

Redescription of *Leporinus jamesi* (Characiformes: Anostomidae), a poorly known species of *Leporinus* from the lowlands of the central Amazon, Brazil

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The poorly known *Leporinus jamesi* is redescribed. The species was originally described based on a single specimen collected in the rio Solimões at Manacapuru, in the central Amazon, Brazil. The holotype went missing before the species description was finished and published, and remained lost for more than a hundred years. *Leporinus jamesi* is distinguished from its congeners by having pectoral and pelvic fins dark, 42 to 45 scales on the lateral line, 16 scale series around the caudal peduncle, a body with two conspicuous dark midlateral blotches (the blotch on the caudal peduncle absent or inconspicuous), and four teeth on the premaxilla and dentary, including a bicuspid symphyseal tooth on the premaxilla. A principal component analysis on morphometric traits between combined samples of *L. jamesi* and *L. amazonicus* was performed showing significant morphometric differences between these species. In addition, inaccuracies in Borodin's descriptions of various species of the genus *Leporinus* are discussed.

Leporinus jamesi, uma espécie pouco conhecida, é redescrita. A espécie foi originalmente descrita com base em um único exemplar procedente do rio Solimões em Manacapuru, na Amazônia central, Brasil. O holótipo da espécie foi perdido antes de sua descrição ter sido concluída e publicada, assim permanecendo por mais de cem anos. *Leporinus jamesi* distingue-se dos congêneres por apresentar as nadadeiras peitorais e pélvicas escuras, 42 a 45 escamas na linha lateral, 16 séries de escamas ao redor do pedúnculo caudal, duas manchas escuras conspícuas na lateral do corpo (mancha do pedúnculo caudal ausente ou inconspícua) e quatro dentes no pré-maxilar e no dentário, incluindo um dente bicúspide sinfisiano. Uma análise de componentes principais de características morfológicas realizada entre amostras combinadas de *L. jamesi* e *L. amazonicus* revelou diferenças significativas entre estas espécies. Além disso, imprecisões nas descrições de diversas espécies de *Leporinus* apresentadas por Borodin são discutidas.

Key words: Anostomoidea, Freshwater fishes, Neotropical, Ostariophysi, Taxonomy.

Introduction

Despite its great diversity, relatively few species of *Leporinus* Agassiz, 1829 have been reported to occur in the lowlands of the central Amazon. Beginning in 1865, some species were described on the basis of specimens collected during the Thayer Expedition in central Amazon. Steindachner (1876) described *Leporinus agassizi*, *L. muelleri* (= *L. moralesi*), *L. nattereri*, and *L. trifasciatus*, and Borodin (1929) described *Leporinus fasciatus altipinnis*, *L. cylindriiformis* and *L. jamesi*. From the mid-twenty century to the present, only

seven species of *Leporinus* were described from the central Amazon, including: *L. brunneus* Myers, 1950; *L. klausewitzii* Géry, 1960; *L. pitingai* Santos & Jégu, 1996; *L. uatumensis* Santos & Jégu, 1996; *L. falcipinnis* Mahnert, Géry & Muller, 1997; *L. vanzoi* Britski & Garavello, 2005; and *L. amazonicus* Santos & Zuanon, 2008. *Leporinus cylindriiformis* Borodin, 1929 and *L. jamesi* Borodin, 1929 were both described based on single type specimens, which were illustrated in various positions (Borodin, 1929: plates 9 and 10). Until now, both species have been known only from their holotypes (Sidlauskas *et al.*, 2011). Assignment of additional specimens

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to *L. jamesi* has been hindered because its holotype remained missing for approximately one hundred years. It was lost sometime after the drawings were prepared and before the description was published (Borodin, 1929), and rediscovered in Harvard's Museum of Comparative Zoology less than three decades ago (Horacio Higuchi & Karsten Hartel, pers. comm.).

The aim of this paper is to redescribe *Leporinus jamesi* and diagnose it from congeners. In order to do that, we examined the holotype and additional material, especially specimens collected during the "Expedição Permanente da Amazônia", during which the Amazon river channel and several tributaries were sampled from 1965 to 1970, and specimens recently collected by researchers of the "Instituto Nacional de Pesquisas da Amazônia".

Material and Methods

Measurements and counts were obtained according to Garavello & Santos (2009), with the addition of counts of middorsal scales taken from the tip of the supraoccipital to the dorsal-fin origin; middorsal scales from the dorsal-fin terminus and the caudal-fin origin; middorsal scales between the adipose-fin terminus and the caudal-fin origin; scales along the ventral midline between the isthmus and the pelvic fin; scales between the pelvic fin and anus; scales between the anus and anal-fin origin; and scales from the anal-fin terminus to caudal-fin origin. Examined specimens belong to the following institutions: Academy of Natural Sciences of Drexel University, Philadelphia (ANSP); Natural History Museum, London (BMNH); California Academy of Sciences, San Francisco (CAS); Museum of Comparative Zoology, Cambridge (MCZ); Instituto de Ciencias Naturales, Museo de Historia Natural, Facultad de Ciencias, Universidad Nacional de Colombia, Bogotá (ICNMHN); Museo de Historia Natural "Javier Prado" de la Universidad Nacional Mayor de San Marcos, Lima (MUSM); Museu de Zoologia da Universidade de São Paulo, São Paulo (MZUSP); Instituto Nacional de Pesquisas da Amazônia, Manaus (INPA); and Laboratório de Ictiologia Sistemática do Departamento de Ecologia e Biologia Evolutiva da Universidade Federal de São Carlos, São Carlos (LISDEBE). The principal component analysis follows the procedure of Bookstein *et al.* (1985) and was performed in Statistics Analysis System software (SAS Institute Inc.).

Results

Leporinus jamesi Garman, 1929

Figs. 1-3, 4a-b

Leporinus jamesi Garman, in Borodin, 1929: 281, plate 9 [Manacapuru, Brazil]. - Fowler, 1950: 235, fig. 274 (literature compilation). - Géry, 1977: 158, 159, fig. pg. 168 (literature compilation). - Garavello & Britski, 2003: 76 (literature compilation). - Britski & Garavello, 2007: 25 (literature compilation). - Britski &

Birindelli, 2008: 49 (citation). - Sidlauskas & Vari, 2008: 74 (citation). - Birindelli & Britski, 2009: 4 (citation). - Birindelli, Britski & Lima, 2013: 7, 9 (citation).

