	20.6083 c	24.8350 d
2. Total length (TOL)	2.2691	14.3900 a	14.8582 ab	24.0202 c	28.7500 d
3. Predorsal length (PDL)	0.6600	3.6500 a	4.1083 ab	7.2050 c	8.6683 d
4. Prepectoral length (PPL)	0.4700	2.7150 a	2.6550 ab	4.6400 c	5.8683 d
5. Prepelvic length (PPeL)	0.9004	5.1483 a	5.5383 ab	9.5733 c	11.7483 d
6. Preanal length (PAL)	1.0863	6.2933 a	6.7517 ab	11.6783 c	14.0300 d
7. Preorbital length (POL)	0.1367	0.6917 a	0.6933 ab	1.2367 c	1.6517 d
8. Caudal peduncle length (CPL)	0.2337	0.2350 a	0.3200 ab	0.5083 bc	0.8183 d
9. Head length (HEL)	0.5274	2.9133 a	3.2633 ab	6.1700 c	7.3067 d
10. Maximum head depth (MHD)	0.2982	1.5966 a	1.5016 ab	2.3683 c	2.9716 d
11. Maximum body depth (MBD)	0.3347	1.9033 a	2.0150 ab	2.8033 c	3.3967 d
12. Maximum caudal peduncle depth (MCPD)	0.1524	0.7533 a	0.7500 ab	1.6750 c	1.9867 d
13. Maximum head width (MHW)	0.3931	2.1517 a	2.3100 ab	3.8350 c	4.6550 d
14. Pelvic fin height (PeFH)	0.2245	1.0466 a	1.0966 ab	2.1416 c	2.6323 d
15. Pelvic fin base length (PeFBL)	0.0757	0.2983 a	0.3383 ab	0.6050 c	0.8100 d
16. Pectoral spine height (PSH)	0.1739	1.2267 a	1.3233 ab	1.9883 c	2.1633 d
17. Pectoral fin base length (PFBL)	**0.0918**	**0.5383 a**	**0.6367 b**	**0.9833 c**	**1.1233 d**
18. Anal fin base length (AFBL)	0.9541	6.8150 a	6.5383 ab	8.9983 c	10.9750 d
19. Anal fin height (AFH)	0.1125	0.4683 a	0.4550 ab	1.1700 c	1.2433 cd
20. Dorsal fin base length (DFBL)	0.3341	8.7500 a	8.9767 ab	12.9917 c	15.7869 d
21. Dorsal fin height (DFH)	0.1560	0.7950 a	0.6733 ab	1.6450 c	1.6733 cd
22. Inner mandibular barbel length (IMBL)	0.3423	2.3600 a	2.7850 b	3.3783 c	3.5467 cd
23. Outer mandibular barbel length (OMBL)	0.4160	3.5133 a	3.6017 ab	4.6750 c	4.6867 cd
24. Nasal barbel length (NBL)	0.3433	2.8133 ab	2.8133 ab	3.1283 c	3.3952 cd
25. Maxillary barbel length (MBL)	0.5606	4.6650 a	4.8117 ab	6.2683 c	5.9750 cd
26. Inter mandibular barbel space (IMBS)	0.1076	0.6017 a	0.5450 ab	0.8717 c	1.1933 d
27. Outer mandibular barbel space (OMBS)	0.1665	0.9033 a	0.9200 ab	1.5967 c	2.0217 d
28. Nasal barbel space (NBS)	0.1684	0.7933 a	0.8017 ab	1.4067 c	1.9650 d
29. Maxillary barbel space (MBS)	0.2144	1.1083 a	1.1400 ab	2.1050 c	2.6717 d
30. Premaxillary teeth band width (PmTBW)	0.1825	0.7617 a	0.6830 ab	1.5683 c	2.3333 d
31. Premaxillary teeth band depth (PmTBD)	0.0306	0.2350 a	0.2150 ab	0.2867 c	0.3650 d
32. Vomerine teeth band width (VTBW)	0.1489	0.7717 a	0.7917 ab	1.4550 c	1.9317 d
33. Vomerine teeth band depth (VTBD)	0.0394	0.2383 a	0.2567 ab	0.4550 c	0.3300 d
34. Mouth width (MOW)	0.1918	0.8317 a	0.8917 ab	1.9567 c	2.4300 d
35. Eye diameter (EDIA)	0.0357	0.2400 a	0.2883 b	0.5833 c	0.5517 cd
36. Prefrontal fontannelle length (PFFL)	0.1883	0.7850 a	0.8067 ab	1.5283 c	2.0350 d
37. Frontal fontannelle length (FFL)	0.1184	0.5257 a	0.1617 ab	1.5283 c	1.6833 d
38. Frontal fontannelle width (FFW)	**0.0353**	**0.3000 a**	**0.3633 b**	**0.5900 c**	**0.5450 d**
39. Preoccipital fontannelle length (POFL)	0.4089	2.0600 a	2.3150 ab	4.3417 c	5.3683 d
40. Occipital fontannelle length (OFL)	0.0440	0.3933 a	0.4183 ab	0.4667 c	0.4867 d
41. Occipital fontannelle width (OFW)	0.0269	0.2867 ad	0.2967 ab	0.3867 c	0.2983 bd
42. Frontal fontannelle-occipital fontannelle space (FOS)	0.1207	0.8917 a	0.9617 ab	1.3550 c	1.5617 d
43. Internasal space (INS)	0.1204	0.4467 a	0.5050 ab	0.9950 c	1.3683 d
44. Interorbital space (IOS)	0.2333	1.2933 a	1.3650 ab	2.6733 c	2.9200 d
45. Maxillary body width (MBW)	0.3799	1.6800 a	1.8367 ab	3.2150 c	3.9633 d
46. Caudal fin length (CFL)	0.2921	1.6633 a	1.6717 ab	3.4233 c	3.9133 d
47. Pectoral-pelvic fin space (PPeS)	0.4256	2.5250 a	2.6950 ab	4.6717 c	5.4300 d
48. Pelvic fin-Anal fin space (PeAS)	0.1507	0.8000 a	1.0500 b	1.7800 c	1.8633 cd
49. Occipital dorsal fin space (ODS)	0.1263	0.8067 a	0.8617 ab	1.0933 c	1.4817 d
50. Prenasal length (PNL)	0.0405	0.1967 a	0.2067 ab	0.3033 c	0.4133 d
51. Prenasal barbel length (PNBL)	0.0887	0.3183 a	0.3550 ab	0.6367 c	0.9317 d
52. Nasal-nasal barbel space (NNBS)	0.0567	0.2217 a	0.2433 ab	0.3967 c	0.5167 d
53. Nasal barbel-orbital space (NBOS)	0.0654	0.3550 a	0.3983 ab	0.7017 c	0.8583 d
54. Nasal orbital space (NOS)	0.1117	0.5967 a	0.6833 ab	1.2150 c	1.4633 d

