



A new phreatic catfish of the genus *Phreatobius* Goeldi 1905 from groundwaters of the Iténez River, Bolivia (Siluriformes: Heptapteridae)

LUIS FERNANDEZ¹, LISANDRO J. SAUCEDO², FERNANDO M. CARVAJAL-VALLEJOS³ & SCOTT A. SCHAEFER¹

¹Division of Vertebrate Zoology, Department of Ichthyology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024–5192, USA. E-mail: ¹lfernandez2@amnh.org, schaefer@amnh.org

²Parque Nacional Noel Kempff Mercado, Barrio Equipetrol, Calle 9 Oeste 138, Santa Cruz, Bolivia.

³Laboratorio de Ictiología, Unidad de Limnología y Recursos Acuáticos (ULRA), Facultad de Ciencias y Tecnología (FCyT), Universidad Mayor de San Simón (UMSS), Calle Sucre frente al parque La Torre s/n, zona las Cuadras. Asociación Faunagua, final Av. Max Fernández, Zona Arocagua, Cochabamba, Bolivia. E-mail: fmcvalle@yahoo.com

Abstract

Phreatobius sanguijuela, new species, is described from an artificial well located within the Río Paraguá drainage, a tributary of the Río Iténez, Bolivia. The new species is distinguished from its sole congener, *P. cisternarum*, by the absence of eyes, presence of 25–34 (versus 42–50) dorsal procurrent caudal-fin rays, 14–16 (versus 22–26) ventral procurrent caudal-fin rays, and 45–46 (versus 54–59) vertebrae. Both *Phreatobius* species are phreatic and known only from artificial wells penetrating near-surface aquifers of the Amazon River basin. Material of the new species represents the first records of *Phreatobius* from the upper Amazon, some 2000 km from reported locations of *P. cisternarum* near the Amazon River mouth. *Phreatobius* can be readily distinguished among siluriforms by the following combination of characters: dorsal and ventral procurrent caudal-fin rays extended rostrally, continuous with anal fin ventrally; caudal fin round; anal-fin rays unbranched; mouth prognathous, with jaws displaced dorsally on head; adductor mandibulae muscle hypertrophied, covering most of skull and posteriorly inserting onto first neural spine; first pectoral-fin ray soft, not spinous; bright red in life. This species is under severe threat from overexploitation by local people, who routinely capture and destroy it on the presumption that it represents a dangerous parasite.

Key words: phreatic catfish, *Phreatobius*, groundwaters, Bolivia, new species

Introduction

The Neotropical region is remarkable for its high diversity of subterranean fishes (about 30 species; Weber *et al.* 1998; Weber 2000), comparable only to the diversity of subterranean fishes recorded for central-southern Asia (25 species). The great majority of hypogean fishes from South America are siluriforms belonging to Heptapteridae (several genera), Trichomycteridae (*Trichomycterus*, *Ituglanis*, *Silvinichthys*), Loricariidae (*Ancistrus*) (Reis *et al.* 2006). Fishes known exclusively from phreatic habitats, as revealed by their occasional capture from artificial wells penetrating near-surface aquifers are quite rare compared to the more abundant and diverse fishes that inhabit caves and associated subterranean pools (Fernandez & de Pinna 2005). In South American freshwaters, only three phreatic fishes are known: the characiform *Stygichthys typhlops* Brittan and Böhlke, 1965, and the siluriforms *Phreatobius cisternarum* Goeldi, 1905 and *Silvinichthys bortayro* Fernandez and Pinna, 2005. Basic knowledge of the biology and natural history of phreatic fishes is severely limited by serendipity of their discovery and the relative inaccessibility of the phreatic habitat (Fernandez & de Pinna 2005).