Leporinus "amazonensis" Johannes, 1999: BSWW Report, Nr3: 15 (literature compilation based on Garavello, 1979; *nomen nudum*).

Diagnosis. *Leporinus jamesi* is distinguished from the congeners, except *L. apollo*, *L. affinis*, *L. amazonicus*, *L. brunneus*, *L. cylindriformis*, *L. desmotes*, *L. falcipinnis*, *L. fasciatus*, *L. geminis*, *L. macrocephalus*, *L. muyscorum*, *L. niceforoi*, *L. nigrotaeniatus*, *L. obtusidens*, *L. pearsoni*, *L. pitingai*, *L. trifasciatus*, *L. unitaeniatus*, and *L. yophorus*, by having 42 or more scales on the lateral line (*vs.* less than 42). *Leporinus jamesi* is distinguished from *L. desmotes*, *L. falcipinnis*, *L. fasciatus*, *L. pearsoni*, and *L. yophorus* by having dark midlateral blotches on body (*vs.* body with dark transversal bars), head without dark transversal bars (*vs.* head with a dark transversal bar between the contralateral orbits), and eight branched rays in pelvic fin (*vs.* nine). *Leporinus jamesi* is distinguished from *L. macrocephalus*, *L. muyscorum*, *L. obtusidens*, and *L. trifasciatus* by having four teeth on the premaxilla and dentary (*vs.* three on each). *Leporinus jamesi* is also distinguished from *L. brunneus*, *L. cylindriformis*, *L. geminis*, *L. niceforoi*, *L. nigrotaeniatus*, *L. pitingai*, and *L. unitaeniatus* by having medially dark marks on the pectoral and pelvic fins (*vs.* hyaline), a body with two dark midlateral blotches, the first one relatively large and conspicuous, and the second small and sometimes inconspicuous, and the absence or inconspicuous presence of a third blotch on the caudal peduncle (*vs.* three dark mid-lateral blotches in *L. cylindriformis*, *L. geminis*, *L. niceforoi*; a single midlateral stripe that is sometimes fragmented or inconspicuous in *L. brunneus*; body with a single incomplete mid-lateral stripe running from the vertical through the dorsal-fin origin to the caudal peduncle in *L. nigrotaeniatus*; approximately six transversally elongate midlateral blotches in *L. pitingai*; or a single midlateral stripe in *L. unitaeniatus*). *Leporinus jamesi* is distinguished from *L. amazonicus* by having more than one dark midlateral blotch (*vs.* a single dark midlateral blotch posterior to opercle), 42 to 45 lateral line scales (*vs.* 45 to 47); and three large transversal dark bars in front of the dorsal-fin origin in specimens of approximately 60 mm SL (*vs.* five or seven thin transversal bars).

Description. Medium-sized *Leporinus*; largest examined specimen 154.9 mm SL. Body elongate, its depth approximately 24% of SL; head length approximately 25% of SL and snout length around 37% of head length. Other morphometric traits presented in Table 1. Dorsal profile straight from snout tip to tip of supraoccipital spine and slightly arched from this point to beginning of dorsal-fin origin; juvenile specimens with a weak dorsal hump immediately anterior to dorsal-fin origin; profile

straight along dorsal-fin base and almost straight from dorsal-fin terminus to adipose fin; concave along caudal peduncle, between adipose and caudal fins. Ventral profile slight convex from lower jaw, through pectoral-fin base, to anal-fin origin; straight along anal-fin base, and concave along caudal peduncle.

Snout slender in ventral view; mouth terminal and provided with weakly fringed lips; mouth gap horizontally aligned with lower margin of orbit. Four elongate curved teeth on each premaxilla and four on each dentary (Fig. 2); symphyseal premaxillary tooth bicuspidate, remaining teeth incisor-like and with slightly-acute cutting edge; dentary teeth shorter and also with slightly-acute cutting edge; teeth

gradually decreasing in size. Branchial opening moderate in size; 21 to 27 gill-rakers on first gill arch.

Dorsal-fin rays posteriorly reaching five or six dorsal scales from dorsal-fin terminus, when adpressed. Pectoral-fin tip reaching up to five or six lateral body scales when adpressed; pelvic fin reaching fourth abdominal scale anterior to anus. Anal fin short, tip of longest rays separate from caudal-fin origin by two or three scales, when adpressed; margin of anal fin truncate or convex, when extended. Dorsal-fin rays i-ii,9 (holotype with i,9); pectoral-fin rays i,15; pelvic-fin rays i,8; anal-fin rays ii,7; caudal fin rays i,17,i. Caudal fin forked; upper lobe longer than lower.



Fig. 1. *Leporinus jamesi*: (a) holotype, MCZ 20439, 73.8 mm SL, rio Solimões at Manacapuru; (b) MZUSP 48757, 70.4 mm SL, igarapé Manduaçu at Paraná de Iupiaá; (c) MZUSP 75639, 59.4 mm SL, Paraná de Janauacá at entrance of Lago do Castanho. Scale bars = 10 mm.

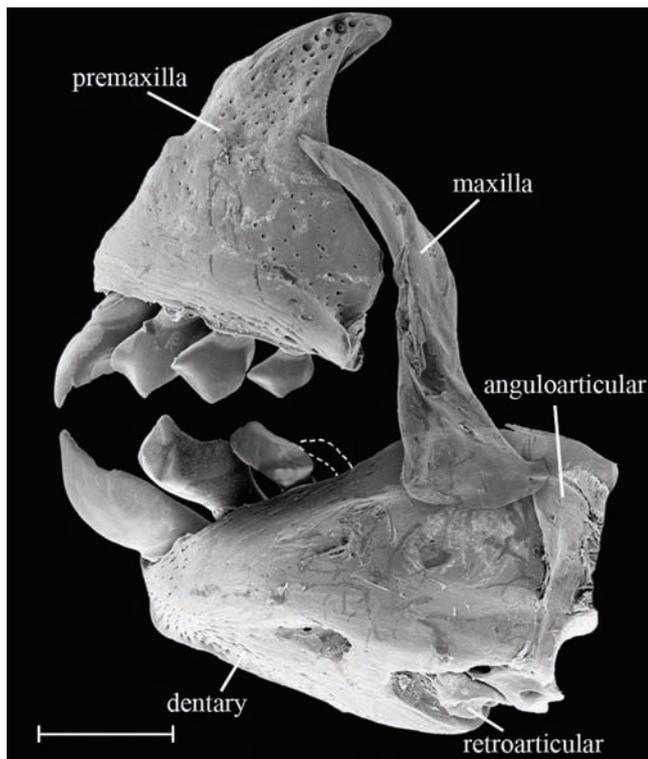


Fig. 2. SEM image of jaws of *Leporinus jamesi*, lateral view, MZUSP 75639, 89.0 mm SL. The dotted line indicates a fourth tooth that is normally present, but that was lost during preparation of the specimen. Scale bar = 1 mm.