Key: a, b, c and d indicates significantly corresponding means at P = 0.05.

Table 2: Congeneric Differences in Ratio Morphometric Data among *Clarias* Species of Anambra River, Nigeria Employing F-LSD

MORPHOMETRIC CHARACTERS	RATIO (% STL) DATA				
	F-LSD Values	***Clarias ebriensis***	***Clarias albopunctatus***	***Clarias gariepinus***	***Clarias anguillaris***
1. Standard length (STL)	-	-	-	-	-
2. Total length (TOL)	0.6672	112.4917 a	112.8353 ab	116.7103 c	115.8580 d
3. Predorsal length (PDL)	0.7070	28.6557 a	31.6493 b	35.0120 c	35.0537 cd
4. Prepectoral length (PPL)	0.8473	21.1607 a	20.4943 ab	22.4937 c	23.6733 d
5. Prepelvic length (PPeL)	0.9525	42.3413 a	42.0823 ab	46.4393 c	47.5290 d
6. Preanal length (PAL)	0.9848	49.3560 a	51.2407 b	56.7687 c	56.5863 cd
7. Preorbital length (POL)	0.4265	5.3820 a	5.2363 ab	6.0227 c	6.7090 cd
8. Caudal peduncle length (CPL)	0.3474	1.8460 a	2.3817 b	2.4817 c	3.2000 cd
9. Head length (HEL)	0.5480	22.7983 a	24.7627 b	30.0460 c	29.5427 cd
10. Maximum head depth (MHD)	0.4934	12.3893 ad	11.9323 b	11.5277 bc	11.3067 cd
11. Maximum body depth (MBD)	0.6489	14.8727 a	15.2287 ab	13.6563 c	13.4903 cd
12. Maximum caudal peduncle depth (MCPD)	0.2960	5.8593 a	5.6553 ab	8.1517 c	8.0553 cd
13. Maximum head width (MHW)	0.4436	16.8610 a	17.5557 b	18.6503 c	18.6597 cd
14. Pelvic fin height (PeFH)	0.3631	8.1530 a	8.2523 ab	10.4050 c	10.5867 cd
15. Pelvic fin base length (PeFBL)	**0.1776**	**2.3203 a**	**2.6563 b**	**2.9140 c**	**3.2330 d**
16. Pectoral spine height (PSH)	**0.0298**	**9.5613 a**	**10.0360 b**	**9.6600 c**	**10.3360 d**
17. Pectoral fin base length (PFBL)	0.1595	4.1943 a	4.8267 b	4.7728 bc	4.6233 cd
18. Anal fin base length (AFBL)	0.8174	53.3127 a	49.6097 b	43.5270 c	44.1040 cd
19. Anal fin height (AFH)	0.3140	3.6663 a	3.4697 ab	5.6710 c	5.0397 d
20. Dorsal fin base length (DFBL)	1.0082	68.4540 a	68.3100 ab	63.1990 c	63.5007 cd
21. Dorsal fin height (DFH)	**0.4119**	**6.3013 a**	**5.1533 b**	**7.9257 c**	**6.8093 d**
22. Inner mandibular barbel length (IMBL)	2.8753	18.5498 ac	21.0560 ab	16.6547 c	14.5307 cd
23. Outer mandibular barbel length (OMBL)	1.7077	27.3910 a	27.2953 ab	23.1717 c	19.2350 d
24. Nasal barbel length (NBL)	1.5591	22.0267 a	20.9510 ab	16.6220 c	13.0330 d
25. Maxillary barbel length (MBL)	2.5149	36.7237 a	36.5610 ab	30.8447 c	24.6273 d
26. Inter mandibular barbel space (IMBS)	0.2659	4.6807 a	4.1230 b	4.2277 bc	4.8050 ad
27. Outer mandibular barbel space (OMBS)	0.2994	7.0477 a	6.9593 ab	7.7473 c	8.1613 d
28. Nasal barbel space (NBS)	0.2925	7.1027 a	6.0347 b	6.9370 ac	7.8543 d
29. Maxillary barbel space (MBS)	0.5141	8.4353 a	8.1837 ab	10.2023 c	10.7960 d
30. Premaxillary teeth band width (PmTBW)	**0.3175**	**5.9590 a**	**5.4207 b**	**7.5940 c**	**9.4083 d**
31. Premaxillary teeth band depth (PmTBD)	**0.0237**	**1.8330 a**	**1.6363 b**	**1.4870 c**	**1.4043 d**
32. Vomerine teeth band width (VTBW)	0.2547	6.0830 a	6.0040 ab	7.0677 c	7.8010 d
33. Vomerine teeth band depth (VTBD)	0.1352	1.8610 a	1.9440 ab	2.2283 c	1.3273 d
34. Mouth width (MOW)	0.3690	6.4747 a	6.8203 ab	9.4683 c	9.8500 d
35. Eye diameter (EDIA)	0.2295	1.9030 a	2.2087 b	2.9630 c	2.3017 bd
36. Prefrontal fontannelle length (PFFL)	0.3365	6.1030 a	6.1637 ab	7.3683 c	8.1373 d
37. Frontal fontannelle length (FFL)	**0.3799**	**4.1267 a**	**4.6893 b**	**7.4510 c**	**6.9330 d**
38. Frontal fontannelle width (FFW)	0.1967	2.4090 a	2.7670 b	2.9063 bc	2.2613 ad
39. Preoccipital fontannelle length (POFL)	0.6239	16.2510 a	17.5803 b	21.1363 c	21.6730 cd
40. Occipital fontannelle length (OFL)	0.1083	3.1163 ac	3.1850 ab	3.1880 cd	2.1020 d
41. Occipital fontannelle width (OFW)	0.1627	2.2877 a	2.2337 ab	1.1916 c	1.2667 d
42. Frontal fontannelle-occipital fontannelle space (FOS)	0.4275	7.0337 a	7.2123 ab	6.5917 c	6.4133 cd
43. Internasal space (INS)	**0.2692**	**3.4653 a**	**3.8227 b**	**4.7837 c**	**5.5243 d**
44. Interorbital space (IOS)	0.3513	10.1433 a	10.3453 ab	11.5173 c	11.6303 cd
45. Maxillary body width (MBW)	0.6912	13.3523 a	14.0253 ab	15.5607 c	15.7437 cd
46. Caudal fin length (CFL)	0.5211	13.0023 a	12.4667 ab	15.8313 c	16.7047 d
47. Pectoral-pelvic fin space (PPeS)	0.5443	19.7950 a	20.5308 ab	22.7370 c	22.2187 cd
48. Pelvic fin-Anal fin space (PeAS)	**0.3833**	**6.3027 a**	**7.9490 b**	**8.6493 c**	**7.5440 d**
49. Occipital dorsal fin space (ODS)	0.4490	6.3603 a	6.5620 ab	5.3460 c	6.0477 ad
50. Prenasal length (PNL)	0.1441	1.5540 ac	1.5693 ab	1.4637 bc	1.6820 ad
51. Prenasal barbel length (PNBL)	**0.1897**	**2.4637 a**	**2.7000 b**	**3.0760 c**	**3.7247 d**
52. Nasal-nasal barbel space (NNBS)	0.1458	1.7249 a	1.8093 ab	1.9243 bc	2.0563 cd
53. Nasal barbel-orbital space (NBOS)	0.1674	2.7877 a	3.0223 b	3.4430 c	3.4737 cd
54. Nasal orbital space (NOS)	0.1823	4.6717 a	5.2073 b	5.9130 c	5.9070 cd