Phreatobius cisternarum described by Goeldi (1905) is known only from relatively shallow wells at several localities near the mouth of the Amazon River (Carvalho 1967; de Pinna 1998; Muriel-Cuna & de Pinna 2005; Fig. 1). de Pinna (1998) mentioned the existence of two additional quite distinctive species, as yet undescribed, from the Río Negro of Brazil. Since its original description, *Phreatobius* remains monotypic and has been aligned with five different siluriform families (de Pinna 1998): Trichomycteridae, Cetopsidae, Clariidae, Plotosidae, and Pimelodidae (Heptapteridae). In the most recent treatment of species-level diversity of neotropical fishes, *Phreatobius* was assigned to the Heptapteridae (Bockmann & Guazzelli 2003). However, Muriel-Cunha and de Pinna (2005) and Ferraris (2007) suggest that the family-level placement of this genus and its single named species is unsettled. Superficial resemblance of *Phreatobius* to the African Clariidae and the exclusively marine Plotosidae is suggested by the elongate body and slender head, as well as by the rostrally extended caudal fin, continuous ventrally with the anal fin and reminiscent of the continuous fin configurations found in members of those families. A recent comprehensive synopsis of *P. cisternarum* was provided by Muriel-Cuna and de Pinna (2005), including observations on color, behavior, and feeding of eight living specimens held in captivity.

In this study, we report the first specimens of *Phreatobius* from Bolivia, which we recognize as a new species based on several unique features, most notable among them the absence of eyes. Specimens of *Phreatobius sanguijuella* n. sp. were collected from artificial wells that provide drinking water to the local community in the vicinity of Porvenir, northern Santa Cruz Department, within the Río Paraguá drainage basin. This species is endangered by environmental degradation due to pollution, water extraction for drinking and irrigation, mineral extraction, and associated erosion. The new species extends the geographical distribution of *Phreatobius* 2000 km to the west (Fig. 1), suggesting that members of the genus are likely to be much more widespread than previously recognized.

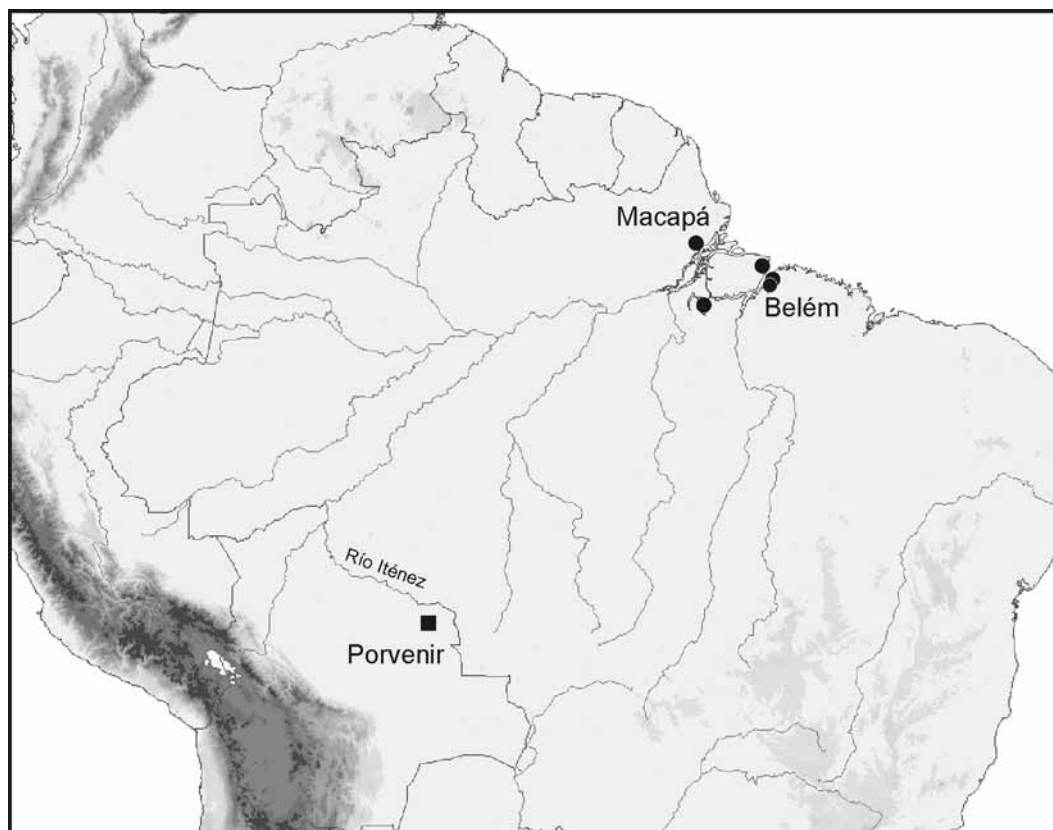


FIGURE 1. Map of northern South America showing the known collection localities for *Phreatobius cisternarum* (circles) and *P. sanguijuella* (square).

