OPEN ACCESS
International Journal of Aquatic Science
ISSN: 2008-8019
Vol. 5, No. 2, 181-197, 2014

Morphological revision of *Ichthyborus besse besse* and *Ichthyborus besse congolensis* (Pisces: Distichodontidae)

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Received: 14 May 2013 **Accepted:** 3 October 2013 **Published:** 30 June 2014

Abstract: Morphological revision was made on thirty specimens of *Ichthyborus besse besse*, and thirty specimens of *Ichthyborus besse congolensis*, taken from the collection of the Royal Museum for Central Africa in Belgium. The aim of this study is to verify the taxonomic status of the two subspecies and determine the morphological characters that characterize the ecological populations of *I. besse besse* from Cameron, Central Africa, and Congo and Schad basins, in their natural range. Variations of 23 morphometric measurements and 10 meristic counts were examined and compared. Principal component analysis along with discriminate analysis indicated that the most important morphometric characters that distinguish *I. besse besse* from *I. besse congolensis* are the snout length (SNL), body depth (BD), the origin of the pelvic (PRPV), anal (PRAN) and pectoral (PRP) fins, caudal peduncle length, in addition the number of: teeth in the upper jaw (TUJ) and the lower jaw (TLJ), scales around the caudal peduncle (CPS), number of scales in the lateral line (LLS). Cluster analysis of morphometric measurements produced a hierarchical cluster separating all individuals of *I. besse besse* from individuals of *I. besse congolensis.* Discriminate analysis of the ecological populations of *I. besse besse* revealed that the caudal fin length (CFL) and body depth (BD) have the bigger loads in separating the ecological populations followed by the inter-orbital width (IOW), eye diameter (ED), dorsal-to-adipose distance (DAD) and snout length (SNL), in addition to the number of teeth in lower jaw (TLJ) and upper jaw (TUJ). Cluster analysis of meristic counts gave better separation of the ecological population of *I. besse besse* than the morphometric measurements. A detailed description of *I. besse besse* and *I. besse congolensis* according to this study is given.

Key Words: *Ichthyborus besse besse*, *Ichthyborus besse congolensis*, morphology

Introduction

The genus *Ichthyborus* belongs to the subfamily Distichodontidae and known to comprise four species with three of them endemic to West Africa. In 1835 Joannis found *Ichthyborus besse* in Thebes (Africa) and called it *Characinus besse* and Gunther (1864) described it as *Ichthyborus microlepis*. Some specimens were secured from various localities

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on the White Nile and were identified by Boulenger (1907) as *I. besse.* This description and identifications were later reconfirmed by Pellegrin (1914), Giltay (1930) and Sandon (1950).

According to Boulenger (1907), the genus is represented by a single species *I. besse*, but Giltay (1930) distinguished two subspecies: *I. besse besse* in the Nile, Tchad basin and Benue, and *I. besse congolensis* in Katanga, Congo. Later, Giltay (1930) made a morphological description which clearly discriminate the two species. Daget (1967) carried a comparative study and gave detailed information about the external morphology, and some ecological and biological character of both *I. besse besse* from Tchad basin and *I. besse congolensis* collected from Congo. The distribution of *I. besse congolensis* (one specimen) in upper and lower Zaire basin was reported by Banister and Bailey (1979). *Ichthyborus besse besse* was observed to have a wide range of natural distribution in Africa. The occurrence of the species was reported in Cameron, Central Africa, Congo and Tchad basins and the Nile basin (Boulenger 1909; Pellegrin 1914; Pekkola 1918; Fowler 1936; Sandon 1950; Daget, 1967, Bailey, 1994) and probably reaches far more westward (Paugy *et al*., 2003).

Considerable numbers of specimens from different regions in Africa are present among the collection of the Royal Museum for Central Africa. In this study, morphological revision was made on specimens of *I. besse besse* from the collection of the Royal Museum for Central Africa, obtained from Tchad, Cameron, Central Africa and the Nile basin, and specimens of *I. besse congolensis* obtained from Congo basin. The main objective of this study was to verify the taxonomic status of the two subspecies and to determine the morphological characters for distinguishing the populations of *I. besse besse* in their natural range. A clear description of each subspecies is given here after. The description was based on the study of thirty specimens of *I. besse besse* and thirty specimens of *I. besse congolensis* specimens from Congo.

Material and Methods

Collection of fish

Sixty specimens of *Ichthyborus besse* were obtained from the collections of the Royal Museum for Central Africa, Tervuren (MRAC). Comparative material included 30 specimens of *I. besse besse* from Schad, Cameron, Central Africa and Sudan; and 30 specimens of *I. besse congolensis* from Congo. All type and co- type materials of nominotypical *Ichthyborus* species were examined. Data on holotype specimens were obtained from the original description of Boulenger (1907); Gunther (1869); Grosse and Coehen (1990).

The institutional abbreviations followed Daget and Grosse (1984). Total length (TL) and postorbital distance (POD) are other

abbreviations.

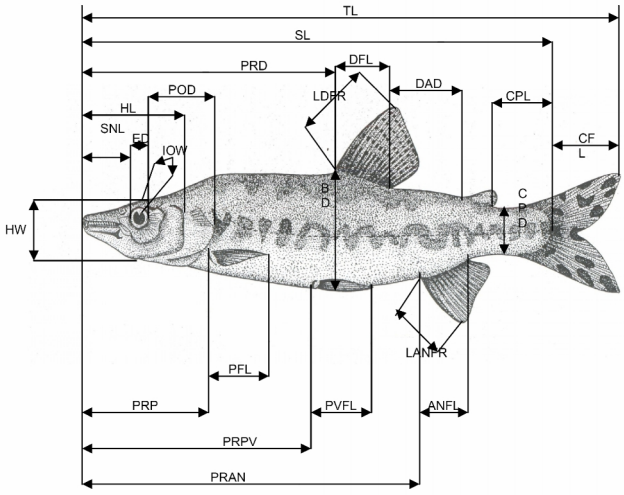

Fig. 1: Principal measurements taken for *I besse*. For explanation of numbers, please refer to the text.

