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MORPHOLOGICAL REVISION OF THE NILE CATFISH *BAGRUS BAYAD* (FORSSKAL, 1775) AND *BAGRUS DOCMAC* (FORSSKAL, 1775) (PISCES : BAGRIDAE)

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Abstract: The present study was designed to revise and compare the morphological characteristics of the sympatric catfishes: *Bagrus bayad* (Forskal, 1775) and *B. docmac* (Forskal, 1775) in Nile waters of Sudan, and to determine the morphological characteristics that contribute mostly to the variation in the two species. In this study, analysis based on measurement of 28 morphological characters (24 morphometeric and 4 meristic) was done using the PAST software. Fifteen morphometric characters were significantly different between the two species. The number of pectoral fin rays and dorsal fin rays also separated *B. bayad* from *B. docmac*. The length-weight relationship of each species and type of growth determined was $Log_{10}W = 0.29349 + 1.7603 \log_{10}SL$ corresponding to $W = 0.29349L^{1.7603}$ for *B. bayad;* $Log_{10}W = 0.54647 + 1.0197 \log_{10}SL$, corresponding to $W = 0.54647 L^{1.0197}$for *B. docmac*. The values (b = 1.7605) for *B. bayad* and (b = 1.0197) for *B. docmac* indicated allometric growth of both species.The results indicated that morphological characters can separate *B. bayad* from *B. docmac.* In addition, both lobes of caudal fin in *B. bayad*, and only upper lobe in *B. docmac* extend into long filaments. Given that morphological and molecular data are only complementary this outcome of morphological phylogeny analysis should be compared, contrasted and combined with the molecular phylogenetics for the populations of both species to more clearly define the taxonomical status of *B. bayad* and *B. docmac* in the Nile waters from different regions in Sudan.

Key words: Allometric growth, *Bagrus bayad, B. docmac,* Length-weight relationship, morphology, cat fish.

INTRODUCTION

The genus *Bagrus* belongs to the family Bagridae (bagrid catfishes) and known to comprise seven species; three species *Bagrus bayad* (Forsskal 1775), *B. docmac* (Forsskal 1775) and *B. degeni* occur in Africa (Boulenger, 1907). These species are observed to have a wide range of natural distribution in all principal river-systems of Africa. They were reported in the Nile River, Lakes Albert and Turkana, Lake Chad, Niger and Senegal Rivers and also found in Setit in Eritrea and the Tekeze basins in Ethiopia (Risch, 1986; Paugy *et al*., 2003). *Bagrus bayad* and *B. docmac* are common throughout the Nile waters in Sudan. The distribution ofboth species in Sudan was reported by Boulenger (1909), Stubbs (1949), Sandon (1950), Risch (1986) and Baily (1994).

The habitats and habits of *Bagrus* fish are fairly similar to those of the Nile perch. Both species are predacious, feeding on small fish, insects, crustaceans, molluscs and fish, some debris and vegetable matter may also be ingested (Baily, 1994). *Bagrus bayad* lives and feeds on or near the bottom, while *B. docmac* is a benthopelagic species, widespread in both shallow and deep water (Olaosebikan and Raji, 1998). Both species are common in Khartoum at any time except

November to December, and can attain a length of 600 mm or more. *Bagrus* is an important food fish in Sudan. It is considered by consumers and fishermen as (grade I) fish with the Nile perch. The flesh of the fish is good for eating and of economic importance commonly sold at high prices.

Environmental changes in the habitats of the fish due to human activities and continuous constructions along the Nile, as well as the pollution of the aquatic environment by fertilizers and pesticides, are expected to cause some morphological changes within these species. As stated by Mohamed (1990), Goncalves *et al*. (1996), Froese and Pauly (1998), Mwanja *et al*. (2011), morphological change and divergence within species are expected to take place when fishes are exposed to new developmental and evolutionary forces that determine their body forms. A change could take place, either through natural hybridization or the effect of the environmental factors that operate in early stages of development (Nei, 1987; Currens *et al*., 1989; Mohamed, 2010).