Material and methods

All measurements were point-to-point, taken with dial calipers and an ocular micrometer on the left side of specimens whenever possible, and follow Muriel-Cuna and de Pinna (2005), except that three measures related to the orbit (preorbital length, orbital diameter, interorbital width) were not measured, due to the absence of eyes in the new species. In addition, the lengths of the dorsal- and anal-fin base were measured from the anterior border of the anterior first fin-ray to the posterior border of the base of the posterior fin-ray. Vertebral counts were taken from radiographs and include those centra bearing a neural spine; the compound caudal centrum (preural 1 + ural 1) was not included.

Institutional abbreviations include UMSS for the Universidad Mayor de San Simón, Cochabamba, Bolivia; MNKP for the Museo de Historia Natural Noel Kempff Mercado, Santa Cruz, Bolivia. Other abbreviations are for head length (HL), standard length (SL), and total length (TL). Elevations are given in meters above sea level. When variable among type specimens, the value of the character state observed in the holotype is denoted by an asterisk.

Phreatobius sanguijuela new species

(Figs. 2–3)

Holotype. UMSS 1785, 42.1 mm SL, Bolivia, Departamento Santa Cruz, Río Iténez basin, Comunidad de Porvenir, artificial well, 6 m depth near Río Paraguá, 172 m elevation, 13° 59' 14.44" S, 61° 32' 27.05" W, collected by L. Saucedo, 1 June 2006. Paratypes. MNKP 5373, 2 specimens: 27.8–32.3 mm SL, same data as holotype.

Diagnosis. Assigned to *Phreatobius* among siluriform genera based on the possession of the following combination of characters: dorsal and ventral procurrent caudal-fin rays extended rostrally, dorsally reaching a vertical position on dorsal-fin base posterior to dorsal-fin insertion, ventrally continuous with anal fin (Fig. 2A); caudal fin round; all anal-fin rays unbranched; mouth prognathous, with jaws displaced dorsally on head; adductor mandibulae muscle hypertrophied, covering most of skull and inserting posteriorly onto first neural spine (Fig. 2B); first pectoral-fin ray soft, not spinous; bright red in life. Uniquely diagnosed relative to its congener by the absence of eyes (versus eyes present, minute; Fig. 3), presence of 25–34 dorsal procurrent caudal fin rays (versus 42–50); 14–16 ventral procurrent caudal fin rays (versus 22–26); 45–46 vertebrae (versus 54–59).

Description. Morphometric data for the holotype and paratypes presented in Table 1. Body round in cross section from head through dorsal-fin origin, gradually more compressed posteriorly, tapering to caudal fin. Dorsal and ventral trunk profiles nearly straight from head to base of caudal fin. Body depth nearly uniform through middle of anal-fin length, narrowing to caudal-fin base. Dorsal head profile markedly wider than trunk, due to hypertrophied jaw adductor musculature (Fig. 2B). Integument of head and body thick, underlain with thick layer of round, adipose bodies individually visible under stereomicroscope; myotomes and intermuscular septa not externally visible.

Head slightly depressed, longer than broad in dorsal view. Snout blunt in dorsal and lateral views. Mouth prognathous, lower jaw extending further anteriorly than upper jaw. Cleft of mouth straight. Lower jaw projected dorsally, its ventral surface markedly convex. Upper jaw strongly depressed, its depth one-third or less than that of lower jaw in lateral view. Mouth as wide as head, its lateral margins strongly curved posteriorly; mouth corner at vertical though anterior third of head length. Upper lips narrow, well defined laterally by fold of integument. Lower lip poorly defined, mostly continuous with ventral surface of head. Eyes absent (Fig. 2B). Branchiostegal membranes mostly free, narrowly attached to isthmus anteriorly at midline, with wide and almost free branchial openings; posterior origin of membranes located immediately dorsal to origin of pectoral fin.

TABLE 1. Morphometric data for holotype and two paratypes of *Phreatobius sanguijuela*, new species. Standard, total, and head lengths are expressed in millimeters; data 1–5 are proportions of standard length; data 6–8 are proportions of head length.

