MAYR'S COEFFICIENT OF DIFFERENCE AND TAXONOMY OF *CLARIAS* (CLARIIDAE – SCOPOLI, 1777)

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ABSTRACT

Coefficient of difference in 54 morphometric characters was studied using 258 Clarias species from Anambra river, Nigeria. There were no differences between C. ebriensis and C. albopunctatus for all the 54 characters studied. The coefficient of difference in morphometric characters of C. ebriensis vs. C. gariepinus indicated that about 90 % of C. ebriensis were significantly different from about 90 % of C. gariepinus in about 34 morphometric characters. Thirty seven differentiating morphometric characters occurred between C. ebriensis and C. anguillaris. Considering the discriminating characters between C. albopunctatus and C. gariepinus, 90 % of C. albopunctatus differed from 90 % of C. gariepinus in about 32 characters. Furthermore, about 90 % of C. albopunctatus differed from 90 % of C. anguillaris in about 35 characters. Differentiating of C. gariepinus from C. anguillaris based on the coefficient of difference was impossible for all the 54 characters studied. The coefficients of difference among all clariids studied were almost identical in 10 characters namely: maximum body depth, pectoral spine height, anal fin base length, inner mandibular barbel length, outer mandibular barbel length, maxillary barbel length, premaxillary teeth band depth, vomerine teeth band depth, prenasal length and nasal - nasal barbel space, with exception of C. ebriensis vs. C. albopunctatus and C. gariepinus vs. C. anguillaris. These characters thus represent "key characters" for differentiating between the "small" and "large" clariids.

Key words: Mayr's Coefficient of Difference, *Clarias,* Clariidae, Taxonomy

INTRODUCTION

Differences in fifty-four morphometric characters among four *Clarias* species Scopoli, 1777 of Anambra river, Nigeria, using F-LSD have been reported (Eyo, 2002 a, b). In the report, *Clarias albopunctatus* and *C. ebriensis* as well as *C. anguillaris* and *C. gariepinus* were shown to have overlapping morphometric character ranges. Differences among the studied *Clarias* species occurred in 2 raw (pectoral fin base length (PFBL) and frontal fontanel width (FFW)), 9 ratio (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)) and not easily established in 6 residual (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. The 2 raw and 9 ratio characters were recommended as important generic and specific key characters in clariid systematics and their ecological and taxonomic implications were reassessed (Eyo, 2002 a).

Similarly, sex differentiating morphometric characters between male and female clariids inhabiting the Anambra river systems employing studentized t -test occurred in 7, 11, 20 and 26 morphometric characters for *Clarias ebriensis*, *C. albopuncatus*, *C. gariepinus* and *C. anguillaris* respectively.

Furthermore, specific differences in the distribution of meristic character among the clariids of Anambra river, Nigeria, utilizing F-LSD, indicated that both the anal fin ray and vertebrae counts were of taxonomic importance. There was a close numerical relationship between the number of anal fin rays and number of vertebrae (Eyo, 2004).

Another univariate statistical tool capable of discriminating 90 % population of species A from 90 % population of species B is Mayr's coefficient of difference (CD) (Mayr, 1969). Thus in the present study, Mayr's

coefficient of difference was employed to test the equality of morphometric character means between the clariid species, the assumption being that if the difference between two mean measurements of populations A and B exceeded the sum of the two standard deviations by 1.28, then about 90 % of species belonging to population A differed from about 90 % of species belonging to population B based on the tested morphometric characters.

MATERIALS AND METHODS

Fish: *Clarias* species were collected from the Anambra River, Nigeria, using set nets (mesh sizes 70 mm – 120 mm) and long line baited with ripe palm fruits. The multiple sampling methods were employed to eliminate gear selectivity and ensure good representation of all sizes of the catfish. Individuals required for morphometric studies were iced and transported to the Department of Zoology, University of Nigeria, where they were kept under refrigeration until used.

The clariids were identified to the genus *Clarias* using (Sydenham, 1983), and to their sub-generic level using Teugels (1982a). The "large" *Clarias* were identified to the species level using (Lowe-McConnell, 1992). The "small" and "large" *Clarias* were identified using (Ezenwaji, 1989) and (Sydenham, 1983) respectively. 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: 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 (54) morphometric characters were measured per individual fish as listed in Table 1. The description of these characters have been presented elsewhere (Eyo, 2002 a). 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 on a scaled fish measuring board, in centimeters to the nearest 0.5 mm.

