Journal of Fish Biology (2005) **67,** 332–369
doi:10.1111/j.1095-8649.2005.00729.x, available online at http://www.blackwell-synergy.com

Redescription of *Mastacembelus liberiensis* Boulenger, 1898 and description of a new West African spiny-eel (Synbranchiformes: Mastacembelidae) from the Konkoure River basin, Guinea

E. J. Vreven* and G. G. Teugels†

Africa Museum, Vertebrate Section, Ichthyology, Leuvensesteenweg, 13, B-3080 Tervuren, Belgium

(Received 11 September 2003, Accepted 14 February 2005)

Mastacembelus liberiensis Boulenger, 1898 of West Africa is discussed with reference to its distribution within the Konkoure River basin (Guinea). The synonymies of *M. reticulatus* Boulenger, 1911 and *M. laticauda* Ahl, 1937 with *M. liberiensis* are both confirmed. Further, intraspecific meristic, morphometric and colour pattern variation within *M. liberiensis* is documented and discussed. Finally, a new species, *M. kakrimensis* sp. nov., endemic to the Konkoure River basin is identified and described.

Key words: geographic variation; Mastacembelidae; *Mastacembelus kakrimensis* sp. nov.; *Mastacembelus liberiensis*; Synbranchiformes; West Africa.

INTRODUCTION

Mastacembelidae are anguilliform percomorph fishes which can attain a maximum length of *c*. 1 m. Peculiar to them is the rostral appendage which bears two tubulated anterior nostrils, one on each side of the central rostral tentacle. The gill opening is reduced due to a connection of the opercular membrane with the lateral body wall. Mastacembelidae have a long series of well separated dorsal spines, hence their name 'spiny-eels'. They also have a short series of anal spines. A pelvic girdle and associated fins are absent. Most species have a large number of small cycloid scales. Finally, in all African species the dorsal, caudal and anal fins are confluent.

Currently four species of *Mastacembelus* are known from the Upper Guinea ichthyofaunal province of West Africa (Travers, 1992*a*, *b*) as defined by Roberts (1975), they are: *Mastacembelus nigromarginatus* Boulenger, 1898, *Mastacembelus praensis* (Travers, 1992), *Mastacembelus taiaensis* (Travers, 1992) and *Mastacembelus liberiensis* Boulenger, 1898. *Mastacembelus liberiensis*

*Author to whom correspondence should be addressed. Tel.: +32 2 7695640; fax: +32 2 7695642; email: vreven@africamuseum.be
†Deceased

is restricted to the coastal rivers of Senegal, Guinea, Sierra Leone, Liberia and Ivory Coast (Travers, 1992*a*, *b*).

In 1992, during fieldwork in Guinea two distinct colour patterns within the mastacembelid specimens collected from the Konkoure River basin were recognized. These patterns can be described and referred to as: a more uniform colour pattern (Group I) and a network colour pattern (Group II) (see below). At present only one species, *M. liberiensis*, is reported from the Konkoure River basin (Travers, 1992*a*, *b*). The observations of colour differences have initiated a more detailed study of the *M. liberiensis* species-complex (hereafter referred to as *liberiensis* complex) which at present contains three nominal species *M. liberiensis*, *Mastacembelus reticulatus* Boulenger, 1911 and *Mastacembelus laticauda* Ahl, 1937. *Mastacembelus reticulatus* and *M. laticauda* are presently considered junior synonyms of *M. liberiensis*, but within the framework of the present revision these synonymies needed confirmation.

MATERIAL AND METHODS

Meristics and morphometrics were taken according to Vreven & Teugels (1996, 1997).

Institutional abbreviations used: BMNH, Natural History Museum, London (U.K.); MNHN, Muséum National d'Histoire Naturelle, Paris (France); MHNB Museum d'Histoire Naturelle, Basel (Switzerland); MRAC, Musée Royal de l'Afrique Centrale, Tervuren (Belgium); NMW, Naturhistorisches Museum, Wien (Austria); RMNH, Rijksmuseum van Natuurlijke History, Leiden (The Netherlands); USNM, National Museum of Natural History, Smithsonian Institution, Washington (U.S.A.); ZMB, Zoologisches Museum der Humboldt-Universität zu Berlin, Berlin (Germany).

For those localities for which the collectors of the specimens provided no co-ordinates reference is made to the co-ordinates given in the country gazetteers or the MRAC locality database. To make this clear the co-ordinates are preceded by a $\pm$. Further, in those cases, that part of the locality used as reference for the co-ordinates is put in italics. All other co-ordinates were copied from the museum labels or listings.

Data were explored and analysed using principal component analysis (PCA) on the correlation matrix of the ln-transformed measurements and the raw meristics. The PCA is used here as a model-free and distribution-free technique for exploring multivariate data sets (Marcus, 1990). All fully examined specimens were included in the analyses. This method allows a size-free comparison of the specimens when the first factor, which accounts mainly for size, is discarded (Humphries *et al*., 1981; Bookstein *et al*., 1985). This was confirmed by plotting the first principal component (PCI) *v*. standard length (L_S).

Non-parametric Mann–Whitney *U* tests were used for univariate comparisons; as far as possible they were done only on samples of similar length classes and calculated on the relative measurements (percentages) and raw meristics.

For the statistical analyses STATISTICA for Windows version 5.1. ('97 Edition) from StatSoft, Inc. was used. Distribution maps were made with MapInfo (MapInfo Professional, Version, 4.0).

The references included in the synonyms and citations list of *M. liberiensis* are those referring to the three nominal species *M. liberiensis*, *M. reticulatus* and *M. laticauda*. Reference to other nominal species, which are recognized in this study as misidentifications of type material of *M. liberiensis*, are also included. References to other nominal species, and which were identified here as misidentifications of non-type material belonging to *M. liberiensis*, are not included.

RESULTS

HISTORIC OVERVIEW

In his 'Reisbilder aus Liberia', Büttikofer (1890) reported *Mastacembelus cryptacanthus* Günther, 1867 as collected on his expedition in Liberia. Steindachner (1895) reidentified these (three) specimens as *Mastacembelus marchei* Sauvage, 1879. He also gave a more accurate description of the locality 'Aus dem Fischermann-See nächst dem Dorfe Solymah'. In the identification key of Boulenger (1898), *M. liberiensis* is described as a new species from Liberia. Boulenger (1898) mentioned in a footnote '*M. marchii* Steind. nec. Sauv. – Liberia.' Based on this information it is assumed that the original description of *M. liberiensis* was based on, or at least referring to, the three specimens Büttikofer (1890) originally described as *M. cryptacanthus*. Today only two syntypes of *M. liberiensis* are preserved (RMNH). The third specimen may be lost, as it is catalogued neither as *M. marchei* nor as *M. cryptacanthus* [B. Herzig & H.J. Paepke, pers. comm.].

Boulenger (1911) described *M. reticulatus* from Sierra Leone based on two specimens. Paugy *et al.* (1990) first proposed the synonymy of *M. reticulatus* with *M. liberiensis* by referring to R.A. Travers (unpubl. data). Travers (1992*b*) confirmed but did not further discuss the synonymy.

Ahl (1937) described *M. laticauda* based on a single specimen from 'Umgebung von Freetown, Etwa 4 Kilometer landëinwärts' in Sierra Leone. Daget & Iltis (1965) proposed the synonymy of *M. laticauda* with *M. liberiensis*. They gave a brief description of *M. laticauda* mentioning the body depth (15 times in total length, L_T), the number of dorsal spines and soft fin rays (D. XXX-90), the number of anal spines and soft fin rays (A. II-85) and the rounded caudal. They especially referred to the colour pattern of *M. laticauda* as being of the same type as *M. liberiensis*.

ANALYSIS: MERISTICS

Two groups can be identified from the Konkoure River basin based on colour pattern and meristics: Group I, with lower total and caudal vertebrae numbers (90–93; median: 91 and 53–56; median: 54–55 respectively) and Group II, with higher numbers (100–104; median: 102 and 60–64; median: 62 respectively).

The meristics of the type material of all nominal species included in the *liberiensis* complex, however, fit into Group I, Group II or are intermediate between both groups. Therefore, additional research has been undertaken to examine the geographical meristic variation within the *liberiensis* complex using a basin by basin approach [non-dimensional species analysis (NDSA); Mayr & Ashlock, 1991]. In total 247 specimens were examined and classified into 19 different river basins [see abscissa of Fig. 1(a),(b)]. For this purpose the 19 river basins have been organized in a logical geographical sequence starting from the Gambia River (Senegal) in the west to the Cess (Cestos) or Nipoue (Liberia and Ivory Coast) in the east. For those localities clearly belonging to a separate river basin but for which it was not possible to unequivocally indicate which one, reference is made to the locality itself rather than to a river basin [*i.e.* Freetown

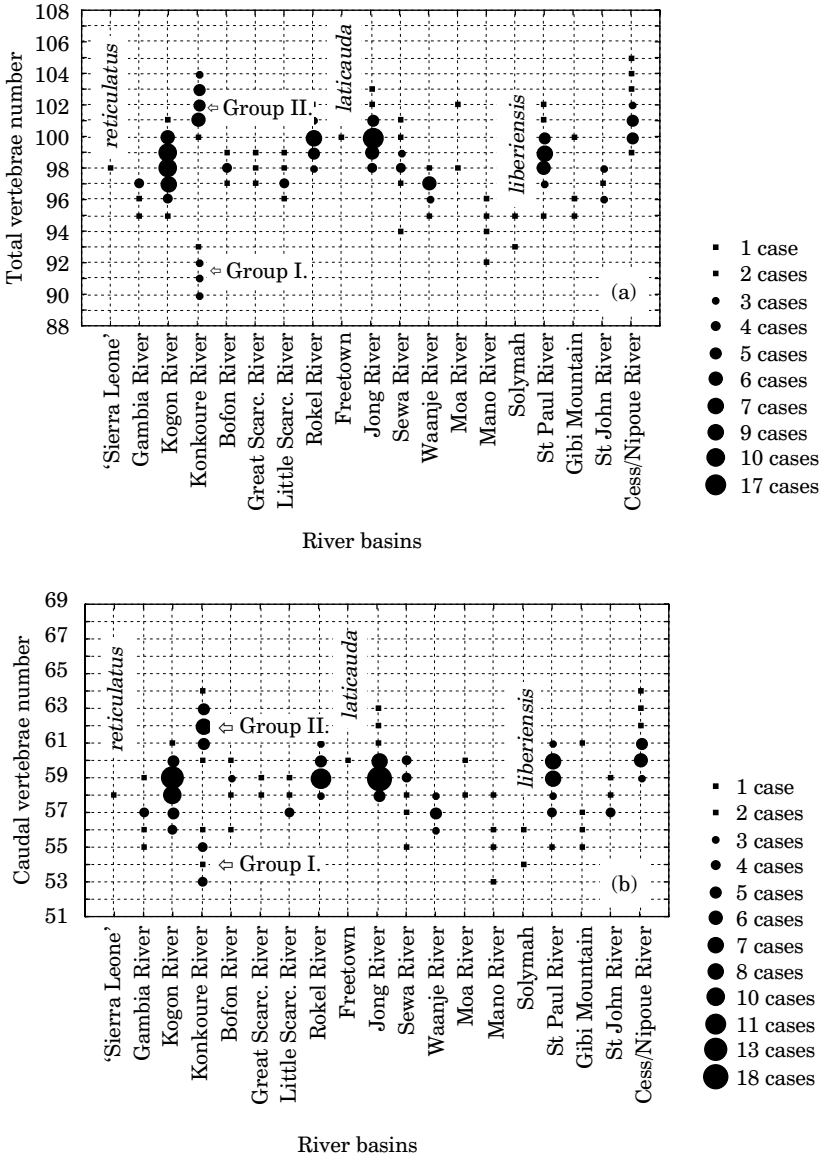

FIG. 1. Frequency scatterplot of vertebrae numbers for all examined specimens included in the *liberiensis* complex, with indication of all type material, for the West African river basins from the Gambia River (Senegal) in the west to the Cess or Nipoue River (Liberia and Ivory Coast) in the east: (a) total vertebrae numbers and (b) caudal vertebrae numbers. Note: the type material of *Mastacembelus reticulatus* is represented at the beginning of the geographical series as its exact origin is unknown.

(type locality of *M. laticauda*) and Solymah (type locality of *M. liberiensis*)]. One other unidentified river basin, 'Sierra Leone', was included at the beginning of the series, for the type material of *M. reticulatus* which comes from an unknown exact locality.

An important intra- and inter-riverine variation was observed for the total and caudal vertebrae numbers [Fig. 1(a),(b)]. The Group I specimens seem to be meristically well differentiated from all specimens from neighbouring river basins, whereas the Group II specimens, even if they also show some differences in total and caudal vertebral numbers compared to the neighbouring populations, generally fit better in the variability of these.

These groups are also supported by another character, namely specimens of Group I are characterized by the complete loss of the preopercular spines with increasing size. As a result, all Group I medium and large sized specimens lack preopercular spines. By contrast the Group II specimens of the Konkoure River basin normally have at least two preopercular spines on each side of the head and the spines are present even in large specimens. All type specimens of *M. liberiensis* or other nominal species considered as synonyms of *M. liberiensis* also have at least two preopercular spines on each side of the head. Further, no other population (*i.e. M. liberiensis* and its synonyms) of the *liberiensis* complex has been found in which there is a reduction in number and size of the preopercular spines with increasing size and age of the specimens, resulting in the complete loss of preopercular spines in medium and large sized specimens.

Based on these preliminary observations Group II is considered to be conspecific with *M. liberiensis* and Group I represents a species new to science, *Mastacembelus kakrimensis* sp. nov.

A first PCA on the correlation matrix has been carried out for nine meristics (Fig. 2) ($n = 197$). The factor loadings of this PCA are given in Table I. The most important factor loadings on PCI are for the total and caudal vertebrae numbers followed by the anal and dorsal soft fin ray numbers. The PCII is defined mainly by the predorsal vertebrae and dorsal spine numbers. *Mastacembelus kakrimensis* sp. nov., is entirely situated on the negative part of the first PC axis whereas *M. liberiensis* is situated partially on the negative and partially on the positive part of the first PC axis (Fig. 2), and there is no overlap between them. Both types of *M. liberiensis*, and especially the paralectotype, however, are situated near to the *M. kakrimensis* species cluster due to the relatively low total and caudal vertebrae numbers of both syntypes. Nevertheless, there is no doubt about their correct identification. Both the lectotype and paralectotype of *M. liberiensis* have two or three preopercular spines whereas all *M. kakrimensis* specimens of comparable L_S or L_T entirely lack preopercular spines (see below). Also the colour pattern of both *M. liberiensis* types, characterized by a well-developed dark brown network enclosing lighter brown, yellowish-white spots, is quite different from that of *M. kakrimensis* specimens. Indeed, *M. kakrimensis* specimens of comparable L_S or L_T are characterized by a far more uniform colour pattern. The types of *M. reticulatus* and the holotype of *M. laticauda* are situated well within the cluster of *M. liberiensis*. A second PCA using the same meristics but excluding all *M. kakrimensis* sp. nov. specimens examined ($n = 189$) did not reveal any different results.

Mann–Whitney *U* tests (Table II) were performed for all nine meristics so as to explore inter-basin differences. No comparisons were made with the type material of *M. reticulatus*, as its exact origin is unknown, or with the type of *M. laticauda* it being the only specimen from Freetown, Sierra Leone.

