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Article

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African weakly electric fishes of the genus *Petrocephalus* (Osteoglossomorpha: Mormyridae) of Odzala National Park, Republic of the Congo (Lékoli River, Congo River basin) with description of five new species

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Abstract

Here we examine new collections of *Petrocephalus* species (Osteoglossomorpha: Mormyridae: Petrocephalinae) made within Odzala National Park in the Republic of the Congo (Lékoli River drainage, northwestern Congo River basin). We compare these collections to type material of all nominal *Petrocephalus* species described from the Congo basin and the adjacent Lower Guinea ichthyofaunal province. Based on morphology and electric signal characteristics we recognize eleven distinct species of *Petrocephalus* in these collections, including five new species described herein: *Petrocephalus binotatus*, *Petrocephalus zakoni* **n. sp.**, *Petrocephalus valentini* **n. sp.**, *Petrocephalus balayi*, *Petrocephalus microphthalmus*, *Petrocephalus odzalaensis* **n. sp.**, *Petrocephalus christyi*, *Petrocephalus sauvagii*, *Petrocephalus pulsivertens* **n. sp.**, *Petrocephalus grandoculis* and *Petrocephalus mbossou* **n. sp.** Each species can be distinguished by a combination of characters, the most important of which are numbers of dorsal and anal fin rays, mouth width, eye size, number of upper jaw teeth and melanin markings. Electric signal waveform characteristics are useful for diagnosing a few of the species. The eleven *Petrocephalus* species of the Odzala assemblage appear to be reproductively isolated biological species based on genetic evidence we have gathered from the mitochondrial cytochrome *b* gene. Our study of *Petrocephalus* type material reveals that *Petrocephalus guttatus* was erroneously assigned to this genus; we now assign this species to *Pollimyrus* within the sister subfamily, Mormyrinae. Additionally, we provide a dichotomous key to the eleven *Petrocephalus* species of Odzala National Park.

Key words: Petrocephalinae, electric fish, electric organ discharge, Central Africa, phylogeny, cytochrome *b*, integrative taxonomy

Résumé

Nous avons récemment réalisé d'importantes collections ichtyologiques de la rivière Lékoli (basin du fleuve Congo) qui draine la partie sud du Parc National d'Odzala (République du Congo), comprenant en particulier de nombreux spécimens de poissons électriques de la famille des Mormyridae. Ici nous avons étudié les *Petrocephalus* (Petrocephalinae, Mormyridae, Osteoglossomorpha) que nous avons comparé au matériel type de toutes les espèces décrites du bassin du Congo et de la région de la Basse Guinée. L'examen de la morphologie externe nous a permis d'identifier 11 espèces de *Petrocephalus* à Odzala–dont cinq d'entre elles sont nouvelles et décrites ici–: *Petrocephalus binotatus*, *Petrocephalus zakoni* **n. sp.**, *Petrocephalus valentini* **n. sp.**, *Petrocephalus balayi*, *Petrocephalus microphthalmus*, *Petrocephalus odzalaensis* **n. sp.**, *Petrocephalus christyi*, *Petrocephalus sauvagii*, *Petrocephalus pulsivertens* **n. sp.**, *Petrocephalus grandoculis* et *Petrocephalus mbossou* **n. sp.** Chacune de ces espèces se distingue des autres par une combinaison unique de plusieurs caractères dont les plus importants sont les nombres de rayons aux nageoires dorsales et anales, la largeur de la bouche, le diamètre de l'œil, le nombre de dents sur la mâchoire supérieure et le patron de pigmentation. La forme des décharges électriques ne permet en pratique que de distinguer quelques espèces. Ces 11 espèces de *Petrocephalus* à Odzala semblent être génétiquement isolées les unes des autres comme le montre une analyse phylogénétique fondée sur la comparaison du gène du cytochrome *b*. Parmi les autres espèces nominales de *Petrocephalus* du Congo et de la Basse Guinée, nous avons constaté que *Petrocephalus guttatus* n'est pas un *Petrocephalus*. Nous le réassignons au genre *Pollimyrus* de la sous-famille des Mormyrinae. Enfin, nous proposons une clé d'identification dichotomique des 11 espèces de *Petrocephalus* présentement connues à Odzala.

Introduction

Petrocephalus Marcusen, 1854 is the sole genus within the African weakly electric fish subfamily Petrocephalinae (Osteoglossomorpha: Mormyridae). This genus currently includes 25 valid species (Eschmeyer & Fricke, 2010) that are distributed across tropical and subtropical freshwater regions of Africa. Morphological (Taverne, 1969) and molecular evidence (Lavoué *et al*., 2000; Sullivan *et al*., 2000) support the monophyly of *Petrocephalus* and its sister relationship to all remaining Mormyridae (subfamily Mormyrinae). Identification of different *Petrocephalus* species is often difficult due to subtle morphological differentiation between many species. Like other mormyrids, *Petrocephalus* species produce weak electric pulses from an electric organ in the caudal peduncle for the purposes of object detection, orientation and communication (Bennett, 1970; Lissmann, 1958; Moller, 1995). While in other mormyrid genera electric organ discharge (EOD) waveforms often differ substantially among species and are useful taxonomic markers, EOD waveforms of *Petrocephalus* are relatively conserved across the genus. The typical EOD

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waveform of *Petrocephalus* is short in duration and exhibits two main phases of alternating polarity, the first of which is head-positive (Bass, 1986; Sullivan *et al*., 2000). Often, one or two additional phases of much smaller relative amplitude are present in the EOD (Lavoué *et al*., 2008). All *Petrocephalus* species examined to date have electric organs composed of simple "NPp"-type electrocytes with non-penetrating stalks innervated on the posterior side of each electrocyte (Bass, 1986).

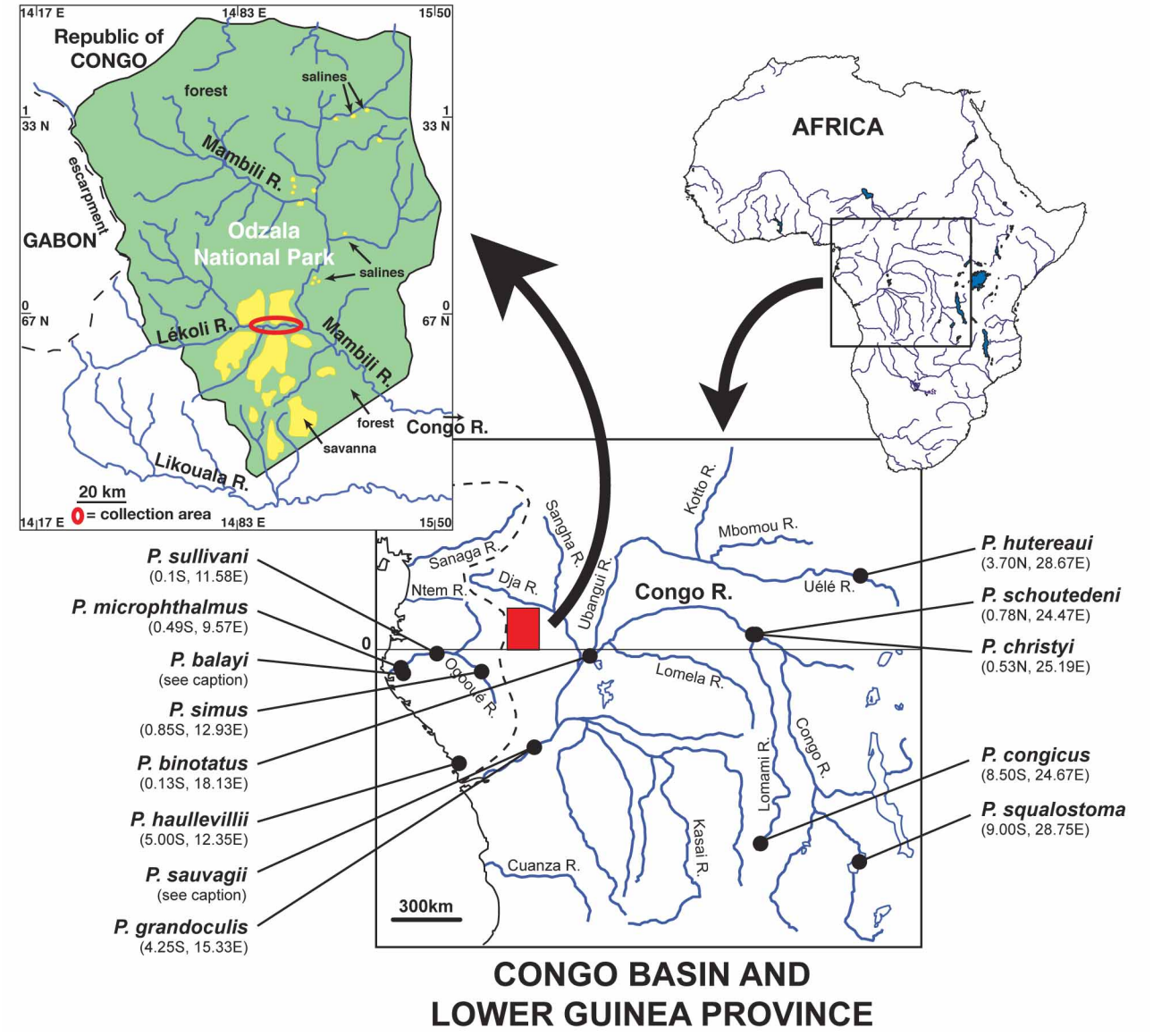

FIGURE 1. Map of Africa (right) showing the entire Congo River and its main tributaries together with the neighboring Lower Guinea province (first inset at center). The boundary between the Congo and Lower Guinea provinces is shown by a dashed line. Filled black circles indicate type localities for all *Petrocephalus* species that were described from either province and were considered valid just prior to the present study. Exact type localities are unknown for *P. balayi* and *P. sauvagii*. Based on our understanding of the chronology of Central African exploration at the time of the descriptions, we estimate these type localities to be the following: the vicinity of Pool Malebo on the Lower Congo River near the modern cities of Brazzaville and Kinshasa [4.25° S, 15.29° E] for *P. sauvagii*; and the vicinity of the present-day city Lambaréné on the Lower Ogooué River [0.7° S, 10.22° E] for *P. balayi*. Second inset at the far left: detailed map of Odzala National Park, located in the Congo River basin. Within the boundaries of the park, forest is shown in green and savannah in yellow. The red oval indicates our collection area (a segment of the Lékoli drainage system, including the lower parts of two of its tributaries, the Pandaka and Lékénie Rivers).

Despite the apparent conservatism in morphology and EOD waveforms among *Petrocephalus*, a high degree of genetic variation has been noted within nominal species, suggesting the presence of cryptic species

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diversity (Agnèse & Bigorne, 1992; Lavoué *et al*., 2008; van der Bank, 1996). This suspicion was confirmed by the results of two recent collecting trips to Odzala National Park, Republic of the Congo, in the northwestern part of the Congo River basin (Fig. 1). Combining morphological data, EOD recordings and genetic evidence, Lavoué *et al*. (2008) identified eleven species of *Petrocephalus* from these Odzala collections. In the present taxonomic study of Odzala specimens, we now provide morphological diagnoses and descriptions for each of the eleven species, five of which are new. When useful, EOD characteristics are included in our diagnoses. We also expand a cytochrome *b*-based molecular phylogeny, which presently includes 17 species and 59 specimens of *Petrocephalus*, as an independent genetic test of the distinctiveness of these taxa.

Material and methods

Specimen sampling. We collected numerous *Petrocephalus* specimens during two recent trips to Odzala National Park, Republic of the Congo, in August 2002 and June 2006 (Fig. 1). Comparative material came from several localities in Gabon (Lavoué *et al*., 2004), the Dzangha Sangha Reserve (Sangha River, Central African Republic, northwestern Congo basin) and the Lower Congo River in the vicinity of Pool Malebo (Republic of the Congo). We also examined type material (at least part of the type series) for all previously described species from the Congo basin and the Lower Guinea province. We included Lower Guinean species in our comparisons because this region shares faunistic affinities with the Congo River basin (Roberts, 1975). Our molecular analyses (see below) included representatives of the eleven *Petrocephalus* species from Odzala along with representatives of three species from Lower Guinea and additional species from West and East Africa.

In the list of material examined, we indicate the capacity in which each specimen was used as follows: morpho (morphological examination), EOD (analysis of the electric organ discharge), and DNA (cytochrome *b* sequencing).

Morphology. Methods for making counts and measurements follow those of Lavoué *et al*. (2004). We made 20 measurements on each specimen using a digital caliper with a precision of ± 0.1 mm. Abbreviations and definitions for each of these measurements follow those given by Boden *et al*. (1997) with the exception of standard length (SL), mouth position (MP) and mouth width (MW), which follow the definitions of Lavoué *et al*. (2004). We also made seven meristic counts on each specimen: number of branched dorsal fin rays, excluding all unbranched rays (DR); number of branched anal fin rays, excluding all unbranched rays (AR); number of pored scales along the lateral line (SLL); number of scales around the caudal peduncle (ScP); number of scales between the origin of the anal fin and the lateral line, excluding the pored scale itself (SDL); and number of teeth on the lower and upper jaws (TLJ and TUJ, respectively). The number of scales around the caudal peduncle was found not to vary among species (see Descriptions), so this meristic is not reported in Tables 1–10.

We categorized the sex of each specimen into one of two categories—obvious males or all other individuals—by checking the body profile of each preserved specimen along the base of the anal fin. A strongly indented (*versus* straight) anal fin base is exhibited only by sexually mature males (Pezzanite & Moller, 1998).

We investigated the distribution pattern of Knollenorgan-type electroreceptors on the head of *Petrocephalus* specimens. Harder (1968) described three dense clusters of Knollenorgans, which he called the "Augenrosette," "Nackenrosette" and "Kehlrosette," on the heads of some *Petrocephalus* species (Fig. 2). When present, the "Augenrosettes" are situated above the anterior half of the left and right eyes; the "Nackenrosettes" are dorsally situated on each side of the nape, slightly anterior to the opercular openings; and the "Kehlrosettes" are situated anterior to the insertion of the pectoral fins, with part of the rosette extending slightly ventrally from the pectoral fin insertion.

EOD waveforms and electric organ anatomy. In a companion paper to the present work (Lavoué *et al*., 2008) we provided an in-depth analysis and description of EOD waveform variation among the *Petrocephalus* of Odzala, as well as a discussion of its evolutionary significance. Methods for recording EODs and

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quantifying EOD waveform variation are described therein. Here, we summarize only the most salient features of EOD variation among Odzala's *Petrocephalus* species. The EOD recordings we illustrate are raw traces, uncorrected for temperature differences. Details on fine-scale EOD variation not relevant to species diagnosis are given in the companion paper, which also describes our methods for electric organ histology. Our nomenclature for describing electrocyte anatomy follows Bass (1986), Alves-Gomes and Hopkins (1997) and Sullivan *et al*. (2000).

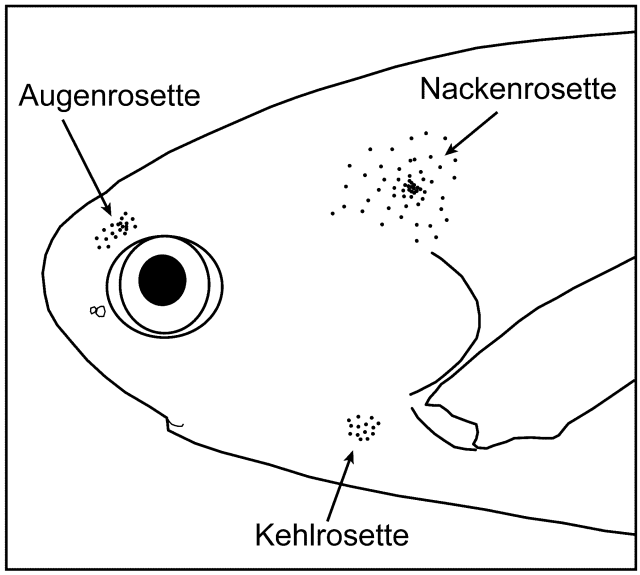

FIGURE 2. Knollenorgan rosettes depicted on a schematic drawing of the head of a specimen of *Petrocephalus pulsivertens* **n. sp.** Dense clusters of Knollenorgan electroreceptors on the heads of this and several other *Petrocephalus* species were described by Harder (1968) as the "Augenrosette," "Nackenrosette" and "Kehlrosette," depending on their position on the head. Each black point represents a single Knollenorgan electroreceptor. Several isolated Knollenorgans occur outside these three rosettes (in this individual of *P. pulsivertens*), but they are not indicated in the drawing for clarity.

DNA sequencing and molecular phylogenetic methods. We expanded the cytochrome *b* (*cytb*) dataset published in Lavoué *et al*. (2008) by adding sequences for two new taxa: *Petrocephalus bovei* (Valenciennes in Cuvier and Valenciennes, 1847) from the Baro River at Gambela, Ethiopia (White Nile basin, CU 94594 [two specimens examined]) and *Petrocephalus catostoma* (Günther, 1866) from the Rufiji River, Tanzania (CU 93895 [one specimen examined]) and from the Wani River, Tanzania (CU 93893 [two specimens examined] and CU 93894 [one specimen examined]). This comparative material is important because it is common for specimens from the Congo basin to be identified as *P. catostoma* in collections, and *P. bovei* has a widespread distribution to the north of the Congo basin. To root the phylogenetic trees we used *Myomyrus macrops* Boulenger 1914, *Mormyrops nigricans* Boulenger, 1899, and *Gnathonemus petersii* (Günther, 1862) as outgroups.

DNA was extracted from 90% ethanol-preserved fin clips or dorsal muscle. PCR amplification and sequencing of the complete *cytb* gene (1,140 base pairs) were as described by Sullivan et al (2000) using the primers designed by Lavoué et al (2008). *Cytb* sequences generated in this study have been deposited to Genbank under accession numbers GU982921 to GU982926.

New *cytb* sequences were aligned by eye with previous sequences using PAUP* ver. 4.1.10 (Sinauer Associates, Inc.). Alignment was trivial without any insertions or deletions. We inferred phylogenetic trees for two different character matrices using maximum likelihood (ML). The first matrix (dataset #1; 1,140 nucleotide positions) included all positions and types of substitution. The second matrix (dataset #2) was the same as the first, except that fast evolving transitions at third codon positions were ignored by replacing third codon position guanines (G) and cytosines (C) with adenines (A) and thymines (T), respectively (Phillips *et al*., 2004).

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Maximum likelihood (ML) trees and the robustness of the internal branches of the best ML tree topologies (one topology for each data matrix) were simultaneously inferred using the program RAxML 7.0.4 (Stamatakis, 2006). We performed bootstrap searches (1,000 replicates) and heuristic phylogenetic searches under the general time reversible model of nucleotide substitution with rate heterogeneity following a discrete gamma distribution (GTR+Γ). We did so using the GTRGAMMA option in RAxML (consult the second part of section 5.1 in the RAxML 7.0.4 Manual for details).

Results

List of *Petrocephalus* species of Odzala

Petrocephalus binotatus Pellegrin, 1924

Petrocephalus binotatus Pellegrin (1924): 1.
[Odzala field identification: *Petrocephalus* sp. 1, OTU 1]

Images. Fig. 3A, photo of a live specimen from Odzala, Fig. 3B, photo of a preserved specimen from Odzala and Fig. 14, drawing of the holotype (MRAC 15191) from Pellegrin (1928), p. 12. Photo of the holotype in Harder (2000).

Type material. Holotype, MRAC 15191 [examined], sex undet., 83.2 mm SL. Democratic Republic of the Congo, Congo River at Ikengo [estimated geographic coordinates: 0.13° S, 18.13° E], H. Schouteden coll.

Other specimens. We have examined 35 additional specimens from Odzala National Park (see "additional material examined").

Diagnosis. The following diagnosis is based on all examined specimens of *P. binotatus*, regardless their geographic origins. *Petrocephalus binotatus* is distinguished from all other *Petrocephalus* species from Lower Guinea and Congo provinces by the following combination of characteristics. Dorsal fin shorter than the anal fin ($1.5 \leq$ AFL/DFL, range = 1.5–1.7). Dorsal fin with at least 20 branched rays (range = 20–24). Anal fin with at least 30 branched rays (range = 30–33). Sixteen teeth or fewer (range = 8–16) in the upper jaw, 24 teeth or fewer (range = 19–24) in the lower jaw. Eye relatively large (HL/ED ≤ 4.0, range = 3.5–4.0). Mouth sub-terminal; ratio of head length to mouth position (HL/MP) between 3.9 and 6.1. Unique pigmentation pattern with the presence of three well defined black patches: (1) a distinct (although sometimes covering only few scales), more or less round/oval, black mark situated slightly anterior to the dorsal fin on each side of the body; (2) a black mark at the base of each pectoral fin; (3) an ovoid black mark centered at the base of the caudal fin that does not extend onto the upper and lower fleshy lobes of this fin. EOD of normal polarity (i.e., first major phase head-positive).

Description. This description corresponds to the Odzala material (e.g., ranges, averages, medians), except where explicit reference is made to the holotype (from Ikengo). Morphometric ratios and meristic data for non-type specimens from Odzala and the holotype are presented in Table 1. *Petrocephalus binotatus*, described by Pellegrin (1924), is a small sized species within the genus *Petrocephalus* (maximum SL observed in Odzala = 88.4 mm, holotype = 83.2 mm). Body ovoid, longer than high ($2.3 \leq$ SL/H ≤ 2.8, average = 2.5, holotype = 2.4) and laterally compressed. Head length of Odzala specimens between 3.7 and 4.0 times in standard length (average = 3.9, holotype = 3.6). Snout short ($6.8 \leq$ HL/SNL ≤ 8.3, average = 7.8, holotype = 5.5) and round. Eye large ($3.5 \leq$ HL/ED ≤ 4.0, average = 3.6, holotype = 3.6). Mouth small ($4.4 \leq$ HL/MW ≤ 5.2, average = 4.7, holotype = 3.2), sub-terminal, opening under the anterior half of the eye. Teeth small and bicuspid, 8 to 16 (median = 10) in a single row in the upper jaw, 19 to 24 (median = 21) in the lower jaw. Dorsal and anal fins originate in the posterior half of the body ($1.5 \leq$ SL/PDD ≤ 1.6) and ($1.6 \leq$ SL/PAD ≤ 1.7), respectively. Pre-dorsal distance slightly greater than the pre-anal distance ($1.0 <$ PDD/PAD ≤ 1.1). Dorsal fin with 20–22 branched rays (median = 21, holotype = 24). Anal fin with 30–33 branched rays (median = 32, holotype = 33). Scales cover the body, except for the head. Lateral line visible and complete with 37 or 38 pored scales along its length. Eleven to 13 scales (median = 12), between the anterior base of the

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anal fin and the lateral line. Caudal peduncle thin (1.8 ≤ CPL/CPD ≤ 2.2, average = 2.0, holotype = 2.3). Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation. Three distinct rosettes of Knollenorgans are present on the head (Augenrosette, Nackenrosette and Kehlrosette).