Key: a, b, c and d indicates significantly corresponding means at P = 0.05

Table 3: Congeneric Differences in Residual Morphometric Data among *Clarias* Species of Anambra River, Nigeria Employing F-LSD

MORPHOMETRIC CHARACTERS	RESIDUAL DATA				
	F-LSD Values	*Clarias ebriensis*	*Clarias albopunctatus*	*Clarias gariepinus*	*Clarias anguillaris*
1. Standard length (STL)	-	-	-	-	-
2. Total length (TOL)	**0.0509**	**-0.4670 a**	**-0.0193 b**	**-0.0077 bc**	**0.0113 cd**
3. Predorsal length (PDL)	0.0566	0.0040	-0.0263	0.0183	-0.0263
4. Prepectoral length (PPL)	**0.1593**	**0.0900 a**	**0.0000 ab**	**0.1800 ac**	**0.6600 d**
5. Prepelvic length (PPeL)	0.1613	-0.0383	-0.0007	0.0150	0.0857
6. Preanal length (PAL)	0.1884	0.0063	0.0000	-0.0097	0.0037
7. Preorbital length (POL)	0.0957	-0.0007	0.0000	0.0283	0.0127
8. Caudal peduncle length (CPL)	0.1691	0.0033	-0.0010	-0.0100	0.0917
9. Head length (HEL)	0.0866	0.0007	-0.0140	0.0287	0.0153
10. Maximum head depth (MHD)	0.1089	0.0030	0.0000	-0.0123	0.0290
11. Maximum body depth (MBD)	0.1138	0.0030	0.0000	0.0580	0.0080
12. Maximum caudal peduncle depth (MCPD)	0.0533	-0.0060	-0.0043	0.0243	0.0200
13. Maximum head width (MHW)	0.0912	-0.0003	0.0000	0.0337	0.0183
14. Pelvic fin height (PeFH)	0.0719	0.0030	0.0010	0.0197	0.0227
15. Pelvic fin base length (PeFBL)	0.0346	0.0010	0.0000	0.0203	0.0160
16. Pectoral spine height (PSH)	0.0697	0.0010	0.0000	0.0107	0.0107
17. Pectoral fin base length (PFBL)	**0.0286**	**0.0403 a**	**0.0000 bc**	**0.0150 bc**	**0.0187 ad**
18. Anal fin base length (AFBL)	0.1463	0.0403	0.0096	-0.0010	-0.0317
19. Anal fin height (AFH)	0.0686	0.0020	0.0000	0.0180	0.0253
20. Dorsal fin base length (DFBL)	**0.1973**	**0.0117 ac**	**0.3260 b**	**0.0023 cd**	**0.0010 ad**
21. Dorsal fin height (DFH)	0.0873	0.0037	0.0000	0.0153	0.0163
22. Inner mandibular barbel length (IMBL)	0.3751	0.0037	-0.0003	-0.0410	-0.0007
23. Outer mandibular barbel length (OMBL)	0.4617	0.0047	-0.0030	0.0023	0.2550
24. Nasal barbel length (NBL)	0.4452	-0.0003	0.0100	-0.1563	0.0067
25. Maxillary barbel length (MBL)	0.5771	0.0053	-0.3170	-0.0032	0.0023
26. Inter mandibular barbel space (IMBS)	0.0828	0.0390	0.0000	0.0233	0.0137
27. Outer mandibular barbel space (OMBS)	**0.0617**	**-0.0007 ab**	**0.0070 bd**	**0.1997 c**	**0.0223 bd**
28. Nasal barbel space (NBS)	0.0243	0.0133	-0.0017	0.0063	0.0163
29. Maxillary barbel space (MBS)	0.0763	0.0010	0.0000	0.0077	0.0390
30. Premaxillary teeth band width (PmTBW)	0.0374	0.0053	0.0007	0.0260	0.0253
31. Premaxillary teeth band depth (PmTBD)	0.0211	0.0003	0.0000	0.0153	0.0267
32. Vomerine teeth band width (VTBW)	0.0442	0.0017	-0.0020	0.0200	0.0187
33. Vomerine teeth band depth (VTBD)	3.9295	0.0070	-0.0027	0.0300	0.2587
34. Mouth width (MOW)	0.0772	-0.0017	0.0160	0.0187	0.0203
35. Eye diameter (EDIA)	**0.0423**	**0.0003 ab**	**-0.0003 bd**	**0.2463 c**	**0.0243 ad**
36. Prefrontal fontannelle length (PFFL)	0.0716	0.0013	-0.0003	0.0293	-0.0150
37. Frontal fontannelle length (FFL)	0.0793	0.0000	-0.0003	0.0323	0.0180
38. Frontal fontannelle width (FFW)	0.0495	0.0020	-0.0003	0.0217	0.0247
39. Preoccipital fontannelle length (POFL)	0.1136	0.0020	-0.0130	0.0180	0.0087
40. Occipital fontannelle length (OFL)	0.1108	0.0087	-0.0003	0.0333	0.0140
41. Occipital fontannelle width (OFW)	0.5773	-0.0120	0.0030	0.0290	0.0047
42. Frontal fontannelle-occipital fontannelle space (FOS)	0.1017	0.0063	0.0087	0.0217	0.0457
43. Internasal space (INS)	0.0510	0.0060	0.0070	0.0250	0.0167
44. Interorbital space (IOS)	0.0561	0.0013	-0.0003	0.0213	0.0270
45. Maxillary body width (MBW)	0.1212	0.0010	-0.0020	0.0330	-0.0140
46. Caudal fin length (CFL)	0.9893	-0.0057	-0.0060	0.0003	-0.0560
47. Pectoral-pelvic fin space (PPeS)	0.3121	0.0217	0.0007	0.0160	-0.0277
48. Pelvic fin-Anal fin space (PeAS)	0.0798	0.0070	-0.0013	-0.0030	0.0143
49. Occipital dorsal fin space (ODS)	0.1331	0.0090	-0.0003	-0.0050	0.0317
50. Prenasal length (PNL)	0.0397	-0.0030	0.0000	0.0057	0.0337
51. Prenasal barbel length (PNBL)	0.0425	-0.0020	0.0003	0.0090	0.0287
52. Nasal-nasal barbel space (NNBS)	0.1903	0.0040	-0.0130	0.0047	0.0100
53. Nasal barbel-orbital space (NBOS)	0.8224	0.0003	0.0010	0.0520	0.0193
54. Nasal orbital space (NOS)	0.0316	0.0003	0.0007	0.0170	0.0217

