

A new *Moenkhausia* (Characiformes: Characidae) from central Brazil, with comments on the area relationship between the upper rio Tapajós and upper rio Paraguai systems

Flávio C. T. Lima¹, Heraldo A. Britski¹ and Francisco A. Machado^{1,2}

- 1) Museu de Zoologia da Universidade de São Paulo, Caixa Postal 42494, 04299-970, São Paulo, SP, Brazil. E-mail: fctlima@usp.br; heraldo@usp.br
- 2) Departamento de Botânica e Ecologia, Universidade Federal do Mato Grosso, 78060-900, Cuiabá, Mato Grosso, Brazil. E-mail: salminus@terra.com.br

Received: 16 May 2007 – Accepted: 12 September 2007

Abstract

A new species of *Moenkhausia* is described from the rio Juba, tributary of the rio Sepotuba (upper rio Paraguai basin), the rio Juruena and its tributary, the rio Papagaio (upper rio Tapajós basin), Mato Grosso state, Brazil. The new species' most remarkable feature is a unique colour pattern in live specimens, which combines eyes that are bright blue on the lower half and bright green (with a bright golden tinge) on the upper half, red pigmentation on the upper lip and a transparent opercle which allows a view of the pinkish red gill filaments. The new species is apparently related to the group containing *Moenkhausia oligolepis* and *M. sanctaefilomenae*, which is also hypothesized to include *M. pyrophthalma*, *M. diktyota* and *M. cotinho*. The occurrence of *Moenkhausia cosmops* in both the headwaters of the upper rio Juruena (rio Tapajós basin) and upper rio Paraguai is congruent with other fish taxa and is indicative that a river capture has recently taken place in the area.

Resumo

Uma nova espécie de *Moenkhausia* é descrita do rio Juba, um afluente do rio Sepotuba (bacia do alto rio Paraguai), do rio Juruena e de seu tributário, o rio Papagaio (bacia do alto rio Tapajós), estado do Mato Grosso, Brasil. A nova espécie apresenta como característica mais destacada o colorido único quando em vida: íris de colorido azul intenso na metade inferior, passando a dourado e esverdeado na metade superior, lábio vermelho-vivo e opérculo em grande parte avermelhado, devido à transparência do osso, permitindo ver os filamentos branquiais. A nova espécie é aparentemente relacionada ao grupo de *Moenkhausia oligolepis* e *M. sanctaefilomenae*, que é hipotetizado como também incluindo *M. pyrophthalma*, *M. diktyota* e *M. cotinho*. A ocorrência desta espécie nas cabeceiras do sistema do alto rio Juruena e alto rio Paraguai é congruente com a de outros táxons de peixes e indica que uma captura de rio relativamente recente deve ter acontecido nesta região.

Zusammenfassung

Beschrieben wird eine neue Art der Salmlegattung *Moenkhausia* vom Rio Juba, einem Nebenfluss des Rio Sepotuba (oberes Paraguai-Becken), vom Rio Juruena und von seinem Nebenfluss, dem Rio Papagaio (oberes Tapajós-Becken), im Staat Mato Grosso in Brasilien. Hauptmerkmal der neuen Art ist ihre unverkennbare Färbung bei den lebenden Exemplaren: v.a. sind die Augen in der unteren Hälfte leuchtend blau, in der oberen Hälfte leuchtend grün (mit einem leuchtend goldenen Schimmer), die Oberlippe rot und der Kiemendeckel durchsichtig, sodass man rosarot die Kiemen hindurchschimmern sieht. Die neue Art gehört offensichtlich zu der Gruppe um *Moenkhausia oligolepis* und *M. sanctaefilomenae*, der nach gegenwärtiger Vorstellung auch *M. pyrophthalma*, *M. diktyota* und *M. cotinho* zuzurechnen sind. Das Vorkommen von *Moenkhausia cosmops* in beiden Oberläufen: im oberen Rio Juruena (Tapajós-Becken) und im oberen Rio Paraguai – entsprechende Beobachtungen liegen für andere Fischgruppen vor – dürften ein Hinweis darauf sein, dass es in neuerer Zeit Verbindungen zwischen beiden Systemen gegeben haben muss.