The present study was, therefore, designed to revise and compare the morphological characteristics of two sympatric catfishes: *Bagrus bayad* (Forsskal, 1775) and *B. docmac* (Forsskal, 1775) by using a combination of both morphometric and meristic characters. The study attempted to taxonomically characterize the populations of these catfishes in the Nile waters of Sudan, and to determine the morphological characteristics that contribute mostly to the variation of the two species. In this study, analysis based on measurement of 28 morphological characters (24 morphometeric and 4 meristic) was done using the software package Paleontology Statistical programme (PAST) (Hammer *et al.,* 2001). It is a tool highly recommended for determining the relationships between species and populations of a species (Thorpe, 1987). The study also considered the length – weight relationships and the type of growth for each species.

MATERIAL AND METHODS

Collection of fish specimens

Fresh specimens of each of *Bagrus bayad* and of *B. docmac* were purchased from the Central Fish Market in Khartoum, Sudan. Fish was washed and weighed. Twenty-four morphometric measurements were taken for each specimen by a fine dial caliper to (0.00) mm, according to Teugels and Audenaerde (1990). All measurements were usually made on the left side of the specimens, unless this side was damaged, the right side was used. The length of fish barbells and four meristic counts were also taken for each specimen. The institutional abbreviations followed Daget and Grosse (1984)

Data analysis

All morphometric measurements taken were expressed as a percentage of standard length (% SL), in order to standardize the data. The measurements of head structures were expressed as percentage of head length (% HL).

Principal component analysis (PCA) was used to extract principal components from the morphometric and meristic characters. Using (PAST 2005), the recorded morphological (24) and meristic (4) characters were subjected to multivariate analysis. To ensure normality and homogenous variances, and to correct for length differences all morphometric measurements (not meristic counts) were $\log_{10}$ – transformed before statistical analyses were performed.

The significant components that contributed most to the variation between the two species were then used in determining the morphological phylogenetic relationships of *B bayad* and *B. docmac* in the Nile waters. The loadings of these variables were done to determine their importance on the variability explained. Component one was not considered for discrimination in case of morphometric measurements, because it is affected by the length of the fish: the longest specimens usually shift to the right, so component 2 and 3 were taken to determine the loading of each character.

Cluster analysis of morphometric and meristic characters was performed separately to identify the similarity of individuals of each subspecies. A hierarchical clustering was established in dendrograms for the individuals of the two species *B. bayad* and *B. docmac* by using the statistical program (Past, 2005).

The length – weight relationships and type of growth of pooled data for each species were estimated by the equation $W = aL^b$, where W = weight of fish in grams, L = SL in cm, *b* = length exponent (slope) and *a* = proportionality constant (intercept). The 'a' and 'b' values were obtained from a linear regression of length and weight of fish: *Log W = log a+ b log L*. The value of the coefficient "*b*"was used to determine the type of growth in each species according to (Bagenal, 1978).The correlation or degree of association (r^2) between length and weight was calculated from linear regression analysis.

Fig. 1a. A photograph of the Nile catfish *Bagrus bayad*

Fig. 1b. A photograph of the Nile catfish *Bagrus docmac*

RESULTS

Morphological description

To a trained eye the two species are easily distinguished by the dimensions of the head, where, *B. bayad*has relatively narrower head compared to*B. docmac* (Fig.1a&b). All specimens of both fish are moderately elongated freshwater fishes, with compressed body and naked skin without scales. They are characterized by the presence of a large adipose fin, originated slightly behind the rayed dorsal, well developed spines of the pectoral fin and well-developed four pairs of un-branched barbells, of which the maxillary pair extends well beyond the spine of the dorsal fin; a dorsal fin with branched rays and one spine; a well developed pelvic fin with 1-2 spines, a medium-sized anal fin, also with branched rays; and a forked caudal fin. The colour of the fish is grey (*B. bayad*) or grayish blue to dark olive (*B. docmac*), darker above and white beneath, and the fins are colourless.

Eight out of nineteen morphometric characters expressed as percentage of standard length, % SL, (Table 1) and seven out of nine morphometric characters expressed as percentage of head length, % HL plus head length, (Table 2) were found to be significantly different ($P < 0.05$) between the two species. These include HW / SL; SNL / SL; PRP / SL; PRAN / SL; DAD / SL; AFL / SL; CPD / SL; BD / SL; HW / HL; SNL / HL; IOW / HL; POL / HL; MXBL / HL; OMBL / HL and INMBL / HL.