Key: a, b, c and d indicates significantly corresponding means at P = 0.05.

The raw and the ratio data of the total lengths (TOL) differed in all species with exception of *C. ebriensis* and *C. albopunctatus*, while their ratio data were insignificantly different among *C. gariepinus* vs. *C. anguillaris*.

The predorsal length (PDL) raw data varied in all species with exception of *C. ebriensis* and *C. albopunctatus*. Their ratio data differed in all species exception of *C. gariepinus* and *C. anguillaris*, while their residual data were similar in all species.

Raw and ratio data of the prepectoral lengths (PPL) were statistically similar in *C. ebriensis* and *C. albopunctatus*.

The raw and ratio morphometric data of the prepelvic length (PPel) were statistically identical among *C. ebriensis* vs. *C. albopunctatus* and their residual data were identical in all species.

The raw morophometric data of the preanal length (PAL) were insignificantly different among *C. ebriensis* vs. *C. albopunctatus*. Furthermore, their ratio data were statistically corresponding among *C. gariepinus* vs. *C. anguillaris*, while, their residual data varied insignificantly among all the examined catfish.

C. ebriensis vs. *C. albopunctatus* were statistically indifferent when considering the raw and ratio morphometric data of their preorbital length (POL). Their residual data were insignificantly different among all the species.

The raw data for the maximum head depth (MHD) was insignificantly different in *C. ebriensis* vs. *C. albopunctatus*. Furthermore, the ratio data of the maximum head depth were statistically identical in *C. ebriensis* vs. *C. anguillaris*, *C. albopunctatus* vs. *C. gariepinus* and *C gariepinus* vs. *C. anguillaris.* There were insignificant differences in all their residual data.

The raw and ratio data of the maximum body depth (MBD) varied insignificantly among *C. ebriensis* vs. *C, albopunctatus*. Furthermore, the ratio data were insignificantly different among *C. gariepinus* vs. *C. anguillaris*. There were insignificant residual data among all the species.

Similarly, the raw and ratio data of the maximum caudal peduncle depth (MCPD) were insignificantly different among *C. ebriensis* vs. *C. albopunctatus*. Additionally, their ratio data were similar among *C. gariepinus* vs. *C. anguillaris*, and their residual data were statistically homogeneous among all the catfish.

Insignificant differences were displayed for the raw morphometric data of maximum head width (MHW) in *C. ebriensis* vs. *C. albopunctatus*. Similarly, the character ratios were identical in *C. gariepinus* vs. *C. anguillaris* and their residual data were statistically similar among all the catfish studied.

The raw and ratio data of the pelvic fin height (PeFH) were insignificantly indifferent in *C. ebriensis* vs. *C. albopunctatus*, while their ratio data for the character was statistically identical among *C. gariepinus* vs. *C. anguillaris*. Their residual data varied insignificantly in all the examined catfish species.

The raw data for the pelvic fin base lengths (PeFBL) were statistically indifferent among *C. ebriensis* vs. *C. albopunctatus*, while their ratios were insignificantly different in all the studied catfish species. Contrary, their residuals were significantly corresponding in all clariids examined.