Résumé

Une nouvelle espèce de *Moenkhausia* est décrite, originaire du rio Juba, tributaire du rio Sepotuba (bassin du haut rio Paraguai), le rio Juruena et son tributaire, le rio Papagaio (bassin du haut rio Tapajós), état du Mato Grosso, Brésil. La caractéristique la plus remarquable de la nouvelle espèce est son patron de coloration, unique pour les spécimens vivants, qui combine des yeux bleu clair sur la moitié inférieure et vert clair (avec une nuance or clair) sur la moitié supérieure et un opercule transparent qui permet de voir les lamelles rose rouge des branchies. La nouvelle espèce est apparemment proche du groupe qui comprend *Moenkhausia oligolepis* et *M. sanctaefilomenae* dont on suppose qu'il inclut aussi *M. pyrophthalma*, *M. diktyota* et *M. cotinho*. La présence du *Moenkhausia cosmops* dans les cours principaux du haut rio Juruena (bassin du rio Tapajós) et du haut rio Paraguai correspond à d'autres taxons de

poissons et indique qu'une confluence de rivières a eu lieu récemment dans la région.

Sommario

Una nuova specie di *Moenkhausia* è descritta dal rio Juba, affluente del rio Sepotuba (bacino superiore del rio Paraguai), dal rio Juruena e i suoi affluenti e dal rio Papagaio (bacino superiore del rio Tapajós), stato del Mato Grosso, Brasile. La caratteristica principale di questa nuova specie è la singolare colorazione degli individui vivi, che combina occhi blu brillante nella metà inferiore e verde brillante (con una vivace sfumatura dorata) in quella superiore, pigmentazione rossa del labbro superiore e opercolo trasparente che consente di avere una visione dei rossi filamenti branchiali. La nuova specie è apparentemente imparentata al gruppo di specie che comprende *Moenkhausia oligolepis* e *M. sanctaefilomenae*, a cui si ipotizza debbano far parte anche *M. pyrophthalma*, *M. diktyota* e *M. cotinho*. La presenza *Moenkhausia cosmops* in entrambe le sorgenti del rio Juruena superiore (bacino del rio Tapajós) e del rio Paraguai superiore è congruente con altri taxa e suggerisce che nell'area è recentemente avvenuto un processo di cattura da parte di uno dei due corsi d'acqua.

INTRODUCTION

The genus *Moenkhausia* Eigenmann, 1908 is one of the most speciose characid genera, currently comprising 64 species that are recognized as valid (Lima et al. 2003, Benine et al. 2004, Géry & Zarske 2004, Zarske et al. 2004, Bertaco & Lucinda 2006, Lima & Birindelli 2006, Lucinda et al. 2007). As most of the genera previously included within the subfamily Tetragonopterinae (cf., e.g., Géry 1977) and now considered as *incertae sedis* within Characidae (Lima et al. 2003), *Moenkhausia* is defined by a combination of characters, none of them unique, which consequently raises serious doubts as to its purported monophyletic nature.

Géry (1977) was the first to recognize sub-groups within the genus *Moenkhausia*, even though he himself admitted that these groups were actually more convenient tools for species identification than hypothesis of putative monophyletic clades (see also Géry & Zarske 2004: 35). In spite of the fact that we still lack an explicit hypothesis of phylogenetic relationships within *Moenkhausia*, the existence of monophyletic groups within the genus has been postulated, for example, the *Moenkhausia lepidura* species-group delimited by Géry (1992; in spite of the reticent attitude of the author himself concerning the monophyly of the group) and a group including *M. oligolepis* (Günther, 1864), *M. sanctaefilomenae* (Steindachner, 1907), *M. pyroph-*

thalma Costa, 1994, *M. diktyota* Lima & Toledo-Piza, 2001 and probably also *M. cotinho* Eigenmann, 1908 (Costa 1994; Lima & Toledo-Piza 2001). Based on characters from the suspensorium bone apparatus, Benine (2002) also discussed putative monophyletic assemblages within the genus.