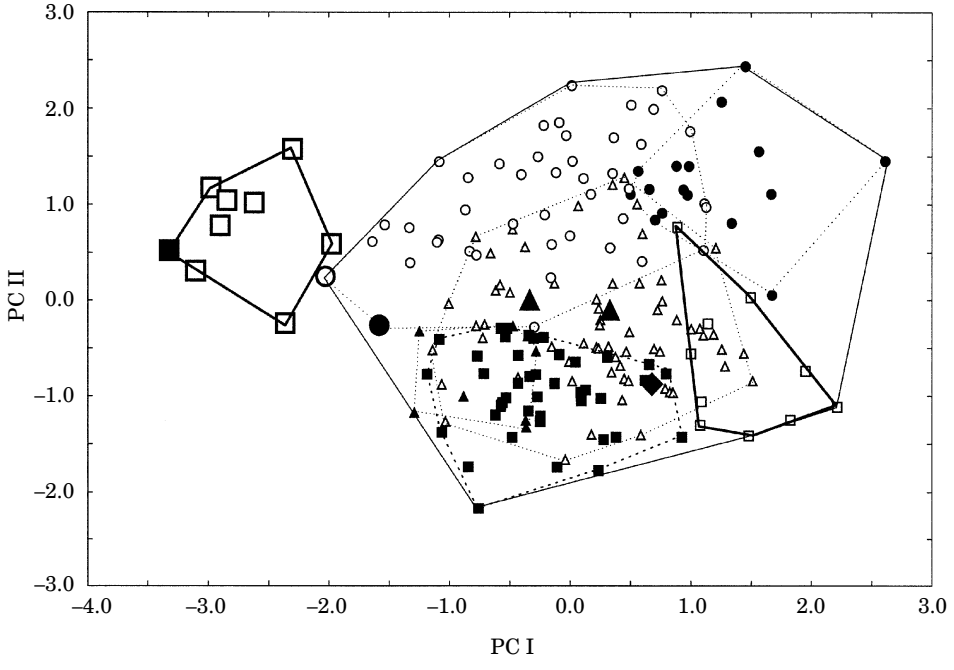

FIG. 2. Plot of a PCA on nine meristics for all examined specimens included in the *liberiensis* complex ($n = 197$). ●, Lectotype and ○, paralectotype of *Mastacembelus liberiensis*; ▲, syntypes of *Mastacembelus reticulatus*; ◆, holotype of *Mastacembelus laticauda*; ■, holotype and □, paratypes of *Mastacembelus kakrimensis* sp. nov. and *M. liberiensis* river basin specimens: ▲, Gambia River (Senegal) (...); ■, Kogon River (Guinea) and Bofon River (Guinea) (---); □, Konkoure River (Guinea) (—); △, Great Scarcies and Kolente River (Sierra Leone) (Guinea) up to Moa River (Sierra Leone) (Guinea) (...); ○, Bendaja, Mano River (Liberia) up to Suakoko, St John River (Liberia) (...); ●, Cess or Nipoue River (Liberia and Ivory Coast) (...). *Mastacembelus kakrimensis* sp. nov. and entire *M. liberiensis* cluster of specimens also enclosed (—).

TABLE I. Factor loadings for the first two PC axes resulting from a PCA carried out on nine meristics for all specimens examined included in the *liberiensis* complex ($n = 197$ specimens). The most important loadings are in bold

	PCI	PCII
Dorsal spines	0·569	**0·660**
Dorsal soft fin rays	**0·771**	−0·341
Anal soft fin rays	**0·822**	−0·230
Caudal soft fin rays	−0·204	−0·516
Predorsal vertebrae	−0·078	**−0·867**
Abdominal vertebrae	0·706	−0·075
Caudal vertebrae	**0·874**	−0·058
In-between vertebrae	0·137	0·561
Total vertebrae	**0·950**	−0·074
Explained variance (% of total variance)	42·5	21·7

TABLE II. Results of the Mann–Whitney U tests for the nine meristics of the *liberiensis* complex specimens of the various river basins: (a) comparison of each *Mastacembelus liberiensis* population with its closest neighbouring river basin populations, (b) comparison of the Gambia and the Cess or Nipoue River basins, being the most extreme western and eastern river basins populated by Mastacembelidae specimens of the *liberiensis* complex and (c) comparison of the *Mastacembelus kakrimensis* sp. nov. with the sympatric *M. liberiensis* Konkoure River basin population and with the neighbouring *M. liberiensis* populations. Bold and underlined values are highly significant ($P \leq 0{\cdot}001$) after sequential Bonferroni correction for multiple comparisons. Bold and italic values are significant ($P \leq 0{\cdot}05$) after sequential Bonferroni correction for multiple comparisons. Only comparison with at least one (highly) significant meristic difference are tabulated. DS, dorsal spines; SDFR, soft dorsal fin rays; SAFR, soft anal fin rays; SCFR, soft caudal fin rays; PV, predorsal vertebrae; AV, abdominal vertebrae; CV, caudal vertebrae; IV, in-between vertebrae; TV, total vertebrae number. Counts follow Vreven & Teugels (1996)

(a)	Kogon *v.* Konkoure	Kogon *n*	Konkoure *v.* Bofon	Konkoure *n*	Bofon *n*	Jong *v.* Sewa	Jong *n*	Sawa *n*	St John *v.* Cess or Nipoue	St John *n*	Cess or Nipoue *n*
DS	**0·000000**	40	0·001351	20	8	0·165781	36	12	0·094199	7	19
SDFR	***0·000234***	38	0·047171	17	7	***0·000031***	26	10	***0·000012***	7	17
SAFR	**0·000001**	38	0·031280	17	8	0·373791	26	10	***0·000012***	7	17
SCFR	0·819350	35	0·739613	10	7	0·773706	23	8	0·086546	7	17
PV	0·000660	40	0·354218	20	8	0·005279	36	12	0·001715	7	19
AV	0·192118	40	0·062511	20	8	0·026242	36	12	0·002213	7	19
CV	**0·000000**	39	**0·000002**	20	7	0·272206	36	12	***0·000008***	7	18
IV	0·882605	40	0·850014	20	7	0·580513	36	12	0·041016	7	19
TV	**0·000000**	39	**0·000002**	20	7	0·003187	36	12	0·041016	7	18

(b)	Gambia *v.* Cess or Nipoue	(c)	Kogon *v.* *M. kakrimensis*	*M. kakrimensis v.* Konkoure	*M. kakrimensis v.* Bofon	*M. kakrimensis n*
DS	***0·000041***	DS	0·014124	**0·000002**	0·004388	10
SDFR	0·001126	SDFR	**0·000000**	**0·000001**	***0·000175***	9
SAFR	0·013214	SAFR	***0·000008***	***0·000001***	***0·000329***	9
SCFR	0·013077	SCFR	0·287099	0·356232	0·499755	9
PV	**0·000001**	PV	**0·000000**	***0·000044***	0·000548	10
AV	0·021678	AV	**0·000000**	**0·000000**	***0·000046***	10
CV	**0·000003**	CV	**0·000000**	**0·000000**	***0·000103***	10
IV	0·033902	IV	0·189282	0·286493	0·314788	10
TV	**0·000001**	TV	**0·000000**	**0·000000**	***0·000103***	10

The Cess or Nipoue River basin cluster of specimens shows only a limited overlap with the Liberian River basin cluster of specimens, *i.e.* the Mano up to the St John River basin populations (Fig. 2). Both populations are significantly different for several meristics (Table II).

There is little overlap between the Liberian (see above) and Guinean *M. liberiensis* populations, *i.e.* Kogon, Konkoure and Bofon River basin populations. The Sierra-Leone *M. liberiensis* River basin population has an intermediate position, partially overlapping with both (Fig. 2). An east-west cline for the predorsal vertebrae and dorsal spine numbers is to be noted.

No overlap is observed between the Konkoure River basin *M. liberiensis* cluster of specimens and the neighbouring *M. liberiensis* populations, *i.e.* the Bofon and Kogon River basin populations (Fig. 2). Indeed, the Konkoure population is highly significantly different from both for several meristics (Table II).

There is no overlap between the Konkoure River basin *M. kakrimensis* and *M. liberiensis* clusters of specimens. Both are highly significantly different for

several meristics (Table II). Also no overlap is observed between the *M. kakrimensis* cluster of specimens and both, the neighbouring Kogon and Bofon River basin *M. liberiensis* clusters of specimens. Several meristics are also found to be highly significantly different between *M. kakrimensis* and the Kogon River basin *M. liberiensis* population and significantly different between the former and the Bofon River basin *M. liberiensis* population (Table II).

A closer look at the geographical variation for the dorsal spine, the predorsal vertebrae, and the abdominal vertebrae numbers (Fig. 3) reveals, from east to west, a clinal decrease of the dorsal spine number and a clinal increase of the predorsal vertebrae number whereas, on the contrary, the abdominal vertebrae number is quite stable throughout the distribution range of *M. liberiensis*. Therefore, the observed variation in the total vertebrae numbers [Fig. 1(a)] is mainly due to variation in the caudal vertebrae numbers [Fig. 1(b)].

Furthermore, the variation in predorsal vertebrae numbers is also related to some morphometric variation observed within *M. liberiensis*. An increase in predorsal vertebrae number (from east to west) is related to an increase in the distance from head, the posterior edge of pectoral fin and the upper or lower pectoral-fin base, to the origin of first dorsal spine.

ANALYSIS: MORPHOMETRICS

A PCA on the correlation matrix was carried out on 26 ln-transformed morphometrics ($n = 235$) (Fig. 4). The most important factor loadings on PCII are for the distance between the posterior edge of the pectoral fin and the origin of the first dorsal spine, and for the distances between the ventral and dorsal edges of the pectoral-fin base and the origin of the first dorsal spine (Table III). The PCIII is defined mainly by the minimum interorbital distance and the eye diameter. *Mastacembelus kakrimensis* sp. nov. is entirely situated within *M. liberiensis*. A PCA on the same morphometrics but excluding all *M. kakrimensis* sp. nov. specimens examined ($n = 189$) did not reveal any new results.

Mann–Whitney *U* tests were performed for the different 'river basin' groups, analysing the distance from the posterior edge of the pectoral fin to the origin of the first dorsal spine (PPF-FDS) as a per cent of head length (L_H), the variable with the highest factor loading on PCII (Table IV). No comparisons were made with the type material of *M. reticulatus* as the exact origin of this material is unknown, and with the type of *M. laticauda* which is recorded from 'Freetown' (Sierra Leone). Both the lectotype and paralectotype of *M. liberiensis* have a rather high value for the PPF-FDS ($\%L_H$) distance (Fig. 5). In both specimens, however, the pectoral fins seem deformed or distortedly preserved. Further, western populations, such as the Gambia and the Kogon and Bofon River basin populations, have a larger distance for this measurement when compared to eastern populations, such as the Cess or Nipoue River basin population.

There is no overlap between the Gambia, the Kogon and Bofon River basin *M. liberiensis* cluster of specimens on one hand and the *M. liberiensis* Cess or Nipoue River basin cluster of specimens on the other (Fig. 4). The PPF-FDS ($\%L_H$) distance is highly significantly different between the Gambia and the Cess or Nipoue River basin population (Table VI). An east-west cline is observed for

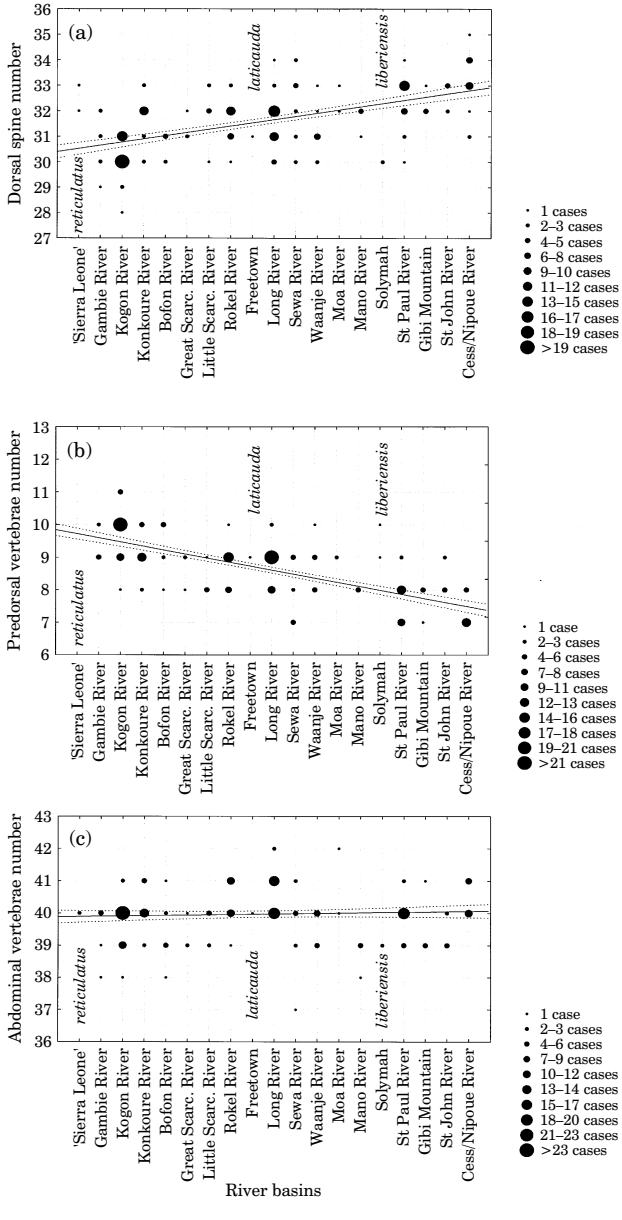

FIG. 3. Frequency scatterplot of meristics for all specimens examined and identified as *Mastacembelus liberiensis*, with indication of all type material, for the West African River basins from the Gambia River (Senegal) in the west to the Cess or Nipoue River (Liberia and Ivory Coast) in the east. A regression line is fitted to the points in the scatterplots (—) with 95% CI (---) (type material of *Mastacembelus reticulatus*, 'Sierra Leone' not included). (a) Dorsal spine numbers (Mann–Whitney *U* test: Gambia River compared to the Cess or Nipoue River, $P = 0{\cdot}000041$; $y = 30{\cdot}397 + 0{\cdot}127x$), (b) predorsal vertebrae numbers (Mann–Whitney *U* test: Gambia River compared to the Cess or Nipoue River, $P = 0{\cdot}000001$; $y = 9{\cdot}849 - 0{\cdot}124x$), and (c) abdominal vertebrae numbers (Mann–Whitney *U* test: Gambia River compared to the Cess or Nipoue River, $P = 0{\cdot}021678$; $y = 39{\cdot}888 + 0{\cdot}009x$). Note the type material of *M. reticulatus* is represented at the beginning of the geographical series as its exact origin is unknown.