Morphometric measurements

Twenty-three morphometric measurements (Fig.1) and ten meristic counts were taken for each specimen according to Teugels and Thys van den Audenaerde (1990). All measurements were taken on the left side of the specimens, unless this side was damaged, the right side was used and were point-to-point measurements taken by a fine dial caliper to (0.00) mm. The measurements included: Total length (TL): distance between anterior tip of snout and end of upper lobe of caudal fin. Standard length (SL): distance between anterior tip of snout and base of caudal fin at articulation. Head length (HL): distance between anterior tip of snout and posterior end of the membranous edge of opercula. Head width (HW): the greatest dimension with gill covers closed in normal position. Snout length (SNL): distance between tip of snout and to anterior border of the eye. Inter-orbital width (IOW): the minimal distance between orbits (bone to bone). Eye diameter (ED): distance between anterior and posterior border of eye. Body depth (BD): maximum vertical depth at anterior insertion of dorsal fin. Pre-dorsal length (PRD): distance between anterior border of snout and origin of first dorsal fin ray. Pre-pectoral length (PRP): distance between anterior border of snout and articulation of first pectoral fin ray. Pre-anal length (PRAN): distance between anterior border of snout and articulation of first anal fin ray. Pre-pelvic length (PRPV): distance between anterior border of snout and articulation of first pelvic fin ray. Dorsaladipose distance (DAD): distance between posterior base of dorsal fin and anterior origin of adipose fin. Dorsal fin length (DFL): base distance between anterior and posterior origin of dorsal fin. Longest dorsal fin ray (LDFR): distance between articulation of longest ray of dorsal fin with body and the distal end of the ray. Anal fin length (ANFL): base distance between anterior and posterior origin of anal fin. Longest anal fin ray (LANFR): distance between articulation of longest ray of anal fin with body and its distal end. Pectoral fin length (PFL): distance between articulation of first pectoral fin ray with body and the distal end of longest pectoral fin ray. Pelvic fin length (PVFL): distance between articulation of first pelvic fin ray with body and the distal end of

longest pelvic fin ray. Caudal peduncle length (CPL): the distance from the posterior end of anal fin distal end of caudal fin. Caudal peduncle depth (CPD): minimum vertical depth of caudal peduncle. Caudal fin length (CFL): distance between articulation of caudal fin and distal end of longest caudal fin ray. Postorbital distance (POD): distance between posterior border of the orbit and posterior end of the membranous edge of opercula.

Meristic counts

Ten meristic counts taken for each specimen included the number of: dorsal fin rays (DFR), anal fin rays (ANFR), pectoral fin rays (PFR), pelvic fin rays (PVFR); scales along lateral line (LLS)- the number of pored scales counted along the lateral line, including the scales on the caudal fin, scales between dorsal fin and lateral line (DLSC), vertical number of scales above lateral line to anterior origin of dorsal fin, including lateral line scales, scales between pelvic fin and lateral line (VLSC), vertical number of scales below lateral line to anterior origin of pelvic fin, including lateral line scales, scales of caudal peduncle (PSC), number of scales counted around the caudal peduncle, the number of teeth in upper (TUJ) and lower (TLJ) jaws.

Data analysis

For descriptive purposes all measurements were expressed as ratios of standard length (% SL). The measurements of head structures and inter-orbital width were expressed as percentage of head length (% HL). Principal component analysis (PCA) was used to explore the multivariate variable data matrix to reduce the large number of variables into a few biologically meaningful axes (principal components) that explain as much variations as possible (Past, 2005). Raw data of morphometric measurements (not meristic counts) was transformed to logs and used for multivariate analysis. Morphometric measurements were $\log_{10}$- transformed to correct for length differences. The loadings of the variables were done to determine their importance on 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. Division hierarchical cluster based on a matrix of similarity between paired group and single linkage (nearest neighbor) technique was performed. Analysis started out with all individuals grouped into a single cluster and splitting cluster until there are as many cluster as there are individuals. A hierarchical clustering was established in dendrograms for the

individuals of the two subspecies *I. besse besse* and *I. besse congolensis*, and for the ecological population of *I. besse besse*, using the statistical program (Past, 2005).

Depending on our objective to discriminate subspecies and to detect ecological variation, information was detected up to the fourth axis. Morphometric measurements and meristic counts were analyzed separately. Because there was only one specimen from Sudan, so it was not included in this study.

Results and Discussion

Morphological description of *Ichthyborus*

The external morphology of *I. besse besse* greatly resembles that of *I. besse congolensis*. All specimens have elongated compressed silvery body covered by ctenoid scales and a very small adipose fin behind the dorsal fin. The lateral line is distinct and complete straight along the middle of the body side. Snout long, narrow and pointed, mouth large with movable upper jaw upwards. The upper jaw with a pair of canine teeth interiorly, a series of well developed bicuspid teeth directed backwards on each side, and numerous minute sharp cardiform teeth on its inner surface. The lower jaw has some type and series of teeth on each side, but three canine teeth filling between the two of the upper jaw, and numerous minute sharp teeth in the inner surface of the mouth. The cheek is partly naked. Nostrils close together near the eyes. The dorsal fin is located behind the middle of the length of the body, and behind the vertical of the ventral fins. The anal fin of moderate length, and the caudal fin is scaly, deeply forked and the caudal lobes marked with oblong black spots or with oblique dark stripes.

Some morphometric characters expressed as percentage of standard length, % SL, (Tab. 1) and head length, % HL (Tab. 2) were found to be significantly different between the two species ($P<0.05$). Meristics counts revealed more clear discriminating difference between the specimens of the two than morphometric measurements (Tab. 3).

In this study, 16 to 18 rays in the dorsal fin and 15 to 18 rays in the anal fin wewe found in *I. besse besse*, while Daget (1967) found 15 to 18 in dorsal and 14 to 17 anal fin. For *I. besse congolensis*, 15 to 17 rays were found in dorsal and 15 to 18 anal. Daget (1967) reported 15 to 17 rays in dorsal fin of 78 specimens and 16 to 17 in type specimens. Giltay (1930) reported 3 unbranched and 19 to 22 branched rays in dorsal fin in diagnosis of original specimen,

The number of scales in the lateral line of *I. besse besse* was 100 to 112 including those on the base of caudal fin. Boulenger (1909) found 91 to 112 scales for *I. besse besse* from the Nile, and Daget (1967) reported 90 to 107 scales up to extreme of the caudal peduncle, excluding scales on caudal fin. For *I. besse congolensis* 91 to 102 scales were found on the lateral line, while Daget (1967) reported 90 to

102, and types described by Giltay (1930) reported 90 to 96.

