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Scientific Note

A cave population of *Isbrueckerichthys alipionis* (Gosline, 1947) in the Upper Ribeira karst area, southeastern Brazil (Siluriformes: Loricariidae)

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A cave population of the armored catfish *Isbrueckerichthys alipionis* is reported from the Santana Cave, in the rio Betari watershed, Upper Ribeira karst area, Iporanga, São Paulo State, southeastern Brazil. The cave population was compared to an epigean population of *I. alipionis* and no significant differences where found in morphology or degree of pigmentation. As the cave population is known for at least 30 years and is apparently isolated from epigean streams, it is classified as troglophilic. The discovery of this troglophilic species in the Santana Cave is an additional strong argument for the conservation of that cave.

Uma população cavernícola do cascudo *Isbrueckerichthys alipionis* é registrada na Caverna Santana, na bacia do rio Betari, na área cárstica do Alto Ribeira, Iporanga, São Paulo, Brasil. A população cavernícola foi comparada com uma população epígea de *I. alipionis* e nenhuma diferença significativa foi encontrada em morfologia ou grau de pigmentação. Como a população cavernícola é conhecida há pelo menos 30 anos e aparentemente está isolada de cursos d'água epígeos, ela é classificada como troglófila. A descoberta dessa espécie troglofílica na Caverna Santana é um forte argumento adicional para a conservação dessa caverna.

Key words: Cave Fish, Troglophilic, Neotropical, Conservation, Santana Cave.

The Brazilian subterranean ichthyofauna distinguishes worldwide by its diversity, with more than 20 species known to exhibit some degree of eye and pigmentation reduction (classical troglomorphisms), indicating a troglobitic condition (restriction to subterranean habitats). In addition, several putative troglophilic fish populations have also been recorded in Brazilian caves (see Bichuette & Trajano, 2003 for definitions). These species differ in their degree of troglomorphism from those with slightly, but statistically significant, reduced eyes and pigmentation, such as *Pimelodella spelaea* (Heptapteridae; Trajano *et al*., 2004), to those completely anophthalmic and depigmented.

Among these fishes, two species of troglobitic armored catfishes, family Loricariidae, have been described and studied in some detail: *Ancistrus cryptophthalmus* Reis, 1986, and *A. formoso* Sabino & Trajano, 1997. Recently, the first cave callichthyid has been found, its taxonomic study being in progress. Non-troglomorphic armored catfishes have been found in several Brazilian caves (*e.g.*, Trajano, 1991; Bichuette & Trajano, 2003; unpubl. data) representing a non-negligible component of our cave ichthyofauna.

In 1975, during the exploration of a newly discovered network of galleries inside the Santana Cave by a speleological team of the Centro Excursionista Universitário (CEU), the presence of small, pale armored catfish was noticed in a small upper tributary of difficult access. A few cavers reaching those conduits on the subsequent years confirmed the report. More than 30 years after the first notice, within the scope of a large project aiming to survey the diversity, ecology, behavior, and evolution of subterranean fish throughout the country, our research team visited that small tributary and collected some specimens fitting the description of the armored catfish formerly observed there, presently identified as *Isbrueckerichthys alipionis* (Fig. 1). The long-term permanence of this population in a subterranean vadose stream, a quite specialized habitat, makes it worthy of interest both from the scientific and conservation points of view.

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Fig. 1. Slightly depigmented specimen of *Isbrueckerichthys alipionis* from the riacho Taqueupa, inside Santana Cave in southern São Paulo, Brazil.

Herein we present a detailed description of the habitat, notes on behavior, and comparison to an epigean population.

Locality

Taqueupa Creek, a vadose tributary to the rio Betari inside the Santana Cave (cave entrance at 24°31'51"S 48°42'06"W), in the Parque Estadual Turístico do Alto Ribeira – PETAR, Upper Ribeira karst area, Iporanga, southern São Paulo State, Brazil.

Morphometry

The hypogean population of *Isbrueckerichthys alipionis* is morphometrically indistinct from the epigean population living in the rio Betari, the watershed where the Santana Cave is included. That population was studied by Pereira & Reis (2002) and the comparison with the cave population is in Table 1. The examination of the orbital diameter, snout length, and interorbital width reveals that differences in eye size are not noticeable when comparing both populations.