In contrast to the extensive lowlands of the rio Paraguai basin, the Pantanal, the headwaters of the rio Paraguai basin are poorly known ichthyologically (see Willink et al. 2000). However, collecting expeditions in the last few years in both the northern and eastern headwaters of the rio Paraguai basin have improved our ichthyological knowledge of the area considerably (e.g., Lima & Britto 2001, Benine et al. 2004, Lima et al. 2004, Shibatta & Pavanelli 2005). During an expedition across the northern headwaters of the rio Paraguai basin in Mato Grosso state, central Brazil, on which the three authors took part, a new *Moenkhausia* species, clearly related to the *M. oligolepis* species-group, was found. The species was immediately recognized as new by its unique colour pattern in live specimens, that combines red pigmentation on the upper lip, eye with the upper half bright green and lower half bright blue, and for the transparency of the opercle, which allows a view of the pinkish-red colour of the gill filaments. No photographs could be taken of living specimens at that time and only a few specimens were collected, so the description of the new species was postponed. Somewhat unexpectedly, during a recent collecting expedition to the rio Papagaio (a tributary of the rio Juruena, rio Tapajós basin) two of the authors (FCTL and FAM) succeeded in collecting more specimens of the new species, allowing its description, which is herein presented.

MATERIALS AND METHODS

Counts and measurements were taken according to Fink & Weitzman (1974) and Menezes & Weitzman (1990), except for counts of the horizontal scale rows below the lateral line, which are counted to the pelvic-fin insertion. Horizontal scale rows between the dorsal-fin origin and lateral line does not include the scale of median predorsal series situated just anterior to the first dorsal-fin ray. Horizontal scales occur in rows between the lateral line and the pelvic-fin insertion. A lateral scale that extends ventrally to the pelvic insertion, present in some specimens, was counted as a half scale. In the descriptions, the frequency of each count is given in parentheses after the respective

count. An asterisk indicates counts of the holotype. Counts of supraneurals, procurrent caudal-fin rays, branchiostegal rays, gill rakers and unbranched anal-fin rays were taken mostly from cleared and stained paratypes (CS), prepared according to Taylor & Van Dyke (1985). Counts of vertebrae, and in some cases supraneurals and unbranched anal-fin rays, were also taken from radiographed specimens. Vertebrae of the Weberian apparatus were counted as four elements and the fused PU1+U1 of the caudal region as a single element. In the list of material examined, the number of whole specimens is given first, followed by the number of those cleared and stained (if any). Institutional abbreviations used are as follows: MZUSP, Museu de Zoologia da Universidade de São Paulo, São Paulo; MCP, Museu de Ciências da Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre; MNRJ, Museu Nacional, Rio de Janeiro and ANSP, Academy of Natural Science of Philadelphia, Philadelphia.

***Moenkhausia cosmops* n. sp.**

(Figs 1-2)

Holotype: MZUSP 93494, 42.9 mm SL, Brazil, Mato Grosso, Sapezal, córrego Vinte e Cinco de Maio, near its mouth at the Rio Papagaio, 13°35'47" S 58°25'27"W; F. A. Machado, F. C. T. Lima, C. M. C. Leite & N. E. Silva, 11-13 October 2006.

Paratypes: all from Brazil, Mato Grosso. Rio Tapajós basin: MZUSP 93495, 17, 22.3-48.3, 3 CS,

35.2-37.0 mm SL; MCP 41348, 1, 32.5 mm SL; MNRJ 30777, 1, 40.6 mm SL; ANSP 187100, 1, 34.4 mm SL, same data as the holotype.

Rio Paraguai basin: MZUSP 78722, 2, 39.9-48.2 mm SL, Barra dos Bugres, Rio Jubinha, at the confluence with the rio São Tomé (tributary of the rio Sepotuba); G. Borges, F. A. Machado & F. C. T. Lima, 7 March 2002. MZUSP 91122, 3, 21.4-23.3 mm SL, Barra dos Bugres, rio Juba (tributary of rio Sepotuba), PCH Juba Zero, waterfall, 14°43'08"S 58°8'59"W; H. A. Britski, O. Froehlich & F. Marques, 8 March 2002. MZUSP 93496, 3, 30.5-34.1 mm SL, Tangará da Serra, Rio Juba (tributary of rio Sepotuba); G. Borges, March 1994.