I. besse besse has 17 to 20 teeth in upper jaw and 15 to 18 in lower jaw. Boulenger (1909); Pellegrin (1914); Daget (1967) reported 14 to 16 teeth in lower jaw. For *I. besse congolensis*, 19-22/14-18 teeth were found in upper and lower jaws, respectively, while Boulenger (1909); Pellegrin (1914) reported 14 to 16, Giltay (1930); Daget (1967) reported 16 to 17 in the lower jaw.

Tab. 1: Morphomertic measurements of *I. besse besse* and *I. besse congolensis* expressed as percentage of standard length (%SL).

Measurements	*I. besse besse* Range (Mean±SD*)	*I. besse congolensis* Range (Mean±SD)
Standard length (SL) in mm**	106.3-173.9 (140.8±23)	51.7-167 (96.1±31.5)
Head length (HL)	26.1-32.3 (28.8±1.3)	25.7-36.4 (31±2.2)
Head width (HW)	8.2-9.8.(8±0.4)	8.1- 11 (9.1±0.7)
Snout length (SNL)	9.2-12.2 (11±0.7)	6.2- 14.4 (11.1±1.6)
Eye diameter (ED)	4.5-6.8 (5.5 ± 0.6)	5- 7.7 (6.5±0.6)
Inter-orbital width (IOW)	5.7-7.3 (6.5±0.4)	5.5- 7.7 (6.6±0.5)
Body depth (BD)	16.3-23.5 (20.1±1.9)	13.7- 23.5 (18.4±2.3)
Postorbital distance (POD)	12.2-14.6 (13.4±0.6)	13.1-17.4 (14.5±1)
Pre-dorsal length (PRD)	49.8-56.5 (53.3±1.8)	48.4-69.6 (54.9±3.3)
Dorsal-adipose distance(DAD)	14.2-19.4 (17.0±1.3)	13.1-20.3 (16.8±1.6)
Pre-pectoral length (PRP)	24.9-29.2 (27.0±1.2)	20.1-33.8 (28.9±2.7)
Pre-pelvic length (PRPV)	47.9-53.1 (50.5±1.5)	27.3-53.8 (50.1±4.9)
Pre-anal length (PRAN)	69.2-76.3 (73.3±1.6)	49.4-77.4 (71.9±4.9)
Dorsal fin length (DFL)	13.7-18.8 (15.0±0.8)	12.3-18.3 (15±1.3)
Pectoral fin length (PFL)	12.4-15.4 (14.0±0.7)	10.7-17.4 (13.8±1.3)
Pelvic fin length (PVFL)	13.4-17.5 (15.1±1)	12.9-19.4 (15.7±1.4)
Anal fin length (ANFL)	11.1-14.7 (12.7±1)	9.3-17.1 (13.6±1.4)
Caudal fin length (CFL)**	13.6-22.4 (19.5±1.8)	9.4-21.6 (13.5±2.8)
Caudal peduncle length (CPL**)	28.7-37.8 (35.0±2.1)	15.1-45.1 (29.7±5.7)
Caudal peduncle depth (CPD)	7.2-8.8 (8.0±0.4)	6.4-9 (7.5±0.6)

* (SD): Standard deviation. ** Significant difference (P<0.05).

Tab. 2: Morphomertic measurements of *I. besse besse* and *I. besse congolensis* expressed as percentage of head length (%HL).

Measurements	*I. besse besse* Range (Mean±SD*)	*I besse congolensis* Range (Mean±SD)
Head length (HL) in mm	30.6-51.3 (40.5±6.2)	18.8-51 (29.4±8.7)
Head width (HW)	26.3-33.9 (30.6±1.)	25.7-34.5 (29.4±2.8)
Snout length (SNL)**	35.1-40 (38.1±1.3)	21-44.8 (35.5±5.1)
Eye diameter (ED)	15.4-24 (19±2)	16.3 - 25.6 (21±2.1)
Inter-orbital width (IOW)	18.7-25.64 (22.5±1.7)	18-26.1 (21.4±1.9)
Body depth (BD)**	56.5-84.2 (70±7.7)	42.6-81.9 (59.9±10.4)
Postorbital distance (POD)	42.2-53 (46.5±2.8)	42-57.9 (47.1±4.3)
Pre-dorsal length (PRD)**	166–200.4 (185.2±7.7)	150.5-240.1 (178.9±19)
Dorsal-adipose distance(DAD)	47.4-69.9 (59.2±5.6)	45.6-66.2 (54.7±6.7)
Pre-pectoral length (PRP)	85.8-101.1 (93.8±3.1)	69.3-106.2 (92.9±8)
Pre-pelvic length (PRPV)**	160.3-190.2 (175.3±6.9)	94-180.7 (160.6±19.7)
Pre-anal length (PRAN)**	221.9-273.5 (254.8±11.7)	170.2-262.5 (231.9±22)
Dorsal fin length (DFL)	45.2-64.4 (52.3±4.1)	41.6-63 (49±5.5)
Pectoral fin length (PFL)	43.1-54 (48.5±2.6)	32.2-53 (44.8±5.6)
Pelvic fin length (PVFL)	46.3-60.3 (52.4±3)	41.6-60 (50.8±5.2)
Anal fin length (ANFL)	37.6-51.1 (44.1±4.1)	28.8-54.8 (43.9±6)
Caudal fin length (CFL)**	46.9-75 (66.8±6.1)	32.5-67.3 (43.7±8.5)
Caudal peduncle length (CPL)**	101.3-132.9 (121.8±8.1)	52.3-142.2 (95.8±20.1)
Caudal peduncle depth (CPD)	23.8-31.6 (27.8±1.75)	18.6-31.5 (24.3±3)

* (SD): Standard deviation. ** Significant difference (P<0.05).

Tab. 3: Range of meristics counts for *I. besse besse* and *I. besse congolensis*.