Analysis: Mayr's coefficient of difference (CD) (Mayr, 1969) was employed to test the equality of means of morphometric characters between the clariid species. If the difference between two mean measurements of populations A and B exceeded the sum of the two standard deviations by 1.28, then about 90 % of population A differed from about 90 % of population B. Coefficient of difference was computed as: mb - ma/SDa + SDb where mb and ma are mean measurements of morphometric character for populations B and A respectively, SDa and SDb are standard deviations of measured character for population A and B respectively, and a and b being specific morphometric characters of the different clariid species respectively.

RESULTS

The coefficients of differences among the clariids are presented in Table 1. From the data, there were no differences between *C. ebriensis* and *C. albopunctatus* in all the 54 characters studied.

Considering *C. ebriensis* vs. *C. gariepinus* about 90 % of *C. ebriensis* were significantly different from about 90 % of *C. gariepinus* in about 34 characters. These characters were: standard length, total length, predorsal length, prepelvic length, preanal length, caudal penduncle length, head height, maximum caudal penduncle depth, maximum head width, pelvic fin base height, pelvic fin base length, pectoral fin base length, anal fin height, dorsal fin height, maxillary barbel space, premaxillary teeth band width, vomerine teeth band width, mouth width and eye diameter. Other characters exhibiting differences were prefrontal fontennelle length, frontal fontennelle length, frontal fontennelle width, preoccipital fontennelle length, occipital fontennelle length, occipital fontennelle width, internasal space, interorbital space, maximum body width caudal fin length, pectoral-pelvic fin space, prenasal barbel length, nasal barbel-orbital space and nasal orbital space.

The assessment of the differentiating characters between *C. ebriensis* and *C. anguillaris* revealed that 90 % of *C. ebriensis* differed from 90 % *C. anguillaris* in 37 characters. The characters included standard length, total length, predorsal length, prepectoral length, prepelvic length, preanal length, preorbital length, caudal peduncle length, Head length, maximum caudal peduncle depth, maximum head width, pelvic fin height, pelvic fin base length, pectoral fin base length, anal fin height, dorsal fin height, outer mandibular barbel space, nasal barbel space,

Mayr's coefficient of difference among *Clarias* species

Table 1: Mayr's coefficient of difference among *Clarias* species of Anambra River, Nigeria