Bagrus docmac has greater ratios of HW/SL, DAD/SL, CPD/SL, BD/SL; HW/HL, SNL/HL, IOW/HL and POL/HL compared to *B. bayad*. The maxillary barbell was (297.5 % HL) for *B. bayad* compared to (282 % HL) for *B. docmac.* The outer mandibular was (55 % HL), inner mandibular (98 % HL) in *B. bayad* and (48 %HL) and (94 / %HL), respectively, in *B. docmac*. The two species differ significantly ($p < 0.05$) in the number of rays of dorsal, pectoral and pelvic fins, where *B. bayad* has more fin rays compared to *B. docmac* (Table 3).

Multivariate analysis

Principal component analysis of the data from the 20 morphometric measurements revealed that approximately 56% of the total variation was explained along one component(Table 4)and the second component of variation accounted for 27.9% of the total variability. The third component of variation accounted for 4.9% of the total variability. The Eigen values for all components were positiveindicating that all used variables have some effect on the morphological variation of the *bagrus* species.The length of adipose fin, ADFL, HL and SNL, had the biggest loads in separation of the two species (Figure 2).

Principal component analysis of the data from four meristic counts revealed that approximately 51.2% of the total variation was explained along one component, which is the number of rays in pelvic fin, PVFR. The second component of variation was the number of rays in dorsal fin, DFR, which accounted for 36.1% of the total variability, and the third component of variation accounted for 10.3% of the total variability, and that was the number of rays in pectoral fin (Table 5).

Cluster analysis

The $\log_{10}$–transformations of morphometric measurements were subjected to mixture analysis based on the matrix of distance of Neighbour-Joining clustering, using Euclidean similarity measure. The data produced hierarchical clusters of *B. bayad* and *B. docmac* specimens in a distance dendrogram (Figure 3). The first major dichotomy grouped all specimens of *B. bayad* and specimens of *B. docmac* into two separate clusters, and each cluster continued to divide into sub-clusters until the individual of each species clustered together at the end of the spectrum. On the other hand, cluster analysis of meristic counts produced two separate sub-clusters, where all individual of each species clustered together at the end of the spectrum (Figure 4). Specimens of *B. docmac* showed more divisions compared to specimens of *B. bayad*, indicating the presence of more variations in meristic counts within *B. docmac* species. Generally,cluster analysis indicated the existence of significant morphological differences between the two species.

Length – weight relationships

The length-weight relationship of each species and type of growth determined by the regression analysis according to the formula ($W = aL^b$), was found to be $\text{Log}_{10}W = 0.29349 + 1.7603 \log_{10}SL$, corresponding to $W = 0.29349L^{1.7603}$) for *B. bayad*. The regression coefficient for the pooled data was ($r^2 = 0.62966$), (Figure 5). The length-weight relationship of *B. docmac* was found to be ($\text{Log}_{10}W = 0.54647 + 1.0197 \log_{10}SL$), corresponding to ($W = 0.54647 L^{1.0197}$). The regression coefficient for the pooled data was ($r^2 = 0.59526$), (Figure 6). The values of the regression coefficients ($b = 1.7605$) for *B. bayad*, and ($b = 1.0197$) for *B. docmac* indicate allometric growth of both species; that is growth in which each part of the body grows with changing proportions.

Table 1. Morphometric measurements (Mean ± SD) for *Bagrus bayad* and *B. docmac* expressed as percentage of standard length (%SL).