Meristic counts	*I. besse bess*e	*I. besse congolensis*
Dorsal fin rays (DFR)*	16-18	15-17
Anal fin rays (ANFR)	15-18	15-18
Pectoral fin rays (PFR)*	14-19	13-17
Pelvic fin rays (PVFR)	10-12	10-12
Lateral line scales (LLS)*	100-112	91-102
Dorsal – to – lateral line scales (DLSC)	13.5-15.5	13.5-15.5
Ventral - to - lateral line scales (VLSC)	10.5-12.5	10.5-12.5
Scales around peduncle (PSC)*	29-34	27-32
Teeth in upper jaw (TUJ)*	34-40	38-44
Teeth in lower jaw (TLJ)*	30-38	28-36

Multivariate analysis

Principal component analysis of the data from the 23 morphometric measurement revealed that approximately 89.6% of the total variation was explained along one component and the second component of variation accounted for 4% of the total variability. The morphological results obtained in the present study indicated that a combination of morphological (morphometric and meristic) characters can be used to separate *I. besse besse* and *I. besse congolensis*, although few specimens of *I. besse congolensis* overlapped with specimens of *I. besse congolensis* (Fig. 2 and 3). The number of teeth in the upper jaw (TUJ) and the lower jaw (TLJ) were the factors that have the biggest load in this separation followed by the number of scales around the caudal peduncle (CPS) and the number of scales in the lateral line (LLS).

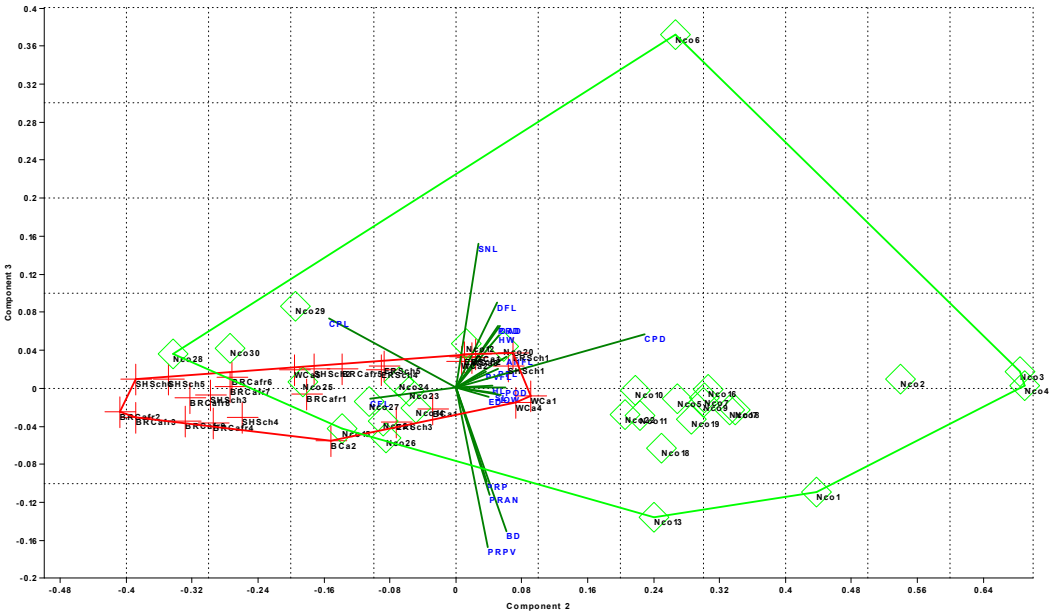

Fig. 2: The relationship of *I. besse besse* and *I. besse congolensis*, based on morphometric measurements, and the factors that have the biggest loads on their separation.

Cluster analysis

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. The data produced hierarchical clusters of *I. besse besse* and *I. besse congolensis* specimens in a distance dendrogram (Fig. 4). The first major dichotomy grouped all specimens of *1. besse besse* plus four specimens of *I. besse congolensis* in a sub-cluster separate from specimens of *I. besse congolensis*. The second division grouped 16

specimens of *I. besse besse* in a sub-cluster separate from another sub-cluster which composed of 13 specimens of *I. besse besse* plus four specimens of *I. besse congolensis*.

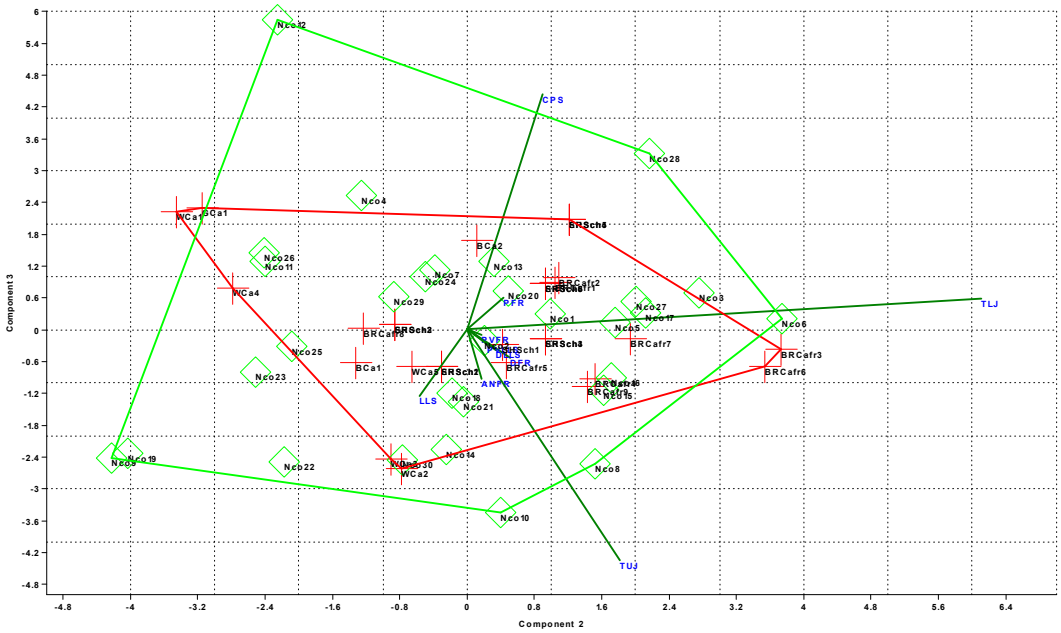

Fig. 3: The relationship of *I. besse besse* and *I. besse congolensis*, based on meristic counts, and the factors that have the biggest loads on their separation.