The raw data for the pectoral spine heights (PSH) were insignificantly different among *C. ebriensis* vs. *C. albopunctatus*. Their ratios were statistically different in all clariids and contrary, their residuals were insignificantly corresponding in all studied catfish.

The raw data for the pectoral fin base length (PFBL) exhibited significantly different ($P>0.05$) in all species, while their ratios varied insignificantly among *C. gariepinus* vs. *C. anguillaris*. Additionally, their residual data varied insignificantly among *C. albopunctatus* vs. *C. gariepinus* and *C. ebriensis* vs. *C. anguillaris*.

Similarly, the raw data of the anal fin base length (AFBL) were insignificantly different ($p>0.05$) in all the species with exception of *C. ebriensis* vs. *C. albopunctatus*. Their ratios varied insignificantly in *C. anguillaris* vs. *C. gariepinus*, while their residuals were statistically identical in all species.

The raw data of the anal fin heights AFH) varied insignificantly in *C. ebriensis* vs. *C. albopunctatus* and *C. gariepinus* vs. *C. anguillaris*. Their ratios were significantly indifferent in *C. ebriensis* vs. *C. albopunctatus* while their residuals were statistically identical in all the catfish species examined.

The dorsal fin base lengths (DFBL) were insignificantly different in *C. ebriensis* vs. *C. albopunctatus* for both their raw and ratio data. Furthermore, the ratio data exhibited insignificant difference in *C. gariepinus* vs. *C. anguillaris*. Their residual data were almost statistically identical in *C ebriensis* vs. *C. gariepinus*, *C. gariepinus* vs. *C. anguillaris* and *C. ebriensis* vs. *C. anguillaris*. The dorsal fin heights (DFH) raw data were statistically different in *C. ebriensis* vs. *C. albopunctatus* and *C. gariepinus* vs. *C. anguillaris*. Their ratio data varied significantly in all the catfish studied, while their residual data varied insignificantly in all the catfish studied.

The inner mandibular barbel length (IMBL) raw and ration data were insignificantly different in *C. anguillaris* vs. *C. gariepinus*. Furthermore, their ratio data varied insignificantly in *C. ebriensis* vs. *C. gariepinus*. Their residual data were insignificantly different in all clariid species examined.

The outer mandibular barbel lengths (OMBL) raw and ratio data were statistically indifferent in *C. ebriensis* vs. *C. albopunctatus*. Additionally, the raw data was indifferent in *C. gariepinus* vs. *C. anguillaris*, while their residual data varied insignificantly in all the catfish species studied.

The nasal barbel lengths (NBL) raw and ratio data differed insignificantly in *C. ebriensis* vs. *C. albopunctatus*. Additionally, the raw data were insignificantly different for *C. ebriensis* vs. *C. anguillaris* and *C. gariepinus* vs. *C. anguillaris*. Their residual data were insignificantly different in *Clarias* species examined. Similarly, the maxillary barbel lengths (MBL) raw and ratio data differed insignificantly in *C. ebriensis* vs. *C. albopunctatus*. Their raw data were equally significantly indifferent for *C. gariepinus* vs. *C. anguillaris*, while their residual data were statistically identical in all catfish species studied.

Insignificant differences for the raw data of inner mandibular barbel spaces (IMBS) were exhibited by *C. ebriensis* vs. *C. albopunctatus*. Additionally, the ratio data differed insignificantly in *C. albopunctatus* vs. *C. gariepinus* and *C. ebriensis* vs. *C. anguillaris* and their residual data differed insignificantly in all the species. The outer mandibular barbel spaces (OMBS) raw and ratio data were almost homogeneous in *C. albopunctatus* vs. *C. ebriensis*, *C. ebriensis* vs. *C. anguillaris* and *C. albopunctatus* vs. *C. anguillaris*. Their residual data were statistically similar in all catfish studied.

The nasal barbel space (NBS) raw and ratio data were statistically similar in *C. ebriensis* vs. *C. albopunctatus* and their residual data were insignificantly different in all catfish species examined. Similarly, the maxillary barbel spaces (MBS) raw and ratio data were statistically homogeneous in *C. ebriensis* vs. *C. albopunctatus* and their residual data varied insignificantly in all clariid species studied.

Significant differences were exhibited by all species with regard to raw data (with exception of *C. ebriensis* vs. *C. albopunctatus*) and ratio data of the premaxillary teeth band width (PmTBW). Their residuals differed insignificantly in all catfish species. The raw and ratio data of the premaxillary teeth band depths (PmTBD) were significantly heterogeneous in all species with exception of the raw data of *C. ebriensis* vs. *C. albopunctatus*, while their residuals were significantly indifferent in all the examined catfish.

Considering the vomerine teeth bandwidths (VTBW) raw and ratio data, significant differences occurred in all studied fish species with exception of C. *ebriensis* vs. *C. albopunctatus.* Likewise, their residuals differed insignificantly in all studied *Clarias* species. The vomerine teeth band depths (VTBD) raw and ratio data, were statistically non-identical in all species, with exception of *C. ebriensis* vs. *C. albopunctatus*. Their residual data were statistically homogeneous in all examined clariids.

The mouth width (MOW) raw and ratio data were significantly indifferent in *C. ebriensis* vs. *C. albopunctatus*. Their residual data varied insignificantly in all the clariid species.

Unlike the mouth width, the eye diameter (EDIA) raw data was significantly indifferent in *C. gariepinus* vs. *C. anguillaris*, while the ratio data differed insignificantly in *C. albopunctatus* vs. *C. anguillaris*. Furthermore, their residual data was only significantly different in *C. gariepinus* and insignificant different were exhibited by *C. albopunctatus* vs. *C. anguillaris* and *C. ebriensis* vs. *C. anguillaris*.

The prefrontal fontanelle lengths (PFFL) raw and ratio data were significantly indifferent for *C. ebriensis* vs. *C. albopunctatus*. Their residual data varied insignificantly in all species. The frontal fontanelle lengths (FEL) raw data were significantly homogeneous in C. *ebriensis* vs. C. *albopunctatus* and the ratio data exhibited significance differences while their residuals differed insignificantly in all catfish studied.

