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A NEW SUBTERRANEAN SPECIES OF *PHREATOBIUS* GOELDI, 1905 (SILURIFORMES, *INCERTAE SEDIS*) FROM THE SOUTHWESTERN AMAZON BASIN

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ABSTRACT

A new species of the previously monotypic catfish genus Phreatobius is described from an artificial well in the village of Rio Pardo, located 90 km south of the city of Porto Velho, State of Rondônia, Brazil, in the drainage area of the Rio Branco (Rio Madeira system, Amazon basin). Phreatobius dracunculus n. sp. differs from its only congener, P. cisternarum, by the absence of eyes (vs. present), the lack of dark integumentary pigmentation (vs. faint dark pigment always present), the presence of five pectoral-fin rays (vs. four), ventral procurrent rays 11-13 (vs. 22 to 26), dorsal procurrent rays 29-31 (vs. 42 to 50), fewer vertebrae (52 or 53 vs. 59 to 64) and the larger pseudotympanus. The new species shows all diagnostic characters so far proposed for Phreatobius, including an unusual red coloration in life. The localities of the two species of Phreatobius are approximately 1900 km apart. That, in association with their peculiar and mostly inaccessible habitats, indicates that the genus may be widely distributed in the Amazon basin.

KEYWORDS: blind catfish, subterranean fishes, Madeira basin, habitat, taxonomy.

INTRODUCTION

The catfish *Phreatobius cisternarum* is one of the most peculiar members of the Neotropical freshwater fish fauna. It lives mainly in subterranean waters around the mouth of the Amazon river and most specimens so far have been secured from hand-dug wells, with epigeal records also from leaf litter in the State of Amapá (MPEG 3325, M. Goulding, pers. comm.; MZUSP 93260, 95071, 95072, 95073, JMC pers.

obs.). The species displays typical adaptations seen in hypogean fishes, such as reduction of eyes and of dark integumentary pigmentation. In addition to those, many other morphological peculiarities also make the species distinctive at a glance from other Neotropical catfishes, such as a paddle-shaped caudal region formed by a caudal-fin extended dorsally and ventrally by numerous large procurrent rays, ventrally confluent with the anal-fin, a strongly prognathous lower jaw, massively hypertrophied jaw muscles and a bright red

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coloration in life. The internal anatomy of *P. cisternarum* is equally unusual, which has resulted in uncertainties about its familial allocation. The species has been allied to six different siluriform families, in various combinations, in the course of its taxonomic history: Trichomycteridae, Cetopsidae and Auchenipteridae (Goeldi, 1905; Eigenmann, 1918; Myers, 1944), Clariidae and Plotosidae (Fuhrmann, 1905, 1906), and Heptapteridae or Pimelodidae (Reichel, 1927; Myers & Weitzman, 1966; Chardon, 1968; Stewart, 1986; Buckup, 1988; Bockmann, 1998). For a whole century following its discovery, *P. cisternarum* remained known from very few individuals collected fortuitously at long intervals. Recently, collecting efforts focused on the species yielded more numerous specimens for study, which formed the basis for a redescription of the species (Muriel-Cunha & de Pinna, 2005).

In 2005, specimens of a form clearly allied to *P. cisternarum* were found in an artificial well in the Brazilian State of Rondônia and forwarded to the care of the first author. Examination and comparisons showed that the specimens clearly represent a distinct species, yet closely related to *P. cisternarum*. The new species has been mentioned once in the literature (Trajano, 2007), in a survey of the evolution of troglolithic fishes, but remains unnamed and undiagnosed. The fact that the two known species of *Phreatobius* are both subterranean and occur on nearly opposite sides of the Brazilian Amazon, separated by at least 1900 km in straight line, raises intriguing questions about the evolution of the genus. The purpose of this paper is to diagnose and to describe the new species, to compare it with *P. cisternarum* and to refine the diagnosis of *Phreatobius* as to incorporate the range of variation revealed by the new form.

MATERIAL AND METHODS

Morphometric data were taken with digital calipers to the nearest 0.1 mm. Definition of measurements follow Muriel-Cunha & de Pinna (2005). Principal caudal-fin rays were counted as those directly attached to the hypural plate. Vertebral number included all unfused vertebrae (which in *Phreatobius* correspond to those bearing a neural spine) plus four anterior ones (three fused in the Weberian complex and a free first one), plus the compound caudal centrum ($PU_1 + U_1$) counted as one. The relative positions of first dorsal- and anal-fin pterygiophores were made in reference to counts of free vertebrae. Internal-anatomical data were taken from x-rays made with a Faxitron MX20 digital microradiographic system.

Comparative material examined: *Phreatobius cisternarum*, a total of 8 specimens, all from Brazil: MNRJ 11569, 1 ex, 30.9 mm SL, State of Amapá, Macapá, hand-dug well, coll. R.H.G. Damasceno, Dec 1965; MPEG 3325, 1 ex, 41.3 mm SL, State of Amapá, city of Amapá, rio Amapá Grande, coll. M. Goulding, 01 Jan 1984; MPEG 7649, 1 ex, 38.5 mm SL, State of Pará, Ananindeua, hand dug well, coll. A.F. Nascimento Filho, 01 Mar 1993; MZUSP 84568, 1 ex, 44.5 mm SL, State of Pará, Benfica, hand-dug well 4,4 m deep, coll. J.M. Cunha & Sr. Nei, 12 Dec 2003; MZUSP 85475, 1 ex, 42.0 mm SL, same data as MZUSP 84568; MZUSP 85472, 1 ex, 23.8 mm SL, State of Pará, Marajó Island, Salvaterra, hand-dug well 7,8 m deep, coll. J.M. Cunha & S. Colares, 24 Dec 2003; MZUSP 85473, 1 ex, 44.2 mm SL; same data as MZUSP 85472; MZUSP 88396, 1 ex, 41.3 mm SL, State of Pará, Marajó Island, Salvaterra, hand-dug well, coll. J.M. Cunha & J. da Conceição, 11 Dec 2003.