Additional material examined (not types): All from rio Tapajós basin. MZUSP 93552, 2, 17.2-25.4 mm SL, Campos de Júlio, Rio Juruena, headwater below BR 364 old bridge, 14°39'43"S 59°6'42"W. MZUSP 93553, 11, 19.3-31.8 mm SL, Campos de Júlio, Rio Juruena, fazenda Tiroleza, 14°16'38"S 59°5'22"W. MZUSP 93554, 4, 20.4-38.8 mm SL, same data. MZUSP 93555, 1, 22.7 mm SL, Sapezal, Rio Juruena, above Santa Lúcia hydroelectric dam, 13°35'45"S 59°1'58"W. MZUSP 93556, 6, 21.2-30.9 mm SL, 3 CS, 26.3-27.3 mm SL, Sapezal, Rio Juruena, below Sapezal hydroelectric dam, 13°14'47"S 59°0'52"W. MZUSP 93557, 2, 23.3-31.8 mm SL, Sapezal Rio Juruena, above Santa Lúcia hydroelectric dam, 13°37'56"S 59°0'36"W. MZUSP 93558, 3, 23.0-30.9 mm SL, Sapezal, Rio Juruena, above Santa Lúcia hydroelectric dam, 13°39'18"S 59°1'12"W. MCP 41344, 3, 13.9-25.3 mm SL, Sapezal, Córrego do Bacaval, 13°37'19"S 58°17'01" W.



Fig. 1. *Moenkhausia cosmops*, holotype, MZUSP 93494, 42.9 mm SL, immediately before preservation. Photo by L. M. Sousa.

Table I. Morphometric data of *Moenkhausia cosmops*, expressed as percentages of standard length (2-12) and head length (13-6). Data from the holotype (MZUSP 93494) and 20 paratypes (MZUSP 93495, MZUSP 78722, MZUSP 91122, and MZUSP 93496).

Characters	Holotype	Paratypes (N = 20)			
		Range		Mean	Standard deviation
		Low	High		
1) Standard length (mm)	42.9	21.4	48.3	—	—
2) Head length	28.0	29.0	32.7	30.9	0.01
3) Depth at dorsal-fin origin	35.4	30.5	37.4	34.1	0.02
4) Caudal peduncle depth	13.1	11.9	13.9	12.9	0.01
5) Caudal peduncle length	11.9	10.8	13.9	12.5	0.01
6) Snout to dorsal-fin origin	55.9	51.9	58.4	55.5	0.02
7) Snout to pelvic-fin origin	51.0	48.8	53.7	51.6	0.01
8) Snout to anal-fin origin	68.3	65.4	72.9	69.5	0.02
9) Dorsal fin height	31.0	26.7	32.7	29.4	0.02
10) Pectoral-fin length	22.4	19.1	25.5	22.4	0.02
11) Pelvic-fin length	17.5	12.8	20.2	18.1	0.02
12) Anal-fin base length	23.8	20.5	25.2	23.1	0.01
13) Eye diameter	35.8	33.9	40.2	36.9	0.02
14) Snout length	30.0	22.7	31.1	26.7	0.02
15) Interorbital width	38.3	30.7	40.7	34.3	0.03
16) Upper jaw length	50.0	42.3	52.5	47.4	0.02

Diagnosis: The new species can be easily distinguished from all its congeners (and, in fact, from all remaining Characidae) by three unique colour features in live specimens: eye with lower half bright blue and upper half bright green (with a bright golden tinge), upper lip red and most of the opercle transparent, allowing a view of the pinkish-red colour of the gill filaments. Additionally, *Moenkhausia cosmops* can be distinguished from all congeners, except *M. sanctaefilomenae*, *M. oligolepis*, *M. diktyota*, *M. pyrophthalma* and *M. levidorsa*, by the presence of a reticulated colour pattern resulting from the concentration of dark chromatophores on the free margin of the scales. It can be distinguished from *M. diktyota* and *M. levidorsa* Benine, 2002 by the presence of a dark, broad blotch on caudal peduncle and caudal-fin basis. *Moenkhausia cosmops* can be distinguished from *M. pyrophthalma*, *M. oligolepis* and *M. sanctaefilomenae* by lacking a clear area on the caudal peduncle preceding the broad dark peduncular blotch (vs. clear area present). See additional notes on the diagnosis of the new species in the discussion below.

Description: Morphometric data of the holotype and paratypes are presented in Table I. Body compressed, moderately elongate; greatest body depth slightly anterior to dorsal fin origin; dorsal profile of head convex from upper lip to vertical through

anterior nostril; straight to slightly concave from latter point to tip of supraoccipital spine. Predorsal profile of body slightly convex, posteroventrally inclined along dorsal-fin base; body profile straight from dorsal-fin base terminus to adipose fin, slightly concave between latter point to origin of anteriormost procurrent caudal-fin ray; ventral profile of head and body convex from lower lip to anal-fin origin; body profile along anal-fin base straight and posterodorsally inclined; ventral profile of caudal peduncle slightly concave.