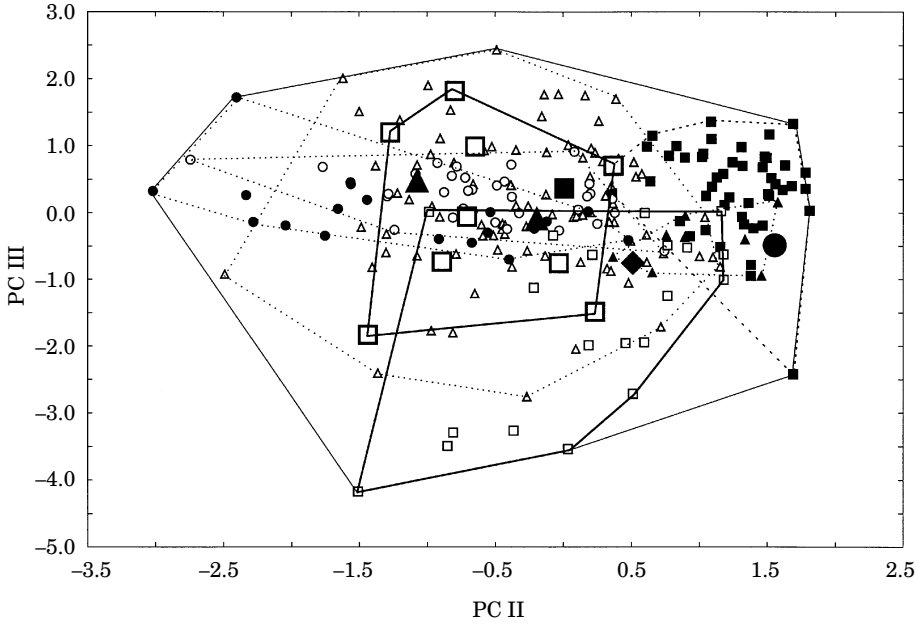

FIG. 4. Plot of a PCA on 26 ln-transformed morphometrics for all examined specimens included in the *liberiensis* complex ($n = 235$). ●, Lectotype of *Mastacembelus liberiensis*; ▲, syntypes of *Mastacembelus reticulatus*; ◆, holotype of *Mastacembelus laticauda*; ■, holotype and □, paratypes of *M. kakrimensis* sp. nov. and *M. liberiensis* river basin specimens: ▲, Gambia River (Senegal) (. . .); ■, Kogon River (Guinea) and Bofon River (Guinea) (---); □, Konkoure River (Guinea) (—); △, Great Scarcies and Kolente River (Sierra Leone) (Guinea) up to Moa River (Sierra Leone) (Guinea) (. . .); ○, Bendaja, Mano River (Liberia) up to Suakoko, St John River (Liberia) (. . .); ●, Cess or Nipoue River. (Liberia and Ivory Coast) (. . .). *Mastacembelus kakrimensis* sp. nov. and entire *M. liberiensis* cluster of specimens also enclosed (—). The paralectotype of *M. liberiensis* is damaged and therefore a complete datasheet for this type was unobtainable and it is not presented on this plot.

the PPF-FDS (% L_H) (Fig. 5), which is related to the meristic clines reported above.

The *M. liberiensis* Konkoure River basin populations shows only limited overlap with the Kogon or the Bofon *M. liberiensis* River basin populations (Fig. 4). The former population is highly significantly different from the Kogon River basin population and significantly different from the Bofon River basin population for the PPF-FDS (%L_H) distance (Table IV). Therefore, its present status seems to deserve further attention in the future.

No overlap is observed between the *M. kakrimensis* and the *M. liberiensis* Kogon and Bofon River Basin populations (Fig. 4). *Mastacembelus kakrimensis* is significantly different from the Bofon population of *M. liberiensis* and highly significantly different from the Kogon population for the PPF-FDS (%L_H) distance (Table IV).

There is an important overlap between the *M. kakrimensis* and *M. liberiensis* Konkoure River basin populations (Fig. 4). The PPF-FDS (%L_H) distance is not significantly different between both ($P = 0{\cdot}018974$, not significant after sequential Bonferroni correction for multiple comparison).

TABLE III. Factor loadings for the first three PC axes resulting from a PCA carried out on 26 ln-transformed morphometrics for all examined specimens included in the *liberiensis* complex ($n = 235$). The PCI is regarded as a size factor, PCII and PCIII as shape factors. The most important loadings on PCII and PCIII are in bold

	PCI	PCII	PCIII
Ln L_S	0·997034	−0·032512	−0·002486
Ln body depth	0·970418	0·071217	0·008240
Ln L_H	0·995954	−0·063932	−0·001650
Ln snout length	0·987776	−0·059503	−0·029823
Ln eye diameter	0·950673	−0·094080	−0·115656
Ln minimum interorbital distance	0·908426	0·021478	**0·403965**
Ln rostral appendage	0·950032	−0·137212	−0·057048
Ln upper jaw length	0·978426	−0·088161	0·013678
Ln post preorbital spine length	0·992945	−0·064351	0·007525
Ln postorbital length	0·994780	−0·053816	0·003467
Ln lower jaw length	0·982282	−0·074656	0·038260
Ln angle of jaw to eye	0·982701	0·003609	−0·039148
Ln post jaw angle length	0·993142	−0·060274	0·002925
Ln gill slit to pectoral-fin origin	0·928105	−0·203145	−0·029052
Ln posterior external nare to eye	0·974772	−0·069249	0·007084
Ln angle of jaws to posterior external nare	0·984175	−0·046499	−0·000315
Ln snout to first dorsal spine	0·994493	0·078730	−0·012663
Ln snout to last externally visible dorsal spine	0·997350	−0·027668	−0·002256
Ln snout to first anal spine	0·996958	−0·028216	0·000234
Ln snout to last externally visible anal spine	0·997316	−0·029892	0·002773
Ln preanal length	0·996940	−0·038267	0·004246
Ln postanal length	0·994767	−0·032656	−0·004706
Ln dorsal edge of pectoral-fin base to first dorsal spine	0·939958	**0·312391**	−0·046519
Ln ventral edge of pectoral-fin base to first dorsal spine	0·924637	**0·351892**	−0·047582
Ln posterior edge of pectoral-fin to first dorsal spine	0·710869	**0·682918**	−0·009518
Ln pectoral-fin length	0·973429	–0·108295	–0·078497
Explained variance (% of total variance)	93·5	3·1	0·8

Finally, a discriminant function analysis (DFA) was carried out on 25 morphometrics, expressed in percentages ($n = 235$). According to this analysis, three specimens (out of 235, 1·3%), including two of the 10 *M. kakrimensis* sp. nov. specimens, were incorrectly classified (20%), *i.e.* according to the analysis they are classified as belonging to *M. liberiensis*. As a result, the inter-specific discriminative power of the model is considered rather poor and therefore these results are not presented here.

In conclusion *M. liberiensis* is considered a valid species having two junior synonyms, *M. reticulatus* and *M. laticauda*. Furthermore, some of the specimens originating from the Konkoure River basin are identified as a new species, *M. kakrimensis* sp. nov. A redescription of *M. liberiensis* and a description of the new species are given below.

TABLE IV. Results of the Mann–Whitney *U* tests for the distance from the posterior edge of the pectoral-fin to origin of the first dorsal spine (PPF-FDS; as a per cent of head length) of the *liberiensis* complex specimens of the various river basins. 1. Comparison of each *Mastacembelus liberiensis* population with its most neighbouring river basin populations; 2. comparison of the Gambia and the Cess or Nipoue River basins, being the most extreme western and eastern river basins populated by Mastacembelidae specimens of the *liberiensis* complex; 3. comparison of *Mastacembelus kakrimensis* sp. nov. with the sympatric Konkoure River basin *M. liberiensis* population, and the neighbouring *M. liberiensis* river basin populations. Bold and underlined values are highly significant ($P \leq 0{\cdot}001$) after sequential Bonferroni correction for multiple comparisons. Bold and italic values are significant ($P \leq 0{\cdot}05$) after sequential Bonferroni correction for multiple comparisons. Only significant or highly significant comparisons are tabulated

		n			PPF-FDS (% L_H)
1.	Kogon	40	*v.*	Konkoure	**<u>0·000001</u>**
	Konkoure	20	*v.*	Bofon	***0·000166***
	Bofon	8			
2.	Gambia	8	*v.*	Cess or Nipoue	**<u>0·000006</u>**
3.	Kogon		*v.*	*M. kakrimensis*	**<u>0·000000</u>**
	M. kakrimensis	10	*v.*	Bofon	***0·000046***

MASTACEMBELUS LIBERIENSIS BOULENGER, 1898 (FIGS 6–8)

Mastacembelus cryptacanthus non Günther, 1867 — Büttikofer, 1890.

Mastacembelus marchei non Sauvage, 1879 — Steindachner, 1895.

Mastacembelus liberiensis Boulenger, 1898 — Boulenger, 1898, 1899, 1905, 1912, 1916; Pellegrin, 1922, 1923; Schultz, 1942; Daget & Iltis, 1965; Freihofer, 1978; Lévêque & Paugy, 1984; Travers, 1984*a*, *b*: data on *M. liberiensis* (=*M. taiaensis*) (Travers, 1992*a*).

Caecomastacembelus liberiensis (Boulenger, 1898) — Travers, 1984*b*; Travers *et al.*, 1986; Teugels *et al.*, 1987.

Aethiomastacembelus liberiensis (Boulenger, 1898) — Teugels *et al.*, 1988; Paugy *et al.*, 1990; Travers, 1992*a*, *b*; Paugy *et al.*, 1994.

Mastacembelus reticulatus Boulenger, 1911 — Boulenger, 1911, 1912, 1916; Pellegrin, 1922, 1923; Bates, 1932; Norman, 1932; Daget, 1950, 1960, 1962, 1963; Daget & Iltis, 1965; Chaytor & Williams, 1966; Williams & Chaytor, 1966; Lévêque & Paugy, 1984; Travers, 1984*a*, *b*; Paugy *et al.*, 1990; D. Chaytor, unpubl. data.

Caecomastacembelus reticulatus (Boulenger, 1911) — Travers, 1984*b*; Travers *et al.*, 1986; Travers, 1992*b*.

Mastacembelus laticauda Ahl, 1937 — Ahl, 1937; Arnold, 1952; Sterba, 1959, 1963; Daget & Iltis, 1965; Paugy *et al.*, 1990; Travers, 1992*b*.

Caecomastacembelus laticauda (Ahl, 1937) — Travers, 1984*b*; Travers *et al.*, 1986.

Type material

Due to its better state of preservation and in order to clearly define *M. liberiensis*, the smallest specimen (233 mm L_T) is designated as lectotype.

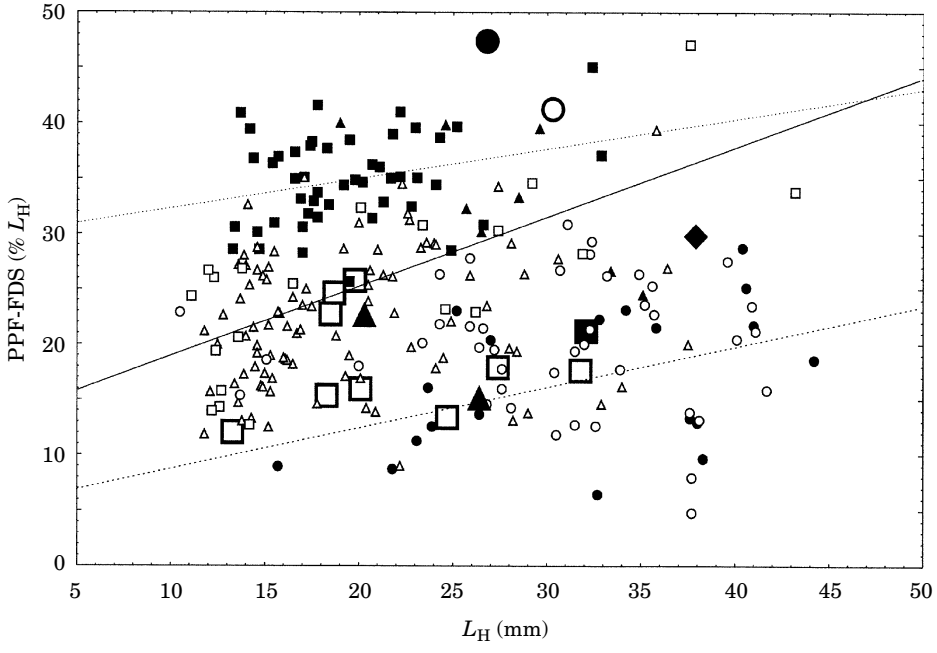

FIG. 5. Scatterplots of distance from the posterior edge of pectoral fin to the origin of first dorsal spine (as a per cent of head length, L_H) and L_H (in mm) for all examined specimens included in the *liberiensis* complex. ●, Lectotype and ○, paralectotype of *Mastacembelus liberiensis*; ▲, syntypes of *Mastacembelus reticulatus*; ◆, holotype of *Mastacembelus laticauda*; ■, holotype and □, paratypes of *Mastacembelus kakrimensis* sp. nov. and *M. liberiensis* River basin specimens: ▲, Gambia River (Senegal); ■, Kogon River (Guinea) and Bofon River (Guinea) (regression line, $y = 30{\cdot}65 + 0{\cdot}334x$: ---); □, Konkoure River (Guinea) (regression line $y = 13503 + 1{\cdot}008x$; —); △, Great Scarcies and Kolente River (Sierra Leone) (Guinea) up to Moa River (Sierra Leone) (Guinea); ○ Bendaja, Mano River (Liberia) up to Suakoko, St John River (Liberia); ●, Cess or Nipoue River (Liberia and Ivory Coast) (regression line $y = 6{\cdot}457 + 0{\cdot}497x$; ...).

Lectotype (designated in this paper): RMNH 5369a., 233 mm L_T; Liberia: Aus dem Fishermann-See nächst dem Dorfe Solymah. *Tala* ± 6°46′;N; 11°19′;W. Büttikofer, no date (see map of Büttikofer, 1890) (Loc. 15).

Paralectotype: RMNH 5369b., 287 mm L_T; same data as for lectotype.

Synonyms

Mastacembelus reticulatus Boulenger, 1911.

Syntypes: BMNH 1911.4.6:2–3., 153–192 mm L_T; Sierra Leone: exact locality not known. Donor: Liverpool School of Tropical Medicine, no date (Loc. 1).

Mastacembelus laticauda Ahl, 1937.

Holotype: ZMB 31301., 364 mm L_T; Sierra Leone: Umgebung von Freetown, Etwa 4 Kilometer landeinwärts. ± 8°30′;N; 13°15′;W. Roloff, February 1936 (Loc. 9).

Etymology

'*liberiensis*': named after the country of origin of the type material, Liberia.

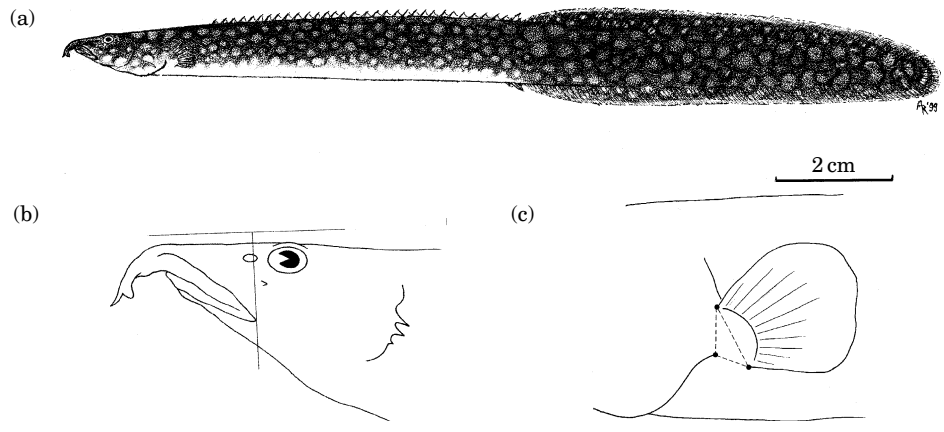

FIG. 6. *Mastacembelus liberiensis*, specimen, 336 mm L_T, 'Danané, rivière Boan, Bassin Cestos', Ivory Coast (MNHN 1979-140). (a) Lateral view, (b) position of the posterior angle of lips in relation to posterior nare and eye [vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout (right side)] and (c) detail of pectoral-fin region (right side). Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines.

'*reticulatus*': from the Latin '*reticulatus*' (net-like, netted) referring to its network colour pattern.

'*laticauda*': from the Latin '*latus*' (broad, wide) and the Latin '*cauda*' (tail) referring to the shape of the tail.