Phreatobius dracunculus, new species

(Figs. 1, 3 and 5)

Holotype: MZUSP 93955, 36.0 mm SL, Brazil, State of Rondônia, hand-dug well in settlement of Rio Pardo, approximately 90 km south of the City of Porto Velho; area of Rio Branco drainage (tributary to Rio Jaci-Paraná, itself tributary to Rio Madeira, Amazon basin), 63°58'08.2"W 9°34'10.7"S, Coll. J.M. Cunha, J. Zuanon & Z.V.P. Siqueira, 01-03 Nov 2006.

Paratypes: All from type locality. MZUSP 93956, 1 ex, 35.8 mm SL; MZUSP 93957, 1 ex, 29.7 mm SL; MZUSP 93958, 1 ex, 31.2 mm SL, collected with holotype; MZUSP 91680, 1 ex, 38.1 mm SL, MZUEL 4761, 2 ex (20.1 and 29.8 mm SL), Coll. Z.V.P. Siqueira, 05-27 Sep 2005.

Diagnosis: Distinguished from its only congener, *P. cisternarum*, by the following characteristics: 1) eyes absent (vs. small eyes present); 2) ventral procurent rays 11-13 (vs. 22 to 26), dorsal procurent rays 29-31 (vs. 42 to 50); 3) vertebrae 52 or 53 (vs. 59-64); 4) five pectoral-fin rays (vs. four); 5) long pectoral fin (50-60% HL; vs. 20-25%); 6) posterior insertion of dorsal-fin approximately at vertical through third anal-fin ray (vs. at vertical through origin of anal-fin); 7) first dorsal-fin pterygiophore inserted immediately posterior to neural spine of free vertebra 12 or 13 (vs. vertebra 17-19); 8) First anal-fin pterygiophore

inserted immediately posterior to hemal spine of free vertebra 16 or 17 (vs. vertebra 22-24); 9) no integumentary dark pigmentation (vs. some faint dark pigment always present); 10) pseudotympanus large, visible in dorsal, lateral and ventral views (vs. pseudotympanus small, visible in lateral view only); and 11) posterior (and only) pores of infraorbital canal nearly aligned transversely on head with posterior nasal pores (vs. posterior infraorbital pores markedly posterior to transverse line through posterior nasal pores); cf. fig. 2, compare with fig. 1 in Muriel-Cunha & de Pinna (2005).

Description: Morphometric data given in Table 1. Cross-section of body at trunk approximately round, becoming more compressed posterior to base of dorsal-fin. Caudal peduncle region strongly compressed. Caudal region expanded dorsally and ventrally by procurrent caudal-fin rays (Fig. 1).

Integument thin, hyaline in live specimens, with vertical folds regularly disposed along sides of trunk in preserved specimens. Myotomes and skeletogenous septa evident externally along most of body except in region along anal fin, thickly covered with adipose tissue.

Head longer than broad, its lateral profile convex in dorsal view. Eyes absent. Anterior naris small, close to upper lip, as long as wide, with a tube of integument prolonged anterodorsally. Posterior nares round and small. Snout round in dorsal view. Mouth as wide as head and prognathous, lower jaw extending further anteriorly than upper one (Fig. 1). Corners of mouth strongly curved posteriorly, reaching slightly beyond vertical through posterior margin of posterior nares in lateral view. In lateral view cleft of mouth straight, located on dorsal fourth of head depth (Fig. 1). Lower jaw projected dorsally, its ventral profile slightly con-

vex. Upper jaw strongly depressed, its depth one-third that of lower one in lateral view. Lips large and thick, well defined laterally by fold of integument. Branchial membranes mostly free, narrowly attached to isthmus. Posterior attachment of branchial membranes immediately dorsal to origin of pectoral fin.

Proportional barbel lengths varying markedly among specimens and on different sides of same specimen. Maxillary barbel, when abducted, not reaching posterior limit of dorsal head musculature in MZUSP 91680, MZUEL 4761 (2 exs), reaching that point in holotype (MZUSP 93955) and reaching anterior third of pectoral fin in MZUSP 93956, MZUSP 93957 and MZUSP 93958. Base of maxillary barbel close to anterolateral corner of upper jaw, at mid distance between corner of mouth and tip of snout. Outer mental barbel slightly shorter than maxillary one, not reaching to vertical through pectoral-fin base in holotype (MZUSP 93955), MZUSP 93956, MZUSP 91680 and MZUEL 4761 (29.8 mm SL), but reaching pectoral-fin base in MZUSP 93958 and anterior third of pectoral-fin in MZUSP 93957. Outer mental barbel broken on right side of MZUEL 4761 (29.8 mm SL) and absent or broken on both sides of MZUEL 4761 (20.1 mm SL). Inner mental barbel shortest and not reaching vertical through corner of mouth in MZUSP 91680 and MZUSP 93956, reaching vertical through the middle distance between corner of mouth and pectoral-fin base in the holotype (MZUSP 93955), almost reaching pectoral-fin base in MZUSP 93958 and reaching that point in MZUSP 93957. Origin of inner mental barbel slightly anterior to that of outer mental barbel. All barbells with fine round tips.

Six cephalic latero-sensory canal pores present dorsally on anterior snout region posterior to nares, corresponding to pores of the supraorbital latero-sen-

TABLE 1: Body proportions of *Phreatobius dracunculus* based on seven whole alcoholic specimens. SL in mm. Measurements 2-9 in proportions of SL; 10-11 in proportion of HL. SD = Standard deviation.

	Holotype	Min	Max	Mean	SD
1. SL	35.98	20.07	38.11	31.17	6.04
2. TL	1.09	1.09	1.17	1.14	0.03
3. Predorsal length	0.41	0.41	0.45	0.43	0.01
4. Prepelvic length	0.39	0.38	0.44	0.40	0.02
5. Preanal length	0.48	0.46	0.52	0.50	0.02
6. Dorsal-fin base length	0.12	0.10	0.12	0.11	0.01
7. Body depth	0.10	0.07	0.10	0.09	0.01
8. Caudal peduncle length	0.32	0.29	0.35	0.32	0.02
9. HL	0.16	0.16	0.19	0.17	0.01
10. Internarial width	0.16	0.15	0.18	0.17	0.01
11. Head width	0.66	0.56	0.68	0.65	0.04

sory canal associated with nasal bone. Anterior pair of pores close to each other, located mesial to base of anterior nares. Posterior pair less widely apart than in *P. cisternarum*. Posterior pores at infraorbital canals nearly aligned, transversely with posterior nasal pores. Latero-sensory canal system absent on most of body, restricted anteriorly to short tube with two pores representing remnant of lateral line.