	Morphometric Characters	Coefficient of difference between two species		
		C. ebriensis vs. *C. albopunctatus*	*C. ebriensis* vs. *C. gariepinus*	*C. ebriensis* vs. *C. anguillaris*
1	**Standard length [STL]**	0.09	1.29	1.36
2	**Total length [TOL]**	0.10	1.41	1.43
3	**Predorsal length [PDL]**	0.33	1.94	1.83
4	**Prepectoral length [PPL]**	0.06	1.22	1.52
5	**Prepelvic length [PPeL]**	0.06	1.47	1.65
6	**Preanal length [PAL]**	0.21	1.71	1.66
7	**Preorbital length [POL]**	0.00	1.20	1.58
8	**Caudal peduncle length [CPL]**	0.49	1.46	1.40
9	**Head length [HEL]**	0.33	2.12	1.91
10	**Maximum head depth [MHD]**	0.15	0.84	1.10
11	**Maximum body depth [MBD]**	0.14	1.01	0.96
12	**Maximum caudal peduncle depth [MCPD]**	0.01	2.03	1.90
13	**Maximum head width [MHW]**	0.22	1.62	1.46
14	**Pelvic fin height [PeFH]**	0.11	1.67	1.61
15	**Pelvic fin base length [PeFBL]**	0.22	1.31	1.56
16	**Pectoral spine height [PSH]**	0.20	1.19	1.24
17	**Pectoral fin base length [PFBL]**	0.43	1.51	1.57
18	**Anal fin base length [AFBL]**	0.12	0.71	0.98
19	**Anal fin height [AFH]**	0.07	2.02	1.63
20	**Dorsal fin base length [DFBL]**	0.08	1.11	1.21
21	**Dorsal fin height [DFH]**	0.35	1.40	1.81
22	**Inner mandibular barbel length [IMBL]**	0.33	1.08	0.92
23	**Outer mandibular barbel length [OMBL]**	0.06	0.77	0.65
24	**Nasal barbel length [NBL]**	0.03	0.44	0.27
25	**Maxillary barbel length [MBL]**	0.09	0.85	0.58
26	**Inner mandibular barbel space [IMBS]**	0.20	0.70	1.25
27	**Outer mandibular barbel space [OMBS]**	0.04	1.23	1.54
28	**Nasal barbel space [NBS]**	0.02	1.50	1.58
29	**Maxillary barbel space [MBS]**	0.07	1.37	1.66
30	**Premaxillary teeth band width [PrTBW]**	0.22	1.62	2.05
31	**Premaxillary teeth band depth [PrTBD]**	0.22	0.51	0.96
32	**Vomerine teeth band width [VTBW]**	0.08	1.79	1.87
33	**Vomerine teeth band depth [VTBD]**	0.17	1.26	0.63
34	**Mouth width [MOW]**	0.19	1.75	2.06
35	**Eye diameter [EDIA]**	0.65	3.56	2.52
36	**Prefrontal fontennelle length [PFFL]**	0.07	1.32	1.56
37	**Frontal fontennelle length [FFL]**	0.40	2.56	2.47
38	**Frontal fontennelle width [FFW]**	0.78	2.52	2.17
39	**Preoccipital fontennelle length [POFL]**	0.35	2.11	1.91
40	**Occipital fontennelle length [OFL]**	0.18	1.60	0.52
41	**Occipital fontennelle width [OFW]**	0.14	1.34	0.12
42	**Frontal fontennelle – Occipital fontennelle space[FOS]**	0.21	1.28	1.47
43	**Internasal space [INS]**	0.24	1.44	1.86
44	**Interorbital space [IOS]**	0.16	1.58	1.67
45	**Maximum body width [MBW]**	0.28	1.56	1.37
46	**Caudal fin length [CFL]**	0.01	2.12	1.76
47	**Pectoral - Pelvic fin space [PPeS]**	0.17	1.63	1.70
48	**Pelvic - Anal fin space [PeAS]**	0.71	2.12	1.78
49	**Occipital - Dorsal fin space [ODS]**	0.20	0.72	1.37
50	**Prenasal length [PNL]**	0.11	0.87	1.26
51	**Prenasal barbel length [PNBL]**	0.26	1.43	1.59
52	**Nasal - Nasal barbel space [NNBS]**	0.18	1.17	1.22
53	**Nasal barbel - Orbital space [NBOS]**	0.32	1.97	1.77
54	**Nasal - Orbital space [NOS]**	0.40	1.96	1.81