Significance difference occurred in all species *vis-a-vis* the frontal fontanelle widths (FFW) raw data. Their ratio data varied insignificantly in *C. albopunctatus* vs. C. *gariepinus* and *C. ebriensis* vs. *C. anguillaris,* while their residual data were insignificantly different in all the species. Furthermore, the preoccipital fontanelle lengths (POFL) raw and ratio data varied insignificantly in *C. ebriensis* vs. *C. albopunctatus*. Moreover, their ratios were indifferent in *C. ebriensis* vs. *C. anguillaris,* while their residuals differed insignificantly in all examined catfish specimens.

The occipital fontanelle widths (OFW) raw data were only significantly different in *C. gariepinus*. The raw data in *C. ebriensis* vs. *C. albopunctatus* and *C. albopunctatus* vs. *C. anguillaris* were statistically indifferent. The occipital fontanelle lengths (OFL) raw data were statistically dissimilar in *C. ebriensis*, *C. gariepinus*, and *C. anguillaris*, nevertheless, slight homogeneity exited between *C. ebriensis* vs. *C. albopunctatus*. This ratio data were statistically identical in *C. ebriensis* vs. *C. gariepinus*, *C. ebriensis* vs. *C. albopunctatus,* and *C. gariepinus* vs. *C anguillaris*, while their residuals were indifferent in all species.

Considering the frontal fontanelle-occipital fontanelle space (FOS), raw and ratio data, significant difference occurred in all catfish with exception of *C. ebriensis* vs. *C. albopunctatus*. Their ratios differed insignificantly in *C. gariepinus* in *C. anguillaris*, while their residuals were significantly indifferent in all examined clariids. Significantly different means of internasal space (INS) raw data were observed in all species with exception of *C. ebriensis* vs. *C. albopunctatus*. Their ratio data varied significantly in all clariids while their residual data were significantly indifferent in all species.

The inter-orbital space (IOS) raw and ratio data were statistically heterogeneous in all catfish examined with exception of *C. ebriensis* vs. *C. albopunctatus*. Likewise the ratio data of *C. anguillaris* along with the residuals in all clariids were significantly indifferent. Similarly, the maximum body widths (MBW) raw and ratio data were significantly non-identical in all species with exception of *C. ebriensis* vs. *C. albopunctatus.* Additionally, the ratio data of *C. gariepinus* vs. *C. anguillaris* along with the residual data in all catfish were statistically similar.

The caudal fin length (CFL) raw and ratio data differed insignificantly in *C. ebriensis* vs. *C. albopunctatus,* and their residuals were indifferent in all species.

The pectoral-pelvic fin spaces (PPeFS) raw data were statistically non-identical in all the species with exception of *C. ebriensis* vs. *C. albopunctatus*. Their ratio data were equally significantly different in all species with exception of *C gariepinus* vs. *C. anguillaris* and their residual data were statistically identical in all *Clarias* species studied.

The pelvic fin-anal fin spaces (PeFAS) raw data varied significantly in all the species with exception of C. *gariepinus* vs. *C. anguillaris* and their ratio data were statistically dissimilar in all the *Clarias* species studied, while their residuals were statistically indifferent among the examined catfish.

The occipital-dorsal fin spaces (ODS) raw and ratio data were insignificantly different in *C. ebriensis* vs. *C. albopunctatus*. Furthermore, the ratio data for *C. ebriensis* vs. *C. anguillaris* were statistically indifferent and their residual data in all species were significantly identical.

The prenasal lengths (PNL) raw and ratio data were significantly identical in *C. ebriensis* vs. C. albopunctatus. Their ratio data differed insignificantly in *C. ebriensis* vs. *C. gariepinus*, *C. albopunctatus* vs. *C. gariepinus* and *C. ebriensis* vs. *C. anguillaris*, while their residuals varied insignificantly in all species.

The prenasal barbel lengths (PNBL) raw data were significantly dissimilar in all species with exception of C. ebriensis vs. *C. albopunctatus*. Their ratio data were statistically different in all species, while their residual data differed insignificantly in all the catfish species examined.

Insignificant differences were exhibited by *C. ebriensis* vs. *C. albopunctatus vis-a-vis* the raw and ratio data of the nasal-nasal barbel space (NNBs). Similarly, the ratio data for *C. albopunctatus* vs. *C. gariepinus* and *C. ebriensis* vs. *C. anguillaris* were significantly indifferent. Their residual data were all statistically similar for all species. The nasal barbel-orbital spaces (NBOs) were insignificantly heterogeneous in *C. ebriensis* vs. *C. albopunctatus*. Their ratio data differed insignificantly in *C. gariepinus* vs. *C anguillaris*, and their residual data varied insignificantly in all species.

Finally, the nasal-orbital spaces (NOS) raw data were statistically similar in *C. ebriensis* vs. *C. albopunctatus*. Furthermore, their ratio data differed insignificantly in *C. gariepinus* while the residual data in all species were statistically identical.

Discussion

Congeneric variations in morphometric characters of *Clarias* species were measured as: (1) absolute variation, that is, the raw (untransformed) data of the morphometric character or part, (2) relative variate, that is, ratio of standard length to the morphometric character and (3) residuals, that is, measures of the regression relationship between the standard length and each morphometric character. Reist (1985) observed that each of these sources of data if properly free from the effects of the other can provide fundamental different insight into the relationship among organism. In the present study each data set was separately analyzed and the basis for further transformation of the data into ratios or residuals was the standard lengths. Unlike Alekseyev and Power (1995), standard lengths were employed instead of fork length because the caudal fin of *Clarias* is not heterocercal but disguised homocercal, thus showing no fork. Furthermore, the total length was not utilized because of its high susceptibility to damage arising from predation and/or mishandling. Included in the size range distributions were wide size ranges of catfish since it was impossible to balance the size range distributions of the specimen across all the species. Preliminary analysis of heterogeneity of variances using Bertlett's test indicated significant heterogeneity in morphometric character of specimens between species, which might have resulted in part from sampling, biases. Therefore, the necessity to transform the raw data to estimate of relative variation or measures of associated variables as a means of correcting for the size

and shape variate arises. It may be logically argued that congeneric differences in size are relevant and thus correcting for size (through transformation) may be unwarranted. However, heterogeneity of morphometric character distribution within each species may unduly bias similarity between taxa. This is especially true since conspecific variation may be in part due to non-biological causes such as sampling biases.