Pectoral-fin rays all soft, i+4 (n=5, holotype) or i+3+i (n=1), a single specimen with 5 branched rays on one side and i+3+i on the other. Fin large, its length about 50-60% of HL and its base narrow. Pelvic fin reaching or covering anal opening, but not reaching anal fin (almost reaching that point in small specimen, MZUEL 4761, 20.1 mm SL). Pelvic-fin bilaterally and intraspecifically variable: MZUSP 93957, both fins v; MZUSP 93955 (holotype) left fin with 5 branched rays, right one i+3; MZUEL 4761 (20.1 mm SL specimen) and MZUSP 93956, both fins with 5 branched rays; MZUEL 4761 (29.8 mm SL specimen), both fins with 5 rays, left one ii+3 and right one i+4; MZUSP 91680, left fin ii+2+i, right one i+2; MZUSP 93958, left pelvic fin i+2+i, right fin i+3+i. Dorsal-fin short, its origin closer to tip of snout than to base of caudal-fin, its base extending posteriorly to vertical through origin of pelvic-fins, its posterior insertion approximately at vertical through the third anal-fin ray and at middle of SL. Seven dorsal-fin rays, all soft, i+6 (n=4), ii+5 (n=2, holotype), ii+4+i, i+1+i+4. First dorsal-fin pterygiophore inserted posterior to neural spine of vertebra 13 (n=6, holotype) or vertebra 12 (n=1). Anal-fin long, with 20 (n=1), 21 (n=1), 22 (n=4, holotype), or 24 (n=1) soft rays, all unbranched. Origin of anal-fin slightly posterior to anal opening. First anal-fin pterygiophore inserted posterior to hemal spine of vertebra 17 (n=6, holotype) or 16 (n=1). Anal-fin continuous posteriorly with ventral procurent caudal-fin rays, but two regions distinguishable by abruptly shorter procurent rays, marked by clear indentation and by slightly more closely-positioned procurent rays, when compared to more widely spaced anal-fin rays (fig. 1). Caudal-fin round (n=3, holotype) or symmetrically lanceolate (n=4), continuous dorsally and ventrally with procurent rays. Procurent caudal-fin rays more numerous dorsally (29-31) than ventrally (11-13). Principal caudal-fin rays 10 (n=4) or 11 (n=3, holotype), all soft, 6 to 10 middle rays branched. Dorsal procurent caudal-fin rays, principal caudal-fin rays, ventral procurent caudal-fin rays and anal-fin rays joined as single extended fin. Vertebrae 52 (n=1) or 53 (n=6, holotype). Two (n=1) or three (n=6, holotype) pairs of pleural ribs, on vertebrae 7 and 8 or 6, 7 and 8,

respectively. In holotype, anterior pleural rib (on vertebra 6) present on one side only. Last pair of pleural rib smaller than preceding ones, associated with hypertrophied parapophysis on vertebra 8. (Fig. 5) Swimbladder occupying entire body width and reaching posterior limit of vertebra 8.

Coloration

Live specimens are light pink, slightly darker alongside the vertebral column due to dorsal aorta (Fig. 1). Numerous adipose bodies create a superficial iridescence especially evident on the middle and posterior portion of body. There is a large translucent area immediately posterior to head, corresponding to the pseudotympanus, forming a light collar seen in dorsal, lateral and ventral views in live specimens (Fig. 1). The fins are hyaline. In preserved specimens, the body is uniformly white, with no trace of dark pigmentation. The only coloration differences are muscle limits and some internal structures seen superficially by transparency. Freshly-preserved specimens have a large greenish blotch in the abdominal region, probably corresponding to the liver. That structure gradually turns brownish and fades after approximately eight months of preservation. A specimen kept for five months in aquarium showed no change in pigmentation.

Distribution: Known from type-locality. Although specimens collected were all from a single well, individuals of *Phreatobius*, probably *P. dracunculus*, were observed (by JMC) swimming in two additional wells in the same area. Reports by locals indicate that the species probably occurs in at least another 12 of 20 wells in the region.

Etymology: The specific epithet, *dracunculus*, is from the Latin *draco*, meaning dragon, combined with a diminutive suffix *-unculus*. The name, a noun in apposition, is a reference to the color and general aspect of the body and fins of the fish.

Ecological notes

The type locality is located just outside of the eastern limit of a conservation unit called Floresta Nacional Bom Futuro, created in 1988 (Olmos, 1998). The stream closest to the type locality is approximately 200 m apart in straight line from the well where specimens of *P. dracunculus* were collected. That stream

joins the Rio Branco approximately 10 km downstream from the type locality. The annual mean pluviosity and temperature are 2.262 mm and 26.7°C respectively, according to the pluviometric station of Porto Velho, period of 1954 to 1993 (Bezerra, 1996).

Specimens of *P. dracunculus* were collected in a recently opened hand-dug well intended for domestic use. According to owners, the well was excavated sometime in September 2005, and fish began to appear approximately ten days later, accidentally trapped in buckets used to extract water. The well is one meter in diameter and approximately five meters in depth. Water fills it up to 2.5 m in the rainy season, but drops to ca. 1 m in the drought (fig 4a). The walls of the well have soft stones and gravel that release a red stain (fig. 4b). They are probably loose conglomerates of the canga type described by Muriel-Cunha & de Pinna (2005), which are composed of ferruginous lateritic rocks widespread in the Amazon region (Costa, 1991). The well water is clear but turns milky when disturbed, which is an indication that the bottom probably has a fine white clay locally known as "tabatinga". Locals reported that similar fish had been seen sporadically in other wells in the region for the past five years.

Two specimens were kept live in aquaria, furnished with rocks from the well and without artificial aeration. One specimen was preserved after one month in captivity and the second was kept alive for approximately three months. Fish stayed in apparent good health the entire period in captivity and showed a general behavior similar to that of *P. cisternarum* as described by Muriel-Cunha & de Pinna (2005). Compared to its sister species, however, *P. dracunculus* specimens seemed more active overall, and spent more time exploring the bottom and middle portions of the water column. The food items in captivity were live earthworms (Fig. 3a), dried blood-worms and fresh dead adult *Artemia*. As with *P. cisternarum*, stress conditions temporarily induced a vertical body position in specimens of *P. dracunculus* (Fig. 3b).