Table 1 continues

	Morphometric Characters	Coefficient of difference between two species		
		C. albopunctatus vs. C. gariepinus	*C. albopunctatus vs. C. anguillaris*	*C. gariepinus vs. C. anguillaris*
1	**Standard length [STL]**	1.28	1.37	0.41
2	**Total length [TOL]**	1.40	1.42	0.41
3	**Predorsal length [PDL]**	1.58	1.59	0.44
4	**Prepectoral length [PPL]**	1.40	1.68	0.50
5	**Prepelvic length [PPeL]**	1.47	1.66	0.47
6	**Preanal length [PAL]**	1.54	1.55	0.42
7	**Preorbital length [POL]**	1.21	1.59	0.59
8	**Caudal peduncle length [CPL]**	0.75	1.04	0.63
9	**Head length [HEL]**	1.90	1.77	0.41
10	**Maximum head depth [MHD]**	1.11	1.32	0.44
11	**Maximum body depth [MBD]**	0.93	0.78	0.37
12	**Maximum caudal peduncle depth [MCPD]**	2.20	2.01	0.40
13	**Maximum head width [MHW]**	1.51	1.39	0.41
14	**Pelvic fin height [PeFH]**	1.73	1.65	0.43
15	**Pelvic fin base length [PeFBL]**	1.03	1.34	0.51
16	**Pectoral spine height [PSH]**	1.14	1.21	0.20
17	**Pectoral fin base length [PFBL]**	1.26	1.38	0.34
18	**Anal fin base length [AFBL]**	0.88	1.12	0.41
19	**Anal fin height [AFH]**	2.30	1.79	0.13
20	**Dorsal fin base length [DFBL]**	1.12	1.22	0.44
21	**Dorsal fin height [DFH]**	1.81	1.80	0.03
22	**Inner mandibular barbel length [IMBL]**	0.46	0.46	0.13
23	**Outer mandibular barbel length [OMBL]**	0.77	0.64	0.01
24	**Nasal barbel length [NBL]**	0.44	0.28	0.21
25	**Maxillary barbel length [MBL]**	0.85	0.51	0.13
26	**Inner mandibular barbel space [IMBS]**	0.88	1.42	0.58
27	**Outer mandibular barbel space [OMBS]**	1.28	1.60	0.49
28	**Nasal barbel space [NBS]**	1.31	1.74	0.65
29	**Maxillary barbel space [MBS]**	1.47	1.76	0.51
30	**Premaxillary teeth band width [PrTBW]**	1.81	2.18	0.80
31	**Premaxillary teeth band depth [PrTBD]**	0.83	1.25	0.60
32	**Vomerine teeth band width [VTBW]**	1.89	1.81	0.63
33	**Vomerine teeth band depth [VTBD]**	1.13	0.10	0.59
34	**Mouth width [MOW]**	1.85	2.18	0.46
35	**Eye diameter [EDIA]**	2.41	1.76	0.18
36	**Prefrontal fontennelle length [PFFL]**	1.45	1.66	0.52
37	**Frontal fontennelle length [FFL]**	2.46	2.37	0.25
38	**Frontal fontennelle width [FFW]**	1.50	1.22	0.25
39	**Preoccipital fontennelle length [POFL]**	1.83	1.75	0.49
40	**Occipital fontennelle length [OFL]**	1.37	0.37	0.78
41	**Occipital fontennelle width [OFW]**	0.87	0.01	0.68
42	**Frontal fontennelle - Occipital fontennelle space[FOS]**	0.90	1.13	0.36
43	**Internasal space [INS]**	1.38	1.83	0.61
44	**Interorbital space [IOS]**	1.53	1.61	0.45
45	**Maximum body width [MBW]**	1.52	1.34	0.37
46	**Caudal fin length [CFL]**	2.04	1.71	0.33
47	**Pectoral - Pelvic fin space [PPeS]**	1.45	1.56	0.36
48	**Pelvic - Anal fin space [PeAS]**	1.35	1.17	0.10
49	**Occipital - Dorsal fin space [ODS]**	0.55	1.21	0.61
50	**Prenasal length [PNL]**	0.85	1.26	0.56
51	**Prenasal barbel length [PNBL]**	1.36	1.55	0.65
52	**Nasal - Nasal barbel space [NNBS]**	1.01	1.12	0.44
53	**Nasal barbel - Orbital space [NBOS]**	1.65	1.72	0.47
54	**Nasal - Orbital space [NOS]**	1.62	1.59	0.42

Significantly different coefficients of difference are underlined.

maxillary barbel space, premaxillary teeth band depth, vomerine teeth band width, mouth width, eye diameter, prefrontal fontennelle length, frontal fontennelle length, preoccipital, fontennelle length, and frontal fontennelle-occipital fontennelle space. Furthermore other differentiating characters were internasal space, inter orbital space, maximum body width, caudal fin length, pectoral-pelvic fin space, pelvic-anal space, occipital-dorsal fin space, prenasal barbel length, nasal barbel-orbital space and nasal orbital space. Furthermore, considering the discriminating characters between *C. albopunctatus* and *C. gariepinus*, 90 % of *C. albopunctatus* differed from 90 % of *C. gariepinus* in 32 characters. The characters were standard length, total length, predorsal length, prepectoral length, prepelvic length, preanal length, head length, maximum caudal peduncle depth, maximum head width, pelvic fin base length, anal fin height, dorsal fin height, nasal barbel space, maxillary barbel space, premaxillary teeth band width, vomerine teeth band width, mouth width, eye diameter, prefrontal fontennelle length, frontal fontennelle length, frontal fontennelle width, preoccipital fontennelle length, occipital fontennelle length, internasal space, interorbital space, maximum body width, caudal fin length, pectoral-pelvic fin space, pelvic-anal fin space, prenasal barbel length, nasal barbel-orbital space and nasal-orbital space.