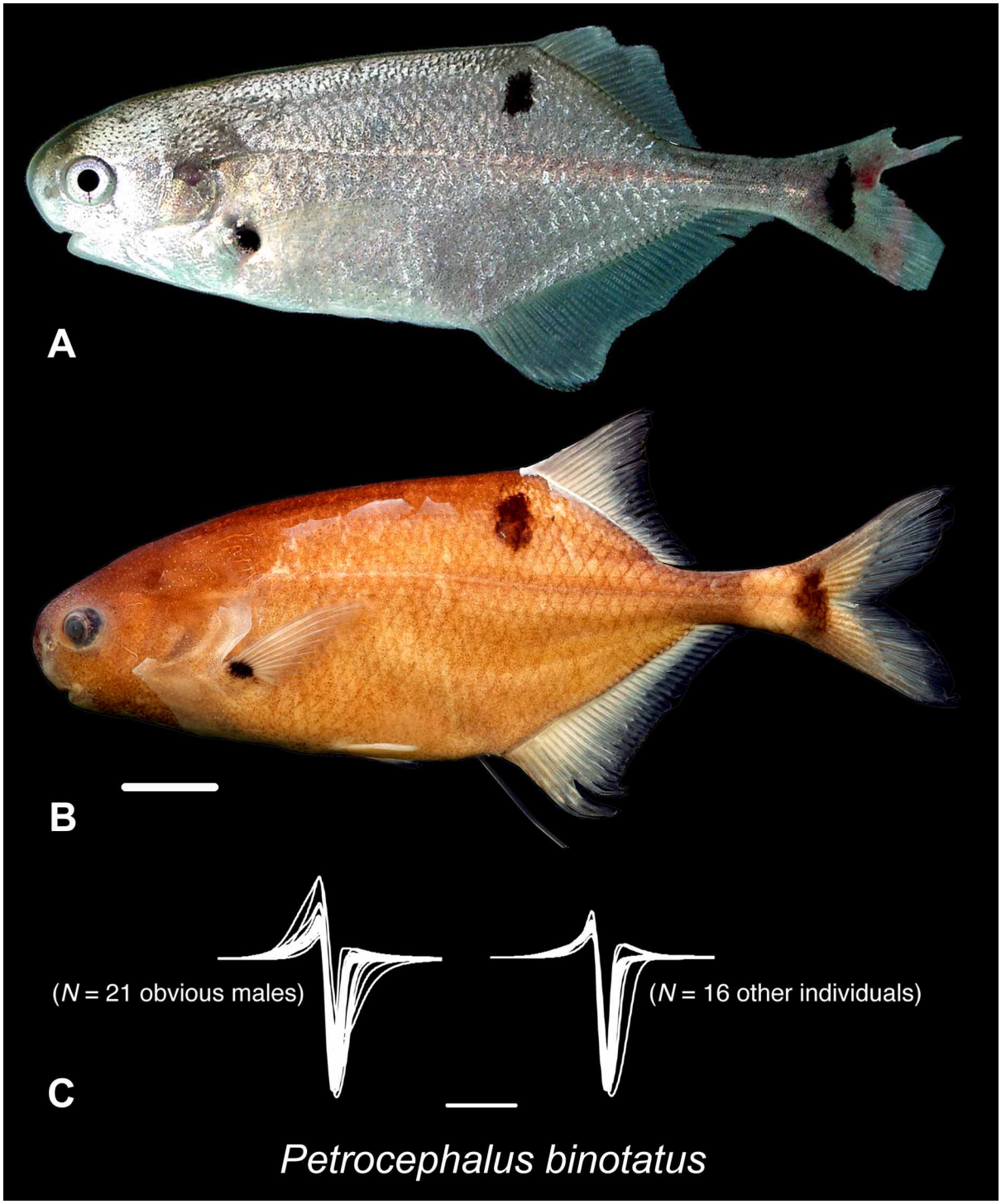

FIGURE 3. *Petrocephalus binotatus* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale: the photo has been maximally enlarged to better illustrate details of body shape, melanin patterning, etc.). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveforms displayed separately for obvious males and other individuals (see text). One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals, given separately for obvious males and all other individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

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TABLE 1. Principal morphometric ratios and meristic counts for the holotype (MRAC 15191) and seven specimens from Odzala (CU 88063, CU 88079, CU 88076, CU 88074, CU 87838, CU 88041, CU 88091) of *Petrocephalus binotatus* (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)	Specimens from Odzala (n=7)		
		Min–Max	Mean	Std–Dev
Standard length (mm)	83.2	65.0–88.4	76.0	8.1
Head length (mm)	23.1	17.3–21.9	19.6	1.6
Ratio of standard length (SL):				
SL/body height (H)	2.4	2.3–2.8	2.5	0.2
SL/head length (HL)	3.6	3.7–4.0	3.9	0.1
SL/pre-dorsal distance (PDD)	1.6	1.5–1.6	1.6	0.0
SL/pre-anal distance (PAD)	1.7	1.6–1.7	1.7	0.0
SL/dorsal fin length (DFL)	4.5	4.2–4.9	4.7	0.3
SL/anal fin length (AFL)	2.8	2.8–3.3	3.0	0.2
SL/caudal peduncle length (CPL)	7.0	6.5–7.6	7.1	0.4
SL/mouth width (MW)	11.6	17.3–18.2	20.3	1.0
Ratio of head length (HL):				
HL/snout length (SNL)	5.5	6.8–8.3	7.8	0.5
HL/mouth width (MW)	3.2	4.4–5.2	4.7	0.3
HL/eye diameter (ED)	3.6	3.5–4.0	3.6	0.2
HL/interorbital width (IOW)	2.3	2.6–3.0	2.8	0.2
HL/head width (HW)	1.9	1.8–1.9	1.8	0.0
HL/mouth position (MP)	3.9	4.4–6.1	5.1	0.6
Ratio of caudal peduncle length (CPL):				
CPL/caudal peduncle depth (CPD)	2.3	1.8–2.2	2.0	0.2
		Min–Max	Median	
Meristic counts:				
Dorsal fin branched rays (DR)	24	20–22	21	
Anal fin branched rays (AR)	33	30–33	32	
Number of scales in the lateral line (SLL)	37	37–38	37	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	11	11–13	12	
Number of teeth in the upper jaw (TUJ)		8–16	10	
Number of teeth in the lower jaw (TLJ)		19–24	21	

Live coloration (Fig. 3A). Body uniformly white-silver, with the presence of three characteristic melanin marks on each side of the body: (1) a distinct, approximately round/oval black mark situated slightly anterior to the dorsal fin, sometimes covering only a few scales; (2) a black spot at the base of the pectoral fin; (3) an ovoid black mark centered at the base of the caudal fin that does not extend onto the upper and lower parts of the caudal fin. Fins translucent.

Distribution (Fig. 1). Apparently endemic to the Congo River basin. Holotype from the locality Ikengo on the Congo River just below Mbandaka. One of the most abundant *Petrocephalus* species in Odzala. We collected *P. binotatus* at several localities along the main channel of the Lékoli River. At the time of our

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collections, however, this species appeared to be absent from small tributary creeks flowing through the forest or savannah.

Petrocephalus binotatus was absent in two recent collections from the Lower Congo River made in the vicinities of the Pool Malebo (one collection by M. Stiassny and B. Schelly in 2002, housed in the American Museum of Natural History; the other by P. Feulner and F. Kirschbaum in 2006, housed in the Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin; *pers. obs.* of material contained in these collections).

Electric organ discharge (Fig. 3C). *Petrocephalus binotatus* males and females produce EODs with overall waveforms that are typical for the genus, being similar to EODs produced by many other congeners. However, this is one of the few *Petrocephalus* species (e.g., the only *Petrocephalus* species in Odzala National Park) for which possible EOD sex differences have been detected thus far in field recordings. As with other *Petrocephalus* species exhibiting possible sex differences, magnitudes of the differences between males and females are small. In Odzala, for example, mean EOD duration (± std. dev.) is 0.330 ± 0.074 msec in obvious adult males and 0.270 ± 0.033 msec in other adult and sub-adult individuals, based on 1.5% voltage deviations from baseline relative to peak-peak amplitude. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al.* (2008) for specimens recorded in Odzala National Park. No EOD recordings are available for the holotype or other specimens collected near the type locality (Ikengo, Congo River, Fig. 1). Electrocytes are assumed to be of type NPp based on characteristics of the EOD, although electrocyte anatomy has not yet been confirmed histologically.

Remarks. Specimens of *P. binotatus* from Odzala resemble the holotype described from the main channel of the Congo River (locality Ikengo, Fig. 1) (Pellegrin, 1924). However, they also exhibit several differences, mainly in head morphology. The holotype has a larger mouth (HL/MW = 3.2 *versus* ≥ 4.4 in Odzala specimens), a longer snout (HL/SNL = 5.5 *versus* ≥ 6.8 in Odzala specimens) and a larger interorbital width (HL/IOW = 2.3 *versus* ≥ 2.6 in Odzala specimens). Additional comparative material from the type locality and other localities in the Congo basin are necessary to determine the taxonomic implications of these differences.

Petrocephalus zakoni n. sp.

[Odzala field identification and in Lavoué *et al.* (2008): *Petrocephalus* sp. 2, OTU 2]

Images. Fig. 4A, photo of a live specimen from Odzala and Fig. 4B, photo of the preserved holotype (CU 88101).

Type material. Holotype, CU 88101 (morpho, EOD), male, 86.0 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.95° E). J.P. Friel, S. Lavoué & J.P. Sullivan coll., 20 August 2002.

Paratypes. CU 88036 (morpho, EOD), sex undet., 81.4 mm SL; CU 88042 (morpho, EOD), male, 78.6 mm SL; CU 88037 (morpho, EOD), sex undet., 79.6 mm SL; CU 88077 (morpho), male, 84.8 mm SL. Republic of the Congo, Pandaka River (Congo basin), Odzala National Park, (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002. CU 88104 (morpho, EOD), sex undet., 83.5 mm SL; AMNH 251426 (ex CU 88100) (morpho, EOD), male, 73.7 mm SL; AMNH 251427 (ex CU 88103) (morpho, EOD), sex undet., 77.2 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.95° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002. CU 88093 (morpho, EOD), male, 67.4 mm SL; AMNH 251424 (ex CU 88088) (morpho, EOD), sex undet., 75.8 mm SL; AMNH 251425 (ex CU 88090) (morpho, EOD), male, 76.0 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002.

Other specimens. We examined 34 other specimens from Odzala National Park (specimen list provided in the section "additional material examined").

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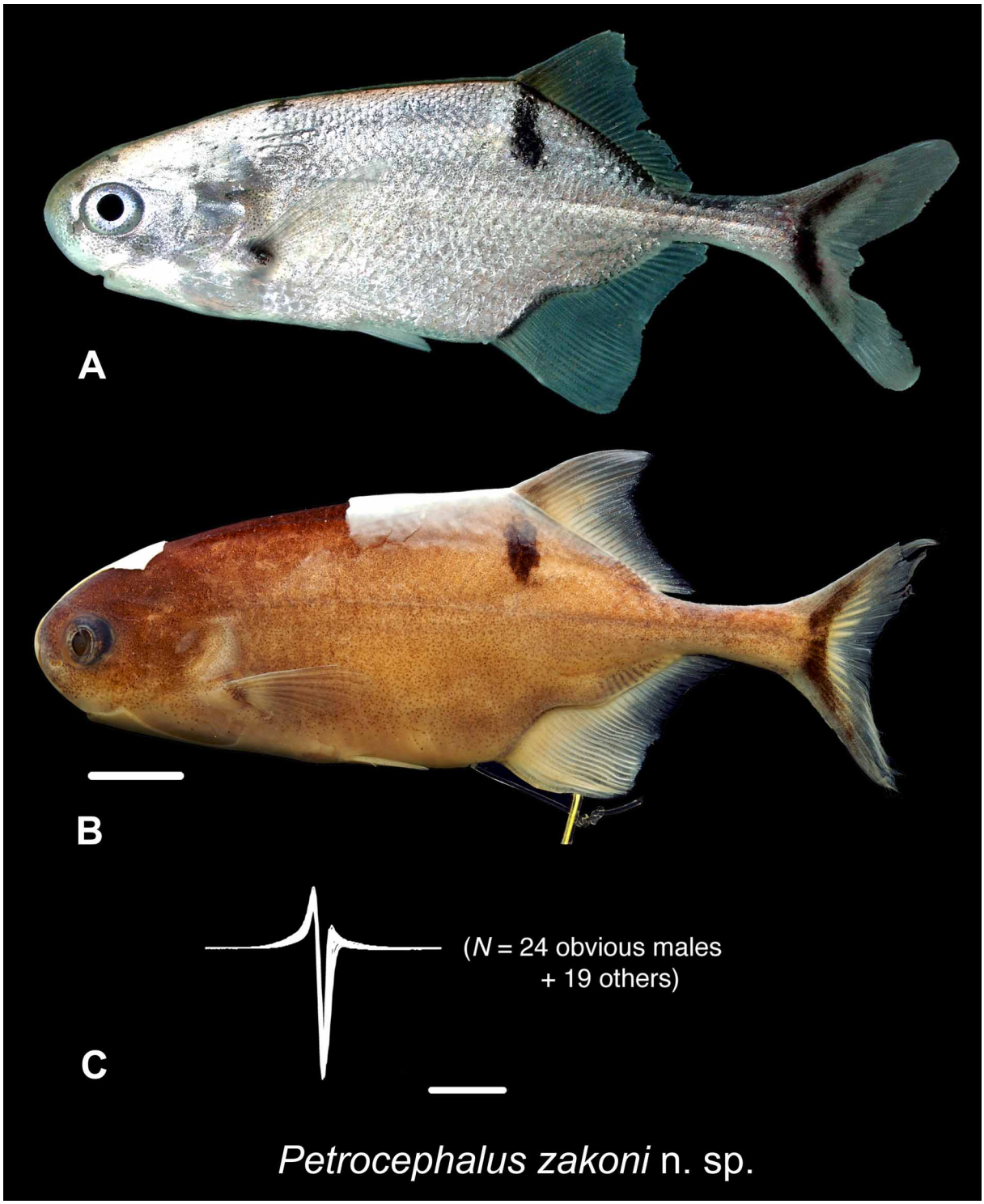

FIGURE 4. *Petrocephalus zakoni* **n. sp.** of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of the preserved holotype (CU 88101; scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

Diagnosis. *Petrocephalus zakoni* **n. sp.** is distinguished from all other *Petrocephalus* species in Central Africa (Lower Guinea and Congo provinces) by the following combination of characteristics. Dorsal fin with 23 or 24 branched rays. Anal fin with 27 or 28 branched rays. Eye large (HL/ED $\leq$ 3.3, range = 3.1–3.3). Mouth small (4.4 $\leq$ HL/MW, range = 4.4–5.0). Ten teeth or fewer (range = 6–10) in the upper jaw. Twenty-

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two teeth or fewer (range = 18–22) in the lower jaw. Unique pigmentation pattern consisting of three well defined black patches (Fig. 4A): (1) an intense dark mark on each side of the body close to the anterior base of the dorsal fin, often extending onto the first dorsal rays, forming a characteristic saddle across the dorsum; (2) a mark on each side of the body at the base of the pectoral fin; (3) a crescent-shaped mark on each side of the body centered at the base of the caudal fin, extending onto the upper and lower parts of the caudal fin. EOD of normal polarity (i.e., first major phase head-positive).

Description. Morphometric ratios and meristic data are given in Table 2 for the holotype and paratypes separately. *Petrocephalus zakoni* **n. sp.** is a small sized species within the genus (maximum SL in the type series = 86.0 mm, maximum SL observed in all specimens = 90 mm). Body ovoid, longer than high (2.5 ≤ SL/H ≤ 2.8, paratype average = 2.6, holotype =2.8) and laterally compressed. Head length between 3.4 and 3.7 times in standard length (paratype average = 3.6, holotype = 3.6). Eye large compared to many *Petrocephalus* species (3.1 ≤ HL/ED ≤ 3.3, paratype average = 3.2, holotype = 3.2). Snout short (6.1 ≤ HL/SNL ≤ 8.5, paratype average = 7.2, holotype = 6.2) and round. Mouth small (4.4 ≤ HL/MW ≤ 5.0, paratype average = 4.7, holotype = 4.5) and sub-terminal, opening under the posterior half of the eye. Teeth small and bicuspid, 6–10 (paratype median = 8, holotype = 9) in a single row in the upper jaw, 18–22 (paratype median = 19, holotype = 20) in the lower jaw. Dorsal and anal fins originate in the posterior half of the body (1.6 ≤ SL/PDD ≤ 1.7, paratype average and holotype = 1.6; 1.6 ≤ SL/PAD ≤ 1.7, paratype average and holotype = 1.6). Pre-dorsal distance roughly equal to the pre-anal distance. Dorsal fin with 23 or 24 branched rays (median = 23, holotype = 24). Anal fin with 27 or 28 branched rays (median = 27, holotype = 28). Scales cover the body, except for the head. Lateral line visible and complete with 36–38 pored scales along its length (paratype average = 37, holotype = 38). Twelve to 14 scales (paratype average = 13, holotype = 14) between the anterior base of the anal fin and the lateral line. Caudal peduncle thin (1.9 ≤ CPL/CPD ≤ 2.3, paratype average = 2.1, holotype = 2.2). Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation. Knollenorgans on the head are not clustered into "rosettes" but, instead, appear as isolated receptor pores, the character state observed in the Mormyrinae.

Live coloration (Fig. 4A). Body uniformly white-silver, with the presence of three characteristic pigmentation marks: (1) a very distinctive black mark just below the anterior base of the dorsal fin on each side, often extending onto the first dorsal rays and making contact over the dorsum with the contralateral mark; (2) a blackish mark, sometimes weak but always visible, at the base of the pectoral fins; (3) a crescent-shaped black mark centered at the base of the caudal fin on each side, extending onto the upper and lower parts of the caudal fin. Fins otherwise translucent.

Distribution (Fig. 1). Apparently endemic to the Congo basin. Abundant in Odzala. We collected *P. zakoni* **n. sp.** at several localities along the main channel of the Lékoli River at night. Elsewhere in the Congo basin, we have identified specimens of *P. zakoni* **n. sp.** from the Lower Congo (Pool Malebo) and from the Sangha River basin (unpublished observations).

Electric organ discharge (Fig. 4C). EOD waveforms produced by *P. zakoni* **n. sp.** are of relatively short duration among *Petrocephalus* (range = 0.164–0.281 msec), but they are, nevertheless, very similar in waveform to the EODs of several other *Petrocephalus* species. EOD sex differences are not apparent in the Odzala population. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al*. (2008). Electrocytes are assumed to be of type NPp based on characteristics of the EOD, although electrocyte anatomy has not yet been confirmed histologically.

Remarks. Given our identification of specimens from the Lower Congo River and the Dzangha-Sangha Reserve (Sangha River), *Petrocephalus zakoni* **n. sp.** is likely a common species in the Congo basin. This species has been previously misidentified as *Petrocephalus christyi* Boulenger, 1920 because its body proportions are similar to those of *P. christyi*. In addition, both species exhibit an intense sub-dorsal melanin marking on the flank. Nevertheless, these species can be distinguished by the presence of a black spot at the base of the pectoral fins in *P. zakoni* **n. sp.** (absent in *P. christyi*), the shape of the sub-dorsal marking (ovoid to saddle-shaped *versus* rounded in *P. christyi*), the waveshape of the EOD (with two main phases and a weak third phase in *P. zakoni versus* four phases in *P. christyi*) and presence/absence of Knollenorgan rosettes on the head (absent in *P. zakoni versus* present in *P. christyi*).

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TABLE 2. Principal morphometric ratios and meristic counts for the holotype (CU 88101) and 10 paratypes (CU 88104, CU 88093, CU 88036, CU 88077, CU 88042, CU 88037, AMNH 250920, AMNH 250921, AMNH 250922, AMNH 250923) of *Petrocephalus zakoni* **n. sp.** (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)	Paratypes (n=10)		
		Min–Max	Mean	Std–Dev
Standard length (mm)	86.0	67.4–84.8	77.8	5.1
Head length (mm)	23.8	19.7–24.0	21.9	1.5
Ratio of standard length (SL):				
SL/body height (H)	2.8	2.5–2.7	2.6	0.1
SL/head length (HL)	3.6	3.4–3.7	3.6	0.1
SL/pre-dorsal distance (PDD)	1.6	1.6–1.7	1.6	0.0
SL/pre-anal distance (PAD)	1.6	1.6–1.7	1.6	0.0
SL/dorsal fin length (DFL)	4.2	4.0–4.3	4.1	0.1
SL/anal fin length (AFL)	3.5	3.3–3.5	3.4	0.1
SL/caudal peduncle length (CPL)	6.9	6.4–7.0	6.7	0.2
SL/mouth width (MW)	16.2	15.5–17.6	16.6	0.7
Ratio of head length (HL):				
HL/snout length (SNL)	6.2	6.1–8.5	7.2	0.7
HL/mouth width (MW)	4.5	4.4–5.0	4.7	0.2
HL/eye diameter (ED)	3.2	3.1–3.3	3.2	0.1
HL/interorbital width (IOW)	3.0	2.4–3.2	2.9	0.2
HL/head width (HW)	1.9	1.8–2.0	1.9	0.0
HL/mouth position (MP)	3.4	3.2–3.9	3.5	0.2
Ratio of caudal peduncle length (CPL):				
CPL/caudal peduncle depth (CPD)	2.2	1.9–2.3	2.1	0.1
		Min–Max	Median	
Meristic counts:				
Dorsal fin branched rays (DR)	24	23–24	23	
Anal fin branched rays (AR)	28	27–28	27	
Number of scales in the lateral line (SLL)	38	36–37	37	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	14	12–14	13	
Number of teeth in the upper jaw (TUJ)	9	6–10	8	
Number of teeth in the lower jaw (TLJ)	20	18–22	19	

Etymology. Named in honor of Harold H. Zakon. In addition to Professor Zakon's many contributions to neuroethology, we recognize the significance of his recent work (Zakon *et al*., 2006), which inspires a new area of research on genes that underlie electrolocation and electrical communication in gymnotiform and mormyroid fishes.

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***Petrocephalus valentini* n. sp.**

[Odzala field identification and in Lavoué *et al*. (2008): *Petrocephalus* sp. 3, OTU 3]

Images. Fig. 5A, photo of a live specimen from Odzala and Fig. 5B, photo of the preserved holotype (CU 88117).

Type material. Holotype, CU 88117 (morpho, EOD), male, 77.2 mm SL. Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan**,** 24 August 2002.

Paratypes. CU 87828 (morpho, EOD), sex undet., 73.6 mm SL; AMNH 251420 (ex CU 87827) (morpho, EOD), male, 70.9 mm SL; AMNH 251423 (ex CU 88116) (morpho, EOD), sex undet., 64.5 mm SL; CU 88120 (morpho, EOD), sex undet., 66.7 mm SL; CU 88118 (morpho, EOD, DNA), sex undet., 58.1 mm SL. Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.93°E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 24 August 2002. CU 87834 (morpho, EOD), male, 70.6 mm SL; AMNH 251422 (ex CU 88073) (morpho, EOD), sex undet., 65.9 mm SL; AMNH 251421 (ex CU 88072) (morpho, EOD), male, 72.9 mm SL. Republic of the Congo, Cuvette-Ouest, Lékénie River at Mboko débarcadère, Odzala National Park (0.62° N, 14.91° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002.

Other specimens. We examined three other specimens from Odzala National Park (specimen list provided in the section "additional material examined").

Diagnosis. *Petrocephalus valentini* **n. sp.** is distinguished from all other *Petrocephalus* species in Central Africa (i.e., Lower Guinea and Congo provinces) by the following combination of characteristics. Dorsal fin with 19–24 branched rays. Anal fin with 24–26 branched rays. Eye large (HL/ED ≤ 3.2, range = 2.9–3.2). Mouth very small (HL/MW ≤ 5.8, range = 4.7–5.8). Twelve teeth or fewer in the upper jaw (range = 7–12), 17 teeth or fewer in the lower jaw (range = 15–17). Pigmentation pattern subtle, including two components: (1) a pale dorsal black mark on each side of the body below the anterior base of the dorsal fin (under the second to sixth dorsal rays); (2) an ovoid mark, sometimes scarcely visible, at the base of the caudal fin, extending weakly onto the upper and lower lobes of the fin. EOD of normal polarity.

Description. Morphometric ratios and meristic data are given in Table 3 for the holotype and paratypes separately. *Petrocephalus valentini* **n. sp.** is a small sized species within the genus (maximum SL = 77.2 mm, holotype). Body ovoid, longer than high (2.8 ≤ SL/H ≤ 3.0, paratype average = 2.9, holotype = 2.8) and laterally compressed. Head length between 3.4 and 3.7 times in standard length (paratype average = 3.6, holotype = 3.4). Snout short (6.5 ≤ HL/SNL ≤ 8.2, paratype average = 7.4, holotype = 6.5) and round. Mouth small (4.7 ≤ HL/MW ≤ 5.8, paratype average = 5.2, holotype = 5.1) and sub-terminal, positioned under the anterior half of the eye. Eye large (2.9 ≤ HL/ED ≤ 3.2, paratype average = 3.0, holotype = 3.1). Teeth small and bicuspid, 7–12 (paratype median = 9, holotype = 9) in a single row in the upper jaw, 15–17 (paratype median = 16, holotype = 17) in the lower jaw. Dorsal and anal fins originate in the posterior half of the body (1.6 ≤ SL/PDD ≤ 1.7 and SL/PAD = 1.6). Pre-dorsal distance approximately equal to the pre-anal distance. Dorsal fin with 19–24 branched rays (paratype median = 22, holotype = 22). Anal fin with 24–26 branched rays (paratype median = 25, holotype = 25). Scales cover the body, except for the head. Lateral line visible and complete with 35–36 pored scales along its length (paratype median = 36, holotype = 35). Nine to 12 scales (paratype median = 11, holotype = 11) between the anterior base of the anal fin and the lateral line. Caudal peduncle relatively thin (2.2 ≤ CPL/CPD ≤ 2.5, paratype average = 2.3, holotype = 2.3). Twelve scales around the caudal peduncle. Skin on head thick, turning opaque with formalin fixation. Knollenorgans clearly organized into two visible rosettes (the Augenrosette and the Nackenrosette). During our examination of specimens, we were uncertain about the definitive presence of the third rosette, the Kehlrosette, as this structure did not appear to us to be as distinct as it is in some other species (e.g., *P. binotatus*). Recently, however, more definitive analysis using toluidine blue staining of the skin suggests that the Kehlrosette is in fact present, but it is indeed smaller and harder to discern than in other *Petrocephalus* (M. Hollmann and B. A. Carlson, *unpub. obs.*).