We used Principal Components Analysis (PCA) to investigate morphometric variation among epigean and hypogean populations of *Isbrueckerichthys alipionis*. The analyses were performed on the co-variance matrix of six (head only) and 24 (entire body, Table 1) log-transformed measurements

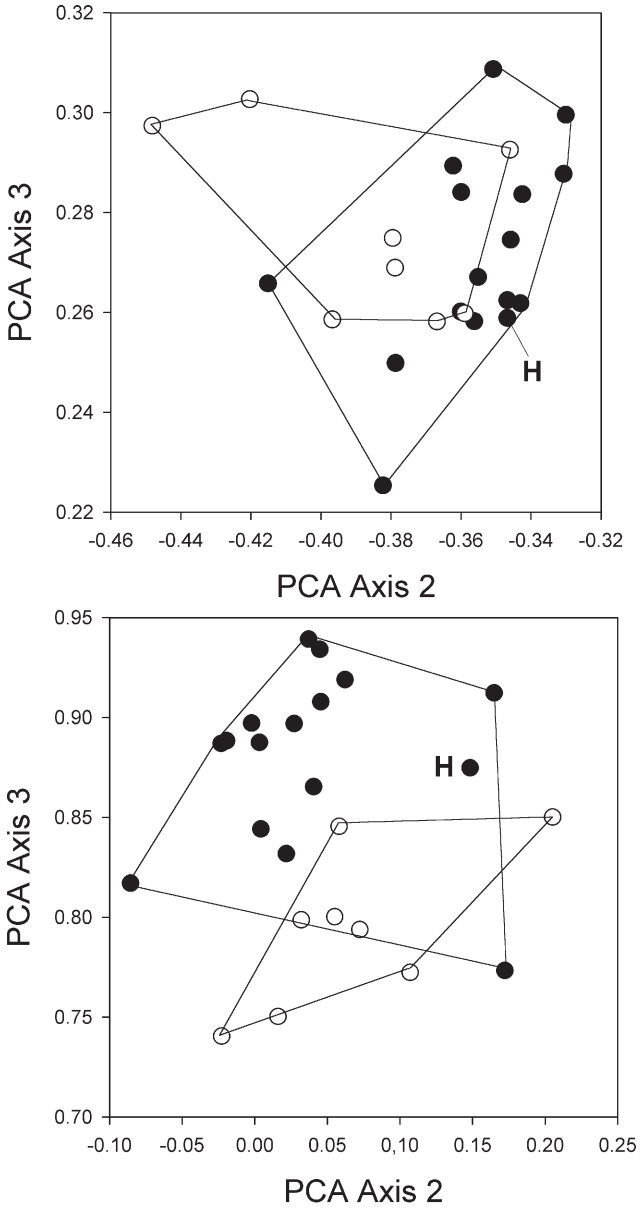

Fig. 2. Plots of factor scores of principal component analysis of *Isbrueckerichthys alipionis*. Above: head measurements only; Below: all measurements. Dot: epigean population; circle: hypogean population. H = holotype.

taken from 24 specimens representing comparable size of both populations. The resulting first principal component included a large proportion of the total variance (77.5% in the head measurements and 79% with all measurements included) and all variable loadings were positive and varied little in magnitude, suggesting that it represents a general size factor. Factor scores were plotted for the PC II and III, interpreted to represent size-free shape (Bookstein, 1989).

Plots of factor scores of principal component II *vs*. III grouped specimens into two largely overlapping clusters (Fig. 2). For the head measurements PC II and III included 10.8 and 4.9% of the total variance, respectively. Measurements

with heavier loadings on PC II are length of mandibular ramus (0.866) and interorbital width (-0.329); on PC III are snout length (-0.531) and orbital diameter (-0.593). For the 24 body measurements PC II and III included 7.9 and 5.7% of the total variance, respectively. Measurements with heavier loadings on PC II are body width at anal fin (-0.682) and body width at dorsal fin (-0.403); on PC III are width of caudal peduncle (-0.757) and orbital diameter (0.461).