DISCUSSION

The discovery of *Phreatobius dracunculus* expands the distribution area of its genus in the Amazon to a latitudinal span of approximately 8°. That is one of the largest known geographical distributions of any hypogean fish genus. It is likely that several new populations or new species await discovery in the vast area between the known occurrences of *P. cisternarum* and *P. dracunculus*.

Phreatobius dracunculus shares all 15 diagnostic characters for *Phreatobius* proposed by Muriel-Cunha & de Pinna (2005). Some of those, however, need refinements and corrections in order to incorporate the specific conditions of characters states displayed by the new species. Below we address each of those characters as presented by Muriel-Cunha & de Pinna (2005), with reference to their condition in *P. dracunculus* and to their value as evidence of monophyly. We give particular emphasis to comparisons with members of the family Heptapteridae, because currently prevailing opinion allies *Phreatobius* with that family.

1 – Extended region of dorsal and ventral procurrent caudal-fin rays, continuous with caudal-fin, dorsally occupying position of adipose fin and ventrally continuous with anal fin. This character is present in *P. dracunculus* in nearly the same condition as in *P. cisternarum*. The only difference is that the procurrent rays are less numerous in the former, with the resulting effect of a smaller area of coverage on the caudal peduncle. This set of modifications associated with the caudal region in species of *Phreatobius* has no parallel among heptapterids or other siluriforms, and constitutes strong evidence of monophyly.

2 – Caudal fin round. The round profile of the caudal fin in *P. cisternarum* distinguishes it from most other known heptapterids, in which the caudal fin is forked or bilobed. Bockmann & Ferraris (2005:130) reported an asymmetrical caudal fin in *Phreatobius*, but we did not confirm that in the material examined. There are, however, a number of cases of round caudal fins in the group, such as in at least some species in each of *Rhamdiopsis*, *Chasmocranus*, *Leptorhamdia* and *Pariolius*. The character, therefore, is not simple to interpret phylogenetically, even within the bounds of a possible heptapterid affinity of *Phreatobius*. Further complications arise from the fact that some specimens (n=4 from 7) of *P. dracunculus* have a lanceolate caudal fin, where the middle principal rays are elongated. Lanceolate caudal fins, while unusual, are known in some heptapterids, such as in some species of *Nemuroglanis*. In all such cases, however, there is some remnant of asymmetry between the lobes, with the rays in the lower lobe shorter than those in the upper one (Bockmann & Ferraris, 2005:130). Those specimens of *Phreatobius dracunculus* with a lanceolate caudal fin seem to be unique among heptapterids in their perfectly symmetrical caudal fins. It is easy to visualize how a symmetrically round fin like that of *P. cisternarum* can be transformed into a symmetrically lanceolate one as seen in *P. dracunculus*, or

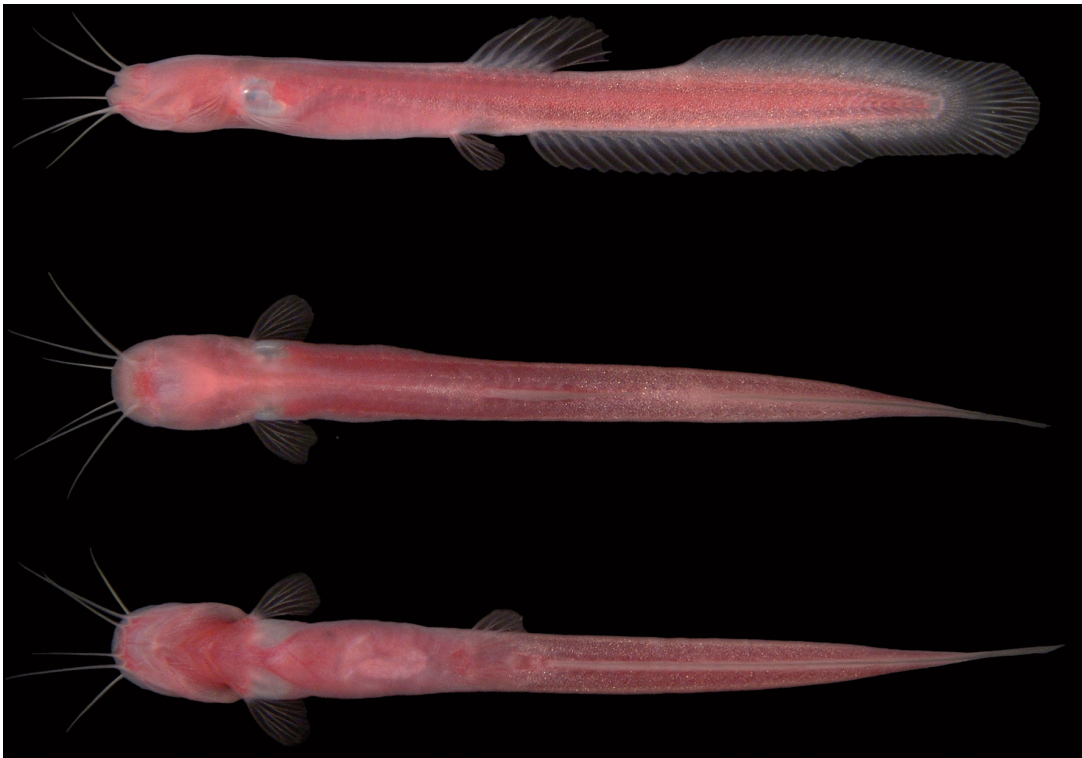


FIGURE 1: *Phreatobius dracunculus*, Holotype, 36.0 mm SL; lateral view; dorsal view of body; and ventral view of live sedated specimen. Photo: L.M. Sousa.