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TABLE 3. Principal morphometric ratios and meristic counts for the holotype (CU 88117) and eight paratypes (CU 87828, CU 87834, CU 88120, CU 88118, AMNH 250924, AMNH 250925, AMNH 250926, AMNH 250927) of *Petrocephalus valentini* **n. sp.** (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)	Paratypes (n=8)		
		Min–Max	Mean	Std–Dev
Standard length (mm)	77.2	58.1–73.6	67.9	5.2
Head length (mm)	22.4	16.0–20.2	18.8	1.4
Ratio of standard length (SL):				
SL/body height (H)	2.8	2.8–3.0	2.9	0.1
SL/head length (HL)	3.4	3.6–3.7	3.6	0.0
SL/pre-dorsal distance (PDD)	1.7	1.6–1.7	1.7	0.0
SL/pre-anal distance (PAD)	1.6	1.6–1.6	1.6	0.0
SL/dorsal fin length (DFL)	4.2	4.3–4.9	4.4	0.2
SL/anal fin length (AFL)	4.1	3.9–4.3	4.1	0.1
SL/caudal peduncle length (CPL)	5.1	5.1–5.8	5.3	0.3
SL/mouth width (MW)	17.5	17.2–20.6	18.9	1.2
Ratio of head length (HL):				
HL/snout length (SNL)	6.5	6.8–8.2	7.4	0.5
HL/mouth width (MW)	5.1	4.7–5.8	5.2	0.4
HL/eye diameter (ED)	3.1	2.9–3.2	3.0	0.1
HL/interorbital width (IOW)	3.2	2.8–3.2	3.0	0.1
HL/head width (HW)	2.1	1.8–1.9	1.9	0.0
HL/mouth position (MP)	4.7	3.6–4.3	3.9	0.3
Ratio of caudal peduncle length (CPL):				
CPL/caudal peduncle depth (CPD)	2.3	2.2–2.5	2.3	0.1
		Min–Max	Median	
Meristic counts:				
Dorsal fin branched rays (DR)	22	19–24	22	
Anal fin branched rays (AR)	25	24–26	25	
Number of scales in the lateral line (SLL)	35	35–36	36	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	11	9–12	11	
Number of teeth in the upper jaw (TUJ)	9	7–12	9	
Number of teeth in the lower jaw (TLJ)	17	15–17	16	

Live coloration (Fig. 5A). Body uniformly white-silver, with two faint black patches, sometimes hardly distinguishable: (1) a dorsal mark on each side of the body, below the anterior base of the dorsal fin under the second to the sixth rays; (2) an ovoid/crescent-shaped mark centered at the base of the caudal fin (sometimes the center of this second mark is less distinguishable than the two arms of the crescent), with each arm slightly extending onto the upper and lower parts of the caudal fin. There is no melanin marking at the base of the pectoral fins. Fins translucent.

Distribution (Fig. 1). Apparently endemic to the Congo basin. Common in Odzala National Park. At night, we collected single specimens cruising in the main channel of the Lékoli River. At the times we

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surveyed Odzala, *P. valentini* seemed absent from the small tributary creeks flowing through the park's forest or savannah. Elsewhere in the Congo basin, *P. valentini* **n. sp.** has been collected from the Lower Congo River in the vicinity of the Pool Malebo (museum specimen records, *pers. obs.*).

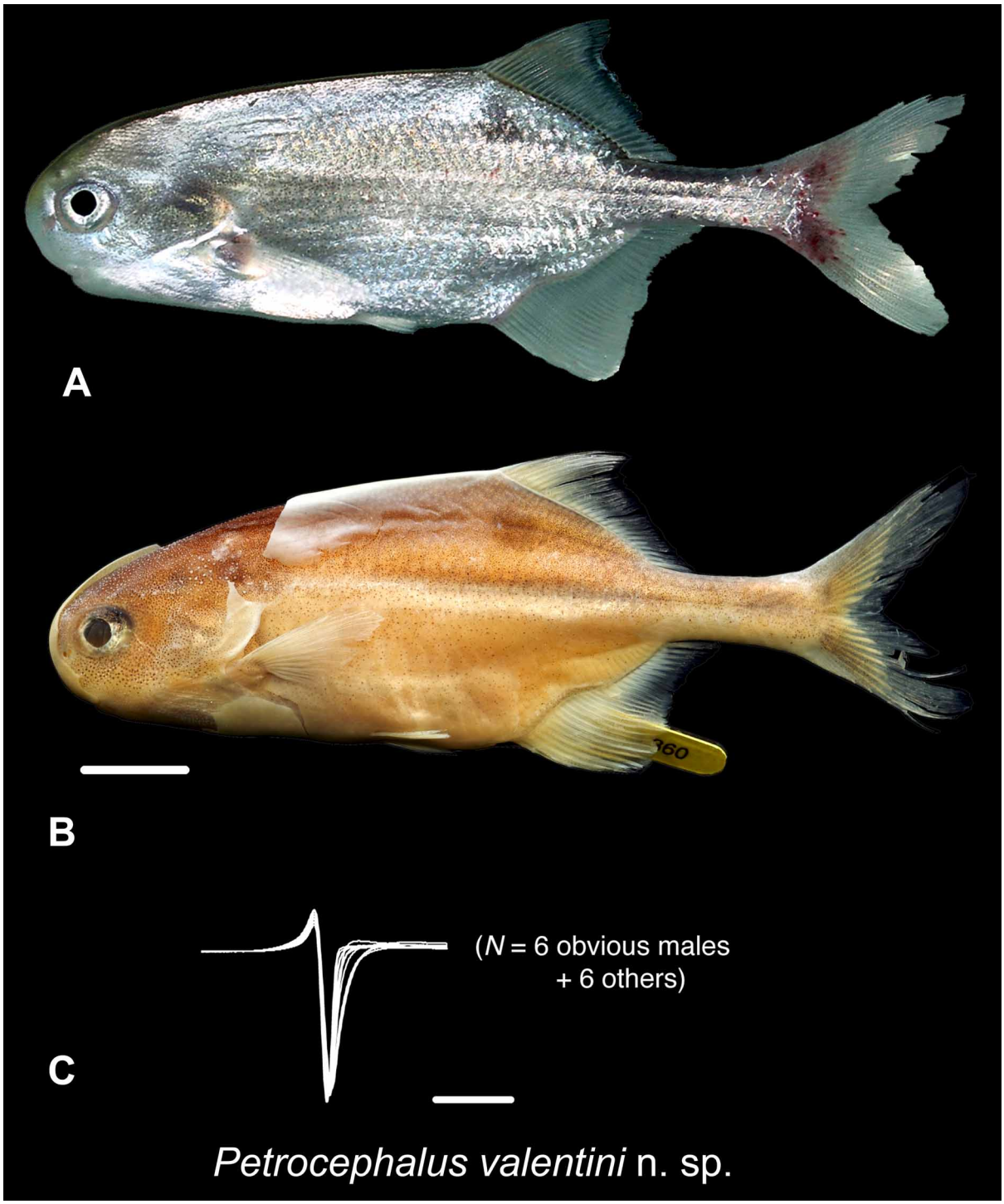

FIGURE 5. *Petrocephalus valentini* **n. sp.** of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of the preserved holotype (CU 88117; scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

Electric organ discharge (Fig. 5C). The EOD waveform produced by *P. valentini* **n. sp.** is similar in its characteristics to those produced by many other *Petrocephalus* species. EOD duration = 0.520 – 1.022 msec.

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Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al*. (2008). Electrocytes are assumed to be of type NPp based on the EOD waveform, although this has not been confirmed histologically.

Remarks. Without careful inspection, it is possible that specimens of *Petrocephalus valentini* **n. sp.** could be misidentified as *Petrocephalus catostoma* or *Petrocephalus simus* because of the absence or near absence of pigmentation patterns in all three species. However, these three species differ from each other in several morphometric measurements and meristic counts, and their geographical distributions, as currently known, are non-overlapping.

Etymology. Named in honor of Mr. Valentin Mbossi, *pinassier extraordinaire* at Odzala National Park. Fieldwork is as important as laboratory bench work and analysis when it comes to investigations of electric fish taxonomy, behavior and evolution. Valentin assisted us during both of our expeditions to Odzala. We use his first name for this species to reflect our appreciation of him as both colleague and friend and to avoid confusion with a similarly named species, below.

Petrocephalus balayi Sauvage, 1883

Mormyrus catostoma – Günther (1867): 116 (*non Mormyrus catostoma* Günther, 1866).
Petrocephalus balayi Sauvage (1883): 159.
Mormyrus ballayi – Sauvage (1884): 195.
Petrocephalus ballayi – Pellegrin (1908): 185. — Boulenger (1909–1916): 52. — Gosse (1984): 108.
Mormyrus amblystoma Günther (1896): 281. — Boulenger (1909–1916): 52.
[Odzala field identification: *Petrocephalus* sp. 4, OTU 4]

Images. Fig. 6A, photo of a live specimen from Odzala, Fig. 6B, photo of a preserved specimen from Odzala and Fig. 14, drawing of the holotype of *Mormyrus amblystoma* from Boulenger (1909–1916). Photos of the preserved holotype of *Petrocephalus balayi* in Lavoué *et al* (2004) and Harder (2000).

Type material. Holotype, MNHN A 6297, sex undet., 85.5 mm SL. Gabon, Ogooué River, without more precision, Expedition Savorgnan de Brazza, Noël Ballay coll.

Other specimens. We examined two other specimens from Odzala National Park (see specimen list provided in the section "additional material examined"). We also examined other specimens from the Lower Guinea province [listed in Lavoué *et al*. (2004)].

Diagnosis. The following diagnosis is based on all examined specimens of *P. balayi*, regardless their geographic origins. *Petrocephalus balayi* is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Dorsal fin with 20–22 branched rays. Anal fin with 26 or 27 branched rays. Eye small (4.5 ≤ HL/ED, range = 4.5–4.9). Mouth very wide (HL/MW ≤ 3.9, range = 2.7–3.9), associated with a very characteristic head shape when viewed from below. Fourteen teeth or more in the upper jaw (range = 14–21). Twenty-eight teeth or more in the lower jaw (range = 28–38). Melanin pattern consisting of the following: (1) a distinct black round mark on each side of the body below dorsal fin origin; (2) an ovoid mark on each side at the base of the caudal peduncle, not extending onto the upper and lower parts of the caudal fin; (3) a black mark, sometimes diffuse but always present, at the base of the pectoral fins. The EOD is of normal polarity.

Description. Table 4 presents morphometric ratios and meristic data for the holotype (from the Ogooué River in Gabon) and for non-type specimens (from Gabon or Odzala) separately. Data given in the following description (e.g., ranges) correspond to the two Odzala specimens we examined, except where explicit reference is made to the holotype. *Petrocephalus balayi*, described by Sauvage (1883), is a large, robust species within the genus *Petrocephalus* (maximum SL observed in Odzala = 95.6 mm SL, holotype = 85.5 mm SL). Body ovoid, longer than high (SL/H = 2.5–2.7, holotype = 2.8) and laterally compressed. Head length between 3.3 and 3.4 times (holotype = 3.3) in standard length. Head width 1.9 times (holotype = 2.2) in head length. Snout short (8.4 ≤ HL/SNL ≤ 9.3, holotype = 8.1), wide and square-shaped. Mouth wide (2.7 ≤ HL/MW ≤ 3.1, holotype = 3.4), sub-terminal, opening under the anterior half of the eye. Teeth small and bicuspid, 30 in a single row in the lower jaw and 20–21 in the upper jaw. Eye small (4.5 ≤ HL/ED ≤ 4.8,

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holotype = 4.6). Dorsal and anal fins originate in the posterior half of the body (SL/PDD = 1.6 and SL/PAD = 1.6), with pre-dorsal distance equal to pre-anal distance. Pre-dorsal distance slightly exceeds pre-anal distance in the holotype (1.0 ≤ PDD/PAD ≤ 1.1). Dorsal fin with 22 branched rays (holotype = 21). Anal fin with 27 branched rays (holotype = 26). Scales cover the entire body, except for the head. Lateral line visible and complete with 36 pored scales. Caudal peduncle relatively thick (1.7 ≤ CPL/CPD ≤ 1.8, holotype = 2.3). Twelve circumpeduncular scales. Skin on head thick, becoming opaque with formalin fixation. Knollenorgans organized into the three rosettes named by Harder (1968).

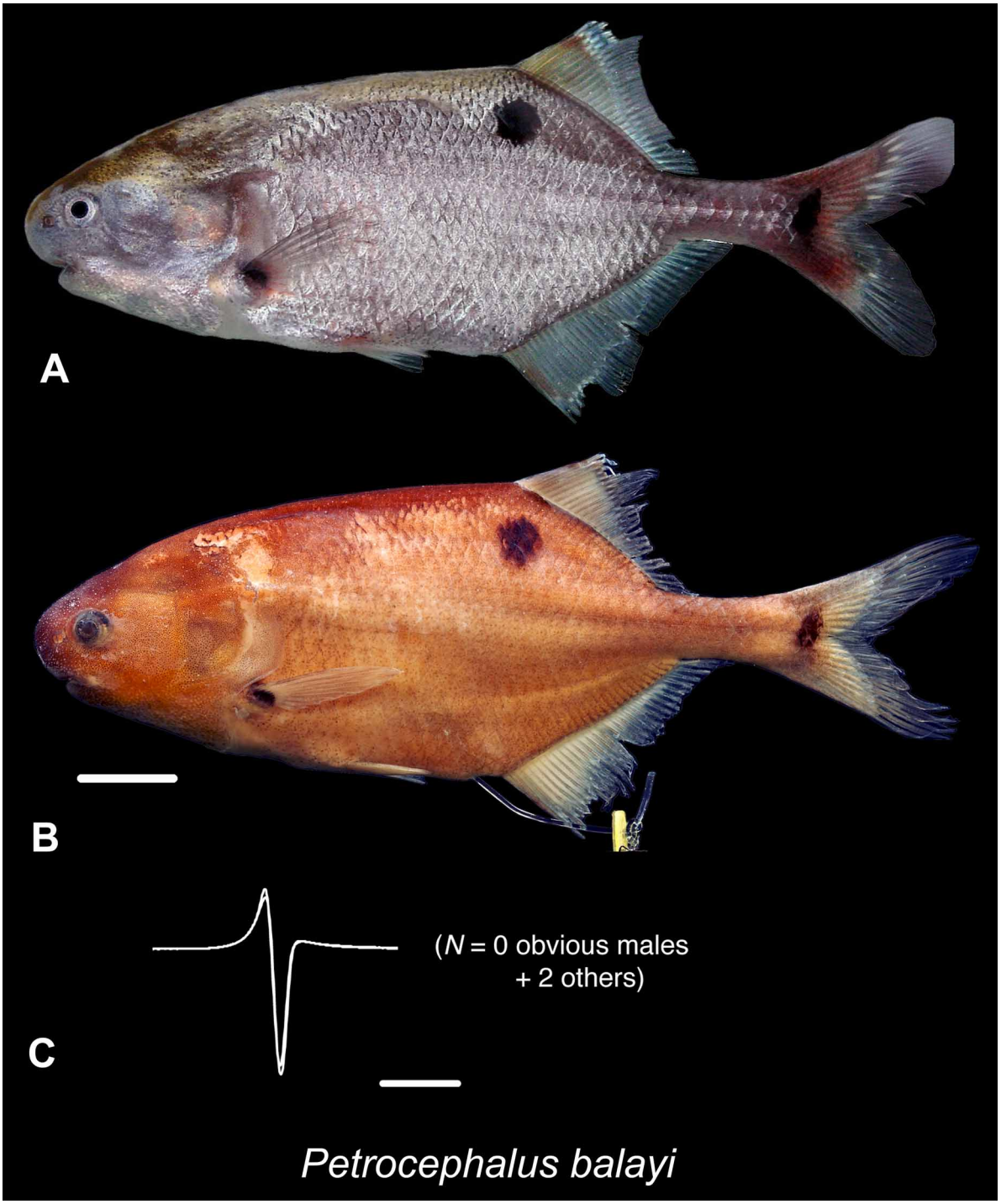

FIGURE 6. *Petrocephalus balayi* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each of two recorded individuals, and they were superimposed together. Both EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as an overlay centered on the largest positive peak (scale bar = 0.2 msec).

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TABLE 4. Principal morphometric ratios and meristic counts for the holotype (MNHN A6297), two non-type specimens from Odzala (CU 87851, CU 88111) and seven non type specimens from Gabon of *Petrocephalus balayi* Sauvage, 1883. (Abbreviations: o= sex category "other" [i.e., not an obvious mature male, but rather a female or immature male]; Std-Dev= standard deviation; Min-Max= minimum-maximum).

	Holotype (o)*	Specimens from Odzala (n=2)	Specimens from Gabon (Ogooué basin) (n=7)*		
		Min–Max	Min–Max	Mean	Std–Dev
Standard length (mm)	85.5	81.3–95.6	82.2–126.0	98.3	17.9
Head length (mm)	25.9	24.2–28.6	23.3–36.0	28.4	4.8
Ratio of standard length (SL):					
SL/body height (H)	2.8	2.5–2.7	2.5–3.0	2.8	0.1
SL/head length (HL)	3.3	3.3–3.4	3.3–3.6	3.5	0.1
SL/pre-dorsal distance (PDD)	1.5	1.6–1.6	1.5–1.6	1.5	0.0
SL/pre-anal distance (PAD)	1.6	1.6–1.6	1.5–1.7	1.6	0.0
SL/dorsal fin length (DFL)	4.5	4.2–4.4	4.3–5.1	4.8	0.2
SL/anal fin length (AFL)	3.8	3.5–3.5	3.4–4.0	3.8	0.3
SL/caudal peduncle length (CPL)	5.7	6.9–7.0	5.1–6.6	6.0	0.4
SL/mouth width (MW)	11.2	9.0–10.4	9.3–13.7	11.1	1.3
Ratio of head length (HL):					
HL/snout length (SNL)	8.1	8.4–9.3	5.4–7.6	6.2	0.9
HL/mouth width (MW)	3.4	2.7–3.1	2.7–3.9	3.3	0.4
HL/eye diameter (ED)	4.6	4.5–4.8	4.5–4.9	4.7	0.1
HL/interorbital width (IOW)	3.2	3.0–3.0	2.6–3.1	2.8	0.2
HL/head width (HW)	2.2	1.9–1.9	1.6–2.0	1.9	0.1
HL/mouth position (MP)	5.9	4.7–4.9	5.0–5.7	5.5	0.3
Ratio of caudal peduncle length (CPL):					
CPL/caudal peduncle depth (CPD)	2.3	1.7–1.8	1.9–2.2	2.0	0.1
		Min–Max	Min–Max	Median	
Meristic counts:					
Dorsal fin branched rays (DR)	21	22–22	20–22	22	
Anal fin branched rays (AR)	26	27–27	26–27	26	
Number of scales in the lateral line (SLL)	38	36–36	35–37	36	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	11	10–10	10–12	11	
Number of teeth in the upper jaw (TUJ)	16	20–21	14–18	-	
Number of teeth in the lower jaw (TLJ)	38	30–30	28–37	-	

*Data from Lavoué *et al*. (2004)

Live coloration (Fig. 6A). Body gray/silver, slightly darker dorsally. The head is also slightly darker than the rest of the body. Iridescent pigment along side of body sometimes visible with correct orientation of light. Pigmentation pattern with three black patches: (1) a distinct round black mark on each side of the body below the dorsal fin origin; (2) an ovoid black mark on each side at the base of the caudal peduncle that does not extend onto the upper and lower parts of the caudal fin; (3) a black mark, sometimes diffuse in larger individuals but always present, at the base of the pectoral fins. The fins themselves are translucent.

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Distribution (Fig. 1). *Petrocephalus balayi* occurs in the southern part of the Lower Guinea province and in the Congo River basin, including Odzala and the Lower Congo River (David & Poll, 1937; Lavoué *et al*., 2004; Poll, 1939; Sauvage, 1883). In Odzala, *Petrocephalus balayi* seems to prefer the small tributary creeks flowing through forest. In Gabon (Lower Guinea province), *P. balayi* occurs in the lower courses of the Ogooué River and numerous associated lakes (and their tributary streams), as well as in small coastal creeks from south of the Ogooué to the Congo River basin. Records from the upper part of the Lower Guinea province and elsewhere appear to be misidentifications (*pers. obs*.).

Electric organ discharge (Fig. 6C). EOD recordings are only available for a small number of individuals: one specimen from the coastal river Doumvou at Doumvou, Gabon [03.33S–10.73E] (*S. Lavoué & V. Mamonekene coll., 24 July 2001*) (Lavoué *et al*., 2004); and two specimens from Odzala National Park, Republic of the Congo (Lavoué *et al*., 2008). Among these few recordings, the overall waveform of EODs produced by *P. balayi* seems to be typical for the genus, similar to those produced by several other *Petrocephalus* species. EOD duration = 0.324 – 0.340 msec. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al*. (2008), who confirmed histologically that electrocytes in *P. balayi* are of type NPp.

Remarks. Almost all measurements and meristic counts of Odzala specimens fall within the range of values defined by the holotype and other specimens from Gabon. The EOD waveforms of the Odzala specimens and those from Gabon are similar (Lavoué *et al*., 2004).

Petrocephalus microphthalmus Pellegrin, 1908

Petrocephalus microphthalmus Pellegrin (1908): 185.
[Odzala field identification: *Petrocephalus* sp. 5, OTU 5]

Images. Fig. 7A, photo of a live specimen from Odzala, Fig. 7B, photo of a preserved specimen from Odzala and Fig. 14, drawing from Poll (1967) of a specimen collected in Angola. Photo of the holotype (MNHN 1908–211) in Lavoué *et al*. (2004).

Type material. Holotype, MNHN 1908–211, male, 73.7 mm SL. Gabon, Ogooué basin at Ngomo (Lower Ogooué) [estimated 0.82S, 9.95E], E. Haug coll.

Other specimens. We examined 14 other specimens from Odzala National Park (specimen list provided in the section "additional material examined"). A list of additional specimens examined from Lower Guinea is given in Lavoué *et al*. (2004).

Diagnosis. We prepared the following diagnosis using all the specimens of *P. microphthalmus* that we examined, regardless their geographic origins. *Petrocephalus microphthalmus* is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Short dorsal fin with only 18 or fewer branched rays (range 15–18). Long anal fin with 23–27 branched rays. Eye small ($4.0 \leq$ HL/ED, range = 4.1–4.8). Mouth moderately wide ($3.5 \leq$ HL/MW ≤ 4.9). Only 9–11 teeth in the upper jaw, 14–20 teeth in the lower jaw. Absence of black pigment patches, except for a characteristic black blotch on the anterior dorsal fin rays near the origin of this fin. Body silvery/purplish, iridescent. Electroreceptors on the head are not clustered into "rosettes" but, instead, appear as isolated receptor pores. EOD of normal polarity with two main phases and, in Odzala, a third minute phase of very low amplitude.