Congeneric differences in raw morphometric character data among the *Clarias* species occurred only in two (3.70 %) of the fifty-four characters studied (Table 1). They were the pectoral fin base length (PFBL) and the frontal fontanel width (FFW). Although both characters were abnormally distributed in *C. gariepinus* and *C. albopunctatus* indicating low sample size, the same sample size (n=30) was maintained for all the species. The observed heterogeneity and abnormal distributions may be as a result of inherent species variations exhibited by the characters (Eyo, 1997).

Clarias species posses two permanent fontanelles that are marked by depressions in the skull bones and are therefore easily identified externally. Anteriorly, in the dorsal mid-line of the frontal bone is an elongated frontal fontanelle, and some distance behind is the occipital fontanelle on the mid-dorsal line of the occipital bone (Eyo, 1997). From the present studies, the untransformed (raw) frontal fontanelle width ranged between 0.30 cm in *C. ebriensis* to 0.59 cm in *C. gariepinus*, while their lengths ranged between 0.55 cm in *C. ebriensis* and 1.68 cm in *C. anguillaris*. Sydenham (1978) reported that the frontal fontanelle form is not more than twice as long as wide and is usually about 1.5 times as long as wide in six clariid species. The present studies are not in variance with those of Syndenham (1978). Ezenwaji (1986), while reviewing the problems of *Clarias* taxonomy had relied on the frontal fontanelle measurements of Sydenham (1978). Furthermore, Sydenham (1980), and Sydenham and Olawoye (1981) reported that the frontal fontanelle is short to moderate in length being 5.5 to 7.7 % standard length, and is of the more elongated sole-shape form, being between 2.0 and 2.4 times as long as wide in *C. agboyiensis*. Similarly, the frontal fontanelle is sole-shaped, 3.5 to 5.5 % of standard length and its ratio of width to length is 1.15 to 1.24 in *C. isheriensis* (Sydenham, 1980). In *C. aboinensis*, Sydenham (1981) reported that the frontal fontanelle is 3 times as long as wide, it length being 7 % to 9 % of the standard length. *C. isheriensis* has been synonymized with *C. aboinensis* while C. agboyiensis with *C. jaensis* Boulenger, 1902 (Teugel, 1982). Although, *C. agboyiensis* and *C. jaensis* were not examined in the present studies, the ratio of standard length to the frontal fontanelle widths and lengths exhibited variances from those of Sydenham (1980) and Sydenham and Olawoye (1981).

Teugels (1982) did not consider the taxonomic importance of frontal fontanelle in his key to the subgenera of the genus *Clarias*. The present studies based on identification made using Teugels (1982) key has revealed the taxonomic importance of the frontal fontanelle width raw data all frontal fontanelle length ratio data as diagnostic (key) characters.

The congeneric discrimination of *Clarias* species, revealed that the only untransformed (raw) pair fin character of taxonomic importance is the pectoral fin base length (PFBL). Observation of the pectoral fin reveals a special feature (the pectoral spine) associated with the pectoral fin and differentiating it from the pelvic and other fins. The anterior edge of each pectoral spine is serrated, and the head which articulates with the pectoral girdle, is large and possesses a process used for locking the spine in an extended position. The spines apart from serving as limbs on land are primarily defensive and may prevent *Clarias* from being swallowed by larger predators. The pectoral fin base length raw data ranged from about 0.54 cm in *C. ebriensis* to about 1.12 cm in *C. anguillaris*. Sydenham (1980), Sydenham and Olawoye (1981) did not consider the taxonomic importance of the pectoral fin base

length but rather considered the ratio of the pectoral spine height to the standard lengths as well as width: length ratios of the pectoral spine. Furthermore, Teugels and Van Den Audenaerde (1981) while synonymizing *C. ebriensis* with *C. dahomeyensis* Guntert, 1938 did not employ the pectoral fin base length but rather employed the ratio of pectoral fin spine length to the standard length. Their values and those recorded for *C. ebriensis* in this study were almost in conformity. Teugel (1982) had only employed the serrated nature of the pectoral fin spine while the present studies further reveal the taxonomic importance of pectoral fin base length as key character.

Congeneric differences among the *Clarias* species *vis-a-vis* the ratio data occurred in 16.66 % of the studied characters (Table 2). The pelvic fin base length (PeFBL), the pectoral spine height (PSH), the dorsal fin height (DFH), maxillary teeth band width (MTBW), premaxillary teeth band depth (PmTBD), frontal fontanelle length (FEL), internasal space (INS), pelvic fin – anal space, (PeAS) and prenasal barbel length (PNBL) were of significant taxonomic importance. They were able to discriminate or delimit all the studied Clarias species. These characters are considered as "key characters" for *Clarias* taxonomic.

Observations from the present studies revealed that generally, the pelvic fin retained their primitive abdominal position, and are small, like those of other mud-dwelling fish. In the present study, the pelvic fin base length mean ratios varied between 2.32 % STL in *C. ebriensis* to about 3.23 % STL in *C. anguillaris*. Sydenham and Olawoye (1981) observed 8 - 9 % STL of the pelvic fin length in *C. agboyiensis* and no value was given for *C. ishriensis*. Furthermore, Sydenham and Olawoye (1981) considered the prepelvic distance rather than the pelvic fin base length and recorded 43 to 45 % STL for *C. aboinensis*. Teugels and Thys Van Dan Audenaerde (1981) just like Sydenham and Olawoye (1981) did not utilize the pelvic fin base length but the prepelvic distance. They recorded 41% STL – 49.5% STL for *C. ebriensis* collected from Nigeria. Their values corresponded with values in the present studies for the prepelvic length distributions. Teugels (1982) did not consider the pelvic fin base length and the prepelvic distance distributions as key characters during his revision of the genus *Clarias*, while the present studies indicated the significance of the pelvic fin base length as "key character".