Diagnosis

Within the Upper Guinea ichthyofaunal province, *M. liberiensis* can be distinguished from *M. taiaensis* by its short postanal length [42·3–50·9 (mean 45·9) $\%L_S$ *v.* 53·1–57·9 (55·8) $\%L_S$], increasing with size, and its related low caudal

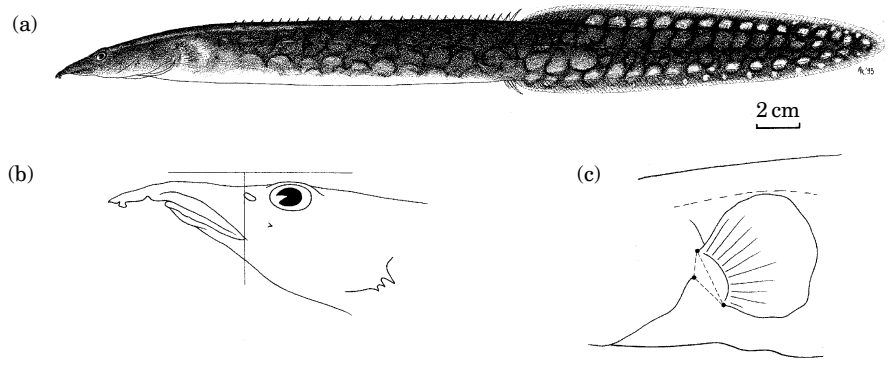

FIG. 7. *Mastacembelus liberiensis*, specimen, 190 mm L_T, 'Galekoulou riv., affl. Kakrima, bassin Konkoure, pont route Kindia-Telimele', Guinea (MRAC 92–59-P-4377). (a) Lateral view, (b) position of the posterior angle of lips in relation to posterior nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout) and (c) detail of pectoral-fin region. Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines.

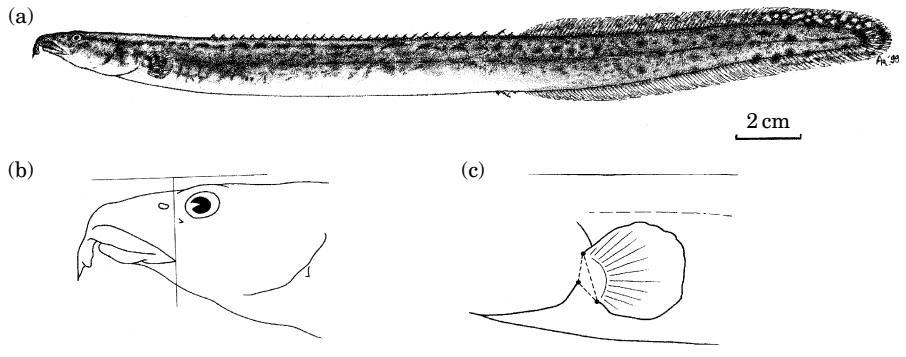

FIG. 8. *Mastacembelus liberiensis*, specimen, 262 mm L_T, 'Mako, rivière Gambie, Bassin Gambie', Senegal (MNHN 1980–1588). (a) Lateral view, (b) position of the posterior angle of lips in relation to posterior nare and eye (vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout) and (c) detail of pectoral-fin region. Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines.

vertebrae number [53–64 (median 59) *v.* 64–74 (72)]. It is distinguished from *M. nigromarginatus* by its origin of the first dorsal spine situated behind the posterior edge of the pectoral fin [4·8–47·4 (24·8)%L_H *v.* (–21·7)–0·0 (–11·8)%L_H] and its related high predorsal vertebrae number [7–11 (9) *v.* 4–6 (5)]. It is distinguished from *M. praensis* by its high dorsal spine number [27 + 1–34 + 1 (31 + 1) *v.* 23 + 1–27 + 1 (25 + 1)] and its related long distance from the anterior border of the snout to the last externally visible dorsal spine [52·6–61·5 (57·2) %L_S *v.* 46·2–52·5 (49·5) %L_S], and the similarly long (*v.* shorter, *M. praensis*) distance from the anterior border of the snout to the last externally visible anal spine, both decreasing with increasing size [53·1–61·9 (57·8) *v.* 51·8–59·3 (56·3)]. *Mastacembelus liberiensis* is most similar to *M. kakrimensis* sp. nov. but can be distinguished by the presence of preopercular spines [1L/1R (very exceptionally) up to 5L/5R (2L/2R), *v.* reduction and finally loss with increasing size in *M. kakrimensis* sp. nov. 0L/0R–2L/2R (0L/0R)], the presence of a preorbital spine [exceptionally 0L/0R, generally 1L/1R (1L/1R) *v.* reduction with increasing size in *M. kakrimensis* sp. nov.], its relatively high total vertebrae number [92–105 (99), Konkoure River basin: 100–104 (102), *v.* 90–93 (91)], and its relatively high caudal vertebrae number [53–64 (59), Konkoure River basin: 60–64 (62), *v.* 53–56 (54/55)].

Description

To illustrate the geographical variation, a representative specimen of the Cess or Nipoue (Liberia and Ivory Coast) (Fig. 6), the Konkoure (Guinea) (Fig. 7) and the Gambia (Senegal) (Fig. 8) River basins are illustrated. Selected meristics and measurements, respectively, are given in Tables V and VI.

Mastacembelus liberiensis has a blunt snout. Posterior angle of the lips situated from about below the horizontal middle of the posterior nare up to below the anterior border of the eye [Figs 6(b), 7(b) and 8(b)]. Upper corner of gill opening slightly anterior to, or below, dorsal point of pectoral-fin base, both points clearly anterior to ventral point of pectoral-fin base. Dorsal point of pectoral

TABLE V. Meristic data for the types and specimens of *Mastacembelus liberiensis*, the types of *Mastacembelus reticulatus* and the holotype of *Mastacembelus laticauda*

	Sierra Leone types *M. reticulatus*		Gambia basin, Senegal				Kogon basin, Guinea				Konkoure basin, Guinea				Bofon basin, Guinea			
	Lectotype	Paralectotype	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median
Predorsal vertebrae	**8**	**8**	9	10	8	**9**	9	11	40	**10**	8	10	20	**9**	8	10	8	**8**
Abdominal vertebrae	**40**	**40**	38	40	8	**40**	38	41	40	**40**	39	41	20	**40**	38	41	8	**39**
In-between vertebrae	**0**	**0**	0	0	8	**0**	0	+1	40	**0**	0	+1	20	**0**	0	0	8	**0**
Caudal vertebrae	**58**	**58**	55	59	8	**57**	56	61	39	**59**	60	64	20	**62**	56	60	7	**59**
Vertebrae total	**98**	**98**	95	97	8	**96–97**	95	101	39	**98**	100	104	20	**102**	96	99	7	**98**
Dorsal spines	**32 + 1**	**31 + 1**	28 + 1	31 + 1	8	**30–31**	27 + 1	30 + 1	40	**29 + 1**	29 + 1	32 + 1	20	**31 + 1**	29 + 1	30 + 1	8	**30 + 1**
Anal spines	**2 + 1**	**2 + 1**	2 + 1	2 + 1	8	**2 + 1**	2 + 1	2 + 1	40	**2 + 1**	2 + 1	2 + 1	20	**2 + 1**	2 + 1	2 + 1	8	**2 + 1**
Dorsal fin rays	**94**	**89**	84	92	8	**89–90**	82	96	38	**91**	88	101	17	**96**	86	101	7	**90**
Anal fin rays	**91**	**84**	83	92	8	**87**	82	98	38	**87**	88	100	17	**92**	95	98	7	**88**
Caudal fin rays	**10**	**10**	9	12	7	**9**	8	11	35	**9**	8	10	10	**10**	9	9	7	**9**
Preopercular spines	**2L/2R**	**2L/2R**	1L/1R	4L/3R	8	**2L/2R**	2L/2R	2L/2R	40	**2L/2R**	2L/2R	3L/3R	20	**3L/3R**	2L/2R	2L/2R	8	**2L/2R**

TABLE V. Continued

	Great Scarcies basin, Sierra Leone				Little Scarcies basin, Sierra Leone				Rokel basin, Sierra Leone				Freetown, Sierra Leone type *M. laticauda* holotype	Jong basin, Sierra Leone			
	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median		Minimum	Maximum	*n*	Median
Predorsal vertebrae	8	9	3	**9**	8	9	7	**8**	8	10	22	**9**	**9**	8	10	36	**9**
Abdominal vertebrae	39	40	3	**39**	39	40	7	**40**	39	41	22	**40–41**	**40**	39	42	36	**40–41**
In-between vertebrae	0	0	3	**0**	0	0	7	**0**	0	1	22	**0**	**0**	0	+1	36	**0**
Caudal vertebrae	58	59	3	**59**	57	59	7	**57**	58	61	22	**59**	**60**	58	63	36	**59**
Vertebrae total	97	99	3	**98**	96	99	7	**97**	98	102	22	**100**	**100**	98	103	36	**100**
Dorsal spines	30 + 1	31 + 1	3	**30 + 1**	29 + 1	32 + 1	7	**31 + 1**	29 + 1	32 + 1	22	**31 + 1**	**30 + 1**	29 + 1	33 + 1	36	**31 + 1**
Anal spines	2 + 1	2 + 1	3	**2 + 1**	2 + 1	2 + 1	7	**2 + 1**	**2 + 1**	2 + 1	22	**2 + 1**	**2 + 1**	2 + 1	2 + 1	36	**2 + 1**
Dorsal fin rays	87	93	3	**90**	84	93	7	**90**	89	99	17	**95**	**97**	88	100	26	**93**
Anal fin rays	85	92	3	**88–89**	83	90	7	**90**	89	96	17	**92**	**91**	85	95	26	**89–90**
Caudal fin rays	9	9	2	**9**	8	9	5	**8**	8	10	16	**9**	**9**	8	10	23	**9**
Preopercular spines	2L/2R	2L/2R	3	**2L/2R**	2L/2R	2L/2R	7	**2L/2R**	2L/2R	2L/2R	17	**2L/2R**	**2L/2R**	**2L/2R**	**2L/2R**	36	**2L/2R**

	Sewa basin, Sierra Leone				Waanje basin, Sierra Leone				Moa basin, Sierra Leone				Mano basin, Liberia		Solymah, Liberia types *M. liberiensis*	
	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median			Lectotype	Paralectotype
Predorsal vertebrae	7	9	12	**8**	8	10	11	**9**	8	8	6	**8**	9	9	**10**	**9**
Abdominal vertebrae	37	41	12	**40**	39	40	11	**40**	38	39	6	**39**	42	40	**39**	**39**
In-between vertebrae	0	0	12	**0**	0	0	11	**0**	0	0	5	**0**	0	0	**0**	**0**
Caudal vertebrae	55	60	12	**59**	56	58	11	**57**	53	58	5	**56**	60	58	**56**	**54**
Vertebrae total	94	100	12	**98**	95	98	11	**97**	92	96	5	**95**	99	98	**95**	**93**
Dorsal spines	29 + 1	33 + 1	12	**32–33**	29 + 1	32 + 1	11	**30 + 1**	30 + 1	**31 + 1**	6	**31 + 1**	32 + 1	31 + 1	**29 + 1**	**29 + 1**
Anal spines	2 + 1	2 + 1	12	**2 + 1**	2 + 1	2 + 1	11	**2 + 1**	2 + 1	2 + 1	6	**2 + 1**	2 + 1	**2 + 1**	**2 + 1**	**2 + 1**
Dorsal fin rays	82	91	10	**86–87**	83	90	11	**88**	82	87	5	**85**	85	85	**82**	**83**
Anal fin rays	82	93	10	**88–89**	80	90	11	**85**	82	87	5	**84**	83	83	**81**	**79**
Caudal fin rays	8	10	8	**9**	8	11	10	**9**	9	9	5	**9**	9	9	**8**	**8**
Preopercular spines	**2L/2R**	**3L/3R**	12	**2L/2R**	1L/2R	2L/2R	11	**2L/2R**	2L/2R	2L/2R	6	**2L/2R**	2L/2R	2L/2R	**2L/2R**	**3L?/3R**

TABLE V. Continued

	St Paul basin, Liberia				Borlor basin, Liberia				St Johns basin, Liberia				Cess or Nipoue basin, Ivory Coast				All specimens examined			
	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median	Minimum	Maximum	*n*	Median
Predorsal vertebrae	7	9	25	**8**	7	8	5	**8**	8	9	7	**8**	7	8	19	**7**	7	11	236	**9**
Abdominal vertebrae	39	41	25	**40**	39	41	5	**39**	39	40	7	**39**	39	41	19	**40**	37	42	236	**40**
In-between vertebrae	0	+ 1	25	**+1**	0	0	5	**0**	0	0	7	**0**	0	+2	19	**+1**	0	+2	234	**0**
Caudal vertebrae	55	61	25	**59**	55	61	5	**57**	57	59	7	**57**	59	64	18	**60–61**	53	64	232	**59**
Vertebrae total	95	102	25	**99**	95	100	5	**96**	95	98	7	**97**	99	105	18	**101**	92	105	232	**99**
Dorsal spines	29 + 1	33 + 1	25	**32 + 1**	31 + 1	32 + 1	5	**31 + 1**	31 + 1	32 + 1	7	**32 + 1**	30 + 1	34 + 1	19	**32 + 1**	27 + 1	34 + 1	236	**31 + 1**
Anal spines	2 + 1	2 + 1	25	**2 + 1**	2 + 1	2 + 1	5	**2 + 1**	2 + 1	2 + 1	7	**2 + 1**	2 + 1	2 + 1	19	**2 + 1**	2 + 1	2 + 1	236	**2 + 1**
Dorsal fin rays	82	94	25	**89**	82	89	5	**87**	82	90	7	**85**	90	97	18	**93**	82	101	210	**90**
Anal fin rays	81	94	25	**89**	82	88	5	**85**	81	87	7	**85**	87	96	18	**90**	79	100	210	**88/89**
Caudal fin rays	7	9	25	**8**	8	9	5	**9**	8	8	7	**8**	7	10	18	**8**	6	12	189	**9**
Preopercular spines	2L/2R	3L/3R	25	**2L/2R**	2L/2R	2L/2R	5	**2L/2R**	2L/2R	3L/3R	7	**2L/2R**	3L/3R	5L/5R	19	**4L/4R**	1L/1R	5L/5R	236	**2L/2R**

TABLE VI. Morphometric data for the types and specimens of *Mastacembelus liberiensis*, the types of *Mastacembelus reticulatus* and the holotype of *Mastacembelus laticauda*