Characters	*B. bayad*	*B. docmac*
Standard length (SL)	252.6 ± 17	308.4 ± 25.5
Head length (HL) / SL	26.9 ± 2.8	25 ± 1.8
Head width (HW) / S*L	17.5 ± 1.7	21.9 ± 2.4
Snout length (SNL) / SL*	16.9 ± 1.8	10.7 ± 1.1
Eye diameter (ED) / SL	3.1 ± 0.6	2.9 ± 0.4
Inter-orbital width (IOW) / SL	7.1 ± 0.4	8.1 ± 0.9
Postorbital length (POL) / SL	15.5 ± 0.7	15.5 ± 1.7
Pre-dorsal length (PRD) / SL	39.9 ± 3.4	39.4 ± 3.2
Pre-pectoral length (PRP) / SL*	25.5 ± 2.3	22 ± 2
Pre-pelvic length (PRPV) / SL	53.3 ± 2.8	54 ± 4.2
Pre-anal length (PRAN) / SL*	76.4 ± 5	74.3 ± 5.3
Dorsal fin length (DFL) / SL	17.6 ± 1.6	6.8 ± 1.4
Dorsal-to-adipose distance (DAD) / SL*	4.8 ± 1.1	9.5 ± 1.2
Adipose fin length (AFL) / SL*	32.9 ± 3.1	30.7 ± 3.4
Pectoral fin length (PRD) / SL	4.5 ± 0.8	4.7 ± 0.6
Pelvic fin length (PRD) / SL	4.5 ± 0.8	4.4 ± 0.5
Anal fin length (PRD) / SL	11.4 ± 0.9	10.8 ± 1
Caudal peduncle length (CPL) / SL	9.5 ± 3.5	10.8 ± 1.5
Caudal peduncle depth (CPD) / SL*	6.7 ± 0.7	9.1 ± 1.2
Body depth (BD) / SL*	18.3 ± 3.2	24.6 ± 3.1

Table 2. Morphometric measurements (Mean ± SD) for *Bagrus bayad* and *B.docmac* expressed as percentage of head length (%HL).

Characters	*B. bayad*	*B. docmac*
Head length	67.9 ± 5.2	77.2 ± 4.3
Head width (HW) / HL*	65.2 ± 5.5	86.8 ± 5.5
Snout length (SNL) / HL*	39 ± 2.8	42.7 ± 3.7
Eye diameter (ED) / HL	11.4 ± 1.4	11.5 ± 2.8
Inter-orbital width (IOW) / HL*	26.5 ± 1.8	32.4 ± 1.1
Postorbital length (POL) / HL*	57.9 ± 5.5	61.8 ± 1.4
Length of maxillary barbell (MXBL) / HL*	297.5 ± 21.9	282 ± 18.2
Length of outer mandibular barbell (OMBL) / HL*	54.6 ± 7.8	48.2 ± 7.1
Length of inner mandibular barbell (INMBL) / HL*	98.2 ± 7.7	93.7 ± 7.9
Length of nasal barbell (NBL) / HL	36.9 ± 12.9	34.5 ± 3.5

Table 3. The range of meristic counts for *Bagrus bayad* and *B. docmac*.

Fins	*B. bayad*	*B. docmac*
Dorsal fin rays (DFR)	10 -12 + (I)	9 - 10 + (I - II)
Pectoral fin rays (PFR)*	10 - 12 + (I -II)	9 -11 + (I)
Pelvic fin rays (PVFR)*	10 -12 + (I)	8 - 9 + (I)

Table 4. Principal component analysis (PCAs) applied to correlation matrixshowing the "eigenvalue" explained by each factor and the percentage of total variance (% variance) attributed to each factor of 20 morphometric measurements of *Bagrus bayad* and *B. docmac.*

PC	Eigenvalue	% variance
1	0.130513	56.046
2	0.0649115	27.875
3	0.011305	4.8548
4	0.00798623	3.4296
5	0.00481729	2.0687
6	0.00347773	1.4935
7	0.0027458	1.1791
8	0.0019956	0.85698
9	0.00140628	0.6039
10	0.000928058	0.39854
11	0.000749236	0.32175
12	0.000568664	0.2442
13	0.000428324	0.18394
14	0.000381402	0.16379
15	0.000282138	0.12116
16	0.000179782	0.077204
17	0.00010294	0.044206
18	5.32E-05	0.022862
19	3.32E-05	0.014254
20	1.09E-34	4.67E-32

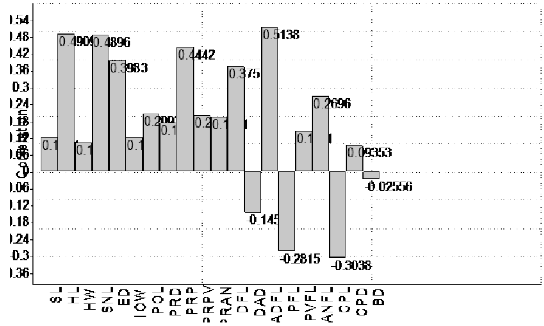

Fig. 2. A diagram based on morphometric measurements of *Bagrus bayad* and *B. docmac* specimens, showing the load of each character on their separation.