	Holotype	Paratype	Paratype
Standard length (mm)	42.1	27.8	32.3
Percentages of SL			
Total length	1.15	1.13	1.14
Body depth	0.10	0.09	0.09
Caudal length	0.30	0.26	0.27
Predorsal length	0.45	0.45	0.45
Preanal length	0.50	0.50	0.52
Prepelvic length	0.41	0.41	0.41
Dorsal-fin base length	0.10	0.09	0.09
Head length	0.17	0.16	0.16
Head length (mm)	7.3	4.4	5.2
Percentages of HL			
Head width	0.71	0.67	0.79

Maxillary barbel long and thin, reaching to slightly beyond posterior margin of pectoral-fin base. Outer mental barbel longer than maxillary barbel, reaching pectoral-fin base or posterior third of pectoral fin. Inner mental barbel shortest, when extended parallel to body reaching to point slightly posterior to margin of branchial membrane; its origin slightly anterior to that of lateral mental barbel. All barbels with fine round tips.

Anterior naris prolonged as tube of integument directed anterodorsally, about twice as long as wide, narial opening small, round, located close to upper lip. Posterior naris large, anterior margin crescentic and framed by low rim of elevated integument, located close to base of maxillary barbel but not continuous with its margin. Distance between two posterior nares slightly greater than that between anterior nares.

Cephalic sensory canals comprised of three pores dorsally on anterior snout region near nares. Anterior pair (pore I of Reichel 1927: fig. 3, 305) closely spaced relative to one another along midline, positioned mesially to base of anterior nares. Mid-posterior pair (pore II) located posteromesially to posterior nares. Posterior pair (pore III) located posterolaterally to posterior nares and aligned with maxillary barbel base. Two laterosensory pores visible in lateral view. Anterior-most (pore V) located approximately at median lateral line of body, posterior (pore VI) located slightly laterodorsally. One large pore (IV) located posterolaterally close to end of head. Anterior portion of mandibular canal with two pores (VII, VIII) located ventrally close to barbel and two posterior (IX, X) pores located laterally. Pores of epiphyseal branch absent. Infraorbital canal absent. Laterosensory canal system absent along most of body, restricted anteriorly to short tube with two pores.

Pectoral fin small, base short; four rays total, all soft, first ray unbranched; last ray markedly shorter than anterior rays. Pectoral-fin insertion approximately horizontal. Pelvic fin with four* (n=2) or five (n=1) rays, one or two branched, all projecting beyond fin membrane. Pelvic fin reaching or covering anus, not reaching anal fin. Dorsal-fin margin straight and short, with seven rays (n=3), none, one or three* branched, all soft; fin origin closer to tip of snout than to base of caudal fin, positioned slightly anteriorly to vertical through pelvic fin origin, its posterior insertion approximately at middle of SL. First dorsal-fin pterygiophore inserted posterior to neural spine of vertebra 13. Anal fin straight in profile and long, with 19 (n=2) and 20* (n=1) unbranched rays. Anal-fin origin located slightly posterior to anus and vertical through dorsal fin origin. First anal-fin pterygiophore inserted on centrum 18. Anal-fin continuous posteriorly with ventral procurrent caudal

fin rays, fins clearly demarcated by slight indentation along membranous fin margin. Caudal fin margin nearly round, continuous dorsally and ventrally with procurrent rays. Principal caudal-fin rays eight branched plus two unbranched* (n=2) or nine branched plus 2 unbranched (n=1), all soft. Dorsal procurrent caudal-fin rays 25, 31 and 34*. Ventral procurrent caudal fin rays 14, 15, 16*; almost vertically aligned, rays becoming gradually longer posteriorly. Caudal peduncle markedly expanded in area of procurrent rays, like a single extended fin. Vertebrae 45 (n=1) and 46* (n=2). Pleural ribs one or three*.

Pigmentation in alcohol: All specimens nearly whitish, without trace of red coloration characteristic of living specimens. Holotype and largest paratype with pigment concentration along midline of body, forming thin midlateral line (Fig. 2A). Tubelike extension of anterior naris white. All barbels white. Pectoral, pelvic, dorsal, anal, and caudal fins, as well as region corresponding to dorsal and ventral procurrent caudal fin rays, lack dark pigment. Coloration in life: Body bright red, slightly translucent, not whitish as in preserved specimens. Outline of vertebral column visible along post-abdominal region. Gut contents evident as dark shadows along ventral translucent region of abdomen.

Etymology. The specific name *sanguijuela* is the local name for these catfishes in this area of Bolivia, treated here as a noun in apposition to the generic name.