Description. Morphometric ratios and meristic data for the holotype (from Gabon) and the non-type specimens (from Odzala and Lower Guinea) are presented in Table 5. However, the following description is based only on the Odzala specimens we examined, except where we make separate reference to the holotype. With a maximum observed standard length of 59.1 mm in Odzala National Park, *P. microphthalmus* is the smallest species in the diverse Odzala assemblage of *Petrocephalus*. Body ovoid, longer than high ($2.6 \leq$ SL/H ≤ 2.8, holotype = 2.7) and laterally compressed. Head length between 3.8 and 4.0 times in standard length (average = 3.9, holotype = 4.0). Snout short ($5.2 \leq$ HL/SNL ≤ 6.4, average = 5.8, holotype = 4.6) and round. Mouth small ($3.6 \leq$ HL/MW ≤ 4.2, average = 3.9, holotype = 3.8), opening under the eye. Teeth small and bicuspid, 9–11 (holotype = 10) in a single row in the upper jaw, 14–16 (holotype = 20) in a single row in the

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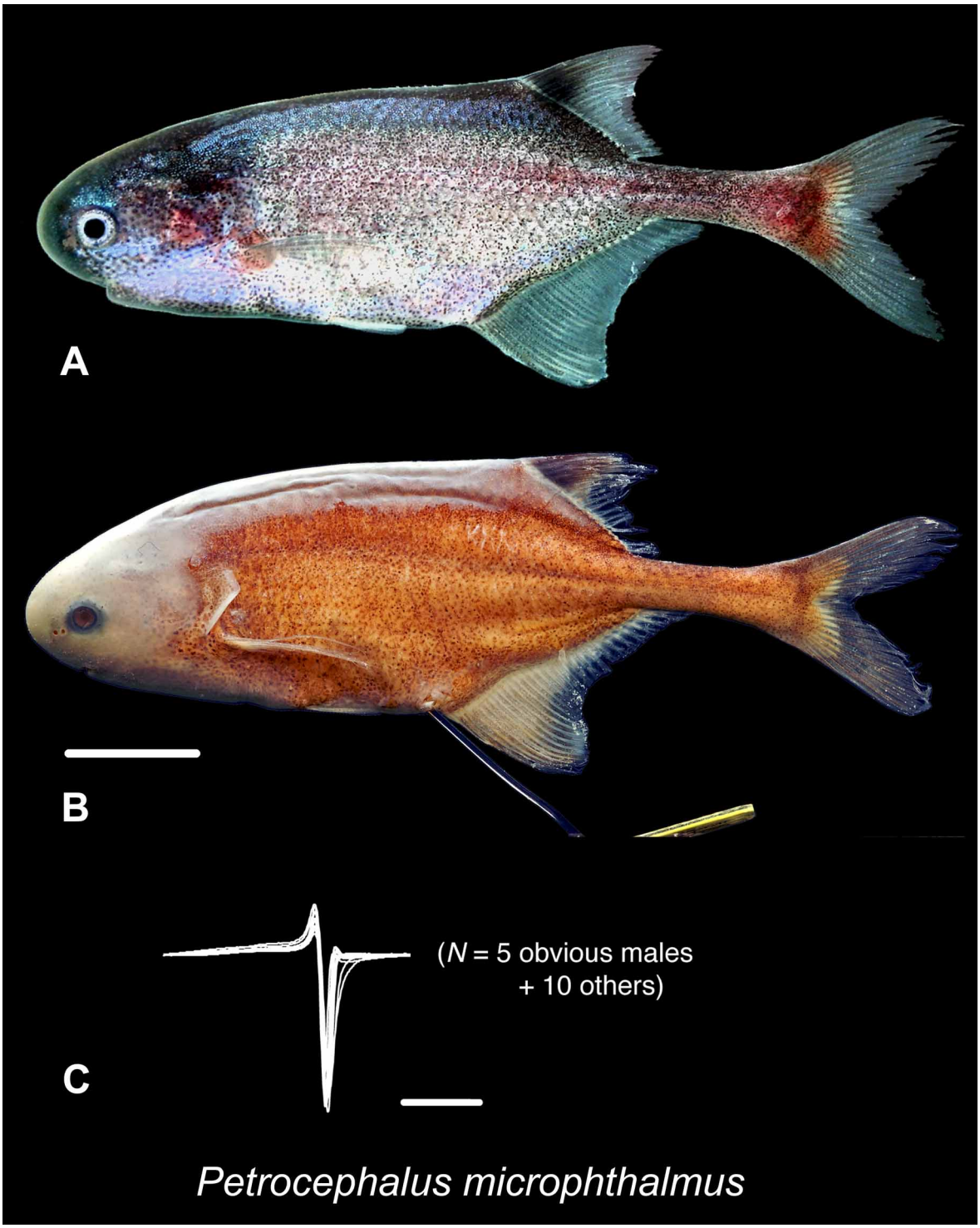

FIGURE 7. *Petrocephalus microphthalmus* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

lower jaw. Dorsal and anal fins originate in the posterior half of the body (SL/PDD = 1.5 and SL/PAD = 1.7). Pre-dorsal distance slightly greater than pre-anal distance (PDD/PAD ≈ 1.1). Dorsal fin with 16–18 branched rays (holotype = 16). Anal fin with 26–27 branched rays (holotype = 25). Scales cover the entire body, except for the head. Lateral line visible and complete with 34 to 35 pored scales along its length (holotype = 36).

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Eight to 10 scales between the anterior base of the anal fin and the lateral line. Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation, containing numerous Knollenorgan electroreceptors that do not form "rosettes" in their typical positions. Instead, Knollenorgans appear as isolated receptor pores in the skin covering the head, the character state observed in the Mormyrinae.

TABLE 5. Principal morphometric ratios and meristic counts for the holotype (MNHN 1908-211), three specimens from Odzala (CU 87938, CU 87940, CU 88003) and 36 specimens from Gabon of *Petrocephalus microphthalmus* Pellegrin, 1908. (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)*	Specimens from Odzala (n=3)			Specimens from Gabon (Ogooué River) (n=36)*		
		Min–Max	Mean	Std–Dev	Min–Max	Mean	Std–Dev
Standard length (mm)	73.7	51.8–59.1	54.7	3.8	52.1–69.9	59.4	4.6
Head length (mm)	18.3	13.4–14.9	14.0	0.8	14.0–16.7	15.1	0.9
Ratio of standard length (SL):							
SL/body height (H)	2.7	2.6–2.8	2.7	0.1	2.7–3.2	3.0	0.2
SL/head length (HL)	4.0	3.8–4.0	3.9	0.1	3.6–4.3	3.9	0.2
SL/pre-dorsal distance (PDD)	1.5	1.5–1.5	1.5	0.0	1.5–1.7	1.6	0.1
SL/pre-anal distance (PAD)	1.7	1.7–1.7	1.7	0.0	1.6–1.9	1.8	0.1
SL/anal fin length (AFL)	5.4	5.0–5.3	5.2	0.2	4.9–6.5	5.5	0.4
SL/dorsal fin length (DFL)	3.3	3.3–3.4	3.3	0.0	3.2–3.9	3.5	0.2
SL/caudal peduncle length (CPL)	5.5	5.5–5.9	5.8	0.2	4.4–5.7	5.1	0.3
SL/mouth width (MW)	15.4	14.2–16.3	15.4	1.1	13.7–19.2	16.3	0.8
Ratio of head length (HL):							
HL/snout length (SNL)	4.6	5.2–6.4	5.8	0.6	4.1–6.2	4.7	0.4
HL/mouth width (MW)	3.8	3.6–4.2	3.9	0.3	3.5–4.9	4.2	0.4
HL/eye diameter (ED)	4.8	4.0–4.5	4.2	0.2	4.1–4.8	4.5	0.2
HL/interorbital width (IOW)	2.6	2.6–3.1	2.8	0.3	2.0–2.8	2.5	0.2
HL/head width (HW)	1.7	1.6–2.0	1.8	0.2	1.7–2.0	1.8	0.1
HL/mouth position (MP)	3.4	3.6–4.2	3.9	0.3	2.8–3.7	3.2	0.2
Ratio of caudal peduncle length (CPL):							
CPL/caudal peduncle depth (CPD)	2.9	2.7–2.7	2.7	0.0	2.6–3.7	3.0	0.4
		Min–Max	Median		Min–Max	Median	
Meristic counts:							
Dorsal fin branched rays (DR)	16	16–18	17		15–18	16	
Anal fin branched rays (AR)	25	26–27	27		23–27	25	
Number of scales in the lateral line (SLL)	36	34–35	35		33–36	35	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	10	8–10	9		8–10	9	
Number of teeth in the upper jaw (TUJ)	10	9–11	10		9–11	10	
Number of teeth in the lower jaw (TLJ)	20	14–16	15		14–20	16	

*Data from Lavoué *et al*. (2004)

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Live coloration (Fig. 7A). Body generally blue-gray, with the dorsum darker than the abdomen. Numerous chromatophores occur below the skin surface. This species can appear metallic blue to violet depending on the angle and intensity of illumination. The color is especially intense on the operculum. The fins are translucent except for the first dorsal fin rays, which are black near their insertion (Lavoué *et al*., 2004).

Distribution (Fig. 1). Present in Congo and Lower Guinea provinces. Holotype from Gabon. Abundant in Odzala, where we collected *P. microphthalmus* in small tributary creeks flowing through forest. Elsewhere in the Congo basin it is present in the Lower Congo River in the vicinity of Brazzaville. In the Lower Guinea province this species is widespread throughout the entire Ogooué and Ntem basins in Gabon, including streams and lakes associated with main river channels (e.g., Lac Zilé). It can also be found along the coastal region from the Sanaga River (Cameroon) in the north to the more southern Niari-Kouilou River (Republic of the Congo).

Electric organ discharge (Fig. 7C). *Petrocephalus microphthalmus* produces EODs of short duration, which are typical of the entire genus. No sex differences have yet been reported in any population. Similar EOD durations have been observed in the Odzala population of *P. microphthalmus* [range = 0.252 – 0.511 msec; Lavoué *et al*. (2008)] and among conspecifics from Gabon [range = 0.380 – 0.561 msec; Lavoué *et al*. (2004)]. A relatively long, slow rise characterizes the initial part of the first head-positive phase in EODs recorded from the Odzala population, often resulting in a shoulder early during the waveform's head-positive rise to P1, the first main peak (Lavoué *et al*., 2008). The early head-positive rise and shoulder are very low in amplitude, however, such that they may only be apparent at high amplifier gain. These subtle waveform features appear to be uncommon in EODs of other *Petrocephalus* species. A similar slow rise (and shoulder) preceding P1 has been recorded among a small number of *P. microphthalmus* individuals from Gabon, but it seems to be much less common than in Odzala. Additional statistics for waveform landmarks and other EOD measurements for the Odzala population are provided by Lavoué *et al*. (2008). Based on histological examination, electrocytes are known to be type NPp (Lavoué *et al*., 2008; Sullivan *et al*., 2000).

Remarks. *Petrocephalus microphthalmus* closely resembles *Petrocephalus schoutedeni* Poll, 1954 and *Petrocephalus catostoma haullevillii* Boulenger, 1912. *Petrocephalus microphthalmus* is distinguished from *P. schoutedeni* mainly by the shape of the caudal peduncle: in the Odzala specimens its length is only 2.7 times (holotype = 2.9 times) its depth, versus 3.4–3.7 times in *P. schoutedeni*. We did not find any unambiguous morphological differences with which to distinguish *P. microphthalmus* and *P. catostoma haullevillii*.

Petrocephalus odzalaensis n. sp.

[Odzala field identification and in Lavoué *et al*. (2008): *Petrocephalus* sp. 6, OTU 6]

Images. Fig. 8A, photo of a live specimen from Odzala and Fig. 8B, photo of the preserved holotype (CU 88048).

Type material. Holotype, CU 88048 (morpho, EOD), sex undet., 92.9 mm SL. Republic of the Congo, Lékénie River at Mboko débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002.

Paratypes. CU 87850 (morpho, EOD), male, 90.1 mm SL; CU 87857 (morpho, EOD), male, 92.6 mm SL; CU 88050 (morpho, EOD), male, 90.4 mm SL; AMNH 251414 (ex CU 87843) (morpho, EOD), male, 87.0 mm SL; AMNH 251417 (ex CU 88056) (morpho, EOD), male, 87.6 mm SL; AMNH 251416 (ex CU 88054) (morpho, EOD), male, 97.6 mm SL; CU 88059 (morpho, EOD), male, 99.3 mm SL; AMNH 251415 (ex CU 87844) (morpho, EOD), male, 87.3 mm SL. Republic of the Congo, Lékénie River at Mboko débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002. CU 88049 (morpho, EOD; caudal peduncle dissected by Lavoué *et al*. (2008) to sample electric organ for histological examination), male, 93.2 mm SL. Republic of the Congo, Lékénie River at Mboko

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débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 12 August 2002.

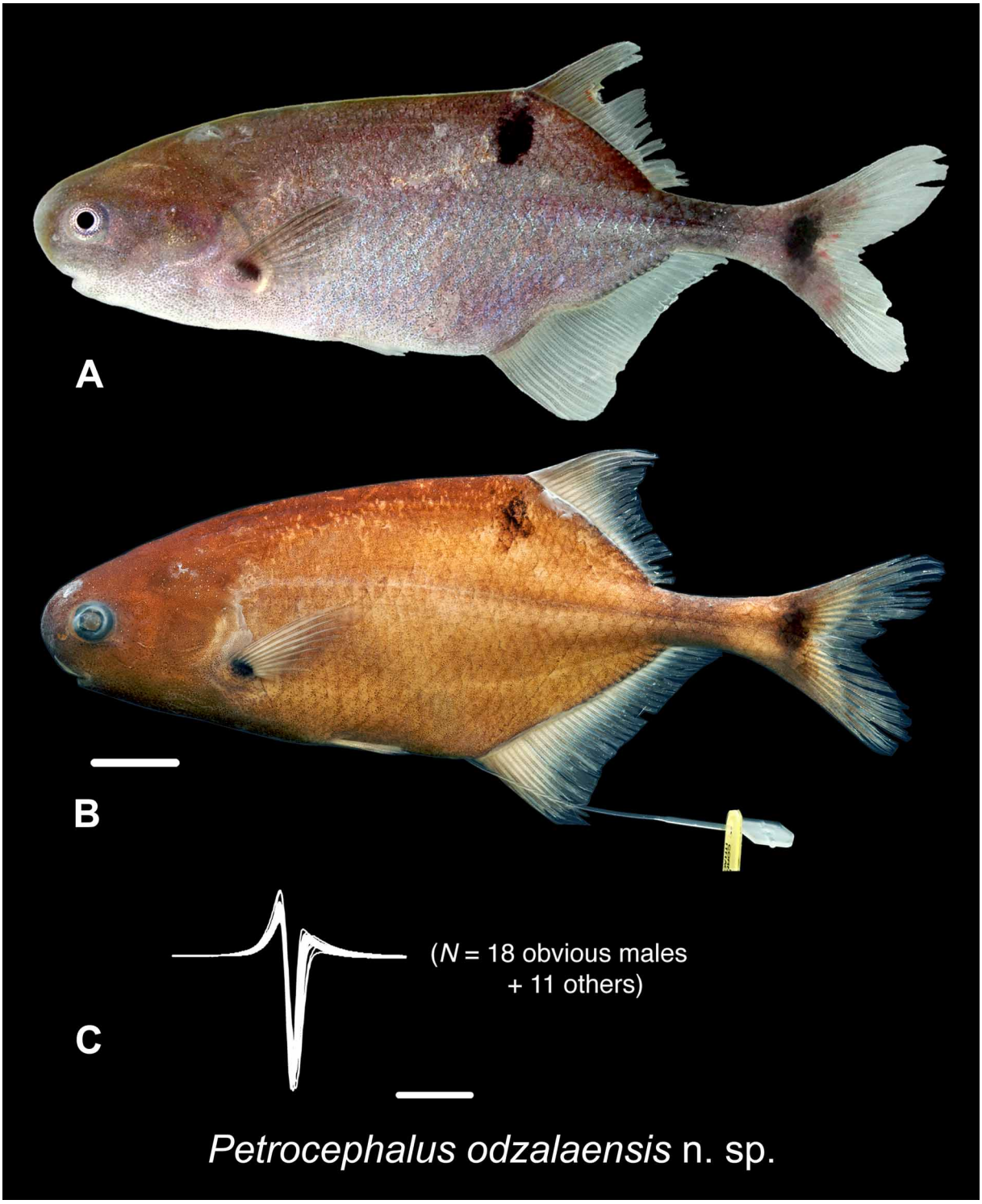

FIGURE 8. *Petrocephalus odzalaensis* **n. sp.** of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of the preserved holotype (CU 88048; scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

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TABLE 6. Principal morphometric ratios and meristic counts for the holotype (CU 88048) and nine paratypes (CU 87857, CU 88049, CU 87850, CU 88050, CU 88059, AMNH 250928, AMNH 250929, AMNH 250930, AMNH 250931) of *Petrocephalus odzalaensis* **n. sp.** (Abbreviations: o= sex category "other" [i.e., not an obvious mature male, but rather a female or immature male]; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (o)	Paratypes (n=9)		
		Min–Max	Mean	Std–Dev
Standard length (mm)	92.9	87.0–99.3	91.7	4.5
Head length (mm)	23.3	22.7–26.6	23.7	1.6
Ratio of standard length (SL):				
SL/body height (H)	2.6	2.7–2.9	2.8	0.0
SL/head length (HL)	4.0	3.7–4.0	3.9	0.1
SL/pre-dorsal distance (PDD)	1.6	1.5–1.6	1.6	0.0
SL/pre-anal distance (PAD)	1.7	1.6–1.7	1.6	0.0
SL/dorsal fin length (DFL)	4.5	4.4–4.7	4.6	0.2
SL/anal fin length (AFL)	3.3	3.3–3.6	3.4	0.1
SL/caudal peduncle length (CPL)	6.9	6.1–7.1	6.8	0.3
SL/mouth width (MW)	17.4	16.0–18.3	16.8	0.8
Ratio of head length (HL):				
HL/snout length (SNL)	6.6	6.2–8.3	7.3	0.7
HL/mouth width (MW)	4.3	4.0–4.8	4.3	0.2
HL/eye diameter (ED)	3.7	3.8–4.2	4.0	0.1
HL/interorbital width (IOW)	2.7	2.5–3.0	2.8	0.2
HL/head width (HW)	1.7	1.7–1.8	1.7	0.1
HL/mouth position (MP)	4.7	4.2–5.0	4.5	0.3
Ratio of caudal peduncle length (CPL):				
CPL/caudal peduncle depth (CPD)	2.1	1.9–2.3	2.1	0.1
		Min–Max	Median	
Meristic counts:				
Dorsal fin branched rays (DR)	22	20–22	21	
Anal fin branched rays (AR)	29	27–29	28	
Number of scales in the lateral line (SLL)	38	36–38	37	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	11	10–14	12	
Number of teeth in the upper jaw (TUJ)	11	8–12	11	
Number of teeth in the lower jaw (TLJ)	18	18–23	20	

Other specimens. We examined 19 other specimens from Odzala National Park (specimen list provided in the section "additional material examined").

Diagnosis. *Petrocephalus odzalaensis* **n. sp.** is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Dorsal fin shorter than anal fin. Dorsal fin with a maximum of 22 branched rays (range = 20–22). Anal fin with a minimum of 27 branched rays (range = 27–29). Mouth sub-terminal; ratio between head length and mouth position is between 4.2 and 5.0. Eye small ($3.7 \leq HL/ED \leq 4.2$). Body pinkish-gray, darker dorsally, with the presence of three distinct pigmentation patches: (1) a distinct ovoid black mark situated below the anterior base of the dorsal fin on each side of the

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body; (2) a small black mark at the base of each pectoral fin; (3) an ovoid black mark on each side that is centered at the base of the caudal fin, not extending onto the upper and lower lobes of this fin. EOD of normal polarity, appearing triphasic at low gain, with two main phases and a small third phase. A final, fourth phase may be present, but it is always extremely small (< 1.5% of total peak-to-peak amplitude).

Description. Morphometric ratios and meristic data for the holotype and paratypes are presented in Table 6. *Petrocephalus odzalaensis* **n. sp.** is a medium sized species within the genus (maximum SL observed = 99.3 mm; holotype = 92.9 mm). Body ovoid, longer than high (2.6 ≤ SL/H ≤ 2.9, paratype average = 2.8, holotype = 2.6) and laterally compressed. Head length between 3.7 and 4.0 times in standard length (paratype average = 3.9, holotype = 4.0). Snout short (6.2 ≤ HL/SNL ≤ 8.3, paratype average = 7.3, holotype = 6.6) and round. Mouth small (4.0 ≤ HL/MW ≤ 4.8, paratype average = 4.3, holotype = 4.3), sub-terminal, opening just under the anterior half of the eye. Teeth small and bicuspid, 8–12 in a single row in the upper jaw (paratype median = 11, holotype = 11), 18–23 in a single row in the lower jaw (paratype median = 20, holotype = 18). Dorsal and anal fins originate in the posterior half of the body (1.5 ≤ SL/PDD ≤ 1.6 and 1.6 ≤ SL/PAD ≤ 1.7, respectively). Pre-dorsal distance slightly greater than the pre–anal distance (1.0 ≤ PDD/PAD ≤ 1.1). Dorsal fin with 20–22 branched rays (paratype median = 21, holotype = 22). Anal fin with 27–29 branched rays (paratype median = 28, holotype = 29). Scales cover the body, except for the head. Lateral line visible and complete with 36–38 (holotype = 38) pored scales along its length. Ten to 14 scales (paratype average = 12, holotype = 11) between the anterior base of the anal fin and the lateral line. Caudal peduncle thin (1.9 ≤ CPL/CPD ≤ 2.3, paratype average = 2.1, holotype = 2.1). Twelve scales around the caudal peduncle. Skin on head thick, turning opaque with formalin fixation. Knollenorgans clustered into the three distinct "rosettes" of Harder (1968).

Live coloration (Fig. 8A). Body background color pinkish-gray, darker dorsally. Pigmentation pattern consisting of three characteristic black patches: (1) a distinct ovoid black mark below the anterior base of the dorsal fin; (2) a small black mark at the base of the pectoral fin; and (3) an ovoid black mark centered at the base of the caudal fin, which does not extend onto the upper and lower lobes. Fins translucent.

Distribution (Fig. 1). Endemic to the Congo basin. Abundant in Odzala. We collected *P. odzalaensis* **n. sp.** at several localities along the main course of the Lékoli River and in some small tributary creeks flowing through forest.

Electric organ discharge (Fig. 8C). The EOD waveform is typical for the genus, similar to EODs produced by many other *Petrocephalus* species. Total EOD duration ranges from 0.231 to 0.339 msec, based on 1.5% voltage deviations from baseline relative to peak-peak amplitude. No EOD sex differences are apparent in the specimens recorded thus far. Lavoué *et al*. (2008) provide additional statistics for waveform landmarks and other EOD measurements. Histological examination confirms that electrocytes are type NPp (Lavoué *et al*., 2008).

Remarks. Based on museum records from the Congo basin (*pers. obs*.), *Petrocephalus odzalaensis* has been misidentified as *Petrocephalus simus* in several instances. The latter species is endemic to the Lower Guinea province (Lavoué *et al*., 2004).

Etymology. Named for Odzala National Park.

Petrocephalus christyi Boulenger, 1920

Petrocephalus christyi Boulenger (1920): 11.
[Odzala field identification: *Petrocephalus* sp.7, OTU 7]

Images. Fig. 9A, photo of a live specimen from Odzala, Fig. 9B, photo of a preserved specimen from Odzala and Fig. 14, drawing of a syntype from Boulenger (1920), p.11. Additional photo of a syntype in Harder (2000).

Type material. Syntypes, MRAC 7145–7151 [five of seven specimens examined]. Democratic Republic of the Congo, Congo basin, tributary Lindi at Bosabangui [in the vicinity of Kisangani, estimated 0.53N, 25.19E], C. Christy coll. [Note that no holotype was designated in the original description of *P. christyi*.]

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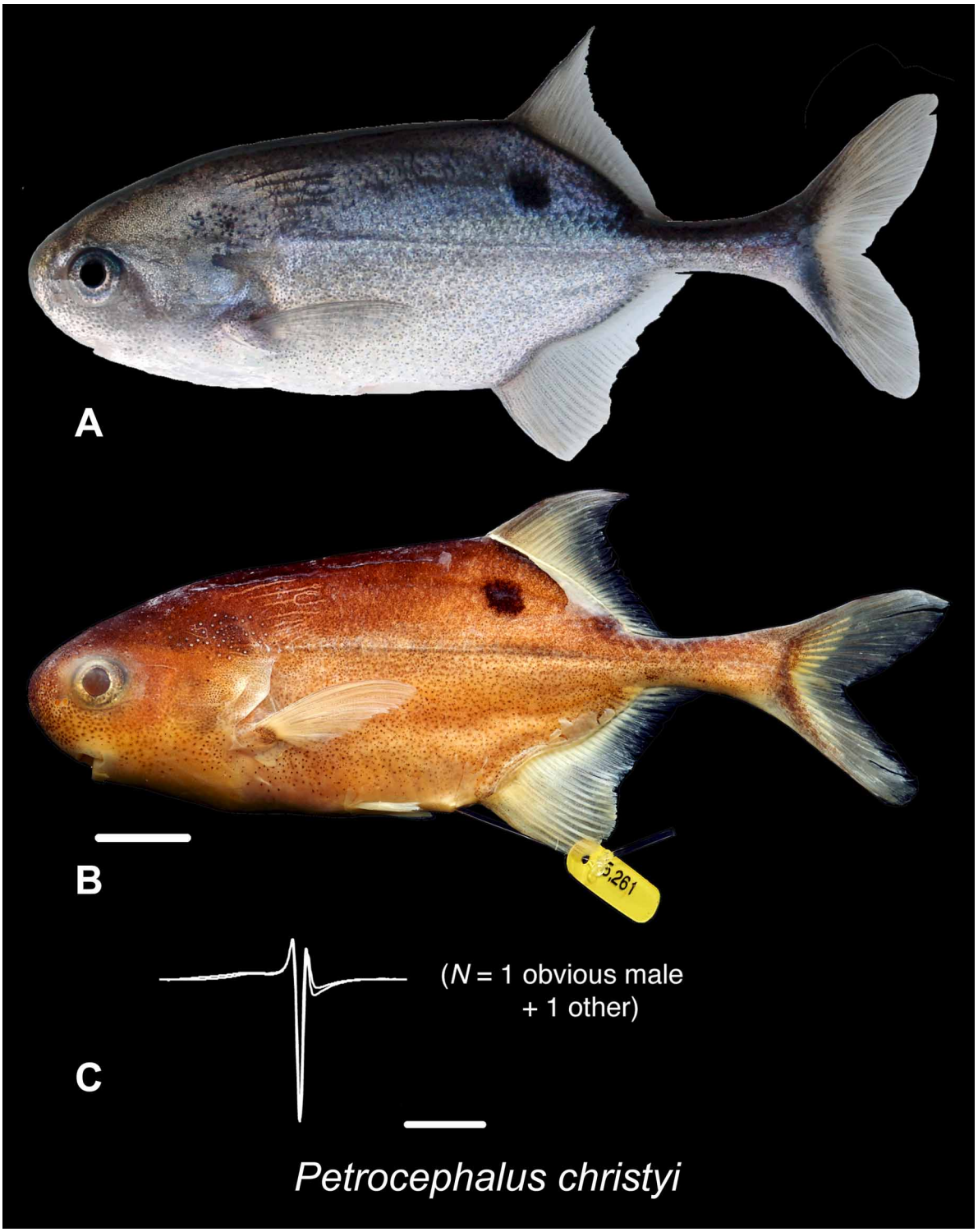

FIGURE 9. *Petrocephalus christyi* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each of two recorded individuals, and they were superimposed together. Both EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as an overlay centered on the largest positive peak (scale bar = 0.2 msec).