Coloration

An individual variation in coloration was observed in the cave population, with some specimens conspicuously paler than others from the same habitat (but still showing the typical coloration pattern with irregular spots) and also in comparison to the epigean conspecifics. A few specimens were brought alive to the laboratory and the differences in coloration were still observed, but they died after some days. Therefore, it is not possible to say how permanent is the paler condition.

Habitat and distribution

The Santana Cave, currently with estimated 7,000+ m of passageways (E. C. Igual, pers. comm.), is one of the largest caves in the State of São Paulo. The loricariids were found in the riacho Taqueupa, a vadose stream (see Trajano, 2001, for habitat classification) crossing the distal end of the Rede Tatus ("Armadillo Net"), an upper net with dry, narrow conduits and large rooms. The riacho Taqueupa appears inside the Rede Tatus, crosses a distance of 15-20 m and disappears again. In one of the occasions when the lowest water levels were observed (April 2007), the maximum depth was around 20 cm in the small pools inhabited by the catfishes; a film of water connected these pools (A. Camargo, pers. comm.). Eight or nine specimens have been seen along 10 m of water course, varying from approximately 3 to 12 cm of total length. These fish displayed a strong avoidance behavior towards the approaching observers, and some went out of the water, moving through humid gravel towards more distant pools (A. Camargo, pers. comm.).

The Rede Tatus is accessed through climbing from the base-level stream (the lowest regional erosional level, corresponding generally to a major river that represents the upper limit of the phreatic zone), the rio Roncador, approximately 1.5 km upstream of the cave main entrance, which is the resurgence of the Roncador. The catfishes were noticed for the first time during the discovering and first exploration and mapping of the Rede Tatus, in January 1975. Due to the great beauty and fragility of the speleothems, visitation has been restricted and controlled by the PETAR authorities. Such necessary and welcome restriction, associated to the difficulties of access and progression and the paucity of biologists with sufficient interest and skills, explain why it took decades until the first specimens were collected.

Table 1. Comparative morphometric and meristic data of cave and epigean populations of *Isbrueckerichthys alipionis*. Values are given as percent of standard length or head length. Data of epigean population includes holotype and paratype.

	Cave Population N=8		Epigean Population N=16	
	Low	High	Low	High
Standard length (mm)	70.5	80.8	52.4	81.5
Percent of Standard Length				
Head length	28.2	31.6	27.6	34.2
Predorsal length	39.4	43.4	40.0	45.2
Postdorsal length	42.3	47.6	41.6	46.8
Dorsal-fin spine length	22.8	24.9	22.2	25.4
Anal-fin spine length	17.2	18.7	15.8	19.6
Pectoral-fin spine length	29.5	31.7	26.6	32.0
Pelvic-fin spine length	21.7	23.8	20.3	24.2
Upper caudal-fin ray	21.5	24.8	21.4	24.0
Lower caudal-fin ray	24.7	26.6	24.4	26.9
Trunk length	16.7	19.6	14.5	18.6
Abdominal length	24.0	26.9	24.1	27.4
Cleithral width	28.3	30.0	27.6	30.7
Body depth at dorsal-fin origin	16.7	21.1	17.5	22.1
Body width at dorsal-fin origin	17.4	24.5	18.8	24.1
Body width at anal-fin origin	11.3	15.6	10.9	18.1
Caudal peduncle length	36.9	37.6	35.6	39.2
Caudal peduncle depth	10.0	10.6	9.1	11.4
Caudal peduncle width	5.0	7.1	4.3	6.5
Percent of Head Length				
Snout length	62.3	68.4	63.1	68.1
Orbital diameter	11.3	13.3	11.0	13.9
Interorbital width	28.3	31.6	26.4	32.2
Head depth	56.4	65.6	52.4	67.5
Mandibular ramus	18.9	25.4	21.8	25.7
Meristics				
Plates in median lateral series	31	33	28	33
Premaxillary teeth	34	42	34	50
Dentary teeth	34	45	35	47
Plates at dorsal-fin base	8	10	7	11
Plates between dorsal and adipose	9	11	9	12
Plates between adipose and caudal	5	6	4	6
Plates at anal-fin base	3	4	3	4
Plates between anal and caudal	12	14	12	14

Discussion

The principal component analyses of both head and entire body measurements failed to discriminate clusters among the two populations of *Isbrueckerichthys alipionis* being investigated, indicating that morphology is highly homogeneous and suggesting no species-level separation. Despite being isolated from one another, the two populations are not morphologically distinct.