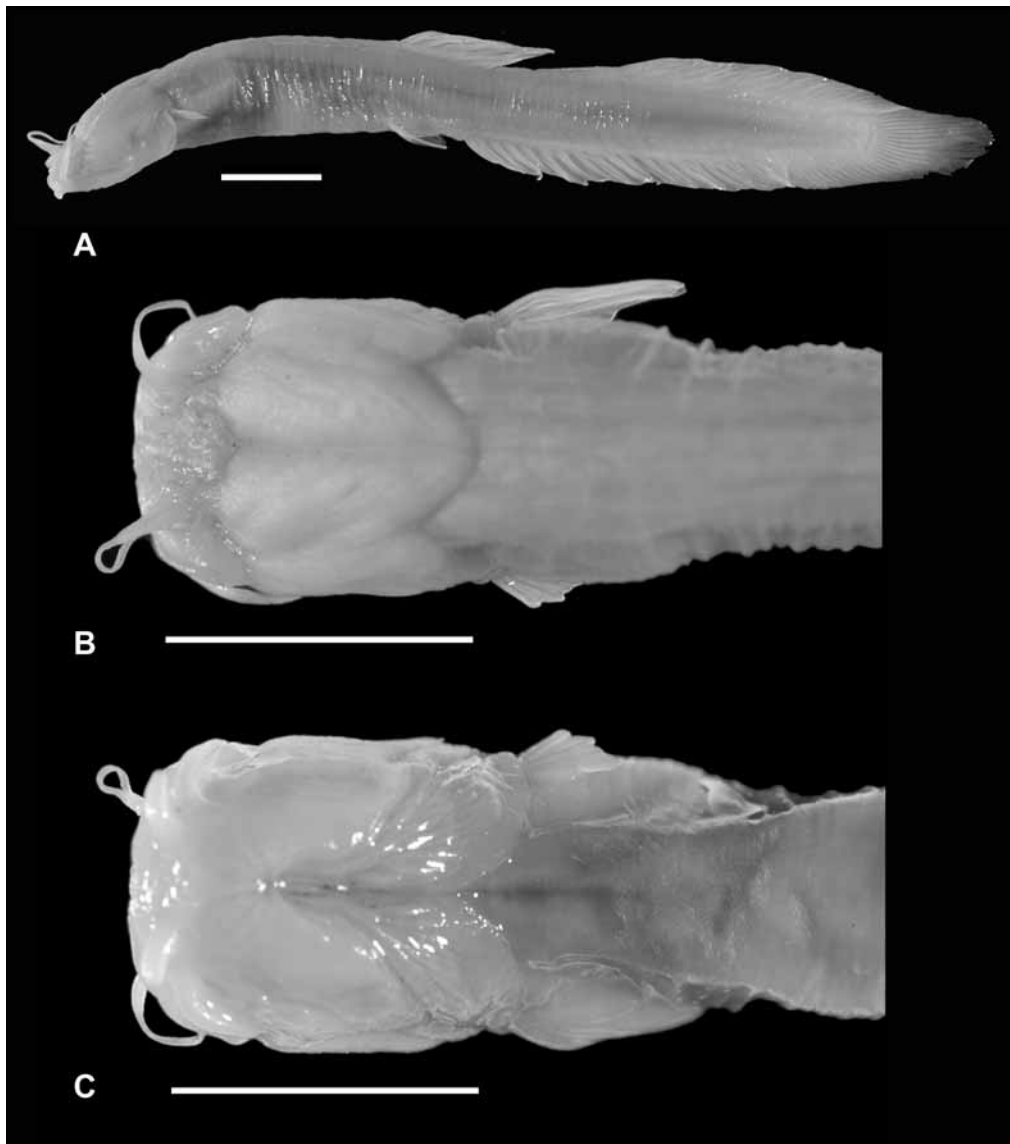


FIGURE 2. *Phreatobius sanguijuela*, new species, holotype, UMSS 1785, 42.1 mm SL. (A) lateral view; (B) dorsal view of head; (C) ventral view of head; scale bar is 5 mm.