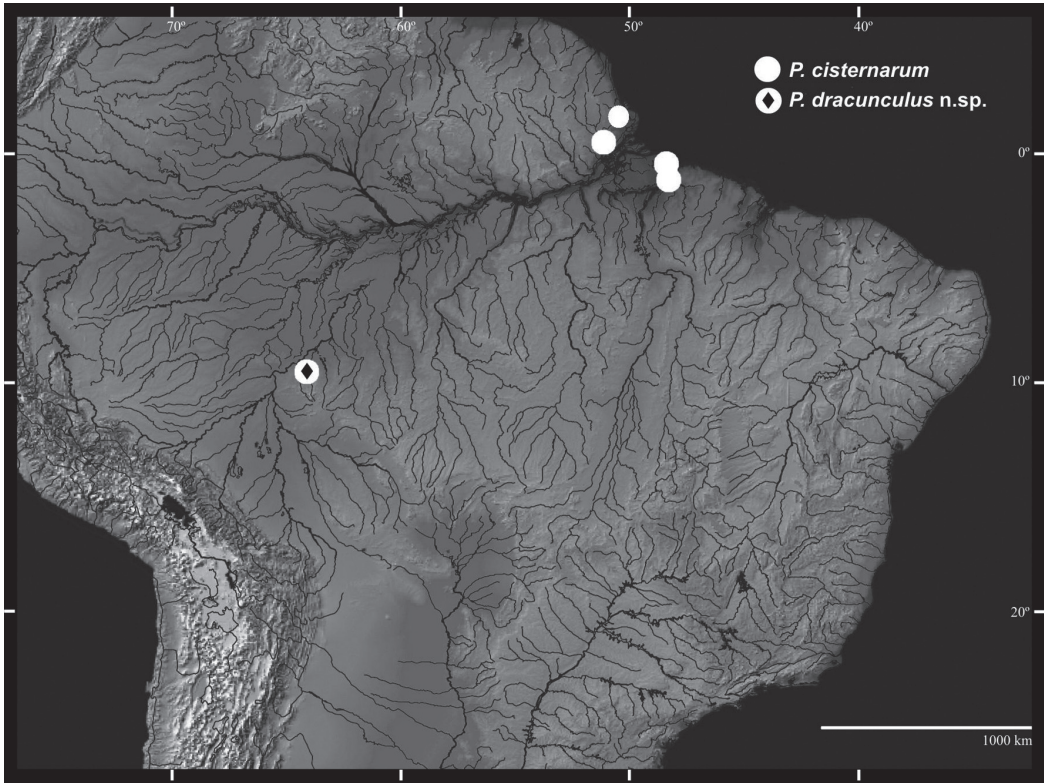


FIGURE 2: Distribution of species of *Phreatobius*

vice-versa, by simple changes in the length of middle principal caudal-fin rays. In view of the great variation in caudal-fin shape seen in heptapterids, plus the different shapes within *P. dracunculus*, the value of this character as evidence of relationships is undefined.

3 – All anal-fin rays unbranched. *Phreatobius dracunculus* shares this condition with its congener. An

entirely unbranched set of anal-fin rays is unique in heptapterids (Bockmann, 1998) and also very unusual among other siluriforms. This character provides valid evidence for the monophyly of *Phreatobius*.

4 – Mouth prognathous, with jaws displaced dorsally on head. The two species of *Phreatobius* have almost identical jaw configurations, with a strongly prognathous

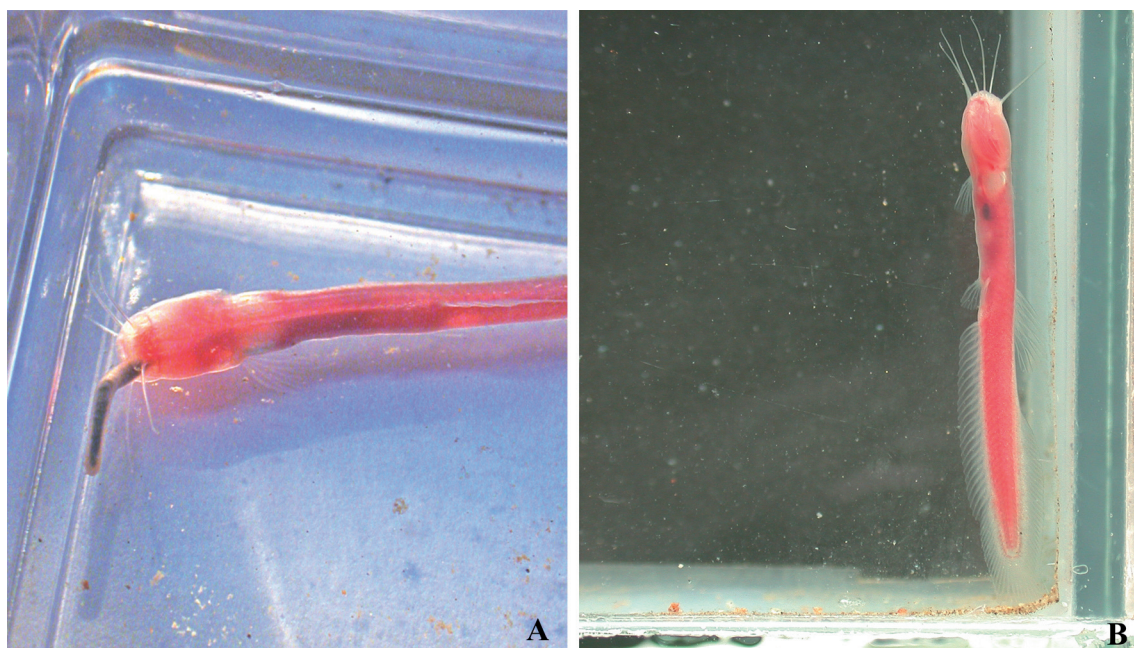


FIGURE 3: A. *Phreatobius dracunculus*, MZUSP 93955, Holotype 36.0 mm SL eating live earthworm; B. MZUSP 93958, Paratype 31.2 mm SL in vertical position. Photos: E. Baena and J.M. Cunha.