Scales relatively small; 42 to 45 (holotype with 43) perforated scales on lateral line; five series of scales between dorsal-fin origin and lateral line; five series of scales between lateral line and pelvic-fin origin; 16 series of scales around caudal peduncle; median dorsal line of trunk with 11 scales between supraoccipital and origin of dorsal fin, 12 or 13 between dorsal and adipose fins, and 8 or 9 between adipose fin and upper caudal-fin base; median ventral line with 18 to 21 scales between isthmus and origin of pelvic fins, 9 to 11 between pelvic fins and anal opening; 2, 3, or 4 scales between anus and anal fin, and 6 to 8 between anal fin and lower caudal-fin base.

Color in alcohol. Color pattern on body and fins somewhat variable; specimens usually with two small and elongate dark-brown blotches on lateral line, first spanning two scale rows vertically and up to five scales longitudinally, and positioned ventral to middle of dorsal-fin base; second spanning one scale row vertically and up to six scales longitudinally, positioned ventral to adipose fin. An inconspicuous and smaller third blotch on caudal peduncle rarely present. In juveniles (up to 60 mm SL), small blotches sometimes appear as interrupted dark-brown stripes from vertical through dorsal-fin origin to caudal peduncle. Dorsum in juvenile specimens with 12 or 13 short transversal dark-brown bars sometimes meeting small dark-brown blotches laterally; three of these bars situated anterior to dorsal-fin origin, two ventral to middle of dorsal-fin base, five between dorsal and adipose fins, and two or three on caudal peduncle. Head dark brown on interorbital space and supraoccipital bone; snout, anterior region of eyes, and infraorbital and subopercular regions light brown; isthmus and abdomen yellowish. Fin membranes with brown chromatophores concentrated on base or covering base of pectoral, pelvic and anal fins; dorsal fin with dark blotches occasionally; adipose fin dark brown. Caudal fin with a column of scales forming a dark arrow-shaped stripe facing backwards at end of caudal peduncle; caudal-fin rays dark-brown, with hyaline interradiation membranes.

Distribution. *Leporinus jamesi* is known from the rio Amazonas, rio Solimões, rio Madeira, rio Ucayali and lower portion of their tributaries at the central Amazonian region in Brazil and Peru (Fig. 3).

Material examined. **Bolivia.** Trinidad. MZUSP 27850, 1, 83.3 mm SL, Laguna Redonda, 19 May 1983, Conv. Piscic. Orstom-Utb. **Brazil.** Acre. MZUSP 49674, 1, 91.4 mm SL, rio Acre, at Seringal Bom Destino, 9°36'S 67°32'W, Porto Acre, 19 Oct 1994, Instituto do Meio Ambiente do Acre. Amazonas. MCZ 20439, 73.8, holotype, rio Solimões, Manacapuru, 3°6'S 61°30'W, 27 Nov to 6 Dec 1865, W. James (Thayer Expedition). MZUSP 7515, 3, 82.1-89.3 mm SL,

Table 1. Morphometrics of *Leporinus jamesi* and *L. amazonicus*. SD = standard deviation, N = number of specimens.

	<i>Leporinus jamesi</i> N=13					<i>Leporinus amazonicus</i> N=12			
	Holotype (mm)	Range		Mean	SD	Range		Mean	SD
		Low	High			Low	High		
1) Standard length (mm)	73.8	50.0	135.2	86.52	22.25-	80.0	258.0	-	-
		Percents of standard length							
2) Head length	24.9	22.8	29.0	25.1	1.70	24.4	27.8	25.8	0.99
3) Trunk length	77.0	71.0	77.2	74.9	1.70	72.2	75.6	74.2	0.99
4) Body depth	26.1	23.3	28.0	24.9	1.03	21.5	27.4	25.1	1.68
5) Predorsal distance	46.1	39.7	51.4	44.4	5.62	42.2	54.4	45.1	1.65
6) Caudal peduncle depth	9.7	8.5	10.4	9.3	0.53	8.5	9.6	9.1	0.33
		Percents of head length							
7) Snout length	36.9	32.4	42.3	37.0	3.16	31.9	38.4	35.8	1.93
8) Interorbital distance	38.2	37.5	47.4	41.0	2.65	35.3	43.6	39.4	1.41
9) Orbital diameter	30.8	24.3	33.5	27.9	2.37	17.5	22.7	20.3	1.45