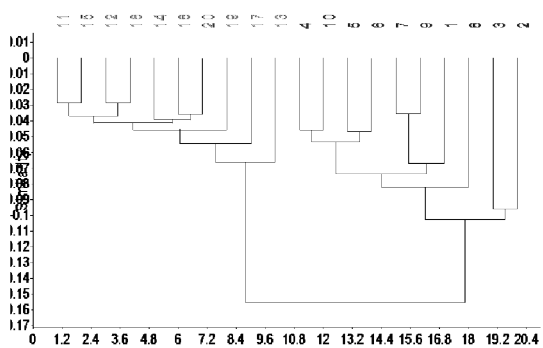

Fig. 3. A division hierarchical cluster of $\log_{10}$– transformed of morphometric measurements of *Bagrus bayad* (red) and *B. docmac*(green), based on a matrix of distance of Neighbour-Joining clustering(nearest neighbor), using Euclidean similarity measure.

Table 5. Principal component analysis (PCAs) applied to correlation matrix showing the "Eigenvalue" explained by each factor and the percentage of total variance (% variance) attributed to each factor of 4 meristic counts of *Bagrus bayad* and *B. docmac.*

PC	Eigenvalue	% variance
PVFR	2.04992	51.248
DFR	1.4451	36.127
PFR	0.412008	10.3
ANFR	0.0929732	2.3243

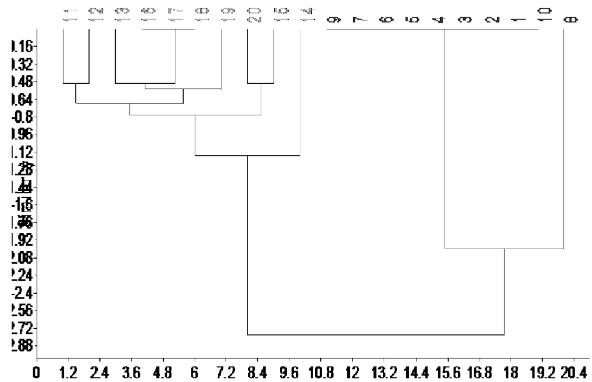

Fig. 4. A division hierarchical cluster of meristic counts of *Bagrus bayad* (red) and *B. docmac*(green), based on the matrix of distance of Neighbour-Joining clustering(nearest neighbor), using Euclidean similarity measure.

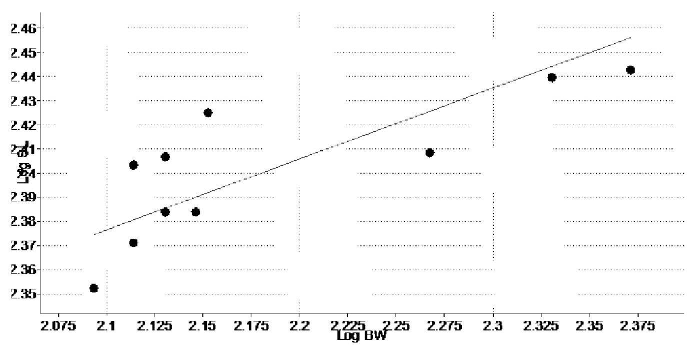

Fig. 5. Regression graph for $Log_{10}Wt$ versus $Log_{10}SL$ of *B. bayad* showing the regression equation.($Log_{10}W = 0.29349 + 1.7603\ log_{10}SL$); $r^2 = 0.62966$.