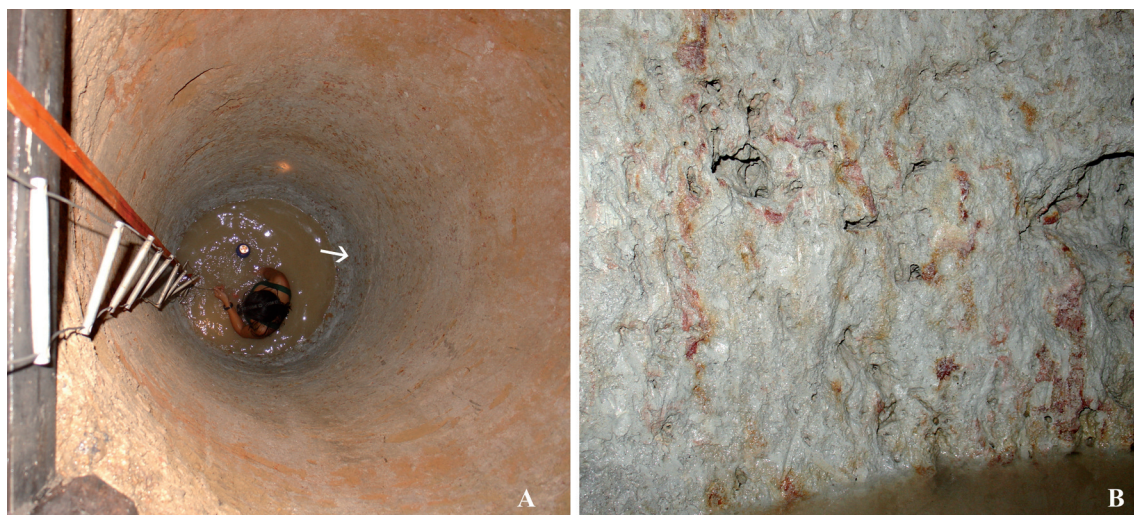


FIGURE 4: A. Well at type locality where specimens of *Phreatobius dracunculus* were collected on Sep 2005 and Oct 2006, 5 m depth, settlement of Rio Pardo, Porto Velho, State of Rondônia, Brazil. Arrow indicates area shown at close range in B; B. Details of ferruginous lateritic in contact with water. Photos J. Zuanon and J.M. Cunha.

thous lower jaw and a general dorsal displacement of jaws on the head in lateral view. Usually in heptapterids and most other catfishes, the mouth is terminal or sub-terminal (Bockmann, 1998). Slightly produced lower jaws exist in some heptapterids, such as in *Phenacorhamdia* and one species of *Nemuroglanis* (*N. lanceolatus*; Bockmann & Ferraris, 2005:130). In both cases, however, the degree of prognathism is less marked than in either species of *Phreatobius*. Also, prognathous heptapterids do not display the remarkable displacement of the jaws to the dorsal part of the head as seen in *Phreatobius*. The general morphology of the mouth is one of the externally distinctive traits traditionally used to diagnose *Phreatobius*, and one that also supports the monophyly of the genus (Bockmann, 1998).

5 – Bright red color in life. This characteristic is one of the most conspicuous traits of *P. cisternarum*, although it can only be appreciated in live or freshly-preserved specimens. The color of the live fish has been illustrated in Muriel-Cunha & de Pinna (2005). Although it obviously derives in major part from the color of blood, it seemingly results from more than simply integumentary transparency due to a reduction of dark skin pigmentation. A special superficial circulatory network is probably involved in the phenomenon as well. *Phreatobius dracunculus* shows a pinkish color, rather distinct from the bright red or wine color of its congener. Pink body color in subterranean fishes

are not unusual, and the condition in *P. dracunculus* seems only slightly more intense than that in other highly troglomorphic catfishes, such as that illustrated in *Taunayia* sp. by Trajano & Bockmann (2000). More detailed information on the structural basis of the red color in species of *Phreatobius* are necessary before the character can be interpreted more thoroughly.

6 – Dorsal-fin spine and locking mechanism absent. The second and first dorsal-fin rays in catfishes are modified into, respectively, the pungent spine and its lock (also called spinelet). This mechanism has been reduced or entirely lost in several siluriform subgroups, including both species of *Phreatobius*. Among various heptapterid taxa, all gradations of development of the spine mechanism can be found, and it is difficult to establish well-defined character-state boundaries. Reductions in the dorsal-fin spine and spinelet similar to that seen in *Phreatobius* occur in species of the genera *Acentronichthys*, *Heptapterus*, *Chasmocranus*, *Paroli* and *Phenacorhamdia* (Bockmann, 1998). This character has been considered as a synapomorphy for *Phreatobius* by Bockmann (1998), but that interpretation depends on the context of a specific heptapterid relationship for the genus and therefore must be considered as circumstantial evidence at this stage.

7 – First pectoral-fin ray soft, not spinous. *Phreatobius dracunculus* has the same morphology of the first pec-



FIGURE 5: *Phreatobius dracunculus*, MZUSP 91680, paratype 38.1 mm SL. Radiograph of head and anterior portion of trunk, dorso-ventral view.

toral-fin ray as *P. cisternarum*, i.e., completely soft and not spinous. The degree of ossification of the first pectoral-fin ray seems to vary continuously among various heptapterids and many other catfish taxa, from a complete spine as in the plesiomorphic condition for catfishes to an entirely soft, segmented ray. As with the previous character, this one can be considered as a synapomorphy for *Phreatobius* only under a specific hypothesis of heptapterid relationships (Bockmann, 1998).

8 – Adductor mandibulae muscle hypertrophied, covering most of skull and posteriorly inserting onto first neural spine. The condition of this character in *P. dracunculus* seems to be similar to that in *P. cisternarum*. In both species, the degree of hypertrophy of the adductor mandibulae is extreme, covering nearly the entire skull roof and posteriorly attaching onto the neural spine of the fourth vertebra (Reichel, 1927; Bockmann, 1998). Although there are several instances of hypertrophy of the adductor mandibulae in heptapterids (e.g. in species of *Brachyglanis*, *Leptorhamdia* and *Myoglanis*), the condition seen in the two species of *Phreatobius* is unparalleled. Among other siluriforms, similar situations are found only in the cave clariid *Horaglanis krishnai* (Menon, 1950) and in some cetopsids (de Pinna et al. 2007).

9 – Dorsal profile of skull concave in lateral view. This character was first proposed by Bockmann (1998) explicitly as an autapomorphy for *Phreatobius*. Radiographs of type specimens of *P. dracunculus* clearly show that the species shares a condition similar to that in *P. cisternarum*, which is therefore a synapomorphy for the genus. It is possible that this character is associated with the extreme hypertrophy of the adductor mandibulae described in the previous character.