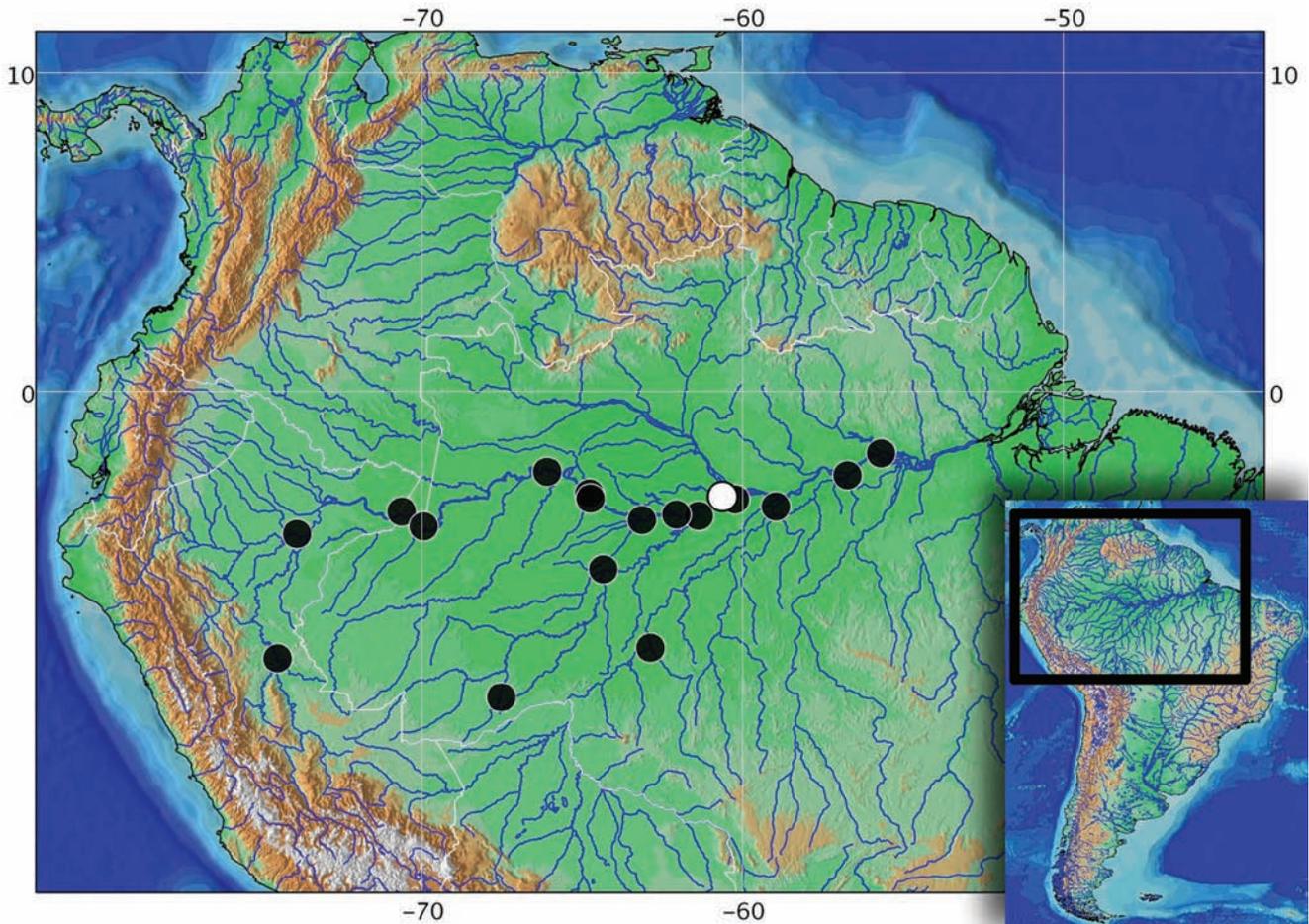


Fig. 3. Map of northern South American showing the distribution of *Leporinus jamesi*. White symbol represents the type locality.

Urucará, Paraná de Urucará, 9 Dec 1967, Expedição Permanente da Amazônia. MZUSP 6374, 16, 74.6-98.1 mm SL, rio Purus at Lago Beruri, 3°53'S 61°22'W, 8-9 Nov 1967, Expedição Permanente da Amazônia. MZUSP 6966, 2, 86.1-104.3 mm SL, rio Madeira, 25 km from Nova Olinda, 5°34'S 64°20'W, 27 Nov 1967, Expedição Permanente da Amazônia. MZUSP 7589, 1, 89.8 mm SL, Paraná do Mocambo near Parintins city, 2°36'S 56°45'W, 10 Dec 1967, Expedição Permanente da Amazônia. MZUSP uncatologued, 1, 66.2 mm SL, rio Solimões, Ilha Sorubim, upriver from Coari, 3°59'S 63°8'W, 29 Sep 1968, Expedição Permanente da Amazônia. INPA 13516, 7, 71.0-81.2 mm SL, rio Solimões, Lago Janauacá, 3°22'S 60°16'W, 14 Sep 1977, Equipe ictiologia INPA. INPA 19176, 1, 106.5 mm SL, rio Solimões at Ilha do Prego in front of Alvarás, 3°11'S 64°46'W, 24 Feb 2000, W. Crampton. INPA 13510, 4, 60.5-114.0 mm SL, rio Solimões at Lago Janauacá, 3°22'S 60°16'W, 16 Sep 1977. INPA 19317, 3, 100.3-116.5 mm SL, rio Tefé at Lago Tefé, Comunidade Nogueira, 3°20'S 64°44'W, 30 Aug 1999, W. Crampton. INPA 13512, 1, 83.0 mm SL, rio Solimões at Lago Janauacá, 3°22'S 60°16'W, 13 Nov 1977, G. M. dos Santos. LISDEBE uncatologued, 3, 77.0-88.4 mm SL, rio Solimões at Lago Janauacá, 3°22'S 60°16'W, 16 Sep 1977, G. M. dos Santos. MZUSP 9556, 1, 78.9 mm SL, Lago Supiá, in front of the city, 3°51'S 62°4'W, Codajás, 24 Sep 1968,

Expedição Permanente da Amazônia. MZUSP 48757, 1, 70.7 mm SL, igarapé Manduaçu at Paraná de Iupia, 2°31'S 66°6'W, Fonte Boa, 1968, Expedição Permanente da Amazônia. MZUSP 48814, 1, 115.4 mm SL, rio Solimões, 2°31'S 66°6'W, Fonte Boa, 25 Oct 1968, Expedição Permanente da Amazônia. MZUSP 55877, 1, 102.0 mm SL, rio Madeira, 1.9 km below Paraná do Urucuritiba, 3°33'1"S 58°54'34"W, 15 Oct 1994, J. Lundberg *et al.* MZUSP 75639, 21, 58.5-94.1 mm SL, 2 CS, 76.1-89.0 mm SL, Paraná de Janauacá at entrance of Lago do Castanho, 14 Sep 1977, P. Bayley. Pará. MZUSP 56531, 1, 146.3 mm SL, rio Amazonas, 28.6 km below Paraná de Santa Rita, 1°56'7"S 55°41'18"W, 23 Oct 1994, O. T. Oyakawa *et al.* MZUSP 58177, 1, 119.1 mm SL, rio Amazonas, 34.1 km below Paraná de Santa Rita, 1°55'7"S 55°37'20"W, 23 Oct 1994, M. Westneat *et al.* MZUSP 7825, 2, 81.7-93.6 mm SL, Faro, Paraná Jacaré, 13 Dec 1967, Expedição Permanente da Amazônia. Rondônia. MZUSP 31480, 1, 154.9 mm SL, rio Madeira at Calama, 8°3'S 62°53'W, Dec 1980, M. Goulding. **Peru.** Ucayali. MZUSP 26118, 3, 55.6-58.5 mm SL, Romainecocha, Pucallpa, Provincia Coronel Protillo, 12 Aug 1977, H. Ortega. MZUSP 26362, 1, 70.6 mm SL, rio Tamaya, at Masisea, Provincia Coronel Portillo, 23 Sep 1975, H. Ortega. MUSM 10307 1, 92 mm SL, Ucayali, C. Portillo, Pucallpa, Yarinacocha, 15 Nov 1996, H. Ortega. MUSM 0478, 1, 89.3 mm SL Ucayali, Pucallpa, Isla