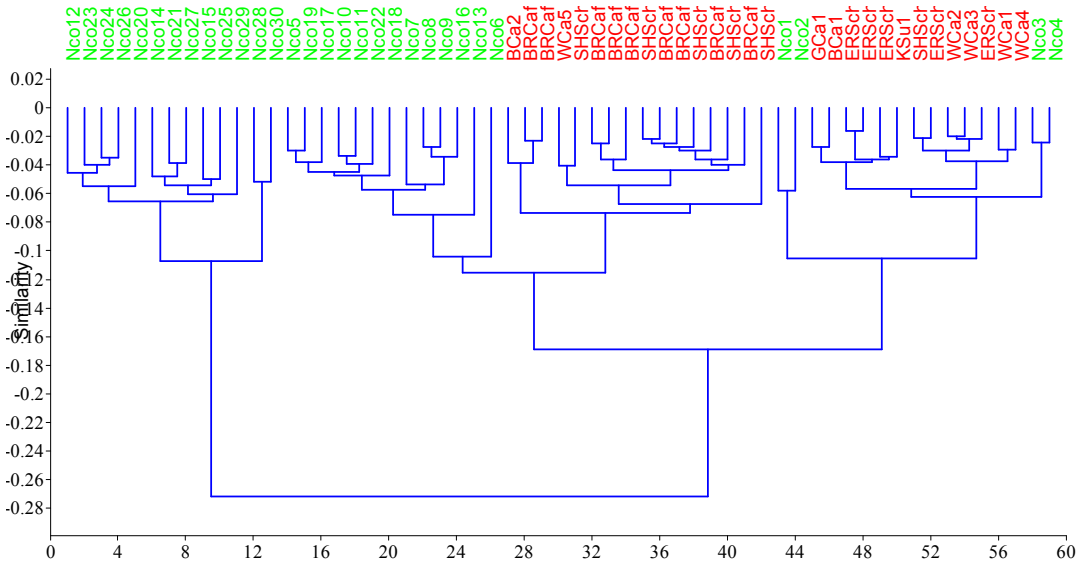

Fig. 4: Hierarchical cluster of *I. besse besse* (Red) and *I. besse congolensis* (Green) based on morphometric measurements, using matrix of similarity between paired group and single linkage (nearest neighbor) method.

On the other hand cluster analysis based on meristic data grouped 21 specimens of *I. besse congolensis* in a separate sub-cluster, and the remaining pecimens of *I. besse besse* plus specimens of *I. besse congolensis* in another sub-cluster. The division continued until all individuals were separated. As shown in Fig. 5, there was no clear separation of *I. besse besse* from *I. besse congolensis* by meristic compared to morphometric characters.

According to the present results the subspecies can be considered as two separate species. A detailed description of each suggested species is provided at the end of this report.

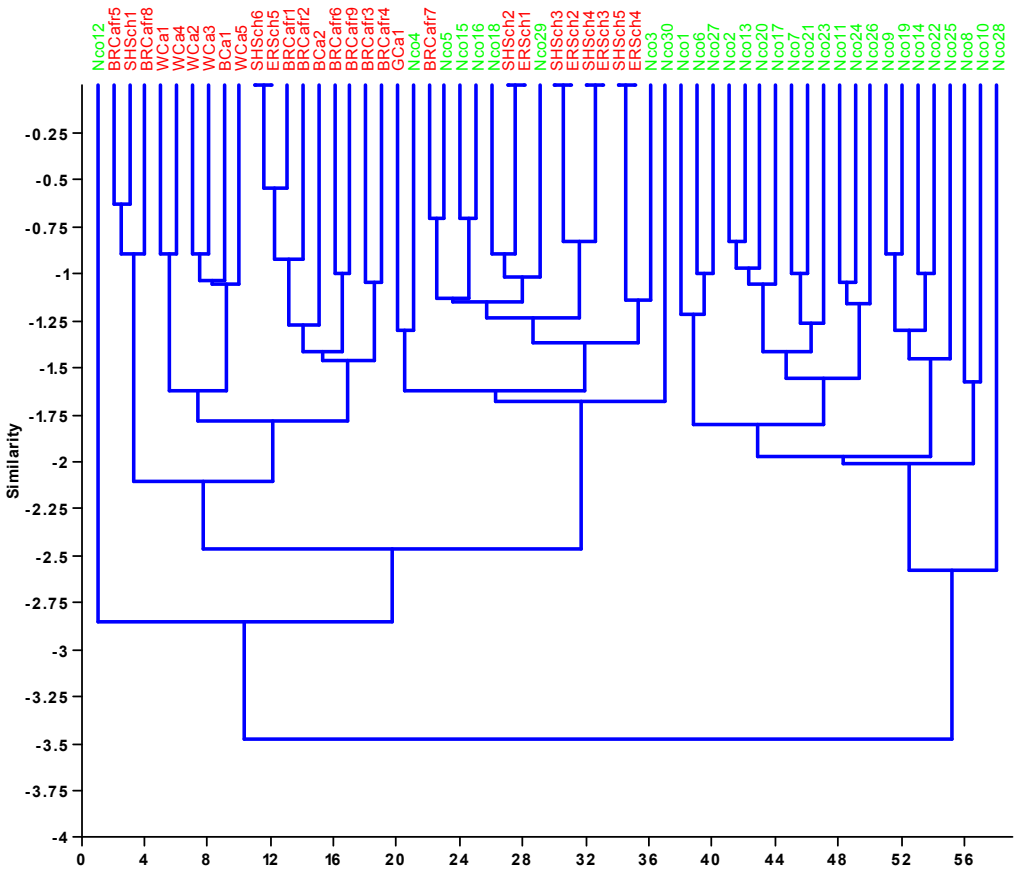

Fig. 5: Hierarchical cluster of *I. besse besse* (Red) and *I. besse congolensis* (Green) based on meristic counts, using matrix of similarity between paired group and single linkage (nearest neighbor) method.

Population study of *I. besse besse*

The population of *I. besse besse* has a wide range in West Africa: Tchad, Cameron, Cetral Africa in addition Sudan. The morphological characteristics of the populations from each locality are shown (Tabs. 4, 5, 6).

Tab. 4: Morphomertic measurements (Mean±SD) for the populations of *I. besse besse* from different regions in Africa, expressed as percentage of standard length (%SL).