10 – Eyes tiny, orbital diameter 2-6% of HL. *Phreatobius dracunculus* differs from *P. cisternarum* in lacking any external vestige of eyes. Although the eyes in *P. cisternarum* are very small, they are present in all specimens as yet available for examination, are provided with well-formed lens and appear functional. The reduction or loss of eyes occurs repeatedly in subterranean fishes. Often, there is some variation in the degree of eye reduction, with some specimens lacking eyes entirely and others having them in varying degrees of reduction. Among neotropical catfishes, such is the case in *Trichomycterus itacarambiensis* (Trichomycteridae), *Ancistrus cryptophthalmus* (Loricariidae), and *Pimelodella kronei* (Heptapteridae). Eyes are entirely lacking in all known specimens of some other sub-

terranean catfish species, such as *Taunayia* sp. (Heptapteridae), *Satan* and *Trogloglanis* (Ictaluridae). The absence of eyes can be considered as an extreme form of eye reduction, in which case the conditions in the two species of *Phreatobius* can be regarded as evidence of relationship. However, considering the highly homoplastic nature of this character in subterranean fishes, it must be regarded as circumstantial evidence for the monophyly of *Phreatobius*. What can be said with some degree of certainty is that the total loss of eyes in *P. dracunculus* is autapomorphic.

11 – Eyes located anteriorly on head (preorbital length 16-26% of HL). The extremely anterior position of the eyes on the head of *P. cisternarum* has no parallel among heptapterids and very few, if any, among other catfishes. The lack of eyes in *P. dracunculus* obviously makes it impossible to observe that character directly. However, the markedly anterior position of its posterior infraorbital pore indicates that the primitive eye area in the species is at least as anterior as in *P. cisternarum*. Examination of juvenile specimens of *P. dracunculus*, currently unknown, may provide a test of that interpretation.

12 – Two pleural ribs. In *P. dracunculus*, there are normally three pairs of pleural ribs Fig. 5 (one specimen only has two pairs only). In that, the species differs from *P. cisternarum*, which always has two pairs of ribs. Most heptapterids have 7-11 ribs, but *Nemuroglanis paucirradiatus* and *Pariolius armillatus* have six, species of *Gladioglanis* have five or six, and *Horiomyzon retropinnatus* has five, the lowest count in the family other than for *Phreatobius* (data from Bockmann, 1998). Thus, three or fewer pleural ribs can be considered as a synapomorphy for *Phreatobius*, with the more extreme reduction to two, in turn, autapomorphic for *P. cisternarum*.

13 – Parapophysis of eighth vertebra elongated. The condition for this character in *P. dracunculus* (Fig. 5) is similar to that in *P. cisternarum*, where the parapophysis of the eighth vertebra is abruptly markedly longer than those of preceding and succeeding vertebrae. Usually in siluriforms and other otophysans, the parapophyses increase or decrease gradually in size. This character has not been recorded in other heptapterids or outgroup siluriforms, and can be considered as synapomorphic for the genus.

14 – Opercle narrow and curved dorsally. As examined in radiographs, the morphology of the opercle in *P. dracunculus* seems very similar to the peculiar shape

in *P. cisternarum* (cf. dePinna, 1998). Its narrow and dorsally-curved shape is therefore a synapomorphy for *Phreatobius*.

15 – Single large cranial fontanel occupying most of skull roof. The vast single cranial fontanel of *P. cisternarum*, which occupies practically the entire skull roof and lacks an epiphyseal bar, is matched by a very similar condition in *P. dracunculus*, as visible in radiographs. This character is a synapomorphy for *Phreatobius*, and one with very few parallels among other siluriforms. Among heptapterids, there is no case of a similar fontanel morphology. A few taxa have fontanels proportionally wider than the plesiomorphic condition, such as *Gladioglanis* and *Nemuroglanis*, where the width of the fontanel is greater than 40% of their lengths (Bockmann, 1998). Normally in heptapterids and the majority of other siluriforms, that figure stays below 30% (Bockmann & Ferraris, 2005:127). In both *Gladioglanis* and *Nemuroglanis*, however, the fontanels retain a normal general morphology, with anterior and posterior components separated by an epiphyseal bar and at least two-thirds of the skull roof still covered by bone. Situations similar to those in species of *Phreatobius* occur only in the primitive Asian clariid *Horaglanis* and in some trichomycterids (members of the subfamily Tridentinae, *Trichomycterus hasemani* and the closely related *T. johnsoni*, and species of *Paravandellia* and *Paracanthopoma*). Those particular taxa seem to be phylogenetically distant from *Phreatobius* (assuming a heptapterid relationship of the genus), and their large fontanel can confidently be considered as convergent with that in species of *Phreatobius*.

The summation of all the direct and indirect evidence discussed above provides overwhelming support to the hypothesis that the two species now included in *Phreatobius* form a monophyletic group. This hypothesis seems to be well-corroborated regardless of the uncertainties about the familial placement of the genus, because several of the putative synapomorphies are unique or nearly unique across large clades of siluriforms. Thus, the inclusion of the new species herein described in the genus *Phreatobius* seems phylogenetically consistent.

It is difficult to estimate whether character information from the new species will facilitate resolution of the phylogenetic position of *Phreatobius* within Siluriformes, because the few specimens available do not allow detailed studies at this time. In some aspects, *P. dracunculus* seems to be slightly less extremely modified than *P. cisternarum*, such as in its shorter caudal

region, more numerous pleural ribs and pectoral-fin rays. Those traits bridge, albeit slightly, the vast morphological gap that exists between *P. cisternarum* and other potentially related catfishes. On the other hand, troglomorphic adaptations, such the total lack of eyes and of dark pigmentation, are clearly more extreme in *P. dracunculus* than in its congener. It is possible that the new species may be useful in breaking the long branch connecting *P. cisternarum* to the rest of Siluriformes, thus increasing the accuracy of phylogenetic resolution. Such effect, however, will be expectedly limited because the two species are quite similar.