	Sierra Leone types *M. reticulatus*		Freetown, Sierra Leone type *M. reticulatus*	Solymah, Liberia types *M. liberiensis*		All specimens examined				
	Lectotype	Paralectotype	Holotype	Lectotype	Paralectotype	Minimum	Maximum	*n*	Mean	S.D.
Standard length, L_S (mm)	**185**	**148**	**350**	**224**	**277**	67	368	236	**177**	77·5
As %L_H										
Snout length	**29·2**	**27·6**	**27·7**	**27·2**	**26·4**	20·8	31·7	**236**	**26·7**	1·7
Eye diameter	**11·0**	**11·3**	**8·4**	**12·3**	**9·6**	7·9	17·1	236	**11·3**	1·7
Minimum interorbital distance	**5·3**	**4·4**	**5·0**	**5·6**	**5·9**	1·4	6·9	236	**4·8**	1·0
Rostral appendage length	**15·9**	**18·7**	**17·9**	**15·7**	**13·9**	6·4	22·0	236	**13·9**	3·0
Postorbital length	**63·3**	**66·0**	**68·1**	**63·4**	**65·4**	59·3	70·3	236	**64·8**	1·7
Angle of jaws to dorsal edge of pectoral fin base	**73·5**	**76·4**	**76·5**	**72·0**	**72·0**	65·5	82·9	236	**73·8**	2·5
Posterior tip of preorbital spine to dorsal edge of pectoral fin base	**72·0**	**73·4**	**76·3**	**68·3**		65·1	79·1	229	**71·6**	2·3
Upper tip of gill slit to pectoral fin origin	**7·6**	**8·4**	**8·4**	**10·8**	**13·2**	5·4	13·4	236	**13·2**	1·5
Upper jaw length	**25·8**	**21·2**	**25·6**	**25·4**		19·6	30·6	235	**25·2**	2·0
Lower jaw length	**19·3**	**16·3**	**23·0**	**20·5**	**23·1**	15·8	25·4	236	**20·2**	1·7
Pectoral-fin length	**22·7**	**23·2**	**28·0**	**24·3**	**21·5**	18·1	30·2	235	**24·7**	2·1
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	**43·6**	**46·3**	**64·6**	**70·5**	**67·0**	35·0	75·6	236	**54·1**	8·7
Ventral edge of pectoral fin base to anterior base of first dorsal spine	**36·4**	**42·4**	**56·2**	**62·3**	**63·4**	29·3	68·2	236	**48·0**	8·4
Posterior edge pectoral fin to anterior base of first dorsal spine	**15·2**	**22·7**	**29·8**	**47·4**	**41·3**	4·8	47·4	235	**24·8**	8·6
Angle of jaws to eye	**14·0**	**11·8**	**14·8**	**12·7**	**14·2**	9·9	15·6	235	**12·8**	1·1
Angle of jaws to posterior external nare	**13·3**	**12·3**	**17·2**	**14·2**	**16·5**	10·6	17·6	236	**13·8**	1·2
Anterior border posterior external nare to eye	**6·8**	**5·9**	**7·4**	**7·1**	**7·6**	4·8	8·4	236	**6·8**	0·7
As %L_S										
Head length	**14·3**	**13·7**	**10·8**	**12·0**	**10·9**	10·8	16·9	236	**13·5**	1·2
Snout to first dorsal spine	**20·3**	**21·3**	**17·6**	**20·5**	**18·5**	16·6	25·1	236	**20·7**	1·9
Snout to last externally visible dorsal spine	**58·9**	**58·2**	**52·7**	**56·5**	**56·3**	52·6	61·5	235	**57·2**	1·8
Snout to first anal spine	**56·3**	**57·0**	**51·0**	**53·6**	**51·9**	49·6	58·5	235	**54·4**	1·7
Snout to last externally visible anal spine	**59·8**	**59·6**	**54·8**	**57·0**	**55·1**	53·1	61·9	235	**57·8**	1·9
Preanal length	**54·2**	**54·9**	**49·7**	**52·2**	**50·6**	48·5	56·8	235	**52·6**	1·6
Postanal length	**45·4**	**45·7**	**49·5**	**46·0**	**46·3**	42·3	50·9	235	**45·9**	1·8
Body depth at anus	**8·0**	**8·3**	**6·1**	**7·4**	**7·9**	6·0	9·5	235	**7·7**	0·8

fin base situated largely above upper corner of gill opening. Gill opening closed for about half or entire vertical distance between the dorsal and ventral edge of the pectoral-fin base [Figs 6(c), 7(c) and 8(c)]. The lateral line is yellowish-white and can be continuous in the anterior part from the head to up to one pectoral-fin length beyond the posterior edge of the pectoral fin. The remaining, more posterior part of the lateral line is always clearly discontinuous.

Preanal length negatively allometric, postanal length positively allometric, latter smaller than former in specimens up to *c*. 300 mm L_S becoming of comparable size in large sized specimens. Distance from anterior border of snout to last externally visible dorsal spine (S-LDS) negatively allometric and comparable to distance from anterior border of snout to last externally visible anal spine (S-LAS) negatively allometric. S-LAS minus S-LDS, (−14·5)–21·4 (mean 4·1) $\%L_S$, expressing a comparable position of the origin of the soft dorsal fin compared to origin of the soft anal fin.

A relatively high number of dorsal spines, with spines increasing in size from first to last. One additional very short spine hidden under the skin and situated anterior to the base of the first dorsal-fin ray. Two externally visible anal spines, the first smaller than the second. One additional very short spine, hidden under the skin, and situated anterior to the base of the first anal-fin ray. First anal pterygiophore well developed, supporting first and second anal spines, and the only pterygiophore supporting two spines.

The neural spine supporting the pterygiophore of the last externally visible dorsal spine, and the haemal spine supporting the pterygiophore of the first anal spine are situated on either the same or, as in most of the specimens, on adjacent vertebrae. In the latter case, the vertebra bearing the neural spine supporting the pterygiophore of the last externally visible dorsal spine is always situated anterior to the vertebra whose haemal spine supports the first anal spine.

The preopercular spine number varies from 1L/1R (Gambia basin, Senegal), up to 5L/5R (Cess or Nipoue basin, Liberia and Ivory Coast) with a median of 2L/2R. Note that the extreme preopercular spine numbers (minimum and maximum) were only encountered in the western *v*. eastern border (Senegal *v*. Liberia and Ivory Coast) populations of the species. Further, the preopercular spines may be hidden under the skin.

There is always a small preorbital spine which, especially in larger specimens, is often hidden under the skin. This spine is reduced, *i.e*. shorter and blunt, in the largest specimens examined.

Maximal observed L_S: 368 mm (MRAC 73-10-P-7333-7338: 383 mm L_T).

Colouration (in alcohol): within *M. liberiensis* an important, geographically related east-west oriented, intraspecific colour pattern variation has been observed. The geographical distribution of the colour patterns is illustrated in Fig. 9.

The western populations [Senegal or Guinea, Figs 9 (number 2) and 8], excluding the Konkoure River basin specimens are characterized by a more uniform colour pattern with a scarcely developed reticulate pattern on the lower sides.

The eastern populations [Liberia, Figs 9 (number 19) and 6], are characterized by the presence of a well-developed dark brown network enclosing lighter brown, yellowish-white, spots.

In between both populations, are the Sierra-Leone populations for which, based on the present data, there seems to be no such clear consistency between the geographical origin of the specimens and their colour pattern. Indeed, there are some apparent inconsistencies in the colour pattern change as for instance the largest Moa River basin specimen [Fig. 9 (number 13)] has clearly a more uniform colour pattern whereas, further west, the large sample of Waanje River basin specimens have a network colour pattern [Fig. 9 (number 12)]. Further, the Sewa, Tage and Bagbe River basin specimens have again a more uniform colour

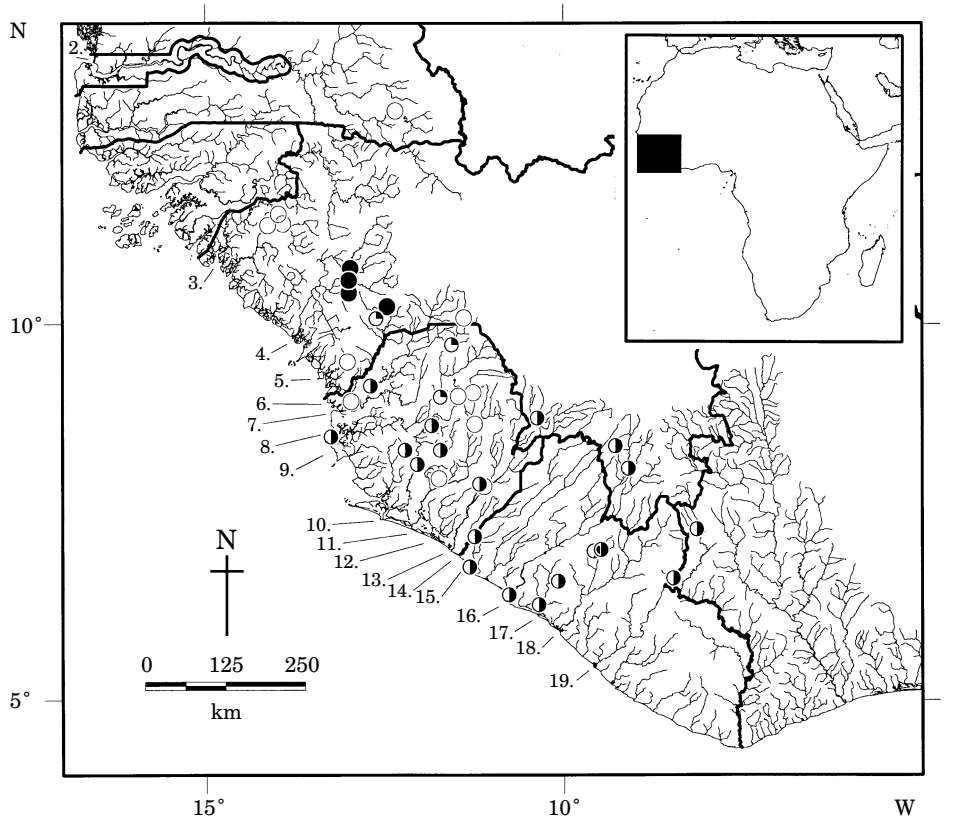

FIG. 9. Geographical distribution of the two major colour patterns recognized within *Mastacembelus liberiensis*. ○, uniform colour pattern, ◑, network colour pattern, ◔, juvenile and intermediate colour patterns and ●, unique colour pattern of the Konkoure River basin specimens. The type locality of *Mastacembelus reticulatus* is not illustrated as the exact origin of its type material is not known (Sierra Leone). 2, Gambia River (Senegal); 3, Kogon River (Guinea); 4, Kakrima and Konkoure Rivers (Guinea) (type locality of *Mastacembelus kakrimensis* sp. nov.); 5, Bofon River (Guinea); 6, Great Scarcies and Kolente Rivers (Sierra Leone) (Guinea); 7, Mongo and Little Scarcies Rivers (Sierra Leone) (Guinea); 8, Rokel River (Sierra Leone); 9, Freetown (Sierra Leone) (type locality of *Mastacembelus laticauda*); 10, Jong, Taia, Sherbo and Pampana Rivers (Sierra Leone); 11, Sewa, Tabe and Bagbe Rivers (Sierra Leone); 12, Waanje River (Sierra Leone); 13, Moa River (Sierra Leone) (Guinea); 14, Bendaja, Mano River (Liberia); 15, Solymah (Liberia) (type locality of *M. liberiensis*); 16, St Paul River, Bromley (Liberia) (Guinea); 17, Harbel and Gibi Mountain (Liberia); 18, Suakoko, St John River (Liberia); 19, Cess or Nipoue River (Liberia and Ivory Coast).

pattern [Fig. 9 (number 11)] whereas, further west, the Jong, Taia, Sherbo and Pampana River basin specimens have again a network colour pattern [Fig. 9 (number 10)].

As a result, a border zone or restricted contact zone between the western and eastern colour patterns could not be located or delimited. Especially, additional medium and large-sized specimens are needed to obtain representative colour pattern descriptions for the different West African coastal river basins, as the colour pattern of these size classes seems to be the most differentiated.

In addition, important size related colour pattern changes have been noted. In small specimens the unpaired fins are white in overall appearance whereas they become dark brown in overall appearance in large specimens. Nevertheless, independent of their locality-related colour pattern characteristics, a white outer margin is still present in large-sized specimens. Moreover, in general, the colour pattern of the small specimens is characterized by a more or less well delimited dark brown lateral band with a highly variable number of white or light brown spots and, sometimes, by the presence of a more or less well developed dark brown network on the tail or the entire body.

A detailed colour pattern description of the examined Konkoure River basin specimens is given below to allow comparison with the sympatric *M. kakrimensis* sp. nov. Overall background colour is uniformly brown (see Fig. 7 for an illustrated specimen). Dorsal, caudal and anal fins are predominantly brownish or black with a small, white outer edge. Specimens $< c.$ 160 mm L_T with more basal part of fins black with a series of white spots which are partly situated on the tail. Specimens $> c.$ 210 mm L_T with dorsal, caudal and anal fins mostly uniformly coloured with a small white outer margin and in some specimens a few small white, yellowish, round spots on basal part of caudal fin region. Specimens between *c.* 120 and 220 mm L_T have an intermediate colour pattern characterized by a fading of the white spots. Pectoral fins are white and mostly without spots. Ventral surface uniformly white, yellowish and sides and tail region marked by a large open reticulate pattern. Open reticulate pattern virtually absent in largest specimens examined (314 and 385 mm L_T). Lips white with a variable part of brown colouration. Rostral appendage also brown. Lateral surface of head beneath eye also marked by a dark brown, open reticulate pattern.

Smallest specimen examined (MRAC 92-059-P-4241, 77 mm L_T) with a reticulate pattern on tail region, but practically absent on sides. Dorsal, caudal and anal fins with a white outer border and a dark brown basal part with a series of white, yellowish spots. Dorsal region lighter brown compared to sides and both well edged from each other in colouration. This specimen was identified as *M. liberiensis* based on its colour pattern affinities with other small sized *M. liberiensis* specimens also originating from the Konkoure River basin, in despite of its low total number of vertebrae (88; this specimen is suspected to be teratological based on the X-ray study revealing a regenerated caudal skeleton). The presence of two well developed preopercular spines does not justify its identification as these are often also present in small sized *M. kakrimensis* sp. nov. (see below). Further investigation, especially on the size related

colour pattern changes, is needed to determine the identification of this supposed teratological specimen.

Distribution (see also Fig. 9)

Mastacembelus liberiensis is present from the Gambia River basin (Senegal) in the west, to the Cess or Nipoue River basin (Liberia and Ivory Coast) in the east, and is endemic to the western part of the discontinuous Upper Guinea ichthyofaunal province as defined by Roberts (1975) and Greenwood (1983). This province, as defined by Roberts (1975), includes most coastal river basins from the Senegal (Senegal), in the west, up to the Volta River basin (Ghana) in the east. Indeed, the Sassandra, Bandama and Comoe River basins were excluded resulting in a clearly discontinuous province. The Sassandra-Bandama-Comoe region was referred to as the Baoule V-gap by Howes & Teugels (1989).

Teugels *et al.* (1988), Travers (1992*b*) and Paugy *et al.* (1994) also mentioned *M. liberiensis* from the Cavally River basin (Ivory Coast), based on material originating from the Cess or Nipoue River basin. As a result, *M. liberiensis* is restricted to the western side of the Baoule-V Gap (Comoe-Bandama-Sassandra region) as defined by Howes & Teugels (1989).

The distribution of *M. liberiensis* also corresponds quite well with the Upper Guinean region as defined by Hugueny & Lévêque (1994) and including all coastal rivers basins from the Tomine River basin (Guinea), in the west, to the St John River basin (Liberia), in the east. It also corresponds quite well with the 'Région de haute Guinée' or 'région guinéenne occidentale' as defined by Paugy *et al.* (1994), including all coastal river basins from the Geba River basin (Guinea), in the west, to the St John River basin (Liberia), in the east. Nevertheless, in both cases, the presence of *M. liberiensis* in the Gambia River basin (Senegal) and the Cess or Nipoue River basin (Liberia and Ivory Coast) crosses the borders of the region.

Generic status

Boulenger (1898) described *M. liberiensis* as a new member of the genus *Mastacembelus*. Travers (1984*b*) placed *M. liberiensis* in the genus *Caecomastacembelus*. Teugels *et al.* (1988) first included *M. liberiensis* in the genus *Aethiomastacembelus* based on the recommendation of R.A. Travers (unpubl. comm.). This placement was followed by Paugy *et al.* (1990). Travers (1992*a*, *b*) later also included *M. liberiensis* in the genus *Aethiomastacembelus* but the reasons for this reassignment have never been stated. Vreven & Teugels (1996) revealed several inaccuracies and contradictions between the type material and the diagnosis of both African genera.