The pectoral spine height unlike the pectoral fin base length (raw data) and the pelvic fin base length ratio data has been extensively used in *Clarias* taxonomy. Sydenham (1978) reported that "the spine is usually slender, without obvious serrations on its margin". Amongst some of the small-mounted *Clarias* (*Clarioides*) species the spine may be markedly stout or robust and may also exhibit obvious serration (Eyo, 1997). In C. *agboyiensis* the pectoral spine were from 9.6% to 11.3 % STL, 10 % -11% STL in *C isheriensis* (Sydenham, 1980), 8% - 11% in *C. aboinensis* (Sydenham and Olawoye, 1981) and 8.6 - 11% in *C. ebriensis* (Teugels and Thys Van Dan Audenaerde, 1981). The mean value recorded in the present studies which ranged from about 9.56% - 10.04% in *C. ebriensis* and *C. anguillaris* respectively conforms with the values of Sydenham (1980), Sydenham and Olawoye (1981) and Teugels and Thys Van Dan Audenaerde (1981).

Another character showing congeneric variation among the clariids is the ratio of dorsal-fin height to the standard length. In the present study, the distributions of the dorsal fin height ratios were abnormal in all the species with exception of *C. gariepinus* females. Sydenham (1980), and Sydenham and Olawoye (1981) observed that the dorsal fin may be adnate to the caudal or it may be separated from it by a distinct space as in *C. gariepinus.* The mean ratios for the character were from about 5.15 % STL in C. *albopunctatus* to about 7.93 % STL in *C. gariepinus*. Sydenham (1980), Sydenham and Olawoye (1981), Teugels and Thys Van Dan Audenaerde (1981) and Teugels (1982)

had no values for the dorsal fin height. They had all considered the dorsal fin ray counts, while the present studies revealed the significance of the dorsal fin height ratio as valuable diagnostic character.

The premaxillary teeth bandwidth (PmTBW) and depth (PmTBD) have been extensively employed for Clarias taxonomy may be due to observable congeneric differences (Sydenham 1978 and Eyo, 1997). Observation from the present study indicated that the premaxillary band varies primarily in the depth-width ratio. The ratios were about 1: 40 in small clariids and about 1: 57 in large clariids. Although, Sydenham (1978, 1980) and Sydenham and Olawoye (1981) had almost similar values with those in this study, the taxonomic importance of the percentage standard length of the premaxillary teeth band depth and width were not exploited by them.

The importance of the percentage standard length of the internasal space (INS) as a character exhibiting congeneric differences has remain unmentioned by previous Clarias taxonomist (Sydenham 1978, 1980; Sydenham and Olawoye 1981; Ezenwaji 1986, 1989; Teugels 1980, Teugels 1982 a, b, c; Teugels and Thys Van Den Audenaerde 1981 and Teugels and Roberts (1987). Observations from the present studies revealed that the internasal space ratios varied heterogeneously from 3.47 % STL in *C. ebriensis* - 5.52 % STL in *C. anguillaris*. Furthermore, other spaces ratio data, like the nasal-orbital space, nasal barbel-orbital space, nasal-nasal barbel space and inter-orbital space ratios of STL were of insignificant taxonomic value.

Other unexploited characters by previous *Clarias* taxonomist were the percentage standard lengths of the pelvic fin-anal fin space and pre-nasal barbel lengths. Observation from the present studies indicated that both character ratios were heterogeneously distributed among the examined clariid catfishes and were significantly different at p=0.05 in all the species thus indicating their valuability as key characters.

Considering the residual data, the distributions of about 48 characters (88.89%) among the examined clariids were insignificantly different (Table 3). The 6 characters (11.11%) exhibiting slight congeneric variations were similar when comparing between members of only the subgenera *Clarias* (*Anguilloclarias)* and *C.* (*Clarioides*); and between members of *Clarias (Clarias).* Thus residuals may seem to be of importance when developing diagnostic characters at the subgeneric level. The character exhibiting congeneric variation and as such of taxonomic importance were the residuals of total lengths, pectoral fin base length, dorsal fin base length, prepectoral length, outer mandibular barbel space and the eye diameter. None of the previous workers on *Clarias* taxonomy had utilized the residuals value of characters in discriminating between species, although, the raw and ratios of the total length, prepectoral length, and eye diameter has been extensively utilized (Sydenham 1978, 1980; Sydenham and Olawoye 1981, Ezenwaji 1986, 1989; Teugels 1980, 1982 a, b, c; Teugels and Thys Van Dan Audenaerde 1981, a, b, c; Teugels and Robert 1987).

Comparing the different morphometric character data sets, the ratio data had higher number of key characters than residuals and raw data and may indicate the more unsuitability of raw data over the residual data in assessing congeneric differences and taxonomic status of the clariids.

Summary

1. The Nigerian Academy of Sciences in 1993 awarded a postgraduate fellowship to aid the research on “Morphometric and Cytogenetic Variation among *Clarias* species (Clariidae) in Anambra River, Nigeria”.
2. The fish were collected from three zones of the River using multiple gear sampling techniques. Identification was effected to species level and confirmed using the keys of Teugels,

1982; Lowe-McConnell, 1972 and Ezenwaji, 1989.

3. Fifty-four morphometric character used were defined as schematically represented, and three data sets were treated: (i) raw, absolute, untransformed data, (ii) ratio, relative measurements expressed as percentage of standard length, (iii) residuals, deviations from the regression line describing the size relationship.
4. All treatment means were separated using F-LSD after testing for normality and heterogeneity of variances.
5. The application of univariate statistical method to the morphometric character between the four species revealed a number of congeneric differences, which may include the pelvic and pectoral base length among others.
6. As evidenced by the univariate method, it was especially 2 raw, 9 ratio and not easily detected 6 residual morphometric characters that prominently contributed to the segregation.
7. These characters are recommended as key taxonomic characters.

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