Independencia, río Ucayali, 7 May 1975, H. Ortega. MUSM 0484, 1, 64.5 mm SL, Ucayali, Pucallpa, Parahuachá Cocha, río Ucayali, 18 Oct 1983, J. Canepa. Loreto. MUSM 29750, 1, 132.1 mm SL, Loreto, Trompeteros, CCA río Corrientes, río Corrientes, playa aguas abajo de Peranito (459382/9607516), 16 Dec 2006, J. Tornailla. MUSM 22381 1, 53.9 mm SL, Loreto, Parinari, río Marañon in front of Berlin, 5 Oct 2001, H. Ortega & E. Castro. Iquitos. MUSM 5212, 1, 76.3 mm SL, Maynas, Iquitos, Cocha, Aguajal, 9 Nov 1989, C. Riofrio, A. Borin & E. Borisako. **Colombia.** ICNMFH 14072, 1, 60 mm SL, Leticia, San Juan de Atacuari, Jul 1995. ICNMFH 7148 1, 95.3 mm SL, río Amazonas at Isla Fantasia, C. F. Jimenez.

Discussion

The holotype of *Leporinus jamesi* was missing by the time that Borodin prepared the description of the species (Borodin, 1929: 270) and, consequently, his description was based in part on the drawing prepared by Paulus Roetter, and in part on the notes made by Garman. However, there are certain inconsistencies between the drawings, Borodin's description and the holotype. Inaccuracies are also observed in the descriptions of other species and subspecies described in Borodin (1929). Borodin's (1929) descriptions were based on specimens collected in Brazil by the Thayer Expedition, conducted by Louis Agassiz during 1865 and 1866, and deposited in the Museum of Comparative Zoology at Harvard University (MCZ). Borodin was later invited by Thomas Barbour, director of the museum at that time, to study the collection of *Leporinus* in connection with drawings of the species and notes made by Garman found in the MCZ after the decease of the latter in 1927 (Borodin, 1929: 270). Borodin stated that Garman's notes are "fragmentary rough drafts", but he credited the authorship of *L. jamesi* "completely to Mr. Garman, because the specimen, which served for the drawing and the fairly good description, has not yet been found in the museum's collections". Myers (1950: 193), in his study of the anostomid genera, also recognized Borodin's (1929) inaccuracies, stating that "Borodin has reviewed the species in the Harvard Museum; this is an important paper, not for its author's work, which is bad, but for the excellent plates made under Louis Agassiz's and Garman's direction, and for its rather complete coverage of Brazilian Amazon forms. However, even the Agassiz plates do not sufficiently and accurately illustrate the dentition".

Borodin (1929) did not identify his illustrator, but the drawings of the species of *Leporinus* he described were made by Paulus Roetter, an artist working under Agassiz's supervision in 1867, just after the decease of Jaques Burkhardt, who was Agassiz's long time illustrator and field companion during the Thayer Expedition (Britski, pers. comm.). Roetter's drawings are accurate and depict several different positions of the fishes, including unusual frontal and ventral

views, and also details of the head, snout, mouth and teeth. They are also generally precise in terms of body shape, proportions, color pattern, and especially number, shape and arrangement of teeth. However, his drawings are sometimes imprecise with respect to the number of scales on the lateral line, and also regarding the number of transverse series and circumpeduncular series of scales, especially if compared with the actual specimens on which Borodin based his descriptions. In the case of *L. jamesi*, 45 lateral line scales are represented in the figure and mentioned in the description, whereas the specimen has actually 43 scales. Similar inconsistencies are also observed in the following species: *L. mormyrops*, 36 or 37 lateral line scales in the description, but 40 in the figure and also according to our examination (MCZ 20369, most likely the drawn specimen); *L. thayeri*, 37 lateral line scales in the description, 39 in the figure and 37 according to our observation (MCZ 20364); *L. conirostris*, 39 or 40 in the description, 42 in the figure and 39 or 40 in the syntypes (MCZ 20372); *L. fasciatus*, 41 to 44 lateral line scales in the description, 45 in the figure; *L. altipinnis*, 41 or 42 lateral line scales in the description, 43 in the figure and 42 according to our observations (MCZ 20487); *L. cylindriciformis*, 44 lateral line scales in the description, 46 in the figure and 42 according to our observations (MCZ 20430); *L. mulleri*, 35 lateral line scales in the description and 38 in the figure; *L. pachyurus*, 40 lateral line scales in the description and 34 in the figure; *L. bahiensis*, 32 to 36 lateral line scales in the description and 38 in the figure. The number of series of scales around the caudal peduncle and the transverse series in the drawings is also inaccurate in several cases, including at least *L. affinis*, *L. conirostris*, *L. crassilabris*, and *L. garmani*. In some of these cases, errors appear to be the artist's misrepresentations of the reality, whereas in others, they seem to be Borodin's mistakes. Nevertheless, some lateral-line scale counts are accurate and consistent among the description, figure and the actual specimens, especially with respect to *L. garmani* and *L. crassilabris*. The arrangement and shape of teeth in the holotype and Roetter's drawing (plate 9, fig. 4 of Borodin, 1929) are extremely similar, and conform to the observed in other examined specimens of *L. jamesi*. A diagnostic feature of *L. jamesi*, accurately illustrated in Roetter's drawings, is the bicuspid symphyseal premaxillary tooth in adult specimens, which is very uncommon among species of *Leporinus*.