Vreven (2005) placed *Caecomastacembelus* and *Aethiomastacembelus* in synonymy with *Mastacembelus*. Nevertheless, the generic level systematics of the, African, Mastacembelidae needs further, thorough revision and, until such time, *M. liberiensis* is here placed in the genus *Mastacembelus*.

Travers (1992*a*) considered *M. liberiensis* a member of the *Mastacembelus paucispinis* (Boulenger, 1899) species-complex, which is characterized by an anterior development of the soft dorsal fin, extending well beyond the level of the anterior end of the soft anal fin. Associated with this anterior development is a low number of dorsal spines and a high number of dorsal fin rays. Six other

species were also considered part of this species-complex: *M. nigromarginatus*, *M. praensis*, *M. sexdecimspinus* (Roberts & Travers, 1986), *M. sanagali* Thys van den Audenaerde, 1972, *M. paucispinis* and another species not named by Travers (1992*a*).

Within this species-complex Travers (1992*a*) recognized a subgroup of three West African species, *M. liberiensis*, *M. nigromarginatus* and *M. praensis* which are characterized by their posterior opercular gill opening sealed from its dorsal edge for half to entire length.

Travers (1992*a*) stated that the anterior development of the dorsal fin in *M. praensis* represents a more derived condition of this character than found in *M. sanagali*, *M. nigromarginatus* or *M. liberiensis*. This is revealed by comparison of the meristic counts of dorsal fin rays and spines of these species (*M. praensis, M. nigromarginatus* and *M. liberiensis*; Travers, 1992*a*) with those listed for *M. sanagali* by Roberts & Travers (1986). The dorsal fin in these species, however, is shorter than in *M. sexdecimspinus* or *M. paucispinis*.

The phylogenetic significance of the extended dorsal fin character was discussed by Roberts & Travers (1986). Their hypothesis that it may be viewed from the least derived (*i.e.* 75–97 dorsal fin rays in *M. liberiensis*) to the most derived (*i.e.* 107–127 dorsal fin rays in *M. paucispinis*) condition as an apomorphic sequence reflecting the close phylogenetic affinities of these species can also accommodate *M. praensis* (89–103 dorsal rays). From the meristic evidence available, the number of dorsal rays in *M. praensis* appears to be somewhat intermediate between *M. sanagali* (91–100) and *M. sexdecimspinus* (112–125). The figures for two other associated characters support this hypothesis (predorsal vertebrae number and number of vertebrae between penultimate dorsal and anal spines supporting pterygiophores; Travers, 1992*a*; Roberts & Travers, 1986).

The inclusion of *M. liberiensis* (and the meristically and morphometically similar and seemingly closely related *M. kakrimensis* sp. nov.) within the *M. paucispinis* species-complex, as proposed by Roberts & Travers (1986) and Travers (1992*a*), is rejected. This exclusion is motivated by the fact that for the difference between the dorsal and anal soft fin ray numbers in *M. liberiensis* there may be an excess in dorsal or anal soft fin rays, depending the specimens examined. Instead, in *M. nigromarginatus* and *M. praensis* there is always an excess in dorsal soft fin rays.

Further, *M. liberiensis* has a lower in-between vertebrae number (0 up to +2) when compared to *M. nigromarginatus* and *M. praensis* (+3 up to +8) (Travers, 1992*a*, *b*), where the in-between vertebral number is defined as the number of vertebrae separating the neural spine supporting pterygiophore of the last externally visible dorsal spine and the haemal spine supporting pterygiophore of first anal spine. This is, as mentioned above, related to the fact that in *M. liberiensis* the origin of the soft dorsal and anal fins are situated 'approximately' at the same level, *cf. M. nigromarginatus* and *M. praensis* where the origin of the dorsal fin is clearly anterior compared to the origin of the anal fin.

Furthermore, Travers' (1992*a*) opinion that the number of predorsal vertebrae, as an associated character, supports inclusion of *M. liberiensis* within the *M. paucispinis* complex is not supported. Instead, *M. liberiensis* has a higher number of predorsal vertebrae when compared to the other species in the

M. paucispinis species-complex (Roberts & Travers, 1986; Travers, 1992*a*, *b*). This is, as mentioned above, related to a position of the origin of the first dorsal spine which is always situated posterior to the posterior edge of the pectoral fin in *M. liberiensis*, *cf. M. nigromarginatus* and *M. praensis* where the origin of the first dorsal spine is anterior to, above or just posterior to the posterior edge of the pectoral fin. The variation in predorsal vertebral numbers is probably not associated with the anterior extension of the dorsal fin.

Finally, *M. liberiensis* seems, based on the presented meristic and morphometric evidence, to be most closely related to and might well be the sister-species of *M. kakrimensis* sp. nov. with which it occurs sympatrically in the Konkoure River basin (Guinea).

Biology and ecology

Chaytor & Williams (1966) reported that the specimens (*M. reticulatus* = *M. liberiensis*) collected at Hastings on the Freetown Peninsula were taken from the river bottom where they lay buried in the mud during the day. They also mentioned the presence of 'hordes' of larval nematodes and larval cestodes derived from Crustacea on which they feed. A small specimen of 75 mm L_S was taken in the Jong River basin (Sierra Leone), by D. Chaytor (unpubl. data) in early November. D. Chaytor (unpubl. data) also stated that *M. reticulatus* (=*M. liberiensis*) breeds at the early rains [April and May (long rainy season) and October and November (short rainy season)].

Other specimens examined

For samples with more than one specimen and without separate numbering the exact number is provided. All lengths are L_T. For location (Loc.) see Fig. 9.

Senegal: MNHN 1980.1588., $n = 8$, 139–284 mm; *Mako*, rivière Gambie, bassin Gambie (±12°52′;N; 12°21′;W). (Loc. 2).

Guinea: MNHN 1960–118., 259 mm; *Seredou*, bassin Saint Paul (±8°23′;N; 9°17′ W). (Loc. 16). MNHN 1986–270., 93 mm; rivière Diani, bassin Saint Paul (*N′1;Zébéla* ± 8°05′;N; 9°06′;W). (Loc. 16). MNHN 1986–271., 113 mm; *Nongoa*, rivière Makona, bassin Moa (±8°45′;N; 10°22′;W). (Loc. 13). MNHN 1986–713., $n = 2$, 113–116 mm; *Kolente*, rivière Kolente, bassin Kolente (±10°06′;N; 12°37′;W). (Loc. 6). MNHN 1986–714., 90 mm; *Kasseri*, rivière Kakrima, bassin Konkoure (±10°16′;N; 12°28′;W). (Loc. 4). MNHN 1991–253., 259 mm; *Konkoure*, rivière Konkoure, bassin Konkoure (±10°27′;N; 13°00′;W). (Loc. 4). MNHN 1991–254., $n = 4$, 147–214 mm; *Marela*, rivière Mongo, bassin Pte Scarcies (±10°07′;N; 11°24′;W). (Loc.7). MRAC 92-59-P-4226-233., 94–296 mm; Kambo riv., affl. Bofon, bassin Forecariah, au Gué de Franciga (±9°32′;N; 13°01′;W). (Loc. 5). MRAC 92-59-P-4241., 77 mm; Kola riv., affl. Kakrima, bassin Konkoure, à ± 2 km de Kaba (±10°47′;N; 12°59′;W). MRAC 92-59-P-4242-250., 143–220 mm; Ndyarendi, riv. Kogon (±11°22′;N; 13°55′;W). (Loc. 3). MRAC 92-59-P-4251-331., 95–204 mm; Kogon, riv. Kogon (±11°22′;N; 13°55′;W). (Loc. 3). MRAC 92-59-P-4332., 290 mm; Pabole, affl. Kogon (±11°21′;N; 14°08′;W). (Loc. 3). MRAC 92-59-P-4333-375., 90–184 mm; Samba Sobe, riv. Kogon (±11°30′;N; 13°59′;W). (Loc. 3). MRAC 92-59-P-4377., 190 mm; Galekoulou riv., affl. Kakrima, bassin Konkoure, pont route Kindia-Telimele (±10°37′;N; 13°00′;W). (Loc. 4). MRAC 92-59-P-4378-4381.,

87–159 mm; MRAC 92-59-P-4382-391., 76–372 mm; Kola riv., affl. Kakrima, bassin Konkoure, à ± 2 km de Kaba (±10°47′;N; 12°59′;W). (Loc. 4). MRAC 93-60-P-34-36., 222–314 mm; Konkouré riv., à Konkouré (±10°27′;N; 13°00′;W). (Loc. 4).

Sierra Leone: BMNH 1915.5.27:26., 138 mm; *Victoria* (±7°39′;N; 12°10′;W; 7°54′;N; 12°54′;W or 7°29′;N; 11°44′;W). BMNH 1932.5.18:105–106., 265 mm; Tributary of Bagbwe R. (*Bagbe* ± 8°42′;N; 11°15′;W) (one of both specimens cleared and stained, not seen). (Loc. 11). BMNH 1958.9.18:287., 267 mm; Mandu (± ?). BMNH 1976.11.12: 193–194., 168–208 mm; Mayombe (±8°10′;N; 12°26′;W). BMNH 1981.6.19:214., 105 mm; River Tabé, above Bumpe (± ?). BMNH 1985.6.12:113., 130 mm; *Yele*, R. Taya (±8°25′;N; 11°50′;W/*Taia River*? = Jong River ± 7°32′;N; 12°23′;W). MNHN 1990–104., $n = 15$, 77–124 mm; MNHN 1991–0681., $n = 4$, 100–218 mm; MNHN 1992-0705., $n = 7$, 105–197 mm; *Bumbuna*, rivière Rokel/Seli, Bassin Rokel/Seli (±9°03′;N; 11°44′;W). (Loc. 8). MNHN 1990–105., $n = 7$, 107–331 mm; *Yfin*, rivière Bagbe, Bassin Serwa (±9°07′;N; 11°16′;W). (Loc. 11). MNHN 1990–436., $n = 6$, 92–153 mm; MNHN 1990–437., $n = 2$, 97–106 mm; MNHN 1991–0682., $n = 13$, 69–218 mm; MNHN 1992-0706., $n = 4$, 93–178 mm; *Matotaka*, rivière Pampana, bassin Jong (±8°39′;N; 11°51′;W). (Loc. 10). MNHN 1990–438., $n = 2$, 108–125 mm; *Moussaia*, rivière Mongo, bassin Kabala (±9°45′;N; 11°34′;W). (Loc. 7). MNHN 1990–439., 349 mm; *Katiri*, rivière Kaba, bassin Little Scaries (±9°11′;N; 12°42′;W). (Loc. 7). MNHN 1990–440., 253 mm; *Bendugu*, rivière Pampana, bassin Pampana (±9°04′;N; 11°29′;W). (Loc. 10). MNHN 1991–0683., $n = 19$, 97–255 mm; *Mongheri*, rivière Teye, bassin Jong (±8°19′;N; 11°44′;W). (Loc. 10). MRAC 73-10-P-7339-7342., 83–131 mm; *Kasewe* Forest, marigots de la reserve forestière (±8°19′;N; 12°13′;W). (Loc. 10). MRAC 73-10-P-7343., 295 mm; *Rokupr*, bras de la riv. Great Scarcies (±9°00′;N; 12°58′;W). (Loc. 6). MRAC 73-10-P-7344-7349., 97–155 mm; *Foya*, marigots at marais, Basin of River Taja (±8°08′;N; 12°03′;W). (Loc. 10). MRAC 73-10-P-7350-7352., 152–188 mm; MRAC 73-10-P-7353., 91 mm; MRAC 73-10-P-7354-7360., 181–236 mm; *Towahun-Tangahun*, ±12 km. SO de Kenema, marigots trib. sup. de la riv. Waanje (±7°52′;N; 11°11′;W). (Loc. 12). MRAC 73-10-P-7361., 170 mm; *Majihun*, ruiseau tributaire de la riv. Moa (±7°52′;N; 11°07′;W). (Loc. 13). USNM 288838., $n = 2$, 109–120 mm; Sewe River, at Godoma, 7 miles south of *Bo* (±7°58′;N; 11°45′;W). (Loc. 11). USNM 288840., $n = 3$, 67–121 mm; *Bo*, at Christ the King College, Pools located on grounds (±7°58′;N; 11°45′;W). (Loc. 11). USNM 319493., 229 mm; Found preserved with no data at Bo government school (*Bo*? ± 7°58′;N; 11°45′;W). (Loc. 11).

Liberia: MRAC 73-10-P-7362., 307 mm; *Suakoko* (±6°59′;N; 9°35′;W). (Loc. 18). USNM 114768., $n = 3$, 256–304 mm; North of central experiment station, *Suakoko*, Gbeyar-Yar Creek (±6°59′;N; 9°35′;W). (Loc. 18). USNM 118749., $n = 2$, 272–275 mm; Mountain stream *Gibi Mountain*, Si Mountain (±6°35′;N; 10°05′;W). (Loc. 17). USNM 118750., $n = 3$, 70–310 mm; *Harbel* (±6°16′;N; 10°21′;W). (Loc. 17). USNM 118751., $n = 6$, 99–222 mm; *Bendaja* (±7°10′;N; 11°15′;W). (Loc. 14). USNM 118752., $n = 23$, 151–356 mm; *Bromley* (±6°24′;N; 10°46′;W). (Loc. 16). USNM 193855., $n = 3$, 196– 354 mm; *Gbarnga* district, streams and tributaries to St Johns River, fish trap baited with Cassava root and palm nuts, all seasons (±7°00′;N; 9°29′;W). (Loc. 18).

Ivory Coast: MRAC 73-10-P-7332., 294 mm; MRAC 73-10-P-7333-7338., 265–383 mm; *Toyebli*, riv. Cess (±6°37′;N; 8°29′;W). (Loc. 19). MNHN 1979 140., $n = 5$, 216–380 mm; MNHN 1979–141., $n = 5$, 104–193 mm; *Danané*, rivière Boan, bassin Cestos (±7°16′;N; 8°09′;W). (Loc. 19). MHNB 4490., 209 mm; MHNB 4491., 225 mm; *Danané* (±7°16′;N; 8°09′;W). (Loc. 19).

MASTACEMBELUS KAKRIMENSIS SP. NOV. (FIG. 10)

Mastacembelus flavomarginatus non Boulenger, 1898 — Daget, 1962, 1963.
Mastacembelus liberiensis non Boulenger, 1898 — Travers, 1992*a* (in part); Travers, 1992*b* (in part); Paugy *et al.*, 1994 (in part).

Type material

Holotype: MRAC 92-59-P-4234., 238 mm L_T; Guinea: Galekoulou riv., affl. Kakrima, bassin Konkoure, pont route Kindia-Telimele, ±10°37′;N; 13°00′;W. G. Teugels, B. Hugueny, M. Pouilly, B. Samoura, Magassouba and Camara, 27 March 1992. (Loc. 4).