Measurements	Schad	Cameron	Central Africa
Standard length (SL) in mm	143.1±24.7	156.5±18.1	122.1±11.6
Head length (HL)	28.8±1.4	28.6±1.3	29.3±0.8
Head width (HW)	8.8±0.4	8.8±0.3	8.8±0.3
Snout length (SNL)	11.1±0.7	10.9±0.7	11.1±0.4
Eye diameter (ED)	5.2±0.5	5.2±0.5	6.1±0.4
Inter-orbital width (IOW)	6.4±0.4	6.9±0.3	6.1±0.3
Body depth (BD)	19.3±1.7	21±2.6	20.2±1.2
Postorbital distance (POD)	13.6±0.6	13.6±0.4	12.9±0.5
Pre-dorsal length (PRD)	53.1±1.3	52.7±2.1	54.5±1.5
Dorsal - adipose distance (DAD)	16.7±1.2	17.8±1.3	16.6±1.4
Pre-pectoral length (PRP)	27.2±1	26.7±1.3	27.3±1.1
Pre-pelvic length (PRPV)	50.2±0.9	51±1	50.6±1.3
Pre-anal length (PRAN)	73.5±1	73.3±2	73.5±1.6
Dorsal fin length (DFL)	14.9±0.5	15.2±0.8	14.8±0.7
Pectoral fin length (PFL)	13.8±0.7	14±0.5	14.1±1
Pelvic fin length (PVFL)	15.3±1.2	14.6±0.8	15.3±0.8
Anal fin length (ANFL)	13.1±0.9	12.1±0.8	12.6±1.2
Caudal fin length (CFL)	19.4± 2.1	18±1.4	20.2±1.1
Caudal peduncle length (CPL)	35±1.45	34.2±2	36.6±1
Caudal peduncle depth (CPD)	7.9±0.3	8.2±0.4	8±0.6

Specimens investigated in this study reveal some discrimination of the ecological populations based on meristic analysis (Fig. 6) more than based on morphomertic measurements (Fig. 7), although there is some overlap. The number of lateral line scales is the factor which has a big load in this separation, followed by teeth in the lower jaw and teeth in upper jaw. Cluster analysis of meristic counts also showed clearer separation of the population from Tchad, Cameron, Cetral Africa and Sudan (Fig. 8) compared to data of morphometric measurements (Fig. 9). Some specimens of *I. besse besse* from Tchad overlapped those from Cameron and Central Africa specimens. This reflected the intermediate ecological position of Tchad specimens.

Tab. 5: Morphomertic measurements (Mean±SD) for the populations of *I. besse besse* from different regions in Africa, expressed as percentage of head length (%HL).

Measurement	Schad	Cameron	Central Africa
Head length (HL) in mm	41.1±7.1	44.7±4.4	35.8±3.5
Head width (HW)	30.8±2.1	30.6±9.6	29.9±1.5
Snout length (SNL)	38.6±1.2	38.1±12	37.9±1.1
Eye diameter (ED)	18.1±1.7	18.1±5.4	20.7±1.5
Inter-orbital width (IOW)	22.3±1.4	24.1±7.1	21.1±1.3
Body depth (BD)	67.2±7	73.3±22	69±4.5
Postorbital distance (POD)	47.2±2.9	47.5±15	44±1.3
Pre-dorsal length (PRD)	184.6±7.1	184.2±57.6	186±6.8
Dorsal - adipose distance (DAD)	58.2±4.1	62.2±18.7	56.6±5.4
Pre-pectoral length (PRP)	94.5±3.6	93.4±29.4	93.3±3.3
Pre-pelvic length (PRPV)	174.7±7	178.3±54.6	172.5±3.9
Pre-anal length (PRAN)	256±13.7	256.4±79.8	250.8±7.7
Dorsal fin length (DFL)	52±3.1	53.3±16.3	50.5±3
Pectoral fin length (PFL)	48±2.2	49±15	48±3.2
Pelvic fin length (PVFL)	53.2±3.5	51±16.6	52.1±1.9
Anal fin length (ANFL)	45.6±3.8	42.4±14.3	43.1±3.9
Caudal fin length (CFL)	67.6±7.3	63±21	69±3.8
Caudal peduncle length (CPL)	121.8±7.7	119.9±37.9	124.8±5
Caudal peduncle depth (CPD)	27.4±1.3	28.7±8.6	27.2±1.9

Tab. 6: Range of meristic counts for the populations of *I. besse besse* from different regions in Africa.

Meristic counts	Schad	Cameron	Central Africa
Dorsal fin rays (DFR)	16-17	16-18	17-8
Anal fin rays (ANFR)	15-17	15-7	17-18
Pectoral fin rays (PFR)	15-17	14-18	16-17
Pelvic fin rays (PVFR)	10-12	10-12	11-12
Lateral line scales (LLS)	100-112	102-108	105-112
Dorsal-to-lateral line scales (DLSC)	13.5-14.5	14.5-15.5	14.5-15.5
Ventral- to-lateral line scales (VLSC)	10.5-11.5	11.5-12.5	11.5-12.5
Scales around peduncle (PSC)	29-32	30-33	32-33
Teeth in upper jaw (TUJ)	34-40	36-40	38-40
Teeth in lower jaw (TUJ)	32-38	30-34	32-36