The coloration of the holotype of *Leporinus jamesi* also does not agree with the pattern represented in the plate 9, fig. 1, of Borodin (1929), especially with respect to the dark blotches on the fins. However, the lack of fin markings in the holotype might be attributed to fading after more than a century of storage in alcohol. Except for the blotches on the fins and the scale counts, the drawing of *L. jamesi* in plate 9 agrees with that of the holotype (MCZ 20439) in all other aspects. Roetter's illustration of *L. jamesi* also shows conspicuous dark blotches on the dorsal

and pectoral fins (Fig. 4a). Those conspicuous dark blotches might represent an “embellishment by the artist”, perhaps based on the observation of a specimen with only inconspicuous marks on the fins (as the specimen of *L. jamesi* in Fig. 4b). However, it is also possible that the holotype may once have had those conspicuous marks, which are now completely faded (Fig. 1a), since fresh specimens of some species of *Leporinus*

have similar blotches on the dorsal and pectoral fins (Fig. 4c). In either case, the dark blotches on the dorsal and pectoral fins probably represent intraspecific variation.

As a result of inconsistencies between the descriptions, the drawings, and the reality, it is sometimes difficult to identify specimens based exclusively on Borodin (1929). This might also help to explain why specimens of *Leporinus jamesi* were

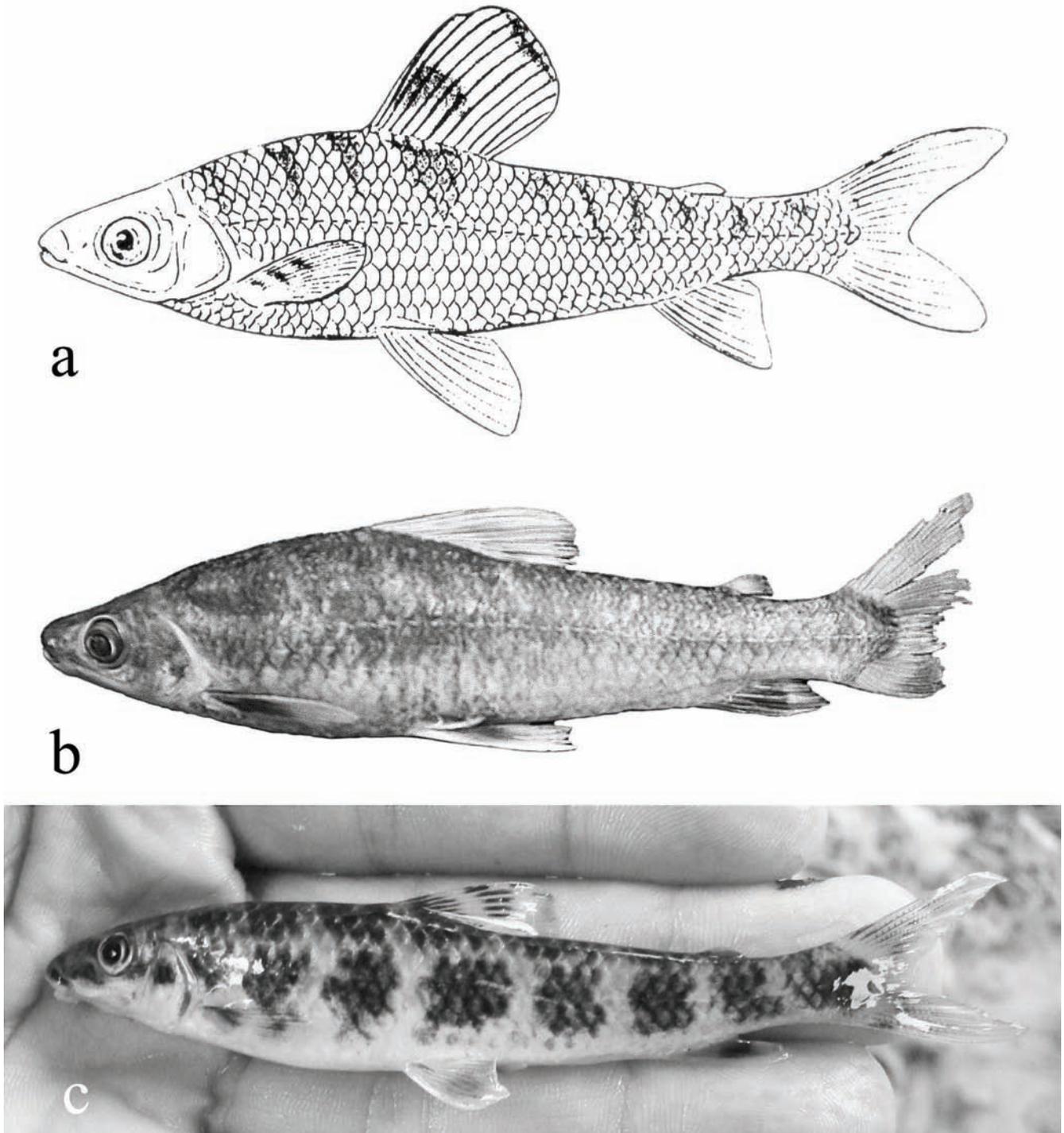


Fig. 4. (a) Roetter’s drawing of *Leporinus jamesi* based on holotype MCZ 20439, 73.8 mm SL, rio Solimões at Manacapuru, and published in Borodin (1929: plate 9); (b) *Leporinus jamesi*, MUSM 29750, 132.1 mm SL, Peru; (c) *Leporinus octomaculatus*, upper rio Paraguay basin, photographed live by Claudio Zawadzki.



Fig. 5. *Leporinus amazonicus*, MZUSP 77507, 43.0 mm SL, rio Solimões at entrance of Lago Anauacá. Scale bar = 10 mm.

ascribed to new species when Garavello (1979) started to study the species of *Leporinus*. Johannes (1999), for instance, followed Garavello (1979)'s unpublished Ph.D. Dissertation in regards to the concept of *Leporinus* “*amazonensis*”. However, during Garavello’s (1979) study, the holotype of *L. jamesi* was still missing, and as a consequence, the species was recognized as valid based only on its original description (Borodin, 1929). Garavello (1979) also recognized some specimens of *Leporinus* from the central Amazon as belonging to an undescribed species, and provisionally named it “*Leporinus amazonensis*”. Nevertheless, this name represents a *nomem nudum* since it was used only in an unpublished study by Garavello, and also because Johannes (1999) did not present a formal description of the species (see article 16 of the ICZN).