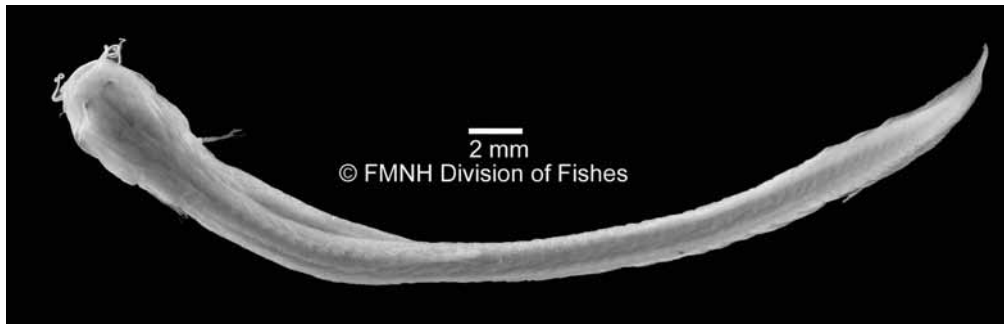


FIGURE 3. *Phreatobius cisternarum*, syntype, FMNH 58580, 32.2 mm SL, dorsal view showing presence of eyes. Photograph by Mike Littmann, image courtesy of ACSI and FMNH Division of Fishes.

Distribution. *Phreatobius sanguijuella* is known only from artificial wells of 6 m depth at Comunidad de Porvenir, near Río Paraguá (Fig. 1). The Río Paraguá forms part of the headwaters of the Río Iténez in eastern Santa Cruz Department, northeastern Bolivia.

Habitat. The artificial wells where *P. sanguijuella* were collected are separated from the Río Paraguá main channel by approximately 2 km. The wells range in depth from 6 to 12 m with a diameter of approximately one meter, with surface openings covered and sidewalls unfinished. The bottom consists of unconsolidated sand and reddish lime. The water is transparent and water depth is about 1 m. The specimens were captured using a bucket during the dry season (June) and they become much less frequent during the rainy season. Water is used locally for human consumption and the catfish are captured incidentally and killed, often mistaken for parasitic leeches (“sanguijuelas”) due to their bright, blood-red coloration.

Discussion

The sensitivity of some stygofaunal species to pollution renders them excellent biological monitors and indicators of declining water quality (Hancock *et al.* 2005). Contamination from sewage, metals, inorganic chemicals, and pesticides has reduced diversity in various stygofaunal communities. Hypogean fishes are likewise susceptible to many threats from environmental degradation, overexploitation of natural resources, and hydrological manipulation. For example, pressure from scarcity of resources and economic isolation serves to endanger the endemic phreatic catfish *Silvinichthys bortayro* in northwest Argentina (Fernandez 2005). Similarly, in this particular region of Bolivia, the soils are nutrient poor and relegate local communities to heavy reliance on cattle ranching. Mining activities represent another environmental threat. A gold mine located in the San Simon Mountains approximately 100 to 130 km from the wells producing the new species discharges contaminated water into the Río Iténez in the extraction process. Understanding the biology of phreatic fishes will aid local efforts to manage groundwater resources, support appropriate legislation for its protection and sustainable use, and spawn collaborative, multi-scale research projects in the new field of ecological hydrogeology. Increased knowledge of and appreciation for these fishes on behalf of the local people must become an important priority as well. Informal communication with the peoples of the Porvenir region indicate that the locals regard *P. sanguijuella* as a parasitic threat to human health, due to its blood-red color and vermiform shape. For these reasons, and perhaps because the fishes are mistaken for leeches, the fishes are killed upon incidental capture when extracting drinking water. Indigenous knowledge is a valuable source of information on the status and trends of individual species and incorporated into the process of resources management by local communities (Hellier *et al.* 1999). Such information would be of particular value when no alternative sources, such as detailed taxonomic surveys, are available.

Finally, discovery of a new *Phreatobius* species separated by some 2000 km distance from its sole congener suggests that phreatic fishes are most certainly much more common and widely distributed than previ-

ously thought. A combination of active survey of existing wells and use of baited traps may be required in efforts to expand our knowledge of phreatic fishes. The presumed limited vagility of *Phreatobius* is also likely untrue. Although there are no estimates of population size, and while the extent of the distribution of local populations is unknown, extreme geographic isolation of a small number of local populations is unlikely, given the persistence of populations over time.