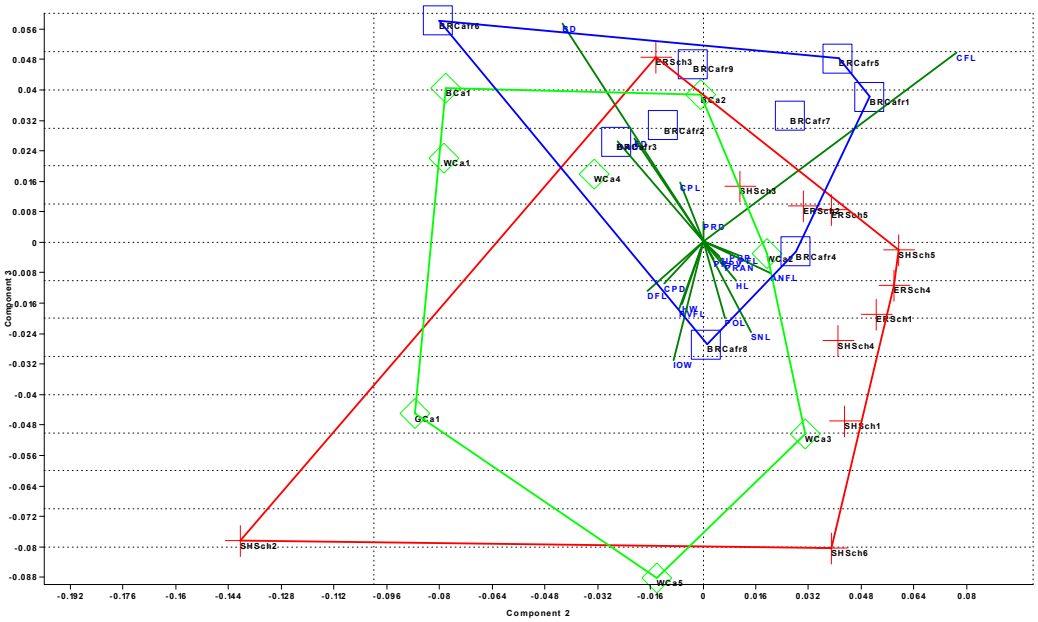

Fig. 6: The relationship of the ecological populations of *I. besse besse* from Schad (Red), Cameron (Green) and Central Africa (Blue), based on morphometric measurements, and the factors that have the biggest loads on separating the populations.

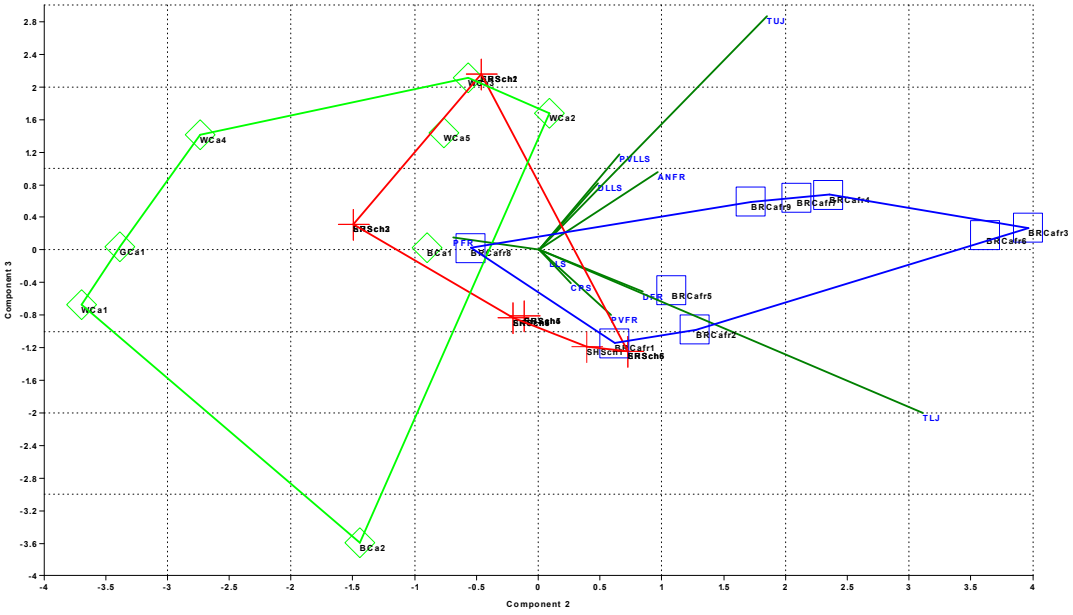

Fig. 7: The relationships of the ecological populations of *I. besse besse* from Schad (Red), Cameron (Green) and Central Africa (Blue), based on meristic counts, and the factors that have the biggest loads on separating the populations.

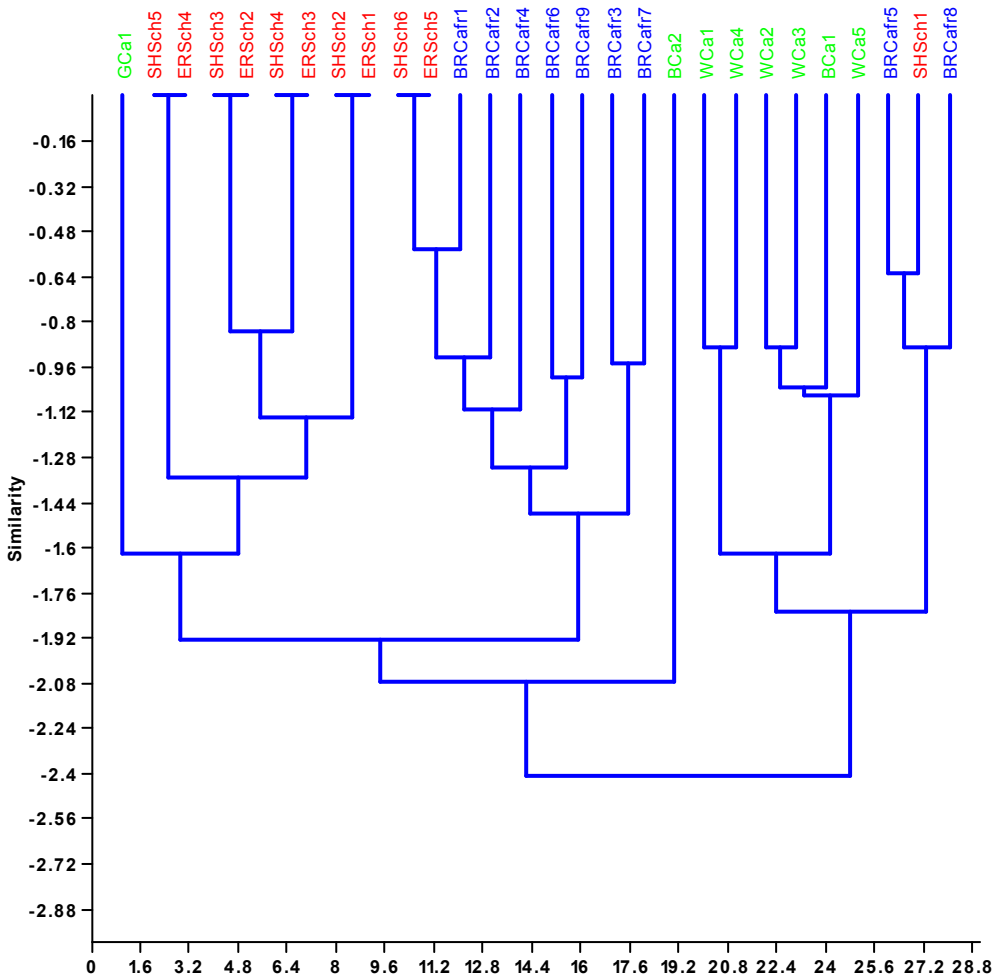

Fig. 8: Hierarchical cluster of the ecological populations of *I. besse besse* from Schad (Red), Cameron (Green) and Central Africa (Blue), based on morphometric measurements, using matrix of similarity between paired group and single linkage (nearest neighbor) method.