Leporinus jamesi is similar in terms of external morphology and co-occurs with *L. amazonicus* in the central Amazon. The differences between *L. jamesi* and *L. amazonicus* are more obvious when comparing young individuals of both species (Figs. 1c and 5). *Leporinus jamesi* is distinguished from *L. amazonicus* by having a body relatively deeper, with the dorsal profile straight from snout tip to the dorsal-fin origin (*vs.* body relatively slender, with dorsal profile convex from snout tip to dorsal-fin origin), three dark transverse bars on dorsum between the supraoccipital and dorsal-fin origin in specimens of approximately 60 mm SL (*vs.* five to seven dark transverse bars on dorsum between supraoccipital and dorsal-fin origin in specimens of approximately 60 mm SL), and the absence of a dark spot on the second, third and fourth scales posterior to the gill opening and immediately ventral to the lateral line scale series (*vs.* present). In addition, *L. jamesi* is most likely a small-sized species (largest known specimen slightly less than 160 mm SL), whereas *L. amazonicus* reaches up to 250 mm SL (Santos & Zuanon, 2008).

Nine morphometric characters of *Leporinus jamesi* and *L. amazonicus* were compared, in a total of 25 specimens from the central Amazonian region. Differences in morphology between *L. jamesi* and *L. amazonicus* were also revealed through a principal component analysis of morphometric

traits (Bookstein *et al.*, 1985) and the morphometric study of the genus *Leporinus* conducted by Garavello *et al.* (1991) (Table 2; Fig. 6). The first principal component (PC1) accounts for 93.55% of total among group variation while the second principal component (PC2) accounts for the remaining 6.45%. The ordination of the two species along principal components in Fig. 6 indicates that they are indeed distinct.

The logarithm transformed values of the morphometric traits: interorbital distance (0.41365); body depth (0.38592); caudal peduncle depth (0.35085) and head length (0.34007), are the fastest growing allometric vectors indexing size-related shape (Table 2; Fig. 6). Differences between *Leporinus jamesi* and *L. amazonicus* on the principal component 1 (PC1) are due to different average sizes of the samples, with *L. amazonicus* having a larger average size than *L. jamesi*. However, interorbital distance (-0.46615), trunk length (0.43702) and orbital diameter (0.43447) were confirmed as differential morphometric characters along the principal component 2 (PC2) that discriminate the two species (Fig. 6). Summing up, based on the morphometric analysis, *L. jamesi* differ from *L. amazonicus* by the proportionally larger orbital diameter and shorter interorbital distance, in addition to the slightly different body and caudal peduncle depth, and head length.

Table 2. Principal component analysis of *Leporinus jamesi* (n=13) and *L. amazonicus* (n=12). Variable loadings for principal components 1 and 2.

Variable	Principal Component 1	Principal Component 2
Percent variance	0.935500	0.064500
Standard length	0.303362	0.325080
Head length	0.340073	-0.020605
Trunk length	0.291481	0.437029
Body depth	0.385927	-0.249588
Predorsal distance	0.336017	-0.056577
Snout length	0.304458	0.339743
Interorbital distance	0.413658	-0.466150
Orbital diameter	0.242096	0.434470
Caudal peduncle depth	0.350851	-0.340475

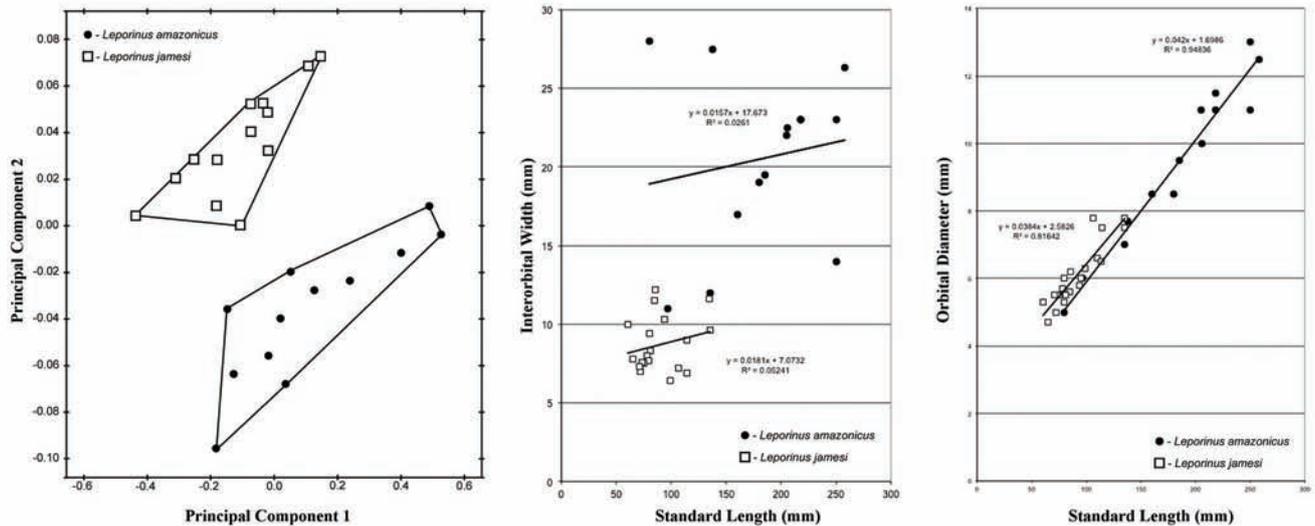


Fig. 6. Scatter plots of individual scores on first two main axes from the principal component analysis of combined samples of *Leporinus jamesi* (white squares) and *L. amazonicus* (black circles) on left; linear regression of the interorbital width (mm) vs. standard length (mm) on center; and linear regression of the orbital diameter (mm) vs. standard length (mm) on right.

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Comparative material examined. *Leporinus amazonicus*.