The riacho Taqueupa is located 15 m above the Santana base level. Its discharge point into the rio Roncador is not known. Likewise, no permanent epigean creeks uphill could be associated to the riacho Taqueupa. Apparently, this drainage is fed by infiltration water from several small autochthonous depressions, running through small rock fractures. The riacho Taqueupa must be permanent otherwise it would not support a differentiating fish population. There is no confirmed record of *Isbrueckerichthys* catfish in the base level rio Roncador. Therefore, the Taqueupa population seems to be currently isolated, but not long enough as for morphological differentiation.

Isbrueckerichthys alipionis has been found in the rio Betari and epigean tributaries. *Isbrueckerichthys* catfish are quite common in these streams, representing 16% of the total number of specimens belonging to 26 fish species reported

for the basin (Buck, 2000). However, none was recorded in caves, except for the population from Taqueupa, supporting the hypothesis of isolation in the latter.

The long-term permanence in the cave habitat and its topographic isolation points to the troglophilic status for the *Isbrueckerichthys alipionis* population in the riacho Taqueupa. In spite of the diversity of non-troglomorphic fishes in Brazilian caves, in few cases there is strong evidence of the occurrence of troglophilic, *i.e.*, self-sustained populations, in which each individual is able to complete its life cycle in the subterranean environment (see Bichuette & Trajano, 2003, for examples). Among loricariids, there is another case of a probable troglophilic armored catfish, which is a large population of *Hypostomus* sp. found in an upper tributary inside the São Bernardo Cave, São Domingos karst area. Dozens of these catfish, apparently well nourished and in good physical conditions, have been found in syntopy with the troglobitic heptapterid *Pimelodella spelaea* (E.Trajano, unpubl. data). Interestingly, their subterranean habitat, a vadose upper tributary, is similar to that of *Isbrueckerichthys alipionis*.

Conservation remarks. Conservation policies for karst systems in Brazil, and in most other countries as well, have used, as the sole biological criteria for protection, the presence of troglobites. Such an oversimplification is clearly an error that jeopardizes the efficacy of these policies. Subterranean ecosystems are the result of complex interactions between unique phenomena, of which the origin of troglobites is one, an extremely interesting indeed, but still one of many aspects. The presently studied *Isbrueckerichthys alipionis* catfish is a rather rare case of non-troglomorphic isolated population adapted to a specialized habitat and a candidate for differentiation leading to speciation in the subterranean environment. It would illustrate a first step in the evolution of troglobitic species, and deserves protection measures more effective than the current restriction of visitation to the Rede Tatus. So, the access to the conduit crossed by the riacho Taquepa should be prohibited, except for strictly scientific purposes, and the quality of water and other environmental variables uphill the Santana Cave should be monitored.

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Material examined: *Isbrueckerichthys alipionis*: Brazil, São Paulo State: rio Ribeira do Iguape drainage: MNRJ 4241 (holotype, 78.9 mm SL) and MNRJ 4242 (1 paratype, 76.6 mm SL), rio Betari, Iporanga. MCP 19607, 21 (5, 70.0-79.3 mm SL), rio Betari at Parque estadual Turístico do Alto Ribeira, Iporanga. MCP 28426, 16 (5, 52.4-81.5 mm SL), rio Betari at bridge of Bairro da Serra, ca 13 km WNW from Iporanga. MZUSP 58550, 33 (4, 74.9-79.7 mm SL), rio Betari, near the Parque estadual Turístico do Alto Ribeira, Iporanga. MCP 20122, 6, 38.7-80.7 mm SL, córrego Areias, ca 1 km SE from Bairro da Serra, on road from Apiaí to Iporanga, Iporanga. MCP 26952, 24, 28.9-87.2 mm SL, rio Betari, Iporanga. MCP 43197 (8, 70.5-80.8 mm SL), riacho Taqueupa, tributary to rio Betari inside Santana Cave (cave entrance at 24°31'51"S 48°42'06"W), in Parque Estadual Turístico do Alto Ribeira – PETAR, Iporanga.

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