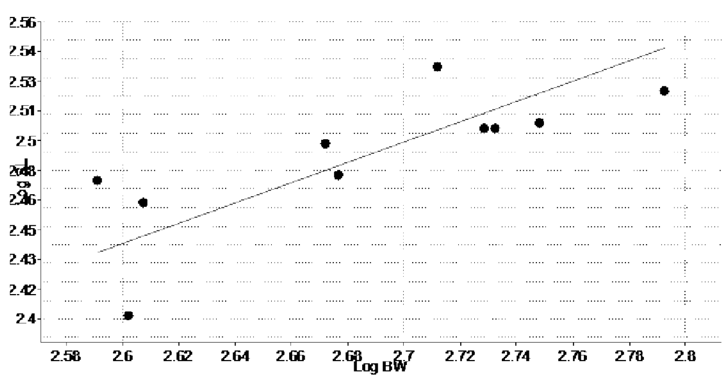

Fig. 6. Regression graph for $Log_{10}Wt$ versus $Log_{10}SL$ of *B. docmac* showing the regression equation.($Log_{10}W = 0.54647 + 1.0197\ log_{10}SL$); $r^2 = 0.59526$.The log_{10}–transformed of morphometric measurements was subjected to mixture analysis based on the matrix of distance of Neighbour-Joining clustering, using Euclidean similarity measure.

DISCUSSION

The present study confirmed the observations of Sandon (1950), that the position of the dorsal and ventral fins and the length of the barbels (maxillary, outer and inner mandibular), which are longer as %HL in *B. bayad* compared to *B. docmac,* can distinguish the two species. Generally the head of *B. bayad* shapes round when viewed from above, and the head of *B. docmac* shapes squarish when viewed from above. The length of adipose fin, ADFL, HL and SNL, had the biggest loads in separation of the two species. Other characters have varying significant loads, some negative and some positive, but can be used to separate the two species. According to Snoke (2004), both positive and negative loads can be used to distinguish species. Some meristic characters such as the number of rays of pectoral fin, PFR has the biggest load to separate *B. bayad* from *B. docmac*, followed by the dorsal fin rays, DFR. In the present study *B. bayad* was found to have (10 – 12) rays in dorsal, pectoral and pelvic fins compared to (9 – 10; 9 – 11 and 5 – 6) of these fins, respectively, in *B. docmac*. Boulenger (1909) recorded (9 -11) rays in dorsal fin and (13 – 15) rays in anal fin of *B. bayad*; (8 -10) rays and (12-14) rays in same fins of *B. docmac.* IUCN (2011) recorded (9 – 10) rays in dorsal fin of *B. bayad* and (8 – 12) for *B. docmac,* which agrees with the present results that *B. bayad* has more fin rays than *B. docmac*. This character may be used to distinguish the two species. Another character is the head width which equal to (65.2 % HL) in *B. bayad* and (86.8 % HL) in *B. docmac*. Boulenger (1909) recorded 1.6 – 1.75 / HL in *B. bayad* and 1.2 – 1.6 / HL in *B. docmac*, while Sandon (1950) recorded 1.6 – 1.7 / HL and 1.3 – 1.6 /HL in the two species, respectively. Azeroual *et al*. (2010) reported 55.2/HL of head width in *B. bayad*.

The length of maxillary barbells may also differentiate the two species. In the present study, the maxillary, outer and inner mandibular barbels were found to be longer in *B. bayad* compared to *B. docmac*.

The morphological results obtained in the present study indicated that a combination of morphological characters can be used to separate the species *B. bayad* from *B. docmac* as was proved by the cluster analysis of these characters. They may also be easily distinguished by the dimensions of the head, which is relatively narrow in *Bagrus bayad*. A further distinctive feature is that in *B. bayad* both lobes of the caudal fin are produced into long filaments whereas in *B. docmac* this is only so for the upper lobe. Given that morphological and molecular data are only complementary and not in competition with one another (Chang, 2004), morphological phylogeny analysis should be compared, contrasted and combined with molecular phylogenetics of both species to more clearly define their taxonomical status in the Nile waters from different regions in Sudan.

A detailed description of each species, based on the present study, is provided below.