Other specimens. We examined two specimens from Odzala National Park and 16 additional specimens from the Sangha River and the Lower Congo River in the vicinity of the Pool Malebo (see specimen list provided in the section "additional material examined").

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TABLE 7. Principal morphometric ratios and meristic counts for five syntypes (MRAC 7145-7151), two specimens from Odzala (CU 88095, CU 88057) and 16 specimens from the Lower Congo and Sangha River (AMNH collection and four uncatalogued specimens, see text) of *Petrocephalus christyi* Boulenger 1920 (Abbreviations: Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Syntypes (n=5)			Specimens from Odzala (n=2)	Specimens from Lower Congo and the Sangha River (n=16)		
	Min–Max	Mean	Std–Dev	Min–Max	Min–Max	Mean	Std–Dev
Standard length (mm)	65.1–100.0	89.5	12.7	50.5–84.7	67.0–109.6	82.5	12.7
Head length (mm)	18.7–26.9	24.5	3.0	16.0-24.2	19.7–30.3	23.6	3.5
Ratio of standard length (SL):							
SL/body height (H)	3.0–3.2	3.1	0.1	2.7–2.9	2.6–2.8	2.7	0.1
SL/head length (HL)	3.5–3.7	3.6	0.1	3.2–3.5	3.2–3.8	3.5	0.1
SL/pre-dorsal distance (PDD)	1.6–1.7	1.6	0.0	1.6–1.6	1.5–1.6	1.6	0.0
SL/pre-anal distance (PAD)	1.6–1.7	1.6	0.0	1.6–1.6	1.6–1.8	1.7	0.0
SL/dorsal fin length (DFL)	4.1–4.4	4.2	0.1	4.3–4.4	4.1–4.4	4.2	0.1
SL/anal fin length (AFL)	3.6–3.8	3.7	0.1	3.7–4.0	3.2–3.7	3.5	0.1
SL/caudal peduncle length (CPL)	5.5–6.1	5.7	0.3	5.7–5.8	5.3–6.5	5.9	0.3
SL/mouth width (MW)	17.7–20.1	18.8	1.0	13.6–14.3	10.7–15.3	12.9	1.4
Ratio of head length (HL):							
HL/snout length (SNL)	5.3–5.7	5.5	0.1	5.3–6.3	4.9–6.7	5.7	0.5
HL/mouth width (MW)	4.7–5.5	5.2	0.4	4.1–4.3	2.9–4.3	3.7	0.5
HL/eye diameter (ED)	3.1–3.8	3.5	0.2	3.2–3.4	3.3–4.2	3.7	0.3
HL/interorbital width (IOW)	2.8–3.6	3.2	0.3	2.9–3.3	2.4–3.1	2.8	0.2
HL/head width (HW)	1.9–2.2	2.1	0.1	1.7–1.9	1.7–2.1	1.8	0.2
HL/mouth position (MP)	3.2–3.5	3.4	0.1	2.9–3.0	2.6–3.4	2.9	0.2
Ratio of caudal peduncle length (CPL):							
CPL/caudal peduncle depth (CPD)	2.5–3.0	2.7	0.2	2.5–2.6	2.4–3.0	2.6	0.2
	Min–Max	Median		Min–Max	Min–Max	Median	
Meristic counts:							
Dorsal fin branched rays (DR)	23–24	24		22–23	22–24	23	
Anal fin branched rays (AR)	26–27	27		25–26	25–29	27	
Number of scales in the lateral line (SLL)	35–39	37		35–37	35–37	36	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	13–14	14		14–15	13–20	18	
Number of teeth in the upper jaw (TUJ)				9–10	9–13	11	
Number of teeth in the lower jaw (TLJ)				19–21	17–22	19	

Diagnosis. The following diagnosis is based on all examined specimens of *P. christyi*, regardless their geographic origins. *Petrocephalus christyi* is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Dorsal fin with 22–24 branched rays. Anal fin with 25–29 branched rays. Eye large (HL/ED $\leq$ 4.2, range = 3.1–4.2). Mouth small (HL/MW $\geq$ 2.9, range = 2.9–

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5.5, but see remarks). Nine to 13 teeth in the upper jaw, 17–22 teeth in the lower jaw. Melanin patterning consisting of two characteristic black patches: (1) a distinct round mark below the anterior base (first to the fifth rays) of the dorsal fin; and (2) a somewhat diffuse crescent-like mark, centered at the base of the caudal fin and extending onto the fleshy dorsal and ventral lobes of this fin. In the small number of individuals recorded so far, the EOD is of normal polarity, with four phases and a relatively slow initial rise.

Description. Morphometric and meristic data for the syntypes, non-type specimens from Odzala and specimens from Lower Congo are separately presented in Table 7. However, the following description corresponds only to the new material collected from Odzala National Park, except where separate reference is made to the Lindi River syntypes. *Petrocephalus christyi* is a medium-sized species within the genus (maximum SL observed in Odzala = 84.7 mm; maximum SL observed in the syntypes = 100.0 mm). Body ovoid, longer than high ($2.7 \leq SL/H \leq 2.9$, syntypes = 3.0–3.2) and laterally compressed. Head length between 3.2 and 3.5 times in standard length (syntypes = 3.5–3.7). Snout of intermediate size ($5.3 \leq HL/SNL \leq 6.3$, syntypes = 5.3–5.7) and round. Eye large ($3.2 \leq HL/ED \leq 3.4$, syntypes = 3.1–3.8). Mouth small ($4.1 \leq HL/MW \leq 4.3$, syntypes = 4.7–5.5), sub-terminal, opening just under the anterior half of the eye. Teeth small and bicuspid, 9 or 10 in a single row in the upper jaw, 19–21 in the lower jaw. Dorsal and anal fins originate in the posterior half of the body, with pre-dorsal distance equal to pre-anal distance (SL/PDD = 1.6 and SL/PAD = 1.6). Dorsal fin with 22 or 23 branched rays (syntypes = 23 or 24). Anal fin with 25 or 26 branched rays (syntypes = 26 or 27). Scales cover the body, except for the head. Lateral line visible and complete with 35–37 (syntypes = 35–39) pored scales along its length. Fourteen to 15 scales (syntypes = 13 or 14) between the anterior base of the anal fin and the lateral line. Caudal peduncle relatively thin ($2.5 \leq CPL/CPD \leq 2.6$, syntypes = 2.5–3.0). Twelve scales around the caudal peduncle. Skin on head thick, turning opaque with formalin fixation, with numerous electroreceptors organized into three distinct rosettes. However, the Augenrosette (above the eye) is not as developed as it is in the other species of *Petrocephalus* exhibiting this rosette.

Live coloration (Fig. 9A). Body uniformly white-silver, with the presence of two characteristic melanin marks: (1) a distinct round mark below the anterior base (first to fifth rays) of the dorsal fin; (2) a rather diffuse crescent-like mark, centered at the base of the caudal fin and extending onto the upper and lower fleshy lobes of this fin. The fins themselves are translucent.

Distribution (Fig. 1). Endemic to the Congo River basin. The type specimens were collected at the locality Bosabangui along the Lindi River, which is close to the city of Kisangani. *Petrocephalus christyi* seems to be rare in Odzala, where we only collected it in the main channel of the Lékoli River at night. In contrast, *Petrocephalus christyi* seems to be abundant in the vicinity of the Pool Malebo (Lower Congo).

Electric organ discharge (Fig. 9C). Bearing in mind that recordings are only available for two specimens collected within Odzala, the EOD of this species does appear to be distinctive. The EOD exhibits normal polarity and is four-phasic with a large, negative-going P2 and smaller peaks, P1, P3 and P4 [see Lavoué *et al.* (2008) for definitions of these waveform landmarks]. Similar to the EODs of the Odzala population of *P. microphthalmus*, a relatively long, slow rise occurs during the initial part of the first head-positive phase in the EODs of both individuals of *P. christyi*. This rise toward P1 has a shoulder-like inflection point, which at magnified gain is seen to possess a small, negative-going local peak. Both the slow rise and inflection point are subtle features of the EOD; they are only visible in amplified traces. Unlike the EODs of *P. microphthalmus*, however, those of the two *P. christyi* individuals possess a prominent head-negative fourth peak (P4), the amplitude of which is 4.5 – 8.6 % of the waveform's total peak-to-peak swing. A prominent P4 is also present in the EOD emitted by the only individual of *Petrocephalus mbossou* **n. sp.** ever recorded (see below), but otherwise a P4 seems to be rare in *Petrocephalus*. Based on 1.5% voltage deviations from baseline relative to peak-peak amplitude and at ambient recording temperatures, duration of the EOD is between 0.284 and 0.390 msec in *P. christyi*, falling in the range of many other *Petrocephalus* species. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al.* (2008). Electrocyte anatomy is presumed to be of type NPp based on the EOD waveform, but this has not yet been confirmed histologically.

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Remarks. Specimens of *P. christyi* from Odzala appear to differ notably from the syntypes of *P. christyi* (from the Lindi River, Fig. 1) in only a single aspect of morphological variation: mouth size. The syntypes have smaller mouths than the Odzala specimens (SL/MW = 17.7–20.1 in the syntypes *versus* 13.6–14.3 in the Odzala specimens; see also the HL/MW ratios in Table 7). Interestingly, specimens from the Lower Congo in the vicinity of the Pool Malebo (Table 7) all have mouths similar in relative size to those of the Odzala specimens. The magnitude of divergence in mouth size relative to the syntypes, and the fact that divergence in this character is consistent for both Odzala and Lower Congo specimens, suggests that populations from these sites may represent a distinct species from the *P. christyi* type material. A sound evaluation of this possible difference requires additional material from other Congo River sites. Until such material becomes available, we conservatively assign the Odzala and Lower Congo specimens described herein to *P. christyi*.

Petrocephalus sauvagii (Boulenger, 1887)

Mormyrus (Petrocephalus) sauvagii Boulenger (1887): 149.
Mormyrus sauvagii Steindachner (1895): 69.
Petrocephalus sauvagii Boulenger (1898): 19 — Taverne (1972): 162 — Gosse (1984): 113.
[Odzala field identification: *Petrocephalus* sp. 8, OTU 8]

Images. Fig. 10A, photo of a live specimen from Odzala, Fig. 10B, photo of a preserved specimen from Odzala and Fig. 14, drawing of the holotype (BMNH 1887.1.13.3) from Boulenger (1909–1916). Photo of the holotype in Harder (2000).

Type material. Holotype, BMNH 1887.1.13.3 "in the creeks of the Lower Congo and the tributary streams, without more precision, unknown coll."

Other specimens. We examined six specimens from Odzala and four additional specimens from the Lower Niger River (specimen list provided in the section "additional material examined").

Diagnosis. We prepared the following diagnosis using all the specimens of *P. sauvagii* that we examined, regardless their geographic origins. *Petrocephalus sauvagii* is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Very wide mouth (HL/MW $\leq$ 3.7, range = 2.7–3.7) associated with a characteristic head shape when viewed from below. Twenty-four to 30 teeth in the upper jaw and 30–34 in the lower jaw. Anal fin with at least 32 branched rays (range = 32–38). Dorsal fin with at least 25 branched rays (range = 25–30). Mouth sub-terminal; ratio between the head length and the mouth position as large as 7.4 (range = 5.5–7.4). Pigmentation pattern with two melanin markings, sometimes of weak intensity or even scarcely visible: (1) an irregularly round black mark below the anterior base (first to fourth rays) of the dorsal fin; and (2) an ovoid blackish mark, often irregularly shaped, at the base of the caudal fin, extending onto the upper and lower fleshy lobes of the fin. EOD of normal polarity, with two main phases followed by a third, smaller phase.

Description. Table 8 provides morphometric ratios and meristic data for the holotype, six non-type specimens from Odzala and four non-type specimens from the Lower Niger River. However, the following description corresponds only to the six Odzala specimens we examined, except where separate reference is made to the holotype. *Petrocephalus sauvagii* is the largest *Petrocephalus* species occurring in the Odzala assemblage (maximum SL observed in Odzala = 189.0 mm, holotype = 146.7 mm). Body ovoid, longer than high (2.7 $\leq$ SL/H $\leq$ 3.4, average = 3.0, holotype = 2.9) and laterally compressed. Head length between 3.5 and 3.7 times in standard length (average = 3.6, holotype = 3.7). Eye small (4.1 $\leq$ HL/ED $\leq$ 4.5, average = 4.3, holotype = 4.6). Snout very short (6.3 $\leq$ HL/SNL $\leq$ 9.9, average = 8.0, holotype = 6.7) and round. Mouth distinctively large (3.1 $\leq$ HL/MW $\leq$ 3.7, average = 3.3, holotype = 3.1), sub-terminal (5.5 $\leq$ HL/MP $\leq$ 7.4, average = 6.6, holotype = 4.9), opening just under the anterior half of the eye. Dentition consisting of many small bicuspid teeth, 24–30 (median = 26, holotype = 26) in a single row in the upper jaw, 30–34 (median = 32, holotype = 30) in a single row in the lower jaw. Dorsal and anal fins originate in the posterior half of the body (1.5 $\leq$ SL/PDD $\leq$ 1.6 and 1.5 $\leq$ SL/PAD $\leq$ 1.7). Pre-dorsal distance equal to, or slightly greater than, pre-anal distance (1.0 $\leq$ PDD/PAD $\leq$ 1.1). Anal fin with 33–38 branched rays (median = 35, holotype = 34).

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Dorsal fin with 26–30 branched rays (median = 28, holotype = 27). Scales cover the body, except for the head. Lateral line visible and complete with 38–41 (median = 39, holotype = 36) pored scales along its length. Twelve to 16 scales (median 14, holotype = 14) between the anterior base of the anal fin and the lateral line. Caudal peduncle relatively thin (2.3 ≤ CPL/CPD ≤ 3.1, average = 2.6, holotype = 2.7). Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation, with Knollenorgan electroreceptors organized into three relatively small rosettes.

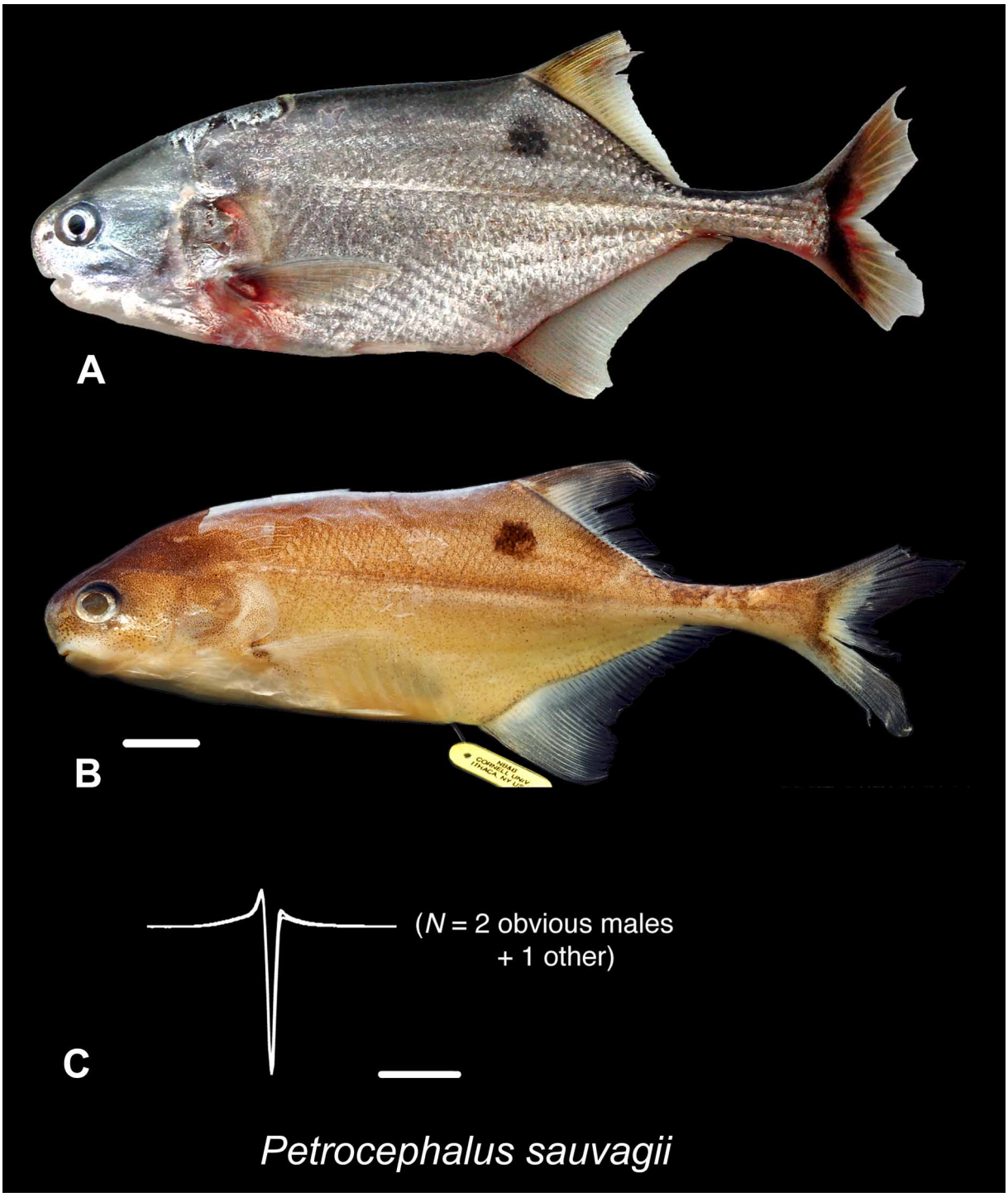

FIGURE 10. *Petrocephalus sauvagii* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

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TABLE 8. Principal morphometric ratios and meristic counts for the holotype (BMNH 1887.1.13.3), six specimens from Odzala (CU 87864, CU 89082, CU 92387) and four specimens from Lower Niger (MNHN 1990-942) of *Petrocephalus sauvagii* (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)	Specimens from Odzala (n=6)			Specimens from Lower Niger (n=4)		
		Min–Max	Mean	Std–Dev	Min–Max	Mean	Std–Dev
Standard length (mm)	146.7	109.2–189.0	156.2	33.3	118.7–127.7	122.0	3.9
Head length (mm)	50.3	31.1–51.6	43.6	8.6	31.2–32.9	32.0	0.8
Ratio of standard length (SL):							
SL/body height (H)	2.9	2.7–3.4	3.0	0.3	2.5–2.7	2.6	0.1
SL/head length (HL)	3.7	3.5–3.7	3.6	0.1	3.8–3.9	3.8	0.0
SL/pre-dorsal distance (PDD)	1.6	1.5–1.6	1.6	0.1	1.6–1.6	1.6	0.0
SL/pre-anal distance (PAD)	1.6	1.5–1.7	1.6	0.1	1.6–1.7	1.6	0.0
SL/dorsal fin length (DFL)	4.5	4.2–4.7	4.5	0.2	4.1–4.5	4.3	0.2
SL/anal fin length (AFL)	3.6	3.1–3.4	3.3	0.1	3.2–3.3	3.2	0.1
SL/caudal peduncle length (CPL)	6.3	6.1–7.7	7.0	0.8	6.0–6.2	6.1	0.1
SL/mouth width (MW)	11.4	11.2–12.9	11.9	0.6	10.2–12.4	11.7	1.0
Ratio of head length (HL):							
HL/snout length (SNL)	6.7	6.3–9.9	8.0	1.5	5.5–6.8	5.9	0.6
HL/mouth width (MW)	3.1	3.1–3.7	3.3	0.2	2.7–3.2	3.1	0.2
HL/eye diameter (ED)	4.6	4.1–4.5	4.3	0.1	4.0–4.2	4.1	0.1
HL/interorbital width (IOW)	3.5	3.5–4.2	3.8	0.3	2.6–2.7	2.7	0.1
HL/head width (HW)	2.1	1.8–2.4	2.1	0.3	1.7–1.9	1.8	0.1
HL/mouth position (MP)	4.9	5.5–7.4	6.6	0.9	4.4–5.4	5.0	0.4
Ratio of caudal peduncle length (CPL):							
CPL/caudal peduncle depth (CPD)	2.7	2.3–3.1	2.6	0.4	2.6–2.8	2.7	0.1
		Min–Max	Median		Min–Max	Median	
Meristic counts:							
Dorsal fin branched rays (DR)	27	26–30	28		25–25	25	
Anal fin branched rays (AR)	34	33–38	35		32–33	32	
Number of scales in the lateral line (SLL)	36	38–41	39		37–40	39	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	14	12–16	14		12–14	13	
Number of teeth in the upper jaw (TUJ)	26	24–30	26				
Number of teeth in the lower jaw (TLJ)	30	30–34	32				

Live coloration (Fig. 10A). Body uniformly white-silver with metallic iridescence. Two characteristic melanin markings are present, sometimes with very weak intensity in large individuals: (1) an irregular round mark below the anterior base (first to fourth rays) of the dorsal fin; (2) an ovoid blackish mark, often irregular in shape, centered at the base of the caudal fin and extending onto the upper and lower fleshy lobes of this fin. The fins themselves (caudal fins and others) are translucent.

Distribution (Fig. 1). *Petrocephalus sauvagii* is the only species of *Petrocephalus* known to occur in both the Congo and Niger basins. There is no record of this species occurring in the Lower Guinea province. The holotype was collected from "*the creeks of the Lower Congo and the tributary streams*" without more

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precision being given on the exact locality (Boulenger, 1887). In Odzala, we collected *P. sauvagii* at several localities along the main course of the Lékoli River and, exclusively at night, in some small tributary creeks flowing through savannah.

Electric organ discharge (Fig. 10C). EOD recordings are only available for three individuals. Thus, generalizations about the EOD features of this species must be made with caution. EOD waveforms of all three individuals are of somewhat short duration for the genus (range = 0.232 – 0.273 msec), but they are, nevertheless, very similar to EODs of several other *Petrocephalus* species. Statistics for waveform landmarks and other EOD measurements for *P. sauvagii* are provided by Lavoué *et al*. (2008), who demonstrated histologically that the electrocytes of this species are type NPp.

Remarks. We noticed some morphological differences between allopatric specimens of *P. sauvagii* from the Niger and Congo basins. Specimens from the Niger basin possess fewer anal fin rays (32–33 *versus* 33–38), a longer snout (HL/SNL = 5.5–6.8 *versus* 6.3–9.9) and a greater interorbital width (HL/IOW = 2.6–2.7 *versus* 3.5–4.2) than Odzala specimens.

Petrocephalus pulsivertens n. sp.

[Odzala field identification and in Lavoué *et al* (2008): *Petrocephalus* sp. 9, OTU 9]

Images. Fig. 11A, photo of a live specimen from Odzala and Fig. 11B, photo of the preserved holotype (CU 88085).

Type material. Holotype, CU 88085 (morpho, DNA), male, 114.8 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.95° E), V. Mbossi, J.P. Friel, S. Lavoué & J.P. Sullivan coll., 16 August 2002.

Paratypes. AMNH 251418 (ex CU 88096) (morpho, EOD), male, 99.9 mm SL; CU 88097 (morpho, EOD, DNA; caudal peduncle dissected by Lavoué *et al*. (2008) to sample electric organ for histological examination), sex undet., 95.0 mm SL; AMNH 251419 (ex CU 88098) (morpho, EOD), sex undet., 103.2 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.95° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 20 August, 2002. CU 87839 (morpho, EOD, DNA), male, 87.3 mm SL; CU 89188 (morpho), sex undet., 98.5 mm SL; CU 89188 (morpho, caudal peduncle dissected by Lavoué *et al*. (2008) to sample electric organ for histological examination, sex undet., 103.6 mm SL; CU 89188 (morpho), male, 107.4 mm SL; CU 89188 (morpho), male, 86.1 mm SL. Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.95° E), V. Mbossi, J.P. Friel, S. Lavoué & J.P. Sullivan coll., 16 August 2002.

Other specimens. We examined five other specimens from Odzala National Park and one from the Sangha River basin (specimen list provided in the section "additional material examined").

Diagnosis. *Petrocephalus pulsivertens* **n. sp.** is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Dorsal fin with at least 25 branched rays (range = 25–27). Anal fin with at least 31 branched rays (range = 31–35). Mouth large (HL/MW ≤ 3.7, range = 3.0–3.7). Fifteen to 21 teeth in the lower jaw; 24–30 teeth in the upper jaw. Eye large (HL/ED ≤ 3.5, range = 3.2–3.5). Pigmentation pattern consists of two distinctive melanin markings (black patches): (1) a distinct ovoid mark below the anterior base of the dorsal fin; and (2) a crescent-like mark, sometimes diffuse, centered at the base of the caudal fin and extending onto the upper and lower parts of the caudal fin. EOD appears to be inverted in polarity, with a first main phase that is negative under the standard recording geometry, resulting in a waveform that is very distinctive in comparison to all known congeners.