Thirty five characters discriminated 90 % of *C. albopunctatus* from 90 % of *C. anguillaris*. The characters were standard length, total length, predorsal length, prepectoral length, prepelvic length, preorbital length, caudal peduncle length, head length, maximum body depth, maximum caudal peduncle depth, maximum caudal peduncle depth, maximum head width, pelvic fin height, pelvic fin height, inner mandibular barbel space, outer mandibular barbel space, nasal barbel space, maxillary barbel space, premaxillary teeth band width, vomerine teeth band width, mouth width, eye diameter, prefrontal fontennelle length, frontal fontennelle length, preoccipital fontennelle length, internasal space, inter orbital space, maximum body width, caudal fin length, pectoral-pelvic fin space, prenasal barbel length, nasal barbel-orbital space and nasal-orbital space. Discriminating *C. gariepinus* from *C. anguillaris* based on the coefficient of difference was impossible for all the 54 characters assessed. The coefficient of differences among all clariids studies was almost identical in 10 characters namely: maximum body depth, pectoral spine height, anal fin base length, inner mandibular barbel length, outer mandibular barbel length, maxillary barbel length, premaxillary teeth band depth, vomerine teeth band depth, prenasal length and nasal-nasal barbel space.

DISCUSSION

Considering Mayr's coefficient of difference between two species, it was evidently clear that no differences existed between *C. ebriensis* and *C. albopunctatus* considering the 54 morphometric characters. This result is contrary to an earlier report, employing F-LSD, of 2 raw data, 9 ratio data and 6 not easily identified differences in morphometric characters among the clariids of Anambra river, Nigeria (Eyo, 2002a). The observed corresponding increased number of sex differentiating characters with *Clarias* definitive size may not be unconnected with variations in their respective growth rates (Eyo 2002 b). Furthermore, discriminating 90 % of *C. ebriensis* from *C. gariepinus*; *C. ebriensis* from *C. anguillaris*; *C. albopunctatus* from *C. gariepinus* and *C. albopunctatus* from C. *anguillaris* were possible utilizing the standard length, total length, prepelvic length, preanal length, head length, maximum caudal peduncle depth, maximum head width, pelvic fin height, anal fin height, dorsal fin height, maxillary barbel space, premaxillary teeth band width, vomerine teeth band width mouth width, prefrontal fontennelle length, frontal fontennelle space, maximum body width, caudal fin length, pectoral-pelvic fin space, prenasal barbel length, nasal barbel-orbital space and nasal-orbital space. None of these characters exhibited any difference among the clariids when F-SLD of raw, ratio and residual data was employed, except for the ratio data of dorsal fin height and residual of standard length (Eyo, 2002a). In fish taxonomy, the analytical tool employed, may pose biased elements that affect proper differentiation of species. Thus statistical tool with explicit taxonomic objective may become a major problem of the fish taxonomist and researcher, as different statistical tools offer different discriminating characters even when utilizing the same data. Previous workers on *Clarias* taxonomy did not pay attention to Mayr's coefficient of difference between species (Sydenham 1978, 1980, Sydenham and Olawoye1981; Teugels 1980, 1982 a, b, c; Ezenwaji 1986, 1989 and Teugels and Roberts

1987) as no mention of it was made, even though they had employed some of these characters. For instance, Sydenham (1978) in re-describing the specimens of six clariid species from West Africa employed such characters as standard length, total length, preanal length, maximum caudal peduncle depth, pelvic fin height anal fin height and dorsal fin height. These characters were subsequently employed by Ezenwaji (1986) and Teugels (1980, 1982 a, b, c.). These characters thus represent "key characters" for discriminating between the "small" and "large" clariids. From the above, it is clear that with regards to Mayr's coefficient of difference, *C. ebriensis* and *C. albopunctatus* as well as *C. gariepinus* and *C. anguillaris* may be sibling (cryptic) species. Lagler, *et al.* (1977) defined sibling species as those species that are morphologically indistinguishable or very similar but are shown to be fully differentiated by genetical, physiological, ecological or behavioral differences that often produced reproductive isolation.

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