***Bagrus bajad* (Forsskål, 1775)**

Synonyms:

Silurus bajad (Forskål, 1775)

Porcus bayad (Geoffroy, 1827)

Bagrus bayad (Ruppel, 1829)

Bagrus bayad (Cuvier & Valenciennes, 1839)

Bagrus bayad (Gunther, 1864)

Bagrus bayad (Petherick's, 1869)

Bagrus orientalis (Boulenger, 1902)

Bagrus bayad macropterus (Pfaff , 1933)

Description: A silvery grey fish, darker above and white beneath. Moderately elongated fish,225 to 277 mm SL, with compressed body. Naked skin without scales, relatively narrow head. Both lobes of caudal fin produced into long filaments.

Measurements %SL: Body Depth 11 to 22.1; Head length 24.7 to 34.7; head width 14.9 to 21.3; snout length 9.5 to 15.1; eye diameter 2.3 to 4.3; inter-orbital width 6.6 to 8; post-orbital length 14.7 to 16.9; dorsal - to - adipose fin 3.2 to 6.6; caudal peduncle length 6.3 to 18.6; caudal peduncle depth 5.5 to 8.

Measurements %HL: Head width 53.7 to 70.6; snout length 34.3 to 43.6; eye diameter 9.2 to 14.1; inter-orbital width 23.1 to 28.5; post-orbital length 43.8 to 62.6; maxillary barbell 272.3 to 339.7; outer mandibular 42.1 to 67.7; inner mandibular 87.2 to 108.9; nasal barbell 27.1 to 50.

Dorsal fin rays 10 - 12 (I - II); of pectoral 10 -12 (I - II), of pelvic 10 – 12 (I); of anal 10 – 12.

***Bagrus docmac* (Forsskal, 1775)**

Synonyms:

Bagrus docmac (Forsskål, 1775)

Bagrus docmac docmac (Forsskål, 1775)

Bagrus docmar (Forsskål, 1775)

Bagrus docmoc (Forsskål, 1775)

Porcus docmac (Forsskål, 1775)

Silurus docmac (Forsskål, 1775)

Bagrus degeni (Boulenger, 1906)

Bagrus koenigi (Pietschmann, 1932)

Bagrus docmac niger (Daget, 1954)

Description: Moderately elongated fish,252 to 343mm SL, with compressed body and naked skin without scales. Body grayish - blue to dark olive, darkerabove and white beneath. The upper lobe of the caudal fin is produced into a long filament.

Measurements/ SL: Body Depth 21.1 to 32..1; Head length 23.1 to 29.6; head width 20 to 28.3; snout length 9.6 to 13.1; eye diameter 2 to 3.6; inter-orbital width 7.2 to 10.3; post-orbital length 13.9 to 19.8; dorsal - to - adipose fin 8.1 to 12.3; caudal peduncle length 8.4 to 13.9; caudal peduncle depth 7.9 to 11.9.

Measurements/ HL: Head width 78.1 to 95.4; snout length 38.8 to 47.7; eye diameter 8.5 to 13.1; inter-orbital width 29 to 35.6; post-orbital length 57.9 to 67.5; maxillary barbell 249.4 to 305.4; outer mandibular 36.6 to 59; inner mandibular 81.8 to 104.1; nasal barbell 28.6 to 40.2.

Dorsal fin rays 9 - 10 (I - II); of pectoral fin 9 -11 (I), of pelvic fin 8 – 9 (I); of anal fin 10- 13.

REFERENCES

Azeroual, A., Entsua-Mensah, M., Getahun, A., Hanssens, M., Lalèyè, P., Moelants, T. and Ntakimazi, G. 2010. *Bagrus docmak*. In: *IUCN Red List of Threatened Species*. Version, 2012.2. <www.iucnredlist.org>.

Bagenal, T.B. 1978. *Methods for Assessment of Fish Production in Freshwater*, 3rd edn. Blackwell, Oxford.

Bailey, R.G. 1994. Guide to the fishes of the River Nile in the Republic of the Sudan. *J. Nat. Hist*., 28: 947-948.

Boulenger, G.A. 1907. *Zoology of Egypt. The Fishes of the Nile.* Hugh Rees Ltd., London.