Description. Morphometric ratios and meristic data for the holotype and paratypes are presented in Table 9. *Petrocephalus pulsivertens* **n. sp.** is a relatively large sized species within the genus *Petrocephalus* (maximum SL observed = 114.8 mm, the length of the holotype). Body ovoid, longer than high (2.6 ≤ SL/H ≤ 2.9, paratype average = 2.7, holotype = 2.8) and laterally compressed. Head length between 3.6 and 3.7 times in standard length (holotype = 3.7). Eye large (3.2 ≤ HL/ED ≤ 3.5, paratype average = 3.4, holotype = 3.5). Snout short (6.1 ≤ HL/SNL ≤ 7.3, paratype average = 6.5, holotype = 6.8) and round. Mouth large (3.0 ≤ HL/

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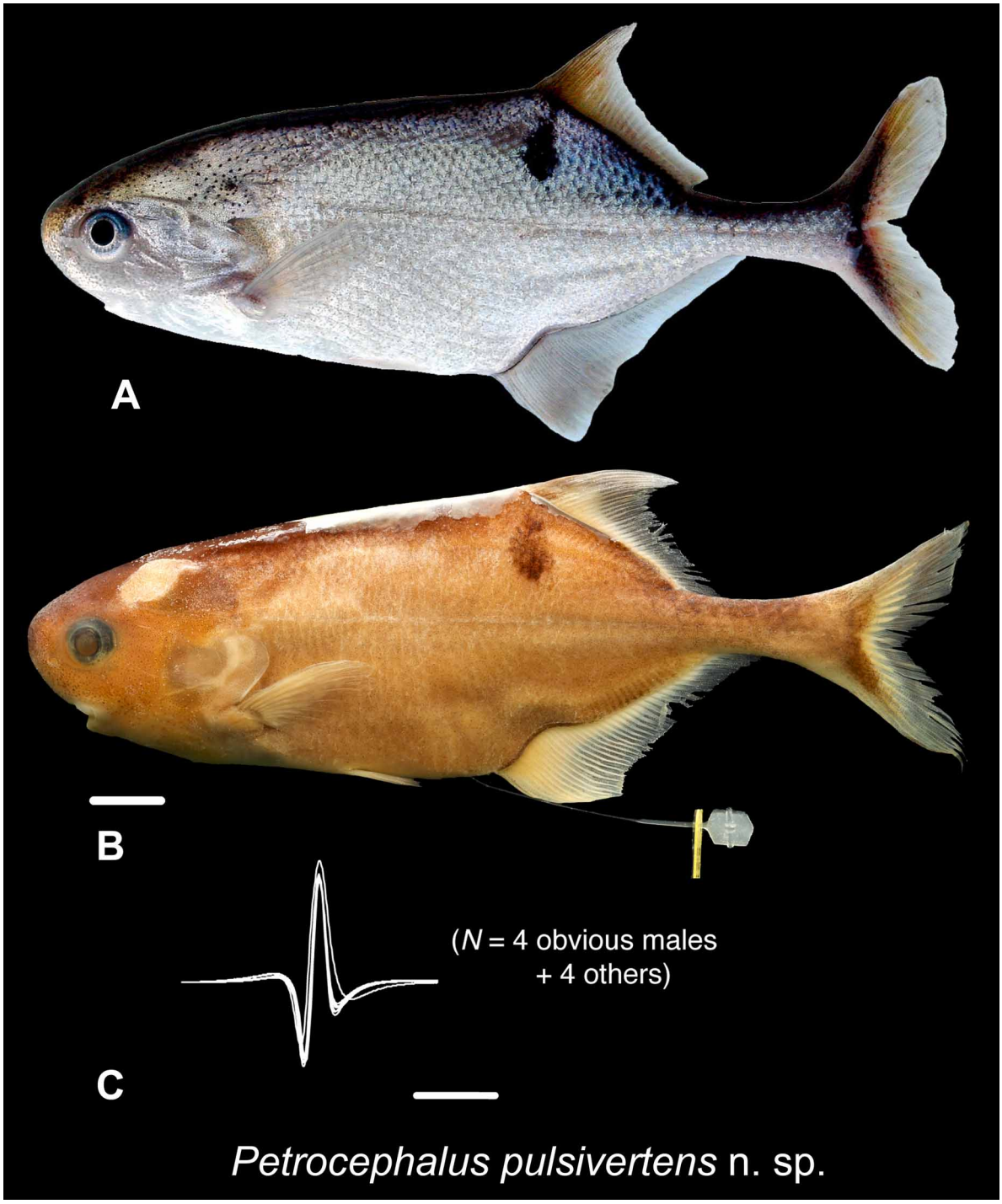

FIGURE 11. *Petrocephalus pulsivertens* **n. sp.** of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of the preserved holotype (CU 88085; scale bar = 1.0 cm). C. EOD waveforms. One EOD was arbitrarily selected from each recorded individual and superimposed with the other recordings (*N* = number of individuals). All EODs are scaled to the same peak-to-peak voltage, and they are plotted (head-positive up) on the same time scale as overlays centered on the largest positive peak of each waveform (scale bar = 0.2 msec).

MW ≤ 3.7, paratype average = 3.3, holotype = 3.0), sub-terminal, opening just under the anterior half of the eye. Teeth bicuspid, small and numerous, 15–21 (paratype average = 18, holotype = 21) in a single row in the upper jaw, 24–30 (paratype average = 28, holotype = 29) in a single row in the lower jaw. Dorsal and anal fins originate in the posterior half of the body (1.6 ≤ SL/PDD ≤ 1.7 and 1.7 ≤ SL/PAD ≤ 1.8, respectively). Pre-dorsal distance equal to, or slightly greater than, pre-anal distance (1.0 ≤ PDD/PAD ≤ 1.1). Dorsal fin with 25–

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27 branched rays (paratype median = 26, holotype = 26). Anal fin with 31–35 branched rays (paratype median = 33, holotype = 34). Scales cover the body, except for the head. Lateral line visible and complete with 38–40 pored scales along its length. Caudal peduncle relatively thin (2.1 ≤ CPL/CPD ≤ 2.3, holotype = 2.2). Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation. Knollenorgan electroreceptors on head clustered into three distinct rosettes.

TABLE 9. Principal morphometric ratios and meristic counts for the holotype (CU 88085) and eight paratypes (CU 88097, CU 87839, CU 89188, AMNH 250932, AMNH 250933) of *Petrocephalus pulsivertens* **n. sp.** (Abbreviations: m= male; Std–Dev= standard deviation; Min–Max= minimum–maximum).

	Holotype (m)	Paratypes (n=8)		
		Min–Max	Mean	Std–Dev
Standard length (mm)	114.8	86.1–107.4	97.6	7.7
Head length (mm)	30.9	23.5–30.9	26.6	2.1
Ratio of standard length (SL):				
SL/body height (H)	2.8	2.6–2.9	2.7	0.1
SL/head length (HL)	3.7	3.6–3.7	3.7	0.1
SL/pre-dorsal distance (PDD)	1.6	1.6–1.7	1.6	0.0
SL/pre-anal distance (PAD)	1.7	1.7–1.8	1.7	0.0
SL/dorsal fin length (DFL)	4.3	3.9–4.3	4.1	0.1
SL/anal fin length (AFL)	3.2	2.9–3.3	3.1	0.1
SL/caudal peduncle length (CPL)	6.5	6.8–6.1	6.6	0.2
SL/mouth width (MW)	11.1	11.1–13.8	12.2	0.8
Ratio of head length (HL):				
HL/snout length (SNL)	6.8	6.1–7.3	6.5	0.4
HL/mouth width (MW)	3.0	3.0–3.7	3.3	0.2
HL/eye diameter (ED)	3.5	3.2–3.5	3.4	0.1
HL/interorbital width (IOW)	3.1	2.9–3.4	3.1	0.2
HL/head width (HW)	1.8	1.8–2.0	1.9	0.1
HL/mouth position (MP)	3.3	3.0–3.5	3.3	0.2
Ratio of caudal peduncle length (CPL):				
CPL/caudal peduncle depth (CPD)	2.2	2.1–2.3	2.1	0.1
		Min–Max	Median	
Meristic counts:				
Dorsal fin branched rays (DR)	26	25–27	26	
Anal fin branched rays (AR)	34	31–35	33	
Number of scales in the lateral line (SLL)	39	38–40	39	
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	14	13–15	14	
Number of teeth in the upper jaw (TUJ)	21	15–21	18	
Number of teeth in the lower jaw (TLJ)	29	24–30	28	

Live coloration (Fig. 11A). Body and head mostly whitish-silvery, but head also exhibits faint metallic blue-purple iridescence. Dorsum darker than the rest of the body. Melanin patterning consists of two distinct black marks: (1) a distinct ovoid melanin mark below the anterior base of the dorsal fin on each side of the

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body and (2) a crescent-like melanin mark, sometimes diffuse, centered at the base of the caudal fin on each side and extending onto the upper and lower parts of the caudal fin. No black mark is present at the base of the pectoral fins. The fins themselves are mostly translucent, with the dorsal and caudal fins sometimes turning slightly yellow after formaldehyde preservation.

Distribution (Fig. 1). Endemic to the Congo River basin. We collected *P. pulsivertens* **n. sp.** along the main course of the Lékoli River. This species seemed to be absent from the small tributary creeks flowing through forest or savannah when we surveyed Odzala National Park. Elsewhere, *P. pulsivertens* **n. sp.** occurs in the vicinities of Brazzaville (i.e., the Pool Malebo), the Dja River (Cameroon) and the Dzangha-Sangha region (Sangha River basin, Central African Republic) (*pers. obs.*), although no EOD recordings have been made of this species outside Odzala.

Electric organ discharge (Fig. 11C). The EOD waveform of *P. pulsivertens* **n. sp.**, which is known only from our recordings in Odzala, resembles an inverted-polarity version of the "typical" *Petrocephalus* EOD. That is, the temporal sequence of electrocyte face firing known for all other *Petrocephalus* (i.e., firing of the posterior electrocyte face preceding firing of the anterior electrocyte face) appears to be reversed in *P. pulsivertens*. At high gain, however, one can see that the very first event in the EOD is a minute head-positive deflection (for an example see Fig. 3D of Lavoué *et al.*, 2008). This waveform feature is consistent with current from the stalks of the posterior electrocyte face (and possibly early current during the beginning of posterior face firing itself) slightly preceding anterior face firing. Despite the waveform inversion, histological examination of electrocytes of *P. pulsivertens* **n. sp.** reveals them to be type "NPp," the character state also shared by all other *Petrocephalus* species investigated to date. We suspect that part of the mechanism underlying the reversed ordering of major peaks in the EOD of *P. pulsivertens* **n. sp.** might involve changes in firing threshold for one or both electrocyte faces (as proposed in Lavoué *et al.*, 2008). This interesting example of waveform inversion in *Petrocephalus* reminds us that careful attention must be paid to the geometry of electrodes during EOD recordings from unknown mormyrid faunas. Given its inverted-polarity appearance, the EOD of *P. pulsivertens* **n. sp.** is immediately recognizable as distinct from those of all other congeners. Based on a threshold of 1.5% of peak-peak amplitude (and at ambient recording temperatures), the duration of the EOD of *P. pulsivertens* **n. sp.** ranges from 0.270 to 0.418 msec, falling in the range of many "typical" *Petrocephalus* EODs. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al.* (2008).

Etymology. From the Latin "*pulsus*," impulse, beating; and from "*vertere,*" to turn, exchange. The name describes the unusual EOD waveform of *P. pulsivertens* **n. sp.** The inverted appearance of this species' EOD is unique among all *Petrocephalus* recorded to date.

Petrocephalus grandoculis Boulenger, 1920

Petrocephalus grandoculis Boulenger (1920): 10.
[Odzala field identification: *Petrocephalus* sp. 10, OTU 10]

Images. Fig. 12A, photo of a live specimen from Odzala, Fig.12B, photo of a preserved specimen from Odzala and Fig. 14, drawing of one syntype from Boulenger (1920), p. 10. Photo of two syntypes in Harder (2000).

Type material. Syntypes, BMNH 1919.9.10.16–17 [examined] and MRAC 7158, 7167 [not examined]. Leopoldville (Kinshasa), Zaire (Democratic Republic of the Congo)[estimated 4.25° S, 15.33° E].

Other specimens. We also examined two specimens from Odzala National Park (specimen list provided in the section "additional material examined").

Diagnosis. The following diagnosis is based on all examined specimens of *P. grandoculis*, regardless their geographic origins. *Petrocephalus grandoculis* is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Very small mouth ($5.2 \leq HL/MW \leq 6.1$). Eight to 11 teeth in the lower jaw. Upper jaw with 18–22 teeth. Eye large ($2.8 \leq HL/ED \leq 3.2$). Snout short ($6.5 \leq HL/SNL \leq 10.7$). Dorsal fin with 24–26 branched rays. Anal fin with 30–33 branched rays. Pigmentation

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pattern consists of two melanin markings (black patches): (1) a distinct, although generally weak, round black mark on each side of the body below the anterior base of the dorsal fin (first to fifth rays); and (2) a crescent-like mark at the base of the caudal fin on each side, not extending onto the rayed portions of the upper and lower caudal fin lobes. EOD of normal polarity.

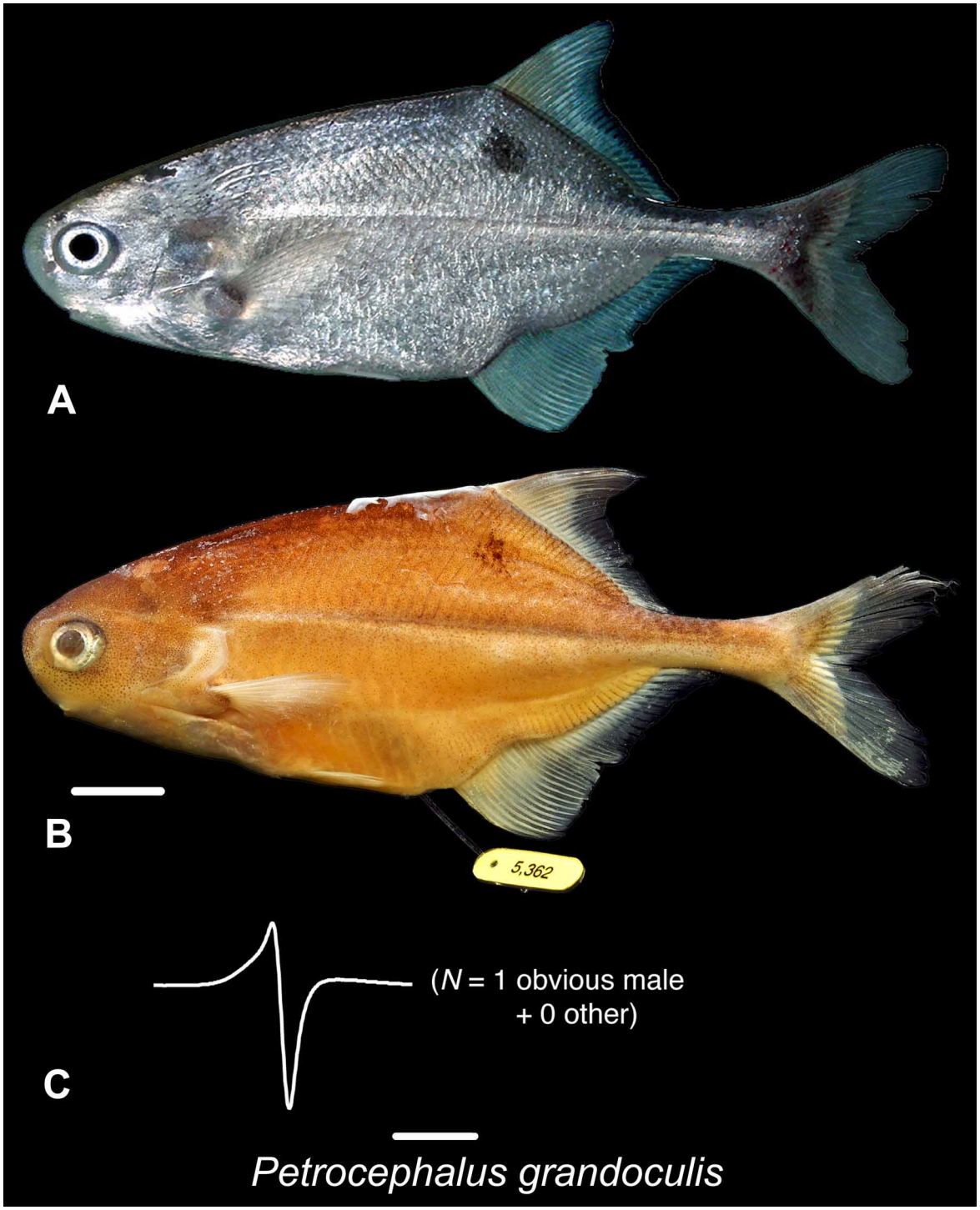

FIGURE 12. *Petrocephalus grandoculis* of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Photograph of a live specimen (no scale). B. Photograph of a preserved specimen (scale bar = 1.0 cm). C. EOD waveform. One EOD was arbitrarily selected from the only individual of this species recorded in Odzala, an obvious male. The EOD is shown here head-positive up (scale bar = 0.2 msec).

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TABLE 10. Principal morphometric ratios and meristic counts for the two syntypes (BMNH 1919.9.10.16-17) and two specimens from Odzala (CU 88119, CU 92385) of *Petrocephalus grandoculis* Boulenger, 1920 and the holotype (CU 92389) of *Petrocephalus mbossou* **n. sp.**, (Abbreviations: o= sex category "other" [i.e., not an obvious mature male, but rather a female or immature male]; Min–Max= minimum–maximum).

	P. grandoculis Syntypes (n=2)	*P. grandoculis* Odzala specimens (n=2)	*P. mbossou* **n. sp.** Holotype (o)
	Min–Max	Min–Max	
Standard length (mm)	74.0–76.0	88.0–97.8	127.1
Head length (mm)	18.4–19.0	23.0–23.5	36.9
Ratio of standard length (SL):			
SL/body height (H)	3.0–3.1	2.5–2.7	3.0
SL/head length (HL)	3.9–4.1	3.8–4.2	3.4
SL/pre-dorsal distance (PDD)	1.6–1.6	1.6–1.6	1.7
SL/pre-anal distance (PAD)	1.7–1.8	1.7–1.7	1.6
SL/dorsal fin length (DFL)	4.2–4.6	4.0–4.1	4.4
SL/anal fin length (AFL)	3.3–3.3	3.1–3.3	4.3
SL/caudal peduncle length (CPL)	5.8–6.1	5.3–6.7	5.2
SL/mouth width (MW)	23.6–23.6	21.7–22.4	16.2
Ratio of head length (HL):			
HL/snout length (SNL)	6.5–6.7	6.5–10.7	5.4
HL/mouth width (MW)	5.7–6.1	5.2–5.9	4.7
HL/eye diameter (ED)	3.1–3.2	2.8–3.1	3.7
HL/interorbital width (IOW)	3.4–3.7	3.2–3.8	4.3
HL/head width (HW)	2.1–2.2	1.8–1.9	2.2
HL/mouth position (MP)	3.7–4.0	4.5–5.0	2.8
Ratio of caudal peduncle length (CPL):			
CPL/caudal peduncle depth (CPD)	3.0–3.0	2.2–3.0	2.9
	Min–Max	Min–Max	
Meristic counts:			
Dorsal fin branched rays (DR)	24–26	25–26	24
Anal fin branched rays (AR)	30–31	32–33	26
Number of scales in the lateral line (SLL)	38–38	37–39	37
Number of scale rows between the anterior base of the anal fin and the lateral line (SDL)	15–15	13–15	11
Number of teeth in the upper jaw (TUJ)	10–11	8–8	12
Number of teeth in the lower jaw (TLJ)	19–20	18–22	14

Description. Table 10 provides morphometric ratios and meristic data for the two Kinshasa syntypes and, separately, for the two non-type specimens from Odzala National Park. The following description applies to the two Odzala specimens, with separate reference to the two syntypes. *Petrocephalus grandoculis* is a medium-sized species within the genus *Petrocephalus* (maximum SL observed = 97.8 mm). Body ovoid, longer than high ($2.5 \leq SL/H \leq 2.7$, syntypes = 3.0–3.1) and laterally compressed. Head length 3.8–4.2 times in standard length (syntypes = 3.9–4.1). Eye quite large ($2.8 \leq HL/ED \leq 3.1$, syntypes = 3.1–3.2). Snout short ($6.5 \leq HL/SNL \leq 10.7$, syntypes = 6.5–6.7) and round. Mouth very small ($5.2 \leq HL/MW \leq 5.9$, syntypes =

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5.7–6.1), sub-terminal, opening under the anterior half of the eye. Teeth small and bicuspid, only eight (syntypes = 10 or 11) in a single row in the upper jaw, 18–22 (syntypes = 19 or 20) in a single row in the lower jaw. Dorsal and anal fins originate in the posterior half of the body [SL/PDD = 1.6 and SL/PAD = 1.7 (syntypes = 1.7–1.8), respectively]. Pre-dorsal distance slightly greater than pre-anal distance (1.0 ≤ PDD/PAD ≤ 1.1). Dorsal fin with 25–26 branched rays (syntypes = 24–26). Anal fin with 32 or 33 branched rays (syntypes = 30 or 31). Scales cover the body, except for the head. Lateral line visible and complete with 37–39 (syntypes = 38) pored scales along its length. Caudal peduncle relatively thin (2.2 ≤ CPL/CPD ≤ 3.0, syntypes = 3.0). Twelve scales around the caudal peduncle. Skin on head thick, becoming opaque with formalin fixation. The numerous Knollenorgan electroreceptors on the head are clearly organized into two visible rosettes (Augenrosette and Nackenrosette). In our examination of specimens, we were uncertain about the definitive presence of the third rosette, the Kehlrosette, as this structure did not appear to us to be as distinct as it is in other species (e.g., *P. binotatus*). However, more definitive recent analysis using toluidine blue staining of the skin now suggests that the Kehlrosette is present, but smaller and harder to discern than in other *Petrocephalus* (M. Hollmann and B. A. Carlson, *unpub. obs.*).

Live coloration (Fig. 12A). Body mostly white-silver. Dorsum slightly darker than the rest of the body. Pigmentation pattern consists of two melanin markings: (1) a distinct, but weak, round black mark below the anterior base of the dorsal fin (first to fifth rays); and (2) a crescent-shaped mark at the base of the caudal fin, which does not extend onto the rayed portions of the upper and lower caudal fin lobes. No black mark is present at the base of pectoral fins. The fins themselves are translucent.

Distribution (Fig. 1). Endemic to the Congo basin. The type locality is situated on the Lower Congo River at Kinshasa. In Odzala, we collected only two specimens of *P. grandoculis* from the main channel of the Lékoli River.

Electric organ discharge (Fig. 12C). EODs have only been recorded from one individual of *P. grandoculis*, which was collected in Odzala National Park. The EOD duration for this individual (0.380 msec, based on 1.5% deviations from baseline) and the general appearance of the waveform are typical for *Petrocephalus*. Statistics for waveform landmarks and other EOD measurements are provided by Lavoué *et al*. (2008). Electrocyte anatomy is unknown, although it is expected to be type "NPp" as deduced from the EOD waveform.

***Petrocephalus mbossou* n. sp.**

[Odzala field identification and in Lavoué *et al*. (2008): *Petrocephalus* sp. 11, OTU 11]

Images. Fig. 13A, photo of the live holotype (CU 92389) and Fig. 13B, photo of the preserved holotype.

Type material. Holotype, CU 92389 (morpho, EOD, DNA), sex undet., 127.2 mm SL. Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), small branch of the Lékoli River, only ca. 300 meters long before it re-enters into the main channel of the Lékoli (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006.

Diagnosis. *Petrocephalus mbossou* **n. sp.** is distinguished from all other *Petrocephalus* species in Central Africa by the following combination of characteristics. Dorsal fin with 24 branched rays. Anal fin with 26 branched rays. Mouth inferior and small (HL/MW = 4.7) with 12 teeth in a single row in the upper jaw and 14 teeth in a single row in the lower jaw. Distance from the anterior extremity of the snout to the corner of the mouth (i.e., MP) only 2.8 times in head length. Weak pigmentation pattern with the presence of two black markings on each side of the body: (1) an irregular patch below the anterior base of the dorsal fin (first ray to the sixth/seventh rays); (2) an irregularly-shaped mark centered at the base of the caudal fin that does not extend onto the rayed portions of the upper and lower caudal fin lobes. EOD of normal polarity (i.e., first major phase head-positive) and very brief duration. Unlike any other *Petrocephalus* species, the second head-positive phase in the EOD (P3) is larger in amplitude than the first head positive phase (P1).