Paratypes: MRAC 92-59-P-4235-240., 133–248 mm L_T; same data as for holotype. (Loc. 4). MNHN 1961–814 (formerly: Lab. d'Hydr. de Diafarabé 59–103), 153 mm L_T; Guinea: Rivière *Kakrima*, bassin Konkouré, ±10°30′;N; 12°58′;W. J. Daget. (Loc. 4). MNHN 1991–252., $n = 2$, 92–130 mm L_T; Guinea: Baraya, rivière Salale, bassin Konkouré, quelques kilometres avant *Konkouré* sur

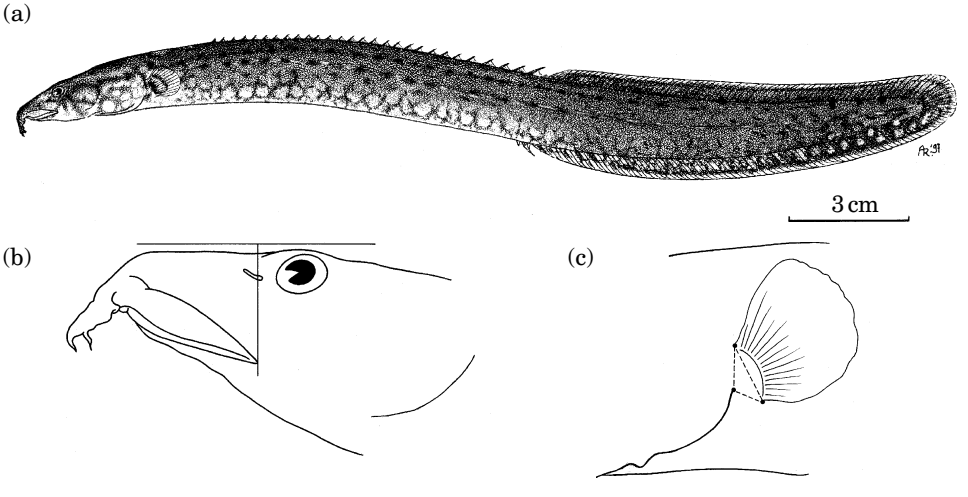

FIG. 10. *Mastacembelus kakrimensis* sp. nov., holotype, 238 mm L_T, from 'Galekoulou riv., affl. Kakrima, bassin Konkoure, pont route Kindia-Telimele', Guinea (MRAC 92–59-P-4234). (a) Lateral view, (b) position of the posterior angle of lips in relation to posterior nare and eye [vertical line is perpendicular to a horizontal line parallel with the upper surface of the snout (right side)] and (c) detail of pectoral-fin region. Upper tip of gill slit, dorsal edge of pectoral-fin base and ventral edge of pectoral-fin base are connected by dashed lines.

la route de Kindia à Telimele, ±10°27′;N; 13°00′;W. G. Teugels, 14 May 1987. (Loc. 4).

J. Daget (pers. comm.) confirmed that the specimen mentioned by Daget (1962) and referred to as *M. flavomarginatus*, and the specimen presently housed in the MNHN (MNHN 1961–814) are one and the same. The collection of the Laboratoire d'Hydrobiologie de Diafarabé (Mali) was transferred to the MNHN, in 1961, when the laboratory was closed following the independence of Mali. Daget (1962) gave the following more detailed collection data: ' ... (Daget) ruisseau affluent de la Kakrima, près du pont de la route Kindia-Télimélé, 14/2/1958.'

Etymology

'*kakrimensis*': named after the Kakrima River a major tributary of the Konkoure River basin (Guinea), 'type locality' of the new species.

Historical note

Mastacembelus kakrimensis sp. nov. has been misidentified in the past as *M. flavomarginatus* (a junior synonym of *M. niger* Sauvage, 1879; Travers, 1992*a*) (Daget, 1962, 1963).

Diagnosis

Within the Upper Guinea ichthyofaunal province *M. kakrimensis* sp. nov. can be distinguished from *M. taiaensis* by its short postanal length [44·1–47·6 (mean 45·8) $\%L_S$ *v.* 53·1–57·9 (55·8)], increasing with size, and its related low caudal vertebrae number [53–56 (54/55) *v.* 64–74 (72)]. It is distinguished from *M. nigromarginatus* by its origin of the first dorsal spine situated posterior to the posterior edge of the pectoral fin [12·0–25·8 (18·6) $\%L_H$ *v.* (–21·7)–0·0 (–11·8)] and its related high predorsal vertebrae number [7–9 (7/8) *v.* 4–6 (5)]. It is distinguished from *M. praensis* by its high dorsal spine number [28 + 1–29 + 1 (29 + 1) *v.* 23 + 1–27 + 1 (25 + 1)] and its related longer distance from the anterior border of the snout to the last externally visible dorsal spine [56·8–60·5 (58·5) $\%L_S$ *v.* 46·2–52·5 (49·5)] and the similarly long (*v.* shorter, *M. praensis*) distance from the anterior border of the snout to the last externally visible anal spine, both decreasing with increasing size [55·8–60·1 (58·2) *v.* 51·8–59·3 (56·3)]. *Mastacembelus kakrimensis* sp. nov. is most similar to *M. liberiensis* but can be distinguished by the reduction and finally loss of its preopercular spines with increasing size [0L/0R–2L/2R (0L/0R) *v.* 1L/1R (very exceptionally) up to 5L/5R (2L/2R)], its reduction of the preorbital spine with increasing size [*v.* exceptionally 0L/0R, generally 1L/1R (1L/1R)], its relatively low total vertebrae [90–93 (91) *v.* 92–105 (99), Konkoure River basin specimens of *M. liberiensis* 100–104 (102)], and its relatively low caudal vertebrae [53–56 (54/55) *v.* 53–64 (59), Konkoure River basin specimens of *M. liberiensis* 60–64 (62)]. Species only known from the upper Konkoure River basin (*i.e.* above the Kaleta Falls) in Guinea.

Description

The holotype of *M. kakrimensis* sp. nov. is illustrated in Fig. 10. Selected meristics and measurements are given respectively in Tables VII and VIII.

Mastacembelus kakrimensis sp. nov. has a blunted snout. Posterior angle of lips situated from about below the horizontal middle of the posterior nare up to its posterior edge [Fig. 10(b)]. Upper corner of gill opening very slightly anterior to dorsal point of pectoral-fin base, both points clearly anterior to ventral point of pectoral-fin base. Dorsal point of pectoral-fin base situated largely above upper corner of gill opening. Gill opening closed for about half, up to entire vertical distance between the dorsal and ventral edge of the pectoral-fin base [Fig. 10(c)]. Lateral line is yellowish-white; can be continuous in anterior part, from the head up to half the distance between head and anus. The remaining, more posterior, part of the lateral line is always clearly discontinuous.

Preanal length negatively allometric, postanal length positively allometric, latter always smaller than former. Distance from anterior border of snout to last externally visible dorsal spine (S-LDS) negatively allometric and comparable to distance from anterior border of snout to last externally visible anal spine

TABLE VII. Meristic data for the types of *Mastacembelus kakrimensis* sp. nov.

	Konkoure, Guinea	All examined specimens holotype + paratypes				
	holotype	Minimum	Maximum	*n*	Median	Frequency
Predorsal vertebrae	**8**	7	9	10	**7/8**	7(5) 8(4) 9(1)
Abdominal vertebrae	**37**	36	38	10	**37**	36(1) 37(8) 38(1)
In-between vertebrae	**0**	0	+1	10	**0**	0(7) + 1(3)
Caudal vertebrae	**53**	53	56	10	**54–55**	9(7) 10(2) 90(3) 91(3)
Vertebrae total	**90**	90	93	10	**91**	92(3) 93(1)
Dorsal spines	**28 + 1**	28 + 1	29 + 1	10	**29 + 1**	28 + 1(4) 29 + 1(6)
Anal spines	**2 + 1**	2 + 1	2 + 1	10	**2 + 1**	2 + 1(10)
Dorsal fin rays	**75**	75	85	9	**79**	75(2) 78(2) 79(2) 81(1) 82(1) 85(1)
Anal fin rays	**79**	76	86	9	**79**	76(1) 78(2) 79(3) 83(1) 84(1) 86(1)
Caudal fin rays	**9**	9	10	9	**9**	9(7) 10(2)
Preopercular spines	**0L/0R**	0L/0R	2L/2R	10	**0L/0R**	0L/0R (8) 1L/1R (1) 2L/2R (1)

TABLE VIII. Morphometric data for the types of *M. kakrimensis* sp. nov.

	Konkoure, Guinea holotype	All examined specimens holotype + paratypes				
		Minimum	Maximum	*n*	Mean	S.D.
Standard length, L_S (mm)	**229**	88	239	10	**162**	49·8
As %L_H						
Snout length	**29·3**	23·2	30·2	10	**27·2**	2·0
Eye diameter	**7·8**	7·8	12·8	10	**10·0**	1·4
Minimum interorbital distance	**4·7**	2·3	5·5	10	**4·1**	1·1
Rostral appendage length	**14·0**	9·3	14·9	10	**12·4**	2·0
Postorbital length	**64·2**	62·2	70·1	10	**65·9**	2·2
Angle of jaws to dorsal edge of pectoral fin base	**68·5**	68·5	75·8	10	**73·0**	2·1
Posterior tip of preorbital spine to dorsal edge of pectoral fin base	**68·8**	68·6	75·2	10	**71·0**	1·9
Upper tip of gill slit to pectoral fin origin	**7·2**	7·0	10·5	10	**8·7**	1·2
Upper jaw length	**27·4**	21·8	29·6	10	**25·4**	2·5
Lower jaw length	**22·7**	18·0	23·6	10	**20·7**	1·9
Pectoral-fin length	**22·7**	20·4	24·6	10	**22·6**	1·5
Dorsal edge of pectoral fin base to anterior base of first dorsal spine	**51·7**	39·3	55·1	10	**46·7**	4·7
Ventral edge of pectoral fin base to anterior base of first dorsal spine	**44·5**	34·8	50·8	10	**42·3**	4·4
Posterior edge pectoral fin to anterior base of first dorsal spine	**21·2**	12·0	25·8	10	**18·6**	4·7
Angle of jaws to eye	**14·0**	11·2	14·5	10	**13·0**	1·0
Angle of jaws to posterior external nare	**15·9**	11·8	17·3	10	**14·2**	1·6
Anterior border posterior external nare to eye	**7·2**	5·9	7·2	10	**6·7**	0·5
As %L_S						
Head length	**14·0**	13·2	15·1	10	**14·0**	0·7
Snout to first dorsal spine	**19·6**	19·6	23·0	10	**20·6**	1·3
Snout to last externally visible dorsal spine	**57·5**	56·8	60·5	10	**58·5**	1·3
Snout to first anal spine	**55·6**	53·1	58·0	10	**55·5**	1·3
Snout to last externally visible anal spine	**58·4**	55·8	60·1	10	**58·2**	1·4
Preanal length	**52·7**	50·8	55·2	10	**53·4**	1·3
Postanal length	**45·6**	44·1	47·6	10	**45·8**	0·9
Body depth at anus	**7·1**	7·1	8·3	10	**7·7**	0·4

(S-LAS) which is also negatively allometric. S-LAS minus S-LDS, (–12·0)–8·1 [mean: (–1·5)] $\%L_S$, expressing a comparable position of the origin of the dorsal fin compared to origin of the soft anal fin.

Preopercular spines are present in small sized specimens ($< \pm 137$ mm L_T) but are absent in medium and large sized specimens ($> \pm 133$ mm L_T). Even for the small-sized specimens examined a reduction of those spines with increasing standard length is observed (Table IX).

A small preorbital spine is present on each side in the smaller sized specimens ($< \pm 137$ mm L_T), but is reduced in medium sized specimens ($> \pm 133$ mm L_T, $< \pm 188$ mm L_T) and is further reduced or absent in larger specimens ($> \pm 153$ mm L_T) (Table IX).

In all specimens, the neural spine supporting the pterygiophore of the last externally visible dorsal spine, and the haemal spine supporting the pterygiophore of the first anal spine are situated on adjacent vertebrae. The vertebra with the neural spine supporting the pterygiophore of the last externally visible dorsal spine is always situated anterior to the vertebra whose haemal spine supports the first anal spine.

Maximal observed L_S: 239 mm (MRAC 92-59-P-4235-4240: 248 mm L_T).

Colouration (in alcohol) (Fig. 10): holotype, uniformly light brown overall background colour. Dorsal midline with a series of dark brown spots. Dark brown band originating at the base of the rostral appendage, passing through the eye, above the pectoral fin and continuing as a series of dark brown spots above the lateral line of the pre- and postanal flanks. The lateral surface of the head beneath the eye line is also marked with, irregularly shaped, white spots and a dark brown reticulate pattern. Lower parts of flanks with a dark brown network enclosing some, large, more or less rounded, yellowish-white spots. Network also visible on the lower part of postanal flanks, but with less contrast. Ventral side of head, belly and abdomen with uniform yellowish-white overall background colour. Dorsal, caudal and anal fins white of background colour. A series of dark brown, black spots on base of dorsal fin and partially on dorsal part of the postanal flanks. In addition, dorsal and caudal fin quite uniformly brown, somewhat darker towards the outer margin of the fin. A series of white spots at base of anal fin extending onto ventral part of the postanal flanks. Anal fin also with a dark brown 'network' enclosing the white spots. Nevertheless, outer margins of dorsal, caudal and anal fins remain white. Pectoral fins white with a few dark brown spots at their base. Paratypes, one of the paratypes (MRAC 92-59-P-4235-4240: 133 mm L_T) differs considerably in colouration compared to the others. The white, yellowish spots surrounded by a distinct dark brown reticulate pattern are present not only on most of the preanal flanks but also on the postanal flanks. In this aspect, the colouration of the latter specimen resembles the network colour pattern of the *M. liberiensis* Cess or Nipoue River Basin specimens. The dorsal region is lighter brown than the flanks and both are well demarcated from each other in colouration with, along the dorsal midline, a series of dark brown spots. The lighter brown colour of the dorsal region is also present in two other paratypes (MNHN 1991–252: 92–130 mm L_T). The latter two specimens differ from the former specimens by a poorly developed reticulate pattern mainly limited to the pectoral fin region, and absent from the postanal region.

TABLE IX. Appearance of the preorbital spine and preopercular spines for the types of *Mastacembelus kakrimensis* sp. nov.

	MNHN 252 paratype	MNHN 252 paratype	MRAC 4235–4240 paratype	MRAC 4235–4240 paratype	MRAC 4235–4240 paratype	MNHN 814 paratype	MRAC 4235–4240 paratype	MRAC 4235–4240 paratype	MRAC 4234 holotype	MRAC 4235–4240 paratype
L_T (mm)	92	130	133	137	150	153	188	215	238	248
Preorbital spine	1L/1R normal	1L/1R normal	1L/1R normal	(1)L/(1)R reduced	(1)L/(1)R reduced	(1)L/(1)R reduced	0L/0R	0L/0R	0L/0R	0L/0R
Preopercular spines	0L/0R	1L/1R reduced	2L/2R hardly spines	0L/0R	0L/0R	0L/0R	0L/0R	0L/0R	0L/0R	0L/0R

Important size related colour pattern changes, comparable to the ones mentioned for *M. liberiensis*, are to be noted. In small specimens the unpaired fins are white in overall appearance whereas they become dark brown in overall appearance in large specimens. Nevertheless, a white outermost margin remains present in large-sized specimens.

Distribution (Fig. 11)

Mastacembelus kakrimensis sp. nov. is known only from the Upper Konkoure River basin (Guinea) (*i.e.* above the Kaleta Falls), and therefore is considered endemic to the basin.

Generic status

Mastacembelus kakrimensis sp. nov. seems, based on the presented meristic and morphometric evidence, to be most closely related to and might well be the sister-species of *M. liberiensis* with which it occurs sympatrically in the Kakrima River, Konkoure River basin (Guinea).