Brazil. Amazonas. INPA 22861, holotype, 218.0 mm SL; INPA 22125, paratype, 1, 186.2 mm SL; INPA 22863, paratype, 1, 97.0 mm SL; INPA 22864, paratype, 1, 135.0 mm SL; INPA 24734, paratype, 1, 250.0 mm SL; INPA 26059, paratype, 1, 207.5 mm SL; INPA 26060, paratype, 1, 175.0 mm SL; INPA 26061, paratype, 1, 156.0 mm SL; INPA 26062, paratype, 1, 138.0 mm SL; INPA 26063, paratype, 1, 245.0 mm SL; MZUSP 77507, 1, 43.0 mm SL; MZUSP 95170, paratype, 1, 205.0 mm SL. *Leporinus brunneus*. **Brazil.** Amazonas. CAS 156347, 1, 70.5 mm SL; SU 16125, holotype, 154.4 mm SL. Mato Grosso. MZUSP 99485, 2, 99.5-111.0 mm SL. **Venezuela.** Amazonas. CAS 20137, paratype, 1, 88.6 mm SL; CAS 20138, paratype, 1, 132.6 mm SL; CAS 116293, paratypes, 2, 167.3-107.4

mm SL; LISDEBE 2261, 3, unmeasured. *Leporinus cylindriformis*. **Brazil.** Pará. MCZ 20430, holotype, 1, 198.6 mm SL.

Literature Cited

- Birindelli, J. L. O. & H. A. Britski. 2009. New species of the genus *Leporinus* Agassiz (Characiformes: Anostomidae) from the rio Curuá, rio Xingu basin, Serra do Cachimbo, Brazil, with comments on *Leporinus reticulatus*. *Neotropical Ichthyology*, 7: 1-10.
- Birindelli, J. L. O., H. A. Britski & F. C. T. Lima. 2013. New species of *Leporinus* from the Rio Tapajós Basin, Brazil, and redescription of *L. moralesi* (Characiformes, Anostomidae). *Copeia*, 2013: 242-251.
- Bookstein, F., B. Chernoff, R. Elder, J. Humphries, J. G. Smith & R. Strauss. 1985. *Morphometrics in Evolutionary Biology*. The Academy of Natural Sciences of Philadelphia, Special Publication 15.
- Borodin, N. A. 1929. Notes on some species and subspecies of the genus *Leporinus* Spix. *Memoirs of the Museum of Comparative Zoology*, 50: 269-290.
- Borodin, N. A. 1931. On the genus *Anostomus* (Family Characinidae). *Bulletin of the Museum of Comparative Zoology*, 72: 37-52.
- Britski, H. A. & J. L. O. Birindelli. 2008. Description of a new species of the genus *Leporinus* Spix (Characiformes: Anostomidae) from the rio Araguaia, Brazil, with comments on the taxonomy and distribution of *L. parae* and *L. lacustris*. *Neotropical Ichthyology*, 6: 45-51.
- Britski, H. A. & J. C. Garavello. 2007. Família Anostomidae. Pp. 23-28. In: Buckup, P. A., N. A. Menezes & M. S. A. Ghazzi (Eds.). *Catálogo das espécies de peixes de água doce do Brasil. Série Livros 23*, Museu Nacional, Rio de Janeiro.
- Fowler, H. W. 1950. Os peixes de água doce do Brasil. I. *Arquivos de Zoologia do Estado de São Paulo*, 6: 1-625.
- Garavello, J. C. 1979. Revisão taxonômica do gênero *Leporinus*

- Spix, 1829 (Ostariophysi, Anostomidae). Unpublished Ph.D. Dissertation, Universidade de São Paulo, São Paulo, 451p.
- Garavello, J. C. & H. A. Britski. 2003. Family Anostomidae. Pp. 71-84. In: R. E. Reis, S. O. Kullander & C. J. Ferraris, Jr. (Eds.). Check List of the Freshwater Fishes of South and Central America. Edipucrs, Porto Alegre.
- Garavello, J. C., S. F. dos Reis & R. E. Strauss. 1991. Discrimination and body form variation in three species of *Leporinus* Spix from Rio Meta, Colombia (Ostariophysi: Anostomidae). *Zoologischer Anzeiger*, 227: 93-97.
- Garavello, J. C. & G. M. Santos. 2009. Two new species of *Leporinus* Agassiz, 1829 from Araguaia-Tocantins system, Amazon basin, Brazil (Ostariophysi, Anostomidae). *Brazilian Journal of Biology*, 69: 109-116.
- Garman, S. 1890. On the species of the genus *Anostomus*. *Bulletin of the Essex Institute*, 22: 15-23.
- Géry, J. 1977. *Characoids of the World*. T. F. H. Publications, New Jersey.
- Johannes, T. 1999. Vorstellung der Revision der Gattung *Leporinus* und die Lösung eines Artproblems mit Hilfe dieser Arbeit. *BSSW Report*, 1999: 14-21.
- Kner, R. 1859. Zur Familie der Characinen. III. Folge der Ichthyologischen Beiträge. *Denkschriften der Kaiserlichen Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Classe*, 17: 137-182.
- Myers, G. S. 1950. Studies on South American fresh-water fishes. II. The genera of anostomine characids. *Stanford Ichthyological Bulletin*, 3: 184-198.
- Santos, G. M. & M. Jégu. 1996. Inventário taxonômico dos anostomídeos (Pisces, Anostomidae) da bacia do rio Uatumã, AM, Brasil, com descrição de duas espécies novas. *Acta Amazônica*, 26: 151-184.
- Santos, G. M. & J. Zuanon. 2008. *Leporinus amazonicus*, a new anostomid species from the Amazon lowlands, Brazil (Osteichthyes: Characiformes). *Zootaxa*, 1815: 35-42.
- Sidlauskas, B. L., J. H. Mol & R. P. Vari. 2011. Dealing with allometry in linear and geometric morphometrics: a taxonomic case study in the *Leporinus cylindricus* group (Characiformes: Anostomidae) with description of a new species from Surinam. *Zoological Journal of the Linnean Society*, 162: 103-130.
- Sidlauskas, B. L. & R. P. Vari. 2008. Phylogenetic relationships within the South American fish family Anostomidae (Teleostei, Ostariophysi, Characiformes). *Zoological Journal of the Linnean Society*, 154: 70-210.
- Steindachner, F. 1876. *Ichthyologische Beiträge (V)*. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe*, 74: 49-240.

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