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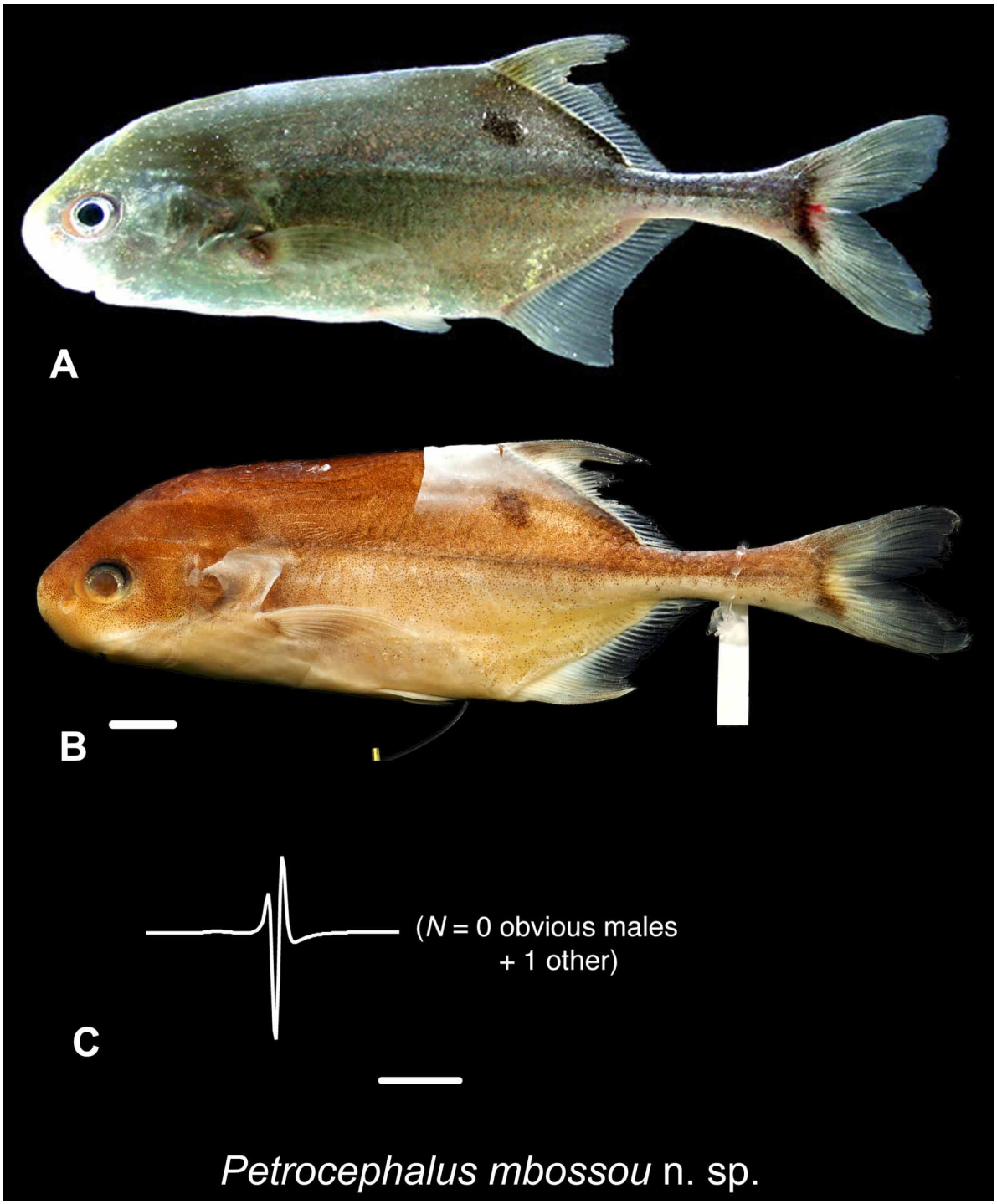

FIGURE 13. *Petrocephalus mbossou* **n. sp.** of the Lékoli River system of Odzala National Park, Republic of the Congo. A. Live photograph of the holotype (CU 92389; no scale). B. Photograph of the preserved holotype (scale bar = 1.0 cm). C. EOD waveform of the holotype. One EOD was arbitrarily selected from all recordings made of this individual. The selected EOD is shown here head-positive up (scale bar = 0.2 msec).

Description. This description is based on data collected solely from the holotype, which is the only specimen of this species collected to date. Table 10 provides morphometric ratios and meristic data for the holotype. *Petrocephalus mbossou* **n. sp.** is a large-sized species within the genus *Petrocephalus* (SL = 127.1 mm). Body ovoid, longer than high (SL/H = 3.0) and laterally compressed. Head length 3.4 times in standard length. Eye large (HL/ED = 3.7). Snout short (HL/SNL = 5.4) and round. Mouth small (HL/MW = 4.7), opening ventrally under the posterior half of the eye. Teeth small and bicuspid, 12 in a single row in the upper

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jaw, 14 in a single row in the lower jaw. Both the dorsal and anal fins originate in the posterior half of the body (SL/PDD = 1.7 and SL/PAD = 1.6, respectively). The pre-dorsal distance is slightly greater than the pre-anal distance. Dorsal fin with 24 branched rays. Anal fin with 26 branched rays. Scales cover the body, except for the head. Lateral line visible and complete with 37 pored scales along its length. Caudal peduncle relatively thin (CPL/CPD = 2.9) with twelve circumpeduncular scales. Skin on head thick, turning opaque with formalin fixation and containing numerous Knollenorgan electroreceptors organized into only two rosettes (the Nackenrosette and the Kehlrosette). The Augenrosette appears to be absent.

Live coloration (Fig. 13A). Body mostly white-silver. Dorsum slightly darker than the rest of the body. Pigmentation pattern consists of two distinct black markings: (1) a black patch of irregular shape below the anterior base of the dorsal fin (first ray to the sixth or seventh ray); (2) an irregularly-shaped mark centered at the base of the caudal fin that does not extend onto the rayed portions of the upper and lower caudal fin lobes. The fins themselves are translucent.

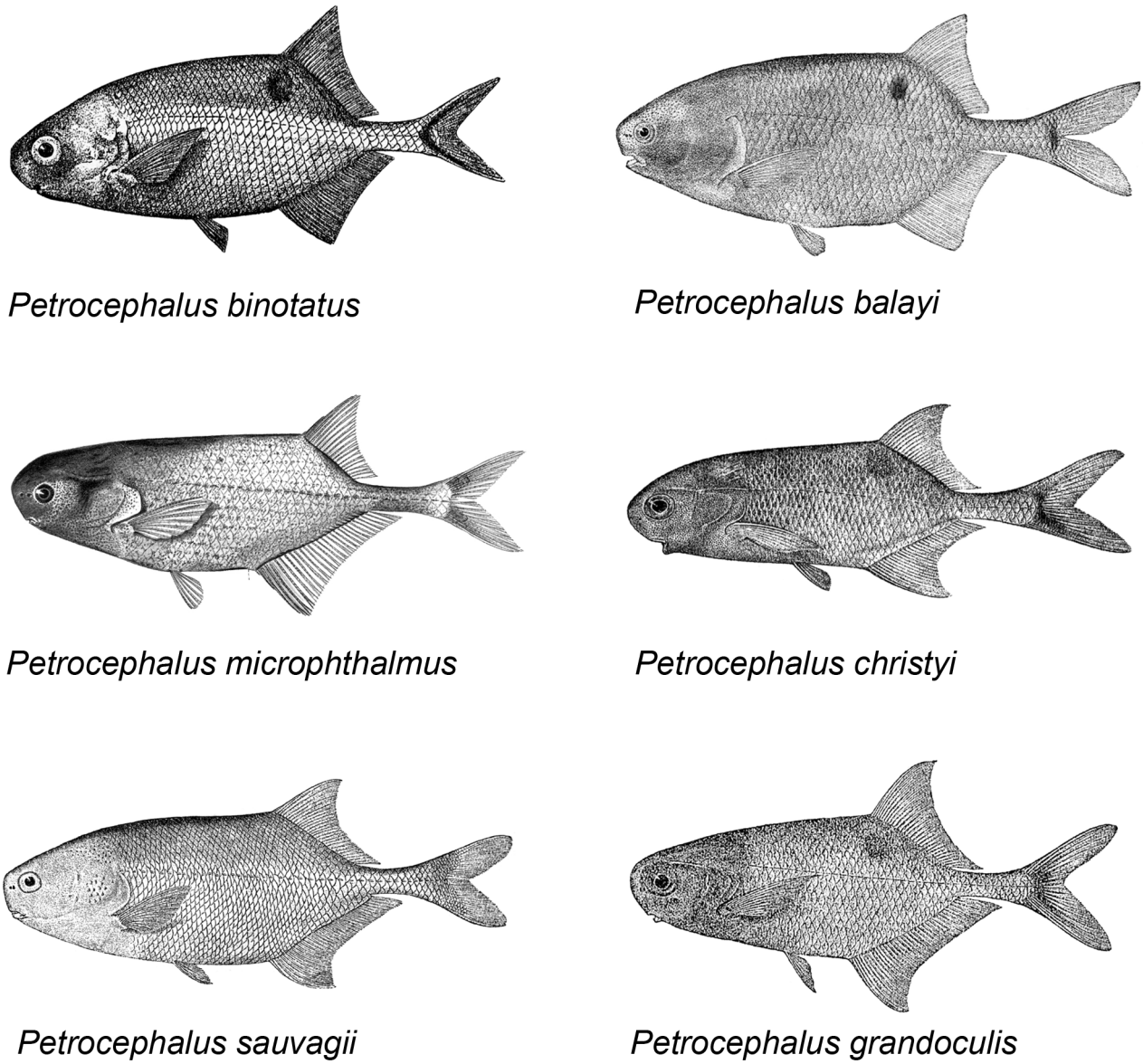

FIGURE 14. Historical illustrations of *Petrocephalus* species described from Congo or Lower Guinea that occur in Odzala. The drawings were reproduced from the following sources: *Petrocephalus binotatus* from Pellegrin (1928); *Petrocephalus balayi* from Boulenger (1909–1916); *Petrocephalus microphthalmus* from Poll (1967); *Petrocephalus christyi* from Boulenger (1920); *Petrocephalus sauvagii* from Boulenger (1909–1916); and *Petrocephalus grandoculis* from Boulenger (1920).

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Distribution (Fig. 1). Endemic to the Congo River basin. The single known specimen of this species was collected in a fish trap, which we had baited with worms and set at night in the main channel of the Lékoli River on the last day of our second trip.

Electric organ discharge (Fig. 13C). EOD recordings are only available for a single individual (the holotype), so the following description of EOD features is in need of elaboration based on additional recordings. In this single individual of *P. mbossou* **n. sp.**, EOD duration is very brief (0.144 msec), and the peak spectral frequency is unusually high (22.11 kHz), compared to other *Petrocephalus* species. In fact, duration and peak spectral frequency of this EOD recording fall outside the range observed for all other *Petrocephalus* individuals/species recorded in Odzala National Park (Lavoué *et al*., 2008). Like EODs of *P. christyi*, the EOD of the holotype of *P. mbossou* **n. sp.** possesses a prominent head-negative, fourth peak (P4), the amplitude of which is 5.7% of the waveform's total peak-to-peak swing. However, unlike the EOD of *P. christyi* (as well those of all other *Petrocephalus* species from Odzala), the second head-positive peak (P3) is larger than the first head-positive peak (P1). Electrocyte anatomy is presumed to be of type "NPp" based on the EOD waveform.

Etymology. The specific epithet is the name given to *Petrocephalus* locally in the Lingala language. Speakers of Lingala recognize *Petrocephalus* as a natural group, which they call "mbossou."

Remarks. We opted to describe *P. mbossou* as a new species based only on the holotype for the following reasons. This individual specimen has a unique *cytb* haplotype and does not belong to any putative species (consisting of two or more specimens) of *Petrocephalus* in our molecular phylogenetic tree, and its body form and EOD are outside the ranges observed for all other Odzala *Petrocephalus* specimens, as well as all type material for *Petrocephalus* species of the Congo and Lower Guinea provinces. In taxonomic investigations of fish faunas from more accessible regions of Africa, it is normally (and reasonably) expected that investigators collect multiple specimens before describing a new species. However, given the remote location of Odzala National Park it may be some time before additional specimens become available. This fact and this species' distinctive morphology, EODs and DNA justify describing *P. mbossou* **n. sp.** at this time with only a single specimen.

Discussion

Our method for clarifying the taxonomy and systematics of weakly electric mormyrid fishes combines three lines of evidence: morphological, electrophysiological and genetic. Application of this integrative and sensitive approach to our collections in Odzala National Park allows us to recognize eleven species of *Petrocephalus* co-occurring in this small region of the Congo River basin (Lavoué *et al*., 2008). Comparisons of these collections with type material for all *Petrocephalus* species described thus far from the Congo and Lower Guinea provinces lead us to describe five of the eleven Odzala taxa as new *Petrocephalus* species.

Electric organ discharge (EOD) waveform variation (among species and between sexes) is generally smaller in the genus *Petrocephalus*, and therefore in the subfamily Petrocephalinae, than it is in the subfamily Mormyrinae (Arnegard *et al*., 2005; Arnegard & Hopkins, 2003; Bratton & Kramer, 1988; Crawford & Hopkins, 1989; Feulner *et al*., 2006; Hopkins, 1981; Kramer, 1997; Lavoué *et al*., 2008; Sullivan *et al*., 2002; Sullivan *et al*., 2000). Although slight EOD differences are usually detectable statistically among *Petrocephalus* species (Kramer & van der Bank, 2000; Lavoué *et al*., 2008; Moritz *et al*., 2009), they are of little practical use for the taxonomic discrimination of most *Petrocephalus* species. In this regard, *P. pulsivertens* of the Odzala assemblage is a notable exception, expressing the most divergent EOD waveform known among all *Petrocephalus* species (Lavoué *et al*., 2008). Despite the EOD waveform similarities among most other *Petrocephalus* species (i.e., on the motor side of electric signaling), we found interesting variation in the patterns with which Knollenorgan electroreceptors are distributed on the heads of species in this genus (Harder, 1968; 2000). These external anatomical differences in electroreceptor distribution raise the possibility that related variation exists in the sensory pathways underlying electrical communication in *Petrocephalus*.

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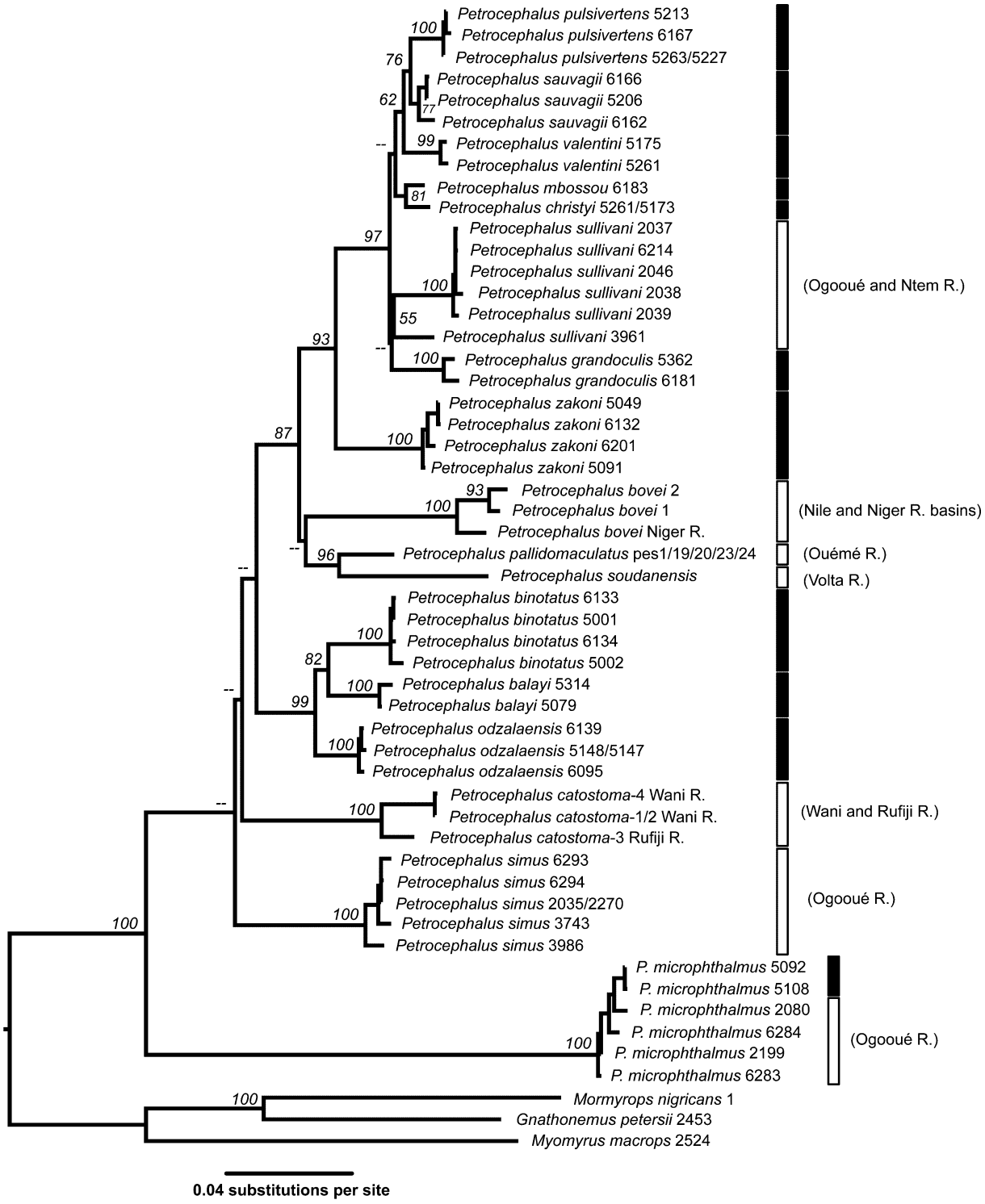

FIGURE 15. *Petrocephalus* phylogeny (17 species, 59 specimens, 53 haplotypes) estimated by maximum likelihood using complete cytochrome *b* sequences (dataset #1; see text). *Gnathonemus petersii*, *Mormyrops nigricans* and *Myomyrus macrops* were used as outgroups to root the tree. Numbers at internal branches are bootstrap proportions (in %) shown only when they exceed 50%. Due to space limitations, support values are not shown for intraspecific relationships. Black vertical bars to the right of the tree indicate specimens sampled from Odzala. White bars (with the river basins from which the specimens were collected) indicate *Petrocephalus* individuals from other regions of Africa. The scale bar corresponds to 0.04 substitutions per site.

Molecular markers, such as the mitochondrial *cytb* gene used in our study, appear to be particularly promising for the elucidation of species boundaries in *Petrocephalus*. Deep genetic divisions among species

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and exclusive monophyly of such taxa appear to be common patterns in the phylogeny of the Petrocephalinae as estimated by *cytb* (Lavoué *et al*., 2008). Given results of our *cytb* sequencing and analysis (Fig. 15), the eleven species of *Petrocephalus* in Odzala National Park appear to be good biological species that are reproductively isolated from one another. However, a practical difficulty associated with the molecular component of our integrative taxonomic approach is its ineffectiveness for immediately identifying new specimens in the field. When applied together, the morphological and electrophysiological components of our approach can provide rapid and reliable field identifications (see our Key to the *Petrocephalus* species of Odzala, below). The single factor that most limits progress on the taxonomy and systematics of *Petrocephalus* is the lack of field collections from vast areas of the Congo River basin and several other regions of Africa.

We have updated our *cytb*-based phylogenetic hypothesis for this genus by adding two new taxa for the present study: *Petrocephalus bovei* and *Petrocephalus catostoma* (Fig. 15). The first of these, *P. bovei*, was described from the Nile River, although it is thought to be widely distributed throughout the Nilo-Sudanian region including the Niger and Nile Rivers, the Lake Chad basin and most of the smaller coastal drainages extending from the Senegal River south along the Gulf of Guinea to the Cross River in Cameroon. *Petrocephalus catostoma* was described from the Rovuma River at the border between Tanzania and Mozambique (Günther, 1866; Whitehead & Greenwood, 1959). This species is widely distributed in East Africa from the Zambezi River system in southern Africa to the Tana River in Kenya, including the basins of Lakes Victoria, Malawi and Tanganyika. Our molecular analysis clearly shows that none of the species of *Petrocephalus* found in Odzala are closely related to *P. bovei* or *P. catostoma* (Fig. 15).

Before this present work, eleven species and sub-species of *Petrocephalus* were recorded from the entire Congo River system (Boulenger, 1909–1916; Daget *et al*., 1984; Harder, 2000; Eschmeyer & Fricke, 2010). Our results now support the recognition of 16 *Petrocephalus* species and sub-species in the Congo basin, with eleven species co-occurring in a single, small river system, the Lékoli, located in the basin's northwestern corner. The immense size of the Congo River basin, the poor sampling of many regions within it and the difficulty of identifying *Petrocephalus* species from preserved material virtually guarantees that this number underestimates the true diversity of Congo basin *Petrocephalus*.

Additional taxonomic remarks

While examining the type specimens of all *Petrocephalus* species known from the Congo and Lower Guinea provinces, we noted that *Petrocephalus guttatus* Fowler, 1936 does not exhibit the characteristic combination of traits diagnostic for this genus. The holotype of *P. guttatus* [from the Kribi Creeks, Lower Guinea region (Fowler, 1936)] lacks all of the following character states typical of *Petrocephalus*: nares closely apposed and directly in front of the eye; all teeth of the lower and upper jaws bicuspid and of the same size; mouth inferior, rictus under eye; Knollenorgan electroreceptors organized into rosettes (Harder, 1968; 2000). Therefore, we provisionally re-assign *Petrocephalus guttatus* to the genus *Pollimyrus* based on the apparent morphological similarity between *Petrocephalus guttatus* and *Pollimyrus isidori* (Valenciennes in Cuvier and Valenciennes, 1847).

The generic assignment of *Petrocephalus hutereaui* (Boulenger, 1913) is also dubious and represents another difficult case. Boulenger (1913) described this species from a single specimen of small size collected in the Upper Congo at Dungu (Fig. 1), but he treated this species as a representative of the genus *Marcusenius*. Our examination of the holotype does not allow us to conclude unambiguously as to which genus this specimen should be assigned. The small size and poor condition of the holotype renders difficult the assessment of diagnostic characters such as the relative position of the nares or the presence/absence of Knollenorgan rosettes. The taxonomic statuses of other doubtful *Petrocephalus* species described from the Congo basin and the Lower Guinea province were previously clarified: *Petrocephalus affinis* Sauvage, 1879 is considered to be a synonym of *Stomatorhinus walkeri* (Günther, 1867); *Petrocephalus marchei* Sauvage, 1879 a synonym of *Ivindomyrus marchei*; *Petrocephalus vanderbilti* Fowler, 1936 a synonym of *Pollimyrus isidori*; and *Petrocephalus anterodorsalis* David and Poll, 1937 a synonym of *Pollimyrus tumifrons* (Boulenger, 1902).

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Comments on the identification of *Petrocephalus* in the Congo and Lower Guinea provinces

During our efforts to place the *Petrocephalus* of Congo and Lower Guinea into discrete morphological categories, we found it convenient to initially divide specimens into two groups depending on the number of branched rays in the dorsal fin. The first group includes species with generally fewer than 19 (rarely 19 or 20) dorsal fin branched rays [i.e., *Petrocephalus catostoma congicus* David and Poll, 1937, *P. catostoma haullevillii*, *P. microphthalmus*, *P. schoutedeni* and *Petrocephalus squalostoma* (Boulenger, 1915)]. The second group contains larger species that almost always exhibit 20 or more branched rays in the dorsal fin [*P. balayi*, *P. binotatus*, *P. christyi*, *P. mbossou* **n. sp.**, *P. odzalaensis* **n. sp.**, *P. pulsivertens* **n. sp.**, *P. sauvagii*, *P. valentini* **n. sp.**, *P. zakoni* **n. sp.**, *Petrocephalus simus* Sauvage, 1879 and *Petrocephalus sullivani* Lavoué, Hopkins and Kamdem Toham, 2004].

In the first morpho-group, *P. catostoma congicus*, *P. catostoma haullevillii*, *P. schoutedeni* and *P. squalostoma* are so far known only from type material, whereas *P. microphthalmus* has been collected throughout a wide distribution. *Petrocephalus catostoma congicus* is easly distinguishable morphologically from the others within this group. The differences between *P. microphthalmus*, *P. schoutedeni* and *P. catostoma haullevillii* need to be further studied with additional collections of *P. schoutedeni* and *P. catostoma haullevillii* that are suitable for integrative comparisons of morphology, EODs and genetic markers.