RESUMO

Uma nova espécie do gênero previamente monotípico Phreatobius é descrita de um poço artificial no Povoado de Rio Pardo, localizado 90 km ao sul da cidade de Porto Velho, Estado de Rondônia, Brasil, na área de drenagem do rio Branco (sistema do Rio Madeira, bacia Amazônica). Phreatobius dracunculus sp. n. difere da única espécie congênera, P. cisternarum, pela ausência de olhos (vs. presente), ausência de pigmentação na pele (vs. algum pigmento escuro sempre presente), presença de cinco raios na nadadeira peitoral (vs. 4), menor número de raios procorrentes ventrais 11-13 (vs. 22 a 26), e menor número de raios procorrentes dorsais 29-31 (vs. 42 a 50), menor número de vértebras (52 ou 53 vs. 59 a 64) e pseudotímpano maior. A nova espécie apresenta todos os caracteres diagnósticos propostos para Phreatobius, incluindo a conspicua coloração vermelha em vida. As localidades das duas espécies de Phreatobius estão aproximadamente a 1900 km de distância. A presença desta espécie em região tão distante da ocorrência de P. cisternarum em associação com o ambiente freático peculiar, evidenciam que o grupo pode estar amplamente distribuído na bacia amazônica.

PALAVRAS-CHAVE: bagre cego, peixe subterrâneo, Rio Madeira, habitat, taxonomia.

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REFERENCES

- BEZERRA, R.B. 1996. *Balanço hídrico em Porto Velho-RO, no período de 1954 a 1993. Através do método de Thornthwaite e Mather (1955)*. UNIR/Departamento de Geografia, Porto Velho, 83p.
- BOCKMANN, F.A. 1998. *Análise filogenética da família Heptapteridae (Teleostei, Ostariophysi, Siluriformes) e redefinição de seus gêneros*. Unpubl. PhD. Thesis, Universidade de São Paulo, São Paulo.
- BOCKMANN, F.A. & FERRARIS, C.J. 2005. Systematics of the neotropical catfish genera *Nemuroglanis* Eigenmann & Eigenmann 1889, *Imparales* Schultz 1944, and *Medemichthys* Dahl 1961 (Siluriformes, Heptapteridae). *Copeia*, 2005(1):124-137.
- BUCKUP, P.A. 1988. The genus *Heptapterus* (Teleostei, Pimelodidae) in southern Brazil and Uruguay, with the description of a new species. *Copeia*, 1988(3):641-653.
- CHARDON, M. 1968. Anatomie comparée de l'appareil de Weber et des structures connexes chez les Siluriformes. *Annales du Musée Royale de l'Afrique Centrale, Série in 8, Sciences zoologiques*, (169):1-277.
- COSTA, M.L. 1991. Aspectos geológicos dos Lateritos da Amazônia. *Revista Brasileira de Geociências*, 21(2):146-160.
- EIGENMANN, C.H. 1918. The Pygidiidae, a family of South American catfishes. *Memoirs of Carnegie Museum*, 7(5):259-373.
- FERRARIS-JR., C.J. 1988. Relationshipss of the Neotropical catfish genus *Nemuroglanis* with a description of a new species (Osteichthyes: Siluriformes: Pimelodidae). *Proceedings Biological Society of Washington*, 101(3):509-516.
- FUHRMANN, O. 1905. Zoologie: *Phreatobius cisternarum*. Compte Rendu des Travaux, quatre-vingt-huitième de la Société Helvétique des Sciences Naturelles, Lucerne. *Archives des Sciences Physiques et Naturelles*, (1905):68-69.
- FUHRMANN, O. 1906. *Scleropages formosum* und über *Phreatobius cisternarum*. *Verhandlungen der Schweizerischen Naturforschenden Gesellschaft*, 88:50-51.
- GOELDI, E. 1905. Nova Zoologica aus der Amazonas-Region: Neue Wirbeltiere. In: Congrès International de Zoologie, 6. *Compte-Rendu*. W. Kundig & Fils, Genève, p.542-549.
- MENON, A.G.K. 1950. On a remarkable blind siluroid fish of the family Clariidae from Kerala (India). *Records of the Indian Museum*, 48:59-66.
- MURIEL-CUNHA, J. & DE PINNA, M. 2005. New data on cistern catfish, *Phreatobius cisternarum*, from subterranean waters at the mouth of the Amazon river (Siluriformes, *incertae sedis*). *Papéis Avulsos de Zoologia*, 45(26):327-339.
- MYERS, G.S. 1944. Two extraordinary new blind nematognath fishes from the Rio Negro, representing a new subfamily of Pygidiidae, with a rearrangement of the genera of the family and illustrations of some previously described genera and species from Venezuela and Brazil. *Proceedings of California Academy of Science*, 23:591-602.
- MYERS, G.S. & WEITZMAN, S.H. 1966. Two remarkable new trichomycterid catfishes from the Amazon basin Brazil and Colombia. *Journal of Zoology*, 149:277-287.
- OLMOS, F.; QUEIROZ FILHO, A.P. & LISBOA, C.A. 1998. Rondônia. SEPLAN/PLANAFLORO/PNDU. BRA/94/007. As Unidades de Conservação de Rondônia. Porto Velho, 94p.
- DE PINNA, M.C.C. 1998. Phylogenetic relationships of Neotropical Siluriformes (Teleostei: Ostariophysi): Historical overview and synthesis of hypotheses. In Malabarba, L.R.; Reis, R.E.; Vari, R.P.; Lucena, Z.M.S. & Lucena, C.A.S. (eds.), *Phylogeny and classification of Neotropical fishes*. EDIPUCRS, Porto Alegre, p.279-330.
- DE PINNA, M.C.C.; FERRARIS, C.J. & VARI, R.P. 2007. A phylogenetic study of the neotropical catfish family Cetopsidae (Osteichthyes, Ostariophysi, Siluriformes), with a new classification. *Zoological Journal of the Linnean Society*, 150:755-813.
- REICHEL, M. 1927. Etude anatomique du *Phreatobius cisternarum* Goeldi, silure aveugle du Brésil. *Revue Suisse de Zoologie*, 34:285-403.
- STEWART, D.J. 1986. Revision of *Pimelodina* and description of a new genus and species from the peruvian amazon (Pisces: Pimelodidae). *Copeia*, 1986(3):653-672.
- TRAJANO, E. 2007. The challenge of estimating the age of subterranean lineages: exemples from Brazil. *Acta Carsologica*, 36(1):191-198.
- TRAJANO, E. & BOCKMANN, F.A. 2000. Ecology and behaviour of a new cave catfish of the genus *Taunayia* from northeastern Brazil (Siluriformes: Pimelodidae). *Ichthyological Exploration of Freshwaters*, 11:207-216.

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