Ichthyborus besse besse (proposed)

Characinus (*Ichthyborus besse*) *besse* (Joannis, 1835)

Ichthyborus besse besse (Boulenger 1909)

Ichthyborus microlepis (Gunther 1864)

Description: Up to 173.9mm silvery grey fish, caudal fin has a small round black spot at the base and caudal lobes marked with oblong black spots. Sides and lower surface have little lighter spots but very clear/nice vermiculate lines. Caudal fin almost entirely covered with fine scales only its hind edge smooth or naked. 17 to 20 teeth on each side of upper jaw, 15 or 19 on each side of lower jaw; 2 upper front canines, 3 lowers;

Measurements: Depth 56.5 to 84.2; width

36.3 to 33.9; snout 35.1 to 41.4, eye 15.4 to 24; interorbital 18.7 to 25.6 % in head. Head length is 26 to 32.6 in standard length.

Scales in lateral line 100-112 (including 4 to 5 in caudal); 13.5 or 15.5 above to dorsal, 10.5 to 12.5 below to ventral; 29 to 32 rows around caudal peduncle. Dorsal fin rays 16-18 (III 19-22, in the type species), of anal 15-18, of pectoral 14-19.

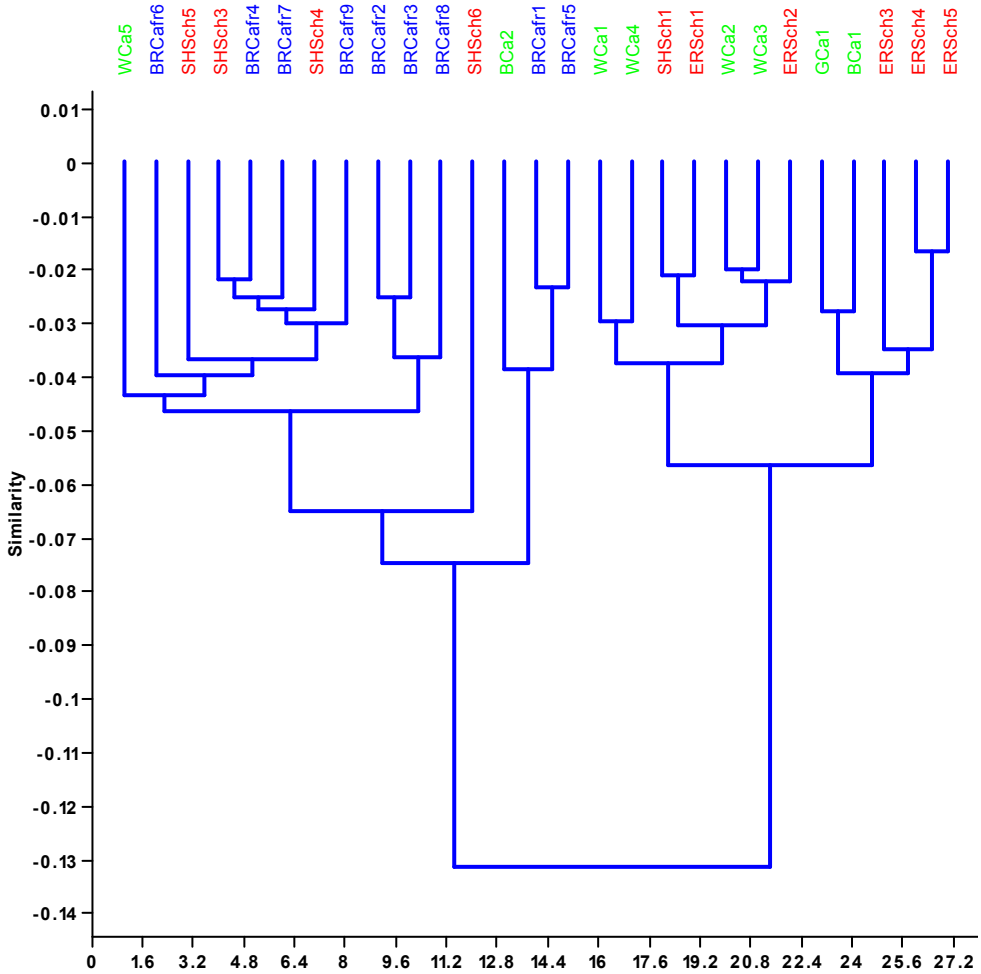

Fig. 9: Hierarchical cluster of the ecological populations of *I. besse besse* from Schad (Red), Cameron (Green) and Central Africa (Blue), based on meristic counts, using matrix of similarity between paired group and single linkage (nearest neighbor) technique

Ichthyborus besse congolensis (proposed)

Ichthyborus besse congolensis (Giltay 1930)
Ichthyborus besse congolensis (Daget 1967)
Ichthyborus besse congolensis (Fowler 1975)
Ichthyborus besse congolensis (Banister and Bailey 1979).

Description: Up to 1675mm silvery grey fish, except for the caudal fin which has worm-like lines and clear empty black circle at the base. Dark spots forming oblique lines on caudal lobes; 19-22 teeth on each side of the upper jaw; 14-18 on the lower jaw; 2 canines at the extremity of the upper jaw and 3 of the lower jaw.

Measurements: As in the type species.

Scales in lateral line scale 91-102. Dorsal fin rays 15-17 (III 19-22, in type species); anal 15-18, pectoral 13-17.

Acknowledgements

I gratefully acknowledge and appreciate the help provided to me by the head and the staff of the Fish Section in the Royal Museum for Central Africa and the fish curators and collection managers in the Museum. This study was supported by a grant for a follow- up training session on FishBase and Fish Taxonomy from the Royal Museum for Central Africa (RMCA).

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