The second morpho-group includes eleven described species and probably several others that remain undescribed. Prior to our work, the taxonomic confusion surrounding species identification in this group was largely due to the use of *P. christyi* and *P. simus* as "wastebasket" species (Bigorne & Paugy, 1991; Lavoué *et al*., 2004). Specimens were erroneously assigned to these taxa without recognizing characters that now help diagnose species within the second morpho-group of *Petrocephalus* (e.g., wide mouths in *P. sauvagii* and *P. balayi*, large eyes in *P. grandoculis* and distinctive melanin markings in *P. zakoni* **n. sp.**, among other characters). For instance, taxonomists tended to indiscriminately assign specimens with a black sub-dorsal patch to *P. christyi*, and specimens without this characteristic melanin marking to *P. simus*, without regard to other aspects of morphological variation (David & Poll, 1937; Poll, 1939; 1967). Attention to EODs and genetic variation, in addition to morphology, has helped to clarify the formerly cryptic taxonomic variation within these once wastebasket species. Furthermore, the integrative taxonomic approach has also facilitated identification of the subtle, but diagnostic morphological traits that distinguish species in this second morpho-group of *Petrocephalus*.

Two species in the second group are immediately recognizable by their extremely wide mouths and square-shaped head profiles when viewed from below (Fig. 6 and 10): *P. sauvagii* and *P. balayi*. Given these features and other distinctive aspects of overall morphology, both species are easy to identify among all other known *Petrocephalus* species of the Congo River basin. Furthermore, they can be distinguished from one another based on number of dorsal fin branched rays, number of teeth in the upper jaw and general melanin patterning (Fig. 6 and 10). *Petrocephalus sauvagii* and *P. balayi* also seem to be adapted to different ecological niches. *Petrocephalus sauvagii* occurs in the main channels of moderate to large rivers, while *P. balayi* is typically collected from small tributary creeks flowing through the forest. Of the last nine species in the second morpho-group, the geographical origins of specimens along with a combination of morphological characters, features of EOD waveforms and molecular data allow us to easily distinguish each species. As an example, *P. pulsivertens* **n. sp.** is readily identified among other species in this group by its relatively wide mouth, presence of more teeth in both jaws, more branched rays in the dorsal and anal fins, unique pigmentation pattern and "inverted" EOD waveform, in addition to other characters.

Attention to the two operational morpho-groups of *Petrocephalus* that we distinguish by number of branched dorsal fin rays facilitates the further taxonomic discrimination of individuals within this genus. However, because our molecular phylogenetic analysis has so far only included one species from the first morpho-group (with DR < 19), *P. microphthalmus*, we cannot yet evaluate to what degree these operational groups correspond to natural species groups (i.e., distinct lineages or clades).

Given the large geographic holes in our understanding of *Petrocephalus* variation across the Congo River basin, any present attempt to provide an identification key to the entire *Petrocephalus* assemblage of the Congo would likely be grossly inadequate for biologists working in this ichthyofaunal province. Nevertheless,

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we do provide a local key to the *Petrocephalus* species of Odzala National Park in the next section, as we now have relatively good knowledge of their diversity in this small area. For a similar key to the four *Petrocephalus* species of Gabon, readers should refer to Lavoué *et al*. (2004).

Key to the *Petrocephalus* species of Odzala

1 Fewer than 18 branched rays (rarely 18) in the dorsal fin; only eight to 10 scale rows between the anterior base of the anal fin and the lateral line; distinct melanin markings absent on the body (i.e., absence of black patches that are species-specific for many other *Petrocephalus* species); rosettes of Knollenorgan electroreceptors absent on the head ... . *Petrocephalus microphthalmus*

\- Usually more than 20 dorsal fin branched rays (sometimes 20; in very rare instances 19); at least 10, usually more, scale rows between the anterior base of the anal fin and the lateral line; distinct melanin markings (black patches) may be present or absent on the body; electroreceptor rosettes present or absent on the head 2

2 Mouth large, its width at most 3.9 times in head length; at least 15 teeth in the upper jaw, usually more 3

\- Mouth small, its width at least 3.6 times (usually 4.0–4.4 times) in head length; usually fewer than 15 teeth in the upper jaw (rarely 15 or 16) 5

3 Anal fin contains 26 or 27 branched rays; 20–22 branched rays in the dorsal fin; three intense black patches of melanin present on each side of the body: a rounded sub-dorsal mark, an ovoid caudal mark and a mark at the origin of the pectoral fin ..... *Petrocephalus balayi*

\- Anal fin contains more than 30 branched rays; more than 24 branched rays in the dorsal fin; only two distinct black patches of melanin on each side of the body: a sub-dorsal mark and a caudal mark 4

4 Eye relatively small (HL/ED $\geq$ 4.0); mouth sub-terminal (HL/MP $\geq$ 4.4), opening under the anterior half of the eye; two distinct melanin marks present but sometimes pale: a rounded sub-dorsal mark and a crescent-like mark at the base of the caudal fin; Knollenorgan electroreceptors organized into three distinct rosettes on head, but rosettes relatively small; EOD waveform typical for the genus, polarity normal (Fig. 10C) ..... *Petrocephalus sauvagii*

\- Eye large (HL/ED $\leq$ 3.5); mouth sub-terminal but positioned more caudally along the ventral margin of the head (HL/MP $\leq$ 3.5), opening under the posterior half of the eye; two distinct melanin marks: a rounded, sometimes irregularly shaped, sub–dorsal black mark and a crescent-like black mark at the base of the caudal fin; three larger rosettes of Knollenorgan electroreceptors present on the head; EOD waveform very distinctive among congeners, appearing to be reversed in polarity compared to EODs of all other *Petrocephalus* species (Fig. 11C) .... *Petrocephalus pulsivertens* **n. sp.**

5 Anal fin contains 30 or more branched rays; melanin markings (black patches) present on the body and always distinctly visible 6

\- Anal fin contains at most 29 branched rays (usually fewer); melanin markings present but sometimes hardly visible 7

6 Dorsal fin contains 24–26 branched rays; eye large (HL/ED $\leq$ 3.2); mouth very small relative to many congeners (HL/MW $\geq$ 5.2); two melanin marks present and distinct but of medium intensity: a rounded sub-dorsal mark and a crescent-like mark at the base of the caudal fin; two readily observed rosettes of Knollenorgan electroreceptors present on the head (Augenrosette and Nackenrosette) plus a Kehlrosette that is rather difficult to observe without staining ..... *Petrocephalus grandoculis*

\- Dorsal fin contains 24 (holotype) or fewer (Odzala specimens) branched rays; eye smaller in size (3.5 $\leq$ HL/ED $\leq$ 4.0); mouth larger (HL/MW $\leq$ 5.2); three distinct melanin marks (black patches) present: an ovoid sub-dorsal mark (sometimes small and covering few scales, but always intense), an ovoid caudal mark and a mark at the origin of the pectoral fin; all three electroreceptor rosettes present on the head and distinct ..... *Petrocephalus binotatus*

7 Melanin markings on body intensely black with sharply defined edges, forming characteristic shapes (e.g., very rounded black sub-dorsal spot or saddle-like sub-dorsal patch, crescent shaped black mark at the base of the caudal fin or round black spot at the caudal fin base) 8

\- Melanin markings of much weaker intensity, consisting of more irregularly–shaped patches and with comparatively diffuse edges 10

8 Small but intense black mark present on each side of the body at the pectoral fin origin; Knollenorgan electroreceptors on the head may or may not be arranged into discrete clusters (i.e., rosettes may be present or absent), but if rosettes are present the Augenrosette is always as well developed as the other rosettes 9

\- No distinct black mark visible at the origin of the pectoral fin; electroreceptors organized into three distinct rosettes on the head, but the Augenrosette is small and not as well developed as the other rosettes ..... *Petrocephalus christyi*

9 Eye large (HL/ED $\leq$ 3.3); sub-dorsal black patch often contacting the contralateral mark over dorsum and most anterior branched rays of the dorsal fin; caudal melanin marking forming a rather uniformly shaped crescent (or "V") that extends onto the upper and lower fleshy lobes of the caudal fin; Knollenorgan electroreceptors on the head are

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not clustered into discrete groups (i.e., rosettes absent).....*Petrocephalus zakoni* **n. sp.**

- Eye small (HL/ED ≥ 3.7); sub-dorsal black patch distinctly rounded, never in contact with the contralateral mark and not extending onto the dorsal fin; caudal mark ovoid rather than crescent- or V-shaped, not extending onto the upper and lower parts of the caudal fin; Knollenorgans on the head are clustered into three rosettes .... *Petrocephalus odzalaensis* **n. sp.**

10 Mouth sub-terminal, opening under the anterior half of the eye; snout short (HL/SNL ≥ 6.5); Knollenorgan electroreceptors on the head are clustered into three rosettes (but a distinctive Kehlrosette is difficult to observe without staining); EOD of normal polarity, often appearing to have an overall biphasic waveform at low gain, although a minute third peak is in fact present (first head-positive peak, P1, much larger in amplitude than second head-positive peak, P3, which never exceeds 10% of total peak-to-peak amplitude).....*Petrocephalus valentini* **n. sp.**

- Mouth sub-terminal but positioned more caudally along the ventral margin of the head, opening under the posterior half of the eye; snout somewhat longer (HL/SNL = 5.4 in the single specimen available, the holotype); Knollenorgans on the head are clustered into only two rosettes (the Nackenrosette and the Kehlrosette), Augenrosette absent; EOD of normal polarity, with more than two phases apparent even at low gain (the only specimen of this species that has been recorded exhibits an EOD containing 4 peaks; the second head-positive peak, P3, is larger in amplitude than the first head-positive peak, P1; amplitude of P3 substantially greater than 10% of total peak-to-peak amplitude) .....*Petrocephalus mbossou* **n. sp.**

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Additional material examined

Comparative non-type material examined:

Petrocephalus binotatus:

Republic of the Congo, Cuvette-Ouest, Lékénie River at Mboko débarcadère, Odzala National Park (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88066 (EOD), sex undet., 59.0 mm SL; CU 88065 (EOD, DNA), sex undet., 76.0 mm SL; CU 88046 (EOD), sex undet., SL not measured; CU 88052 (EOD), male, 79.0 mm SL; CU 88053 (EOD), male, 71.0 mm SL; CU 88063 (EOD, morpho), sex undet., 70.0 mm SL; CU 88064 (EOD, DNA), male, 69.0 mm SL.

Republic of the Congo, Pandaka River (Congo basin), Odzala National Park (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88079 (EOD, morpho), sex undet., 81.0 mm SL; CU 88076 (EOD, morpho), male, 76.0 mm SL; CU 88074 (EOD, morpho), male, 75.0 mm SL; CU 88075 (EOD), sex undet., 71.0 mm SL; CU 88080 (EOD), sex undet., 75.0 mm SL; CU 88081 (EOD), male, 73.0 mm SL; CU 88082 (EOD), sex undet., 54.0 mm SL; CU 87785 (EOD), sex undet., 75.0 mm SL; CU 88028 (EOD), male, 74.0 mm SL; CU 88029 (EOD), male, 74.0 mm SL; CU 88032 (EOD), male, 75.0 mm SL; CU 88031 (EOD), sex undet., 76.0 mm SL; CU 88041 (EOD, morpho), sex undet., 88.0 mm SL; CU 88043 (EOD), male, 73.0 mm SL; CU 88044 (EOD), male, 66.0 mm SL; CU 88045 (EOD), male, 73.0 mm SL.

Republic of the Congo, Lokoué River (Congo basin), Odzala National Park (0.90° N, 15.12° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87830 (EOD), sex undet., 77.0 mm SL; CU 88125 (EOD), male, 74.0 mm SL; CU 87838 (EOD, morpho), sex undet., 90.0 mm SL.

Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88091 (morpho, EOD), sex undet., 79.8 mm SL; CU 88107 (EOD), male, SL not measured.

Republic of the Congo, Lékoli River (Congo basin), Odzala National Park, (0.61° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88067 (EOD), sex undet., 59.0 mm SL; CU 88068 (EOD), sex undet., 59.0 mm SL; CU 88069 (EOD), sex undet., 57.0 mm SL.

Republic of the Congo, Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88123 (EOD), male, 74.0 mm SL.

Republic of the Congo, small stream entering Mambili River from the east between Moba and Lokoué (Congo basin), (0.87° N, 15.11° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88128 (EOD), male, 70.0 mm SL.

Republic of the Congo, Lékéni River at the debarcadère, mouth of the river near the Lékoli River (0.62° N, 14.91°E), M.E Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92390 (EOD, DNA), sex undet., SL not measured; CU 92390 (EOD, DNA); male, 72.0 mm SL.

Petrocephalus zakoni:

Republic of the Congo, Pandaka River (Congo basin), Odzala National Park, (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87787 (EOD), male, 80.0 mm SL; CU 87836 (EOD), male, SL not measured; CU 88033 (EOD), male, 80.0 mm SL; CU 88034 (EOD), sex undet., 85.0 mm SL; CU 88035 (EOD), sex undet., 85.0 mm SL; CU 88038 (EOD), male, 77.0 mm SL; CU 88039 (EOD), male, 75.0 mm SL; CU 88040 (EOD), sex undet., 87.0 mm SL; CU 88078 (EOD), sex undet., 65.0 mm SL.

Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.95° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87840 (EOD), male, 75.0 mm SL; CU 88102 (EOD), sex undet., 83.0 mm SL; CU 88104 (EOD), sex undet., 90.0 mm SL; CU 88105 (EOD), male, 75.0 mm SL; CU 88106 (EOD), sex undet., 85.0 mm SL.

Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88086 (EOD), male, 79.0 mm SL; CU 88087 (EOD), male, 73.0 mm SL; CU 88089 (EOD), sex undet., 83.0 mm SL; CU 88092 (EOD), male, 71.0 mm SL; CU 88094 (EOD), male, 77.0 mm SL; CU 88099 (EOD), sex undet., 85.0 mm SL.

Republic of the Congo, Cuvette Ouest, Lékénie River at Mboko débarcadère, Odzala National Park (0.62° N, 14.91° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87837 (EOD, DNA), male, 75.0 mm SL; CU 88062 (EOD), male, 77.0 mm SL; CU 88110 (EOD), male, 80.0 mm SL; CU 88112 (EOD), male, 72.0 mm SL; CU 88113 (EOD), male, 72.0 mm SL; CU 88114 (EOD), male, 71.0 mm SL; CU 88115 (EOD), sex undet., 69.0 mm SL.

Republic of the Congo, Cuvette Ouest, Lékoli River, Odzala National Park (0.62° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 24 August 2002: CU 88124 (EOD), male, 79.0 mm SL; CU 87778 (EOD), male, 79.0 mm SL.

Republic of the Congo, Cuvette Ouest, Lékoli River, Odzala National Park (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 8 August 2002: CU 88070 (EOD, DNA), sex undet., SL not measured.

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Republic of the Congo, Cuvette Ouest, Lékoli River, just above Lékénie River, Odzala National Park (0.62° N, 14.91°E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 15 August 2002: CU 88084 (EOD), male, 75.0 mm SL.

Republic of the Congo, Lékénie River at the debarcadère, mouth of the river near the Lékoli River (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92391 (EOD, DNA), male, 75.0 mm SL; (EOD), sex undet., 75.0 mm SL; (EOD), male, 73.0 mm SL.

Republic of the Congo, Cuvette Ouest, Lékoli River (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92388 (DNA), sex undet., SL not measured.

Petrocephalus valentini:

Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), Odzala National Park (0.62° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 24 August 2002: CU 88122 (EOD), sex undet., 58.0 mm SL; CU 88121 (EOD), sex undet., 62.0 mm SL.

Republic of the Congo, Cuvette-Ouest, Lékénie River at Mboko débarcadère, Odzala National Park (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 88058 (EOD, DNA), male, 64.0 mm SL.

Petrocephalus balayi:

Republic of the Congo, Pandaka River (Congo basin), Odzala National Park, (0.62° N, 14.94° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 11 August 2002: CU 87851 (morpho, EOD, DNA), sex undet., 95.6 mm SL.

Republic of the Congo, small forest creek draining into the Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.94° E), local women coll. using a traditional fishing method, by temporarily damming and draining the creek and removing fish, 22 August 2002: CU 88111 (morpho, EOD, DNA), sex undet., 81.2 mm SL.

Petrocephalus microphthalmus:

Republic of the Congo, small forest creek draining into Lékoli River, Odzala National Park, (0.62° N, 14.94° E), local women coll. using a traditional fishing method, by temporarily damming and draining the creek and removing fish, 22 August 2002: CU 87938 (morpho, EOD), male, 59.1 mm SL; CU 87996 (EOD), male, 56.0 mm SL.

Republic of the Congo, Pandaka River, Odzala National Park, (0.62° N, 14.92° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87940 (morpho, EOD, DNA), male, 51.8 mm SL; CU 88003 (morpho, EOD), male, 53.3 mm SL; CU 87939 (EOD, DNA), sex undet., 53.0 mm SL; CU 88001 (EOD), sex undet., 55.0 mm SL; CU 88002 (EOD), male, 52.0 mm SL; CU 87998 (EOD), sex undet., 48.0 mm SL.

Republic of the Congo, Grande Saline, Lékoli River (Congo basin), Odzala National Park, (0.61° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 1 August 2002: CU 87841 (EOD), male, SL not measured.

Republic of the Congo, Lékénie River at Mboko débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87999 (EOD), sex undet., 42.0 mm SL; CU 87999 (EOD), male, 63 mm SL; CU 87783 (EOD), sex undet., 52.0 mm SL; CU 88004 (EOD), male, 54.0 mm SL; CU 87997, sex undet., 48.0 mm SL.

Petrocephalus odzalaensis:

Republic of the Congo, Lékénie River at Mboko débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., August 2002: CU 87780 (EOD), sex undet., 95.0 mm SL; CU 88108 (EOD), sex undet., SL not measured; CU 87853 (EOD), male, 93.0 mm SL; CU 87835 (EOD), male, 95.0 mm SL; CU 88109 (EOD), sex undet., 85.0 mm SL; CU 88060 (EOD), male, 87.0 mm SL; CU 88055 (EOD), male, 90.0 mm SL; CU 88047 (EOD), male, 100.0 mm SL; CU 87852 (EOD), male, 98.0 mm SL; CU 88061 (EOD), male, 93.0 mm SL; CU 88051 (EOD), juvenile, 56.0 mm SL.

Republic of the Congo, small forest creek draining into Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.93° E), local women coll. using a traditional fishing method, by temporarily damming and draining the creek and removing fish, 22 August 2002: CU 87848 (EOD), male, 96.0 mm SL; CU 87849 (EOD), sex undet., 103.0 mm SL.

Republic of the Congo, Lékéni River at the debarcadère, mouth of the river near the Lékoli River (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92392 (EOD, DNA), sex undet.; CU 92392 (EOD), male; CU 92392 (EOD, DNA), male; CU 92392 (EOD), sex undet.; CU 92392 (EOD), male; CU 92392 (EOD), male.

Petrocephalus christyi:

Republic of the Congo, small channel around island in Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.95° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 20 August 2002: CU 88095 (morpho, EOD, DNA), male, 84.7 mm SL.

Republic of the Congo, Lékénie River at Mboko débarcadère (Congo basin), Odzala National Park, (0.62° N, 14.90° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 13 August 2002: CU 88057 (morpho, EOD, DNA), sex undet., 50.5 mm SL.

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Central African Republic, Mabondo Island, Sangha River upstream from Bayonga, station JPS-98-012, J.P. Sullivan & J.B. Kindimoungo coll., 13 June 1998: AMNH 227540 (one specimen).

Central African Republic, Bayonga, Sangha River, margin of the river near Doli Lodge, station JPS-98-035 [2.92° N, 6.25° E], J.P. Sullivan coll., 27 June 1998: AMNH 231047 (six specimens) and AMNH 227650 (two specimens).

Republic of the Congo (Congo Brazzaville), Congo River, les rapides, first rapid below Malebo Pool [18.79° S, 13.73° E], U.K. Schliewen, R.C. Schelly, P. Feulner, I.J. Harrison, V. Mamonekene & A.I. Zamba coll., 12 August 2004: AMNH 236748 station CO4-222 (three specimens).

Petrocephalus sauvagii:

Republic of the Congo, Lékoli River, just above Lékénie River (Congo River), Odzala National Park, (0.62° N, 14.9° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 15 August 2002: CU 87864, (morpho, EOD, DNA), female, 136.0 mm SL; CU 89082 two specimens (morpho), female, 189.0 mm SL, female, 182.0 mm SL.

Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), small branch of the Lékoli River, only ca. 300 meters long before it re-enters into the main channel of the Lékoli (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92387 (morpho, EOD, DNA), male, 165.0 mm SL; CU 92387 (morpho), male, 109.2 mm SL; CU 92387 (EOD, DNA), male, 119.0 mm SL.

East side of Niger Delta, Chokoche River about 15 miles North of Port Harcourt (on road to Umvede) [estimated 4.8° N, 7° E], T. Roberts coll.: MNHN 1990–942 four specimens.

Petrocephalus pulsivertens:

Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), small branch of the Lékoli River, only ca. 300 meters long before it re-enters into the main channel of the Lékoli (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., June 2006: CU 92386 four specimens (EOD), male, 112.0 mm SL; (EOD, DNA), sex undet., 102.0 mm SL; (EOD), sex undet., 101 mm SL; (EOD), male, 92.0 mm SL.

Republic of the Congo, Lékoli River just above Lékénie River, Odzala National Park, (0.62° N, 14.91° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 15 August 2002: CU 89089 (one damaged specimen).

Central African Republic, Sangha River, Lossi creek, at bridge, ca. 17 kilometers west of Bayonga (2.76° N, 6.24° E), J.P. Sullivan *et al*. coll., 30 June 1998: AMNH 231054 (morpho), male, 103.2 mm SL.

Petrocephalus grandoculis:

Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), Odzala National Park, (0.62° N, 14.93° E), J.P. Friel, S. Lavoué & J.P. Sullivan coll., 24 August 2002: CU 88119 (morpho, EOD, DNA), male, 95.0 mm SL.

Republic of the Congo, Cuvette-Ouest, Lékoli River (Congo basin), small branch of the Lékoli River, only ca. 300 meters long before it re-enters into the main channel of the Lékoli (0.62° N, 14.91° E), M.E. Arnegard, V. Mbossi, E. Kinzonzi, S. Lavoué, V. Mamonekene & P.B. McIntyre coll., 26 June 2006: CU 92385 (morpho, DNA), male, 98.0 mm SL.

Comparative type material examined:

Petrocephalus ansorgii Boulenger, 1903

Holotype, BMNH 1902.10.25 [Agberi, Lower Niger].

Petrocephalus catostoma (Günther, 1866)

Lectotype designated by Whitehead and Greenwood (1959), BMNH 1863.10.12.4. Paralectotypes: BMNH 1863.10.12.5.6 [Rovuma or Ruvumu, Tanzania, East Africa].

Petrocephalus catostoma congicus David and Poll, 1937

Syntypes, MRAC 30807–30808 [Democratic Republic of the Congo, Congo basin, Mukishi River at Lumami (estimated 0.83° S, 24.40° E), 4 May 1930, R. Massart coll.].

Petrocephalus catostoma haullevillii Boulenger, 1912

Syntypes, BMNH 1912.4.1.181–188, five specimens examined [Chiloango River at Mayilli, Luculla River at Chiloango and Luali River at Chiloango, (estimated 3.93°S, 12.35° E)].

Petrocephalus cunganus Boulenger, 1910

Holotype, BMNH 1910.11.28.27 [Angola, Cuanza River at Cunga].

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Petrocephalus hutereaui (Boulenger, 1913)
Holotype, MRAC P 1805 [Dungu, Uelé, Upper Congo (estimated 3.70° N, 28.67° E)].

Petrocephalus schoutedeni Poll, 1954
Paratypes, MRAC 120058, BMNH 1953.6.24.1 [Democratic Republic of the Congo, Congo River at (estimated 0.78° N, 24.47° E), A. Hulot coll., 1948].

Petrocephalus simus Sauvage, 1879
Syntypes, MNHN A 0892 [Gabon, Ogooué River at the type locality Doumé, near the modern city of Lastoursville, Gabon, (estimated 0.85° S, 12.93° E), Expedition of Savorgnan de Brazza, Alfred Marche coll.].

Petrocephalus squalostoma (Boulenger, 1915)
Syntypes, BMNH 1920.5.26.1 [Democratic Republic of the Congo, Congo basin, Lukinda River tributary of Moero Lake, (estimated 9.00° S, 28.75° E), Stappers' mission to Tanganyika–Moero].

Petrocephalus stuhlmanni Boulenger, 1909
Holotype, BMNH 1907.12.3.1 [Kingani River, Tanzania, East Africa]. Synonym of *Petrocephalus catostoma*.

Petrocephalus sullivani Lavoué, Hopkins and Kamdem Toham, 2004
Holotype, MNHN 2003–619 [Gabon, Ogooué River near the park of La Lopé, (0.1° S, 11.58° N), M.E. Arnegard, C.D. Hopkins, S. Lavoué & T. Uschold coll., 20 August 2001.]. Paratypes, 32 specimens, MNHN 2002–266, CU 88992, CU 83120, MRAC A3–06–P–1–7 and AMNH 233602 [same locality as the holotype.].