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References

- Bockmann, F.A. & Guazznelli, G.M. (2003) Heptapteridae. In: Reis, R.E., Kullander, S.O., & Ferraris, Jr., C.J. (Eds.), *Checklist of the freshwater fishes of South and Central America*. EDIPUCRS, Porto Alegre, Rio Grande do Sul, Brazil, pp 406–431.
- Brittan, M.R. & Bohlke, J.E. (1965) A new blind characid fish from southeastern Brazil. *Notulae Naturae Philadelphia*, 380, 1–4.
- Carvalho, A.L. (1967) Novos dados para o conhecimento de “*Phreatobius cisternarum*” Goeldi (Pisces, Pygidiidae, Phreatobiinae). *Atas do simposio sobre a Biota Amazonica. Conselho Nacional de Pesquisas, Rio de Janeiro*, 3, 83–88.
- Fernández, L. (2005) Risk of extinction of a rare catfish of Andean groundwater and its priority for conservation. *Ambio*, 34, 269–270.
- Fernández, L. & de Pinna, M.C.C. (2005) A phreatic catfish of the genus *Silvinichthys* from southern South America (Teleostei, Siluriformes, Trichomycteridae). *Copeia*, 2005, 100–108.
- Ferraris Jr., C.J. (2007) Checklist of catfishes, recent and fossil (Osteichthyes: Siluriformes), and catalogue of siluriform primary types. *Zootaxa*, 1418, 1–628.
- Goeldi, E.A. (1905) Nova zoologica aus der Amazonas region. Neue Wirbeltiere. In: *Congres International de Zoologie*, 6. *Compte-Rendus W. Kundig and Fils, Geneve*, pp 542–549.
- Hancock, P.J., Boulton, A.J. & Humphreys, W.F. (2005) Aquifers and hyporheic zones: towards an ecological understanding of groundwater. *Hydrogeol*, 13, 98–111.
- Hellier, A., Newton, A.C. & Ochoa Gaona, S. (1999) Use of indigenous knowledge for rapidly assessing trends in biodiversity: a case study from Chiapas, Mexico. *Biodiversity and Conservation*, 8, 869–889.
- Muriel-Cunha, J. & de Pinna, M.C.C. (2005) New data on cistern catfish, *Phreatobius cisternarum*, from subterranean waters at the mouth of the Amazon River (Siluriformes, Incertae Sedis). *Papeis Avulsos Zoologia*, 45, 327–339.
- 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, Rio Grande do Sul, Brazil, pp. 279–330.
- Reichel, M. (1927) Etude anatomique du *Phreatobius cisternarum* Goeldi, silure aveugle de Bresil. *Reviue Suisse Zoologie*, 34, 285–403.
- Reis, R.E., Trajano, E., & Hingst-Zaher, E. (2006) Shape variation in surface and cave populations of the armoured catfishes *Ancistrus* (Siluriformes: Loricariidae) from the Sao Domingos karst area, upper Tocantins River, Brazil. *Journal of Fish Biology*, 68, 414–429.
- Weber, A. (2000) Fish and amphibia. In: Wilkens, H., Culver, D.C. & Humphreys, W.F. (Eds.), *Ecosystems of the world 30, subterranean ecosystems*. Elsevier; Amsterdam, chapter 6, pp. 109–132.
- Weber, A.G., Proudlove, S., Parzefall, J., Wilkens, H. & Nalbant, T.T. (1998) Pisces (Teleostei). In: Juberthie, C. & Decu, V. (Eds.), *Encyclopedia Biospeologica*. Societe de Biospeologie, Moulis, France, pp. 1179–1190.

Note added in proof

Subsequent to the correction of proofs for this paper, we became aware of the publication of a new Brazilian species of *Phreatobius* (Shibatta et al., 2007). The new Brazilian species is apparently not conspecific with the Bolivian species described here, based on the following differences: total vertebrae 45–46 (versus 48–49) [note: reported data for the Brazilian species is adjusted to correspond with our method for counting vertebrae]; 14–16 ventral procurrent caudal-fin rays (versus 11–13); 4 pectoral-fin rays (versus 5); first anal-fin pterygiophore on vertebra 18 (versus 16–17). Shibatta O.A., J. Muriel-Cunha & M.C.C. de Pinna 2007. A new subterranean species of *Phreatobius* Goeldi, 1905 (Siluriformes, Incertae sedis) from the southwestern Amazon basin. *Papeis Avulsos de Zoologia* 47(17), 191–201.