Boulenger, G.A. 1909. *Catalogue of the freshwater fishes of Africa*. London. Vol. 1.

Chang M.L. 2004. Phylogenetics analysis of morphological data (Review). *Human Biol.,* 76(1): 165 – 168.

Currens, K.P., Sharpe, C.S., Hjort, R., Schreck, C.B. and Li, H.W. 1989. Effects of different regimes on the morphometrics of chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*O. mykiss*). *Copeia*., 1989: 689 – 695

Daget, J. and Gosse, J.P. 1984. Distichodontidae. In: Daget, Gosse and Thys van den Audenarde (eds). *Check-list of Freshwater fishes of Africa*, ORSTOM and MRAC, Tervuren: 184-211.

Froese, R., Pauly, D. 1998. Fishbase: concepts, design and data sources. *Naga*, 293 pp.

Goncalves, J.M.S, Bentes, L., Lino, P., Ribeiro, J., Canario, A.V.M., Erzini, K. 1996. Weight - length relationships for selected fish species of the small-scale demersal fisheries of the south and south–west coast of Portugal. *Fish. Res.,* 30: 253 – 256

Hammer, O., Harper, D.A.T. and Ryan, P.D. 2001. *Paleontological statistics software package for education and data analysis*. In: *Paleont. Elect.,*4(1): 4 - 9.

IUCN, 2010. International Union for Conservation of Nature and Natural Resources red list of threatened species. www.iucnredlist.org. http://www.fishbase.org/references/FBRefSummary.php?id=57073.

Mohammed, E.H.A. 1990. *Morphological and biochemical comparison of the catfish Synodontis from the White Nile and Lake Nubia*. Ph.D. thesis, University of Khartoum.

Mohamed E.H.A. 2010. Characterization of two *Synodontis* (Siluriformes: Mochokidae) catfish species in the White Nile and Lake Nubia. *Env. Biol. Fish*., 88: 17 – 23.

Mwanja, M.T., Muwanika, V., Nyakaana, S., Masembe, C., Mbabazi, D., Justus Rutasire, J. and Mwanja, W.W. 2011. Population morphological variation of the Nile perch (*Lates niloticus,* L. 1758), of East African Lakes and their associated waters. *Afr. J. Env. Sci.Technol.*,5(11): 941 – 949.

Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia University Press, New York.

Olaosebikan, B.D. and Raji. A. 1998. Field guide to Nigerian freshwater fishes. Federal College of Freshwater Fisheries Technology, New Bussa, Nigeria. 106 pp

http://www.fishbase.org/references/FBRefSummary.php?id=31256&speccode=5239 .

Paugy, D., Leveque, C. and Teugels, G.G. 2003. *The Fresh and Brackish Water Fishes of West Africa*. IRD Editions. *Sci. Pubs. R.M.C.A*., Belgium., 1: 283 - 287.

Past, 2005. Statistical Package for Scientific analysis.

Risch, L.M. 1986. *Bagridae*. In: J. Daget, J.-P. Gosse and D.F.E. Thys van den Audenaerde (eds.) *Check-list of the freshwater fishes of Africa* (CLOFFA). ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris., 2: 2-35.

Sandon, H. 1950. An illustrated guide to the freshwater fishes of the Sudan. *Sud. Notes Rec.*, Special Publication. London, McCorquogale: 33 - 34.

Snoeks, J. 2004. The Cichlid Diversity of Lake Malawi/Nyasa/Niassa: Identification, Distribution and Taxonomy. 1st ed. Cichlid Press, 360 pages.

Stubbs, J.M. 1949. Freshwater fish of the northern Bahr el Ghazal waters. *Sud. Notes Rec.,* 30: 245 – 251.

Teugels, G.G. and Thys van den Audenarde, D.F.F. 1990. Description of a new species of Bryconaethiops (Teleosti; *Characidae*) from Nigeria and Cameron. *Ichthy. Expl. Freshwaters*., 1(3): 207 - 212.

Thorpe, R.S. 1987. Geographic variation: A synthesis of cause, data pattern and congruence in relation to subspecies, multivariate analysis and phylogenies. *Bull. Zool.,* 54: 3 – 11.