In most African species the number of preopercular spines is size independent, i.e. if preopercular spines are present in small specimens of a species then they are also present in large specimens. Similarly, it is unusual for preopercular spines to

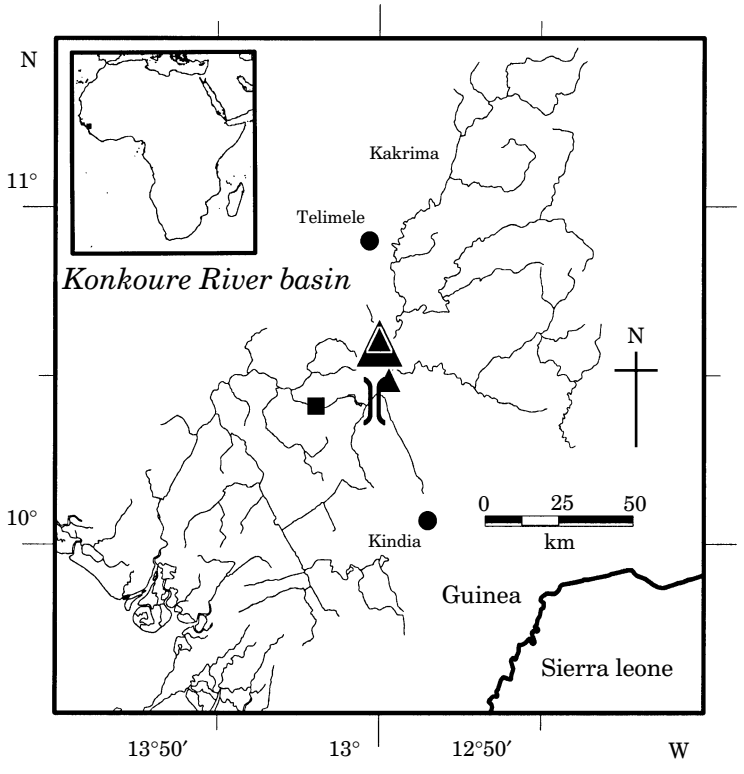

FIG. 11. Konkoure River basin (Guinea) with geographical distribution of *Mastacembelus kakrimensis* sp. nov. based on the localities of the examined material. ▲, holotype (type locality) and ▲, paratype localities. ■, Kaleta Falls; }{, bridge.

be lost, ontogenetically, in Asian mastacembelids [*e.g. Macrognathus maculatus* (Cuvier, 1832); Sufi, 1956]. Therefore, the reduction or complete loss of preopercular spines in medium and large sized specimens of *M. kakrimensis* sp. nov. is considered a derived character state when compared to the presence, at all sizes, of preopercular spines in *M. liberiensis*.

Biology and ecology

The holotype and some of the paratypes (MRAC 92-59-P-4235-240) were captured in a small river, ±1–6 m width, in the riffles. The bottom consisted of rock boulders with aquatic vegetation. The hydrological and physico-chemical conditions at the collection locality of the MNHN 1991–252 paratypes was as follows: salinity 4, conductivity 21 $\mu S\ cm^{-1}$, pH 6·8, temperature 25·2° C (forenoon); a small, shallow river, ±6–7 m wide, with a strong current.

DISCUSSION

The Konkoure River basin contains a high number of endemic species: *Barbus guineensis* Pellegrin, 1913, *Labeo rouaneti* Daget, 1962, *Barbus cadenati* Daget, 1962, *Tilapia rheophila* Daget, 1962, *Amphilius kakrimensis* Teugels *et al.*, 1987 *Synodontis dekimpei* Paugy, 1987 and *Synodontis levequei* Paugy, 1987, *Chrysichthys (Chrysichthys) levequei* Risch, 1988, *Leptocypris konkoureensis* Howes & Teugels, 1989 and *Raiamas levequei* Howes & Teugels, 1989. At present, *M. kakrimensis* sp. nov. is also apparently endemic for the Konkoure River basin and can be added to this list.

The conditions within the Konkoure River basin seem to have favoured speciation. The basin covers a distance of 365 km. It is composed of successive channels connected with each other by rapid zones or falls depending on the nature of the rocks and the hardness of the layers encountered. Its longitudinal profile suggests an extremely young river basin (Daget, 1962). Daget (1962) further discussed the special morphology of the river bed in which erosion may result in sudden changes of direction and abandonment of the old river bed.

Within the Konkoure River basin *M. liberiensis* and *M. kakrimensis* sp. nov. are only collected in the upper part (*i.e.* above the Kaleta Falls) (Fig. 11). Both species are even syntopic, at least at one locality, the Galekoulou River at the bridge on the road between Kindia and Telimele. At present, there is no evidence that one or both species are also present below the Kaleta Falls. Daget (1962) reported, however, that the region was not well collected and Hugueny *et al.* (1996) only used gillnets, a method with limited success compared to electrofishing for the collecting of Mastacembelidae.

We are greatly indebted to J. Snoeks, L. De Vos and two anonymous referees for critically reading previous drafts of the manuscript which has enabled us to substantially improve the quality of the present paper. We thank O. Crimmen, S. Davidson, A.-M. Hine-Woolger and J. Maclaine (BMNH), G. Duhamel, J.C. Hureau and P. Pruvost (MNHN), J. Ineichen and R. Winkler (MHNB), M.J.P. van Oijen (RMNH), R.P. Vari, S. Jewett and L. Palmer (USNM), and H.J. Paepke (ZMB) for the loan of specimens and type material under their care. We are grateful to Miguel Parrent (MRAC) for his help with the radiographs, and to Alain Reygel (MRAC) who made the drawings of the illustrated specimens. We acknowledge the data of D. Chaytor who in 1969 presented

a paper 'The fishes of the River Jong in Sierra Leone', at an International Symposium in Ghana on 'Man-made Lakes'.

References

Ahl, E. (1937). Ueber eine kleine Fischsammlung aus Sierra Leone. *Mitteilungen aus dem Zoologischen Museum in Berlin* **22,** 239–243.

Arnold, J. P. (1952). *Alphabetisches Verzeichnis der bisher eingefürhten fremdländischen Süsswasserfische*. Braunschweig: Verlag Gustav Wenzel & Sohn.

Bates, G. L. (1932). Notes on freshwater fishes collected in Koinadugu and Kono districts. *Sierra Leone Studies* **17,** 26–28.

Bookstein, F., Chernoff B., Elder R., Humphries J., Smith G. & Strauss, R. (1985). Morphometrics in evolutionary biology. *The Academy of Natural Sciences of Philadelphia. Special Publications* **15**.

Boulenger, G. A. (1898). Report on the collection of fishes made by Mr. J. E. S. Moore in lake Tanganyika during his expedition 1895–1896, with an appendix by J. E. S. Moore. *Transactions of the Zoological Society of London* **15,** 1–30.

Boulenger, G. A. (1899). Matériaux pour la faune du Congo. Poissons nouveaux du Congo. 3e partie: Silures, Acanthoptérygiens, Mastacembles, Plectognathes. *Annales du Musée du Congo, Zoologie, Bruxelles, Série I*, **1,** 39–58.

Boulenger, G. A. (1905). A list of freshwater fishes of Africa. *Annals and Magazine of Natural History London* **16,** 36–60.

Boulenger, G. A. (1911). Descriptions of four new African fishes of the genus *Mastacembelus*. *Annals and Magazine of Natural History*. *London* **7** (series 8), 637–639.

Boulenger, G. A. (1912). A synopsis of the fishes of the genus *Mastacembelus*. *Journal of the Academy of Natural Sciences of Philadelphia* **2**, 197–203.

Boulenger, G. A. (1916). *Catalogue of the Freshwater Fishes of Africa in the British Museum (Natural History)*, Vol. 4. London: Trustees of the British Museum.

Büttikofer, J. (1890). *Reisbilder aus Liberia. II. Die Bewohner Liberia's Thierwelt*, Vol. 2. Leyden.

Chaytor, D. E. B. & Williams, M. O. (1966). The freshwater fishes of the Freetown Peninsula. *Bulletin de l'Institut français d'Afrique Noire (I.F.A.N.)* **(A)28,** 1041–1063.

Daget, J. (1950). Poissons d'eau douce de Sierra Leone. *Notes Africaines* **46,** 55–57.

Daget, J. (1960). Poissons de la Volta Noire et de la Haute Comoé (Mission d'Aubenton-Arnoult. oct.-déc. 1959). *Bulletin du Muséum (national) d'histoire naturelle. Paris* **2,** 320–330.

Daget, J. (1962). Les poissons du Fouta Dialon et de la Basse Guinée. *Mémoires de l'Institut Français d'Afrique Noire (IFAN) DAKAR* **65**.

Daget, J. (1963). La réserve naturelle intégrale du Mont Nimba. Poissons (2^{e} note). *Mémoires de l'Institut français d'Afrique Noire (I.F.A.N.)* **66,** 573–600.

Daget, L. & Iltis, A. (1965). Poissons de Côte d'Ivoire (eaux douces et saumâtres). *Mémoires de l'Institut français d'Afrique Noire (I.F.A.N.). Paris* **74**.

Freihofer, W. C. (1978). Cranial nerves of a percoid fish, *Polycentrus schomburgkii* (family *Nandidae*), a contribution to the morphology and classification of the order Perciformes. *Occasional Papers of the Californian Academy of Sciences* **128,** 1–78.

Greenwood, P. H. (1983). The Zoogeography of African freshwater Fishes: Bioaccountancy or Biogeography? In *Evolution, Time and Space: The Emergence of the Biosphere Systematics Association Special Volume* **23** (Sims, R. W., Price, J. H. & Whalley, P. E. S., eds), pp. 179–199. London and New York: Academic Press.

Howes, G. J. & Teugels, G. G. (1989). New bariliin cyprinid fishes from West Africa, with a consideration of their biogeography. *Journal of Natural History* **23,** 873–902.

Hugueny, B. & Lévêque, C. (1994). Freshwater fish zoogeography in West Africa: faunal similarities between river basins. *Environmental Biology of Fishes* **39,** 365–380.
Hugueny, B., Camara, S., Samoura, B. & Magassouba, M. (1996). Applying an index of biotic integrity based on fish assemblages in a West African river. *Hydrobiologia* **331,** 71–78.
Humphries, J. M., Bookstein, F. L., Chernoff, B., Smith, G. R., Elder, R. L. & Poss, S. G. (1981). Multivariate discrimination by shape in relation to size. *Systematic Zoology* **30,** 291–308.
Lévêque, C. & Paugy, D. (1984). Guide des poissons d'eau douce de la zone du programme de lutte contre l'onchocercose en Afrique de l'Ouest. *Convention ORSTOM-OMS*, 1–192.
Marcus, L. F. (1990). Traditional morphometrics. In *Proceedings of the Michigan Morphometrics Workshop, Special Publication 2* (Rohlf, F. J. & Bookstein, F. L., eds), pp. 77–117. Ann Arbor, MI: University of Michigan Museum of Zoology.
Mayr, E. & Ashlock, P. D. (1991). *Principles of Systematic Zoology*, 2nd edn. New York, McGraw Hill International.
Norman, J. R. (1932). A collection of fishes from Sierra Leone. *Annals and Magazine of Natural History. London* **10,** 180–185.
Paugy, D., Lévêque, C., Teugels, G. G., Bigorne, R. & Romand, R. (1990). Freshwater fishes of Sierra Leone and Liberia. Annotated checklist and distribution. *Revue d'Hydrobiologie Tropicale* **23,** 329–350.
Paugy, D., Traore, K. & Diouf, P. S. (1994). Faune ichtyologique des eaux douces d'Afrique de l'Ouest. In *Biological Diversity of African Fresh- and Brackish Water Fishes. Geographical Overviews* (Teugels, G. G., Guégan, J.-F. & Albaret, J.-.J., eds). Koninklijk Museum voor Midden-Afrika, Tervuren, België, Annalen, Zoologische wetenschappen, Musée Royal de l'Afrique Centrale, Belgique, Tervuren, Annales, Sciences Zoologiques **275,** 1–177.
Pellegrin, J. (1922). Les poissons des eaux douces de l'Afrique occidentale. Compte rendu de l'Association française pour l'avancement des sciences. *Paris. Congrès de Rouen* **45,** 633–638.
Pellegrin, J. (1923). *Les poissons des eaux douces d'Afrique occidentale (du Sénégal au Niger)*. (Publications du Comité d'études historiques et scientifiques. Gouvernement Général de l'Afrique Occidentale Française). Paris: Larose.
Roberts, T. R. (1975). Geographical distribution of African freshwater fishes. *Zoological Journal of the Linnean Society* **57,** 249–319.
Roberts, T. R. & Travers, R. A. (1986). *Afromastacembelus sexdecimspinus*, a new species of mastacembelid spiny-eel from rapids in the Cross River basin, Cameroon. *Cybium* **10,** 105–114.
Schultz, L. P. (1942). The freshwater fishes of Liberia. *Proceedings of the United States National Museum, Washington* **92,** 301–348.
Steindachner, F. (1895). Die Fische Liberia's. *Notes from the Leyden Museum* **16**.
Sterba, G. (1959). *Süsswasserfische aus aller Welt*. Leipzig/Iena: Urania-Verlag.
Sterba, G. (1963). *Freshwater Fishes of the World* (translated and revised by D. W. Trucker). London and New York: Viking Press.
Sufi, S. M. K. (1956). Revision of the Oriental fishes of the family Mastacembelidae. *Bulletin of the Raffles Museum* **27**, 93–146.
Teugels, G. G., Skelton, P. H. & Lévêque, C. (1987). A new species of *Amphilius* (Pisces, Amphiliidae) from the Konkoure Basin, Guinea, West Africa. *Cybium* **11,** 93–101.
Teugels, G. G., Lévêque, C., Paugy, D. & Traoré, K. (1988). État des connaissances sur la faune ichthyologique des bassins côtiers de Côte d'Ivoire et de l'ouest du Ghana. *Revue d'Hydrobiologie tropicale* **21,** 221–237.
Travers, R. A. (1984*a*). A review of the Mastacembeloidei, a suborder of synbranchiform teleost fishes, Part I: Anatomical descriptions. *Bulletin of the British Museum (Natural History) Zoological Series* **46,** 1–133.
Travers, R. A. (1984*b*). A review of the Mastacembeloidei, a suborder of synbranchiform teleost fishes, Part II: Phylogenetic analysis. *Bulletin of the British Museum (Natural History) Zoological Series* **47,** 83–150.

Travers, R. A. (1992*a*). *Caecomastacembelus taiaensis* and *Aethiomastacembelus praensis*, two new species of Mastacembelid spiny-eels from West Africa. *Ichthyological Exploration of Freshwaters* **2,** 311–340.

Travers, R. A. (1992*b*). Mastacembelidae. 848–857. In *Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest*, Tome 2 (Lévêque, C., Paugy, D. & Teugels, G. G., eds), pp. 389–902. Tervuren: MRAC and Paris: ORSTOM.

Travers, R. A., Eynikel, G. & Thys van den Audenaerde, D. F. E. (1986). Mastacembelidae. 15–427. In *Check-list of the Freshwater Fishes of Africa, CLOFFA*, Vol. II. (Daget, J., Gosse, J.-P. & Thys van den Audenaerde, D. F. E., eds), Brussels: ISNB, Tervuren: MRAC and Paris: ORSTOM.

Vreven, E. J. (2005). Mastacembelidae (Teleostei; Synbranchiformes) subfamily division and African generic division: an evaluation. *Journal of Natural History* **39,** 351–370.

Vreven, E. J. & Teugels, G. G. (1996). Description of a new Mastacembelid species (Synbranchiformes; Mastacembelidae) from the Zaïre River Basin in Africa. *Copeia* **1996,** 130–139.

Vreven, E. J. & Teugels, G. G. (1997). *Aethiomastacembelus traversi*, a new spiny-eel from the Zaïre River basin, Africa (Synbranchiformes: Mastacembelidae). *Ichthyological Exploration of Freshwaters* **8,** 81–87.

Williams, M. & Chaytor, D. (1966). Some Helminth parasites of freshwater fishes of the Freetown peninsula, Sierra Leone. *Bulletin de l'Institut français d'Afrique Noire (IFAN)* **(A)28,** 563–575.