Jaws equal, mouth terminal; posterior terminus of maxilla reaching vertical through anterior third of orbit; premaxillary teeth in two rows (Fig. 3); outer row with 3 (3), 4* (22) or 5 (2), relatively compressed, tricuspidated teeth; inner row with 5 (26) bulky tri- to pentacuspitated teeth; maxilla with 2* (7), 3 (11) or 4 (9) tri- to unicuspidated teeth; anteriormost tooth largest; dentary with 10 (2), 11* (5), 12 (7), 13 (6), 14 (2) or 15 (3) teeth; anteriormost four teeth larger, bulky, tri- to pentacuspitated, posterior ones uni- to tricuspid.

Scales cycloid, circuli absent on exposed area of scales, with few (3-8) divergent radii extending to posterior margin of scales, more numerous on posteriormost body scales; scales from four uppermost longitudinal scale rows considerably larger than scales from three lowermost scale rows, including

lateral line scale row; some scales on lateral series appearing narrower than remaining (see, e.g., Fig. 1, eleventh and thirteenth scales on second horizontal series above lateral line), apparently resulting from variable degree of exposition of the scales and not from differences in size, giving overall irregular pattern of scale arrangement along body. Lateral line slightly decurved ventrally, incompletely pored, with 9 (3), 10 (2), 11 (3), 12* (4), 13 (4), 14 (3) or 15 (1) perforated scales; lateral series scales including perforated scales 23 (5), 24* (7), 25 (3) or 26 (3); horizontal scale rows between dorsal-fin origin and lateral line 4* (21); horizontal scale rows between lateral line and pelvic-fin insertion 2 (9), 2,5 (3) or 3 (8); scales along mid-dorsal line between distal tip of supraoccipital process and origin of dorsal fin 8 (3) or 9* (17); horizontal scale rows around caudal peduncle 10 (5), 11 (4) or 12* (12); single row of 7 (3), 9 (2), 10 (4), 11* (5), 12 (3) or 13 (3) scales covering base of anteriormost anal-fin rays. Caudal fin scaled, small scales present on upper and lower caudal lobes basal third, scales sheath on lower lobe slightly more developed than upper one.

Dorsal-fin rays II,9; distal margin of dorsal fin straight; dorsal-fin origin slightly ahead to middle of standard length; base of posteriormost dorsal-fin ray slightly ahead from vertical through anal-fin origin; first dorsal-fin pterygiophore inserting posterior to neural spine of eighth (1), ninth* (17) or tenth (1) vertebra. Adipose fin present. Anal-fin

rays V* (7), 15 (10), 16* (7), 17 (3) or 18 (1); distal anal-fin margin straight, rays decreasing caudad gradually in size; anteriormost anal-fin pterygiophore inserting behind haemal spine of fourteenth (1), fifteenth* (16) or sixteenth (1) vertebra. Pectoral-fin rays I, 10 (1), 11 (3), 12 (12), 13 (4) or 14* (1); tip of pectoral fin reaching vertical through pelvic-fin insertion; pelvic-fin rays I,7. Caudal fin forked, lobes slightly rounded, similar in size; principal caudal-fin rays 10+9 (6); 9 (3) or 10 (2) dorsal procurrent caudal-fin rays and 8 (5) ventral procurrent caudal-fin rays. First gill arch with 0 (2) or 1 (2) hypobranchial, 7 (4) or 8 (1) ceratobranchial, 1 (4) on cartilage between ceratobranchial and epibranchial, and 5 (2) or 6 (3) epibranchial gill-rakers. Vertebrae 28 (2), 29 (11) or 30* (8); supraneurals 4 (3) or 5 (2). Branchiostegal rays 4 (5); three branchiostegal rays originating from anterior ceratohyal and one from posterior ceratohyal.

Colour in alcohol: Ground colour tan, slightly darker dorsally; snout and top of head densely covered by small dark chromatophores, resulting in overall dark pigmentation; opercle and infraorbitals with minute, relatively numerous dark chromatophores.

Scales on body except ventral region anterior to anal fin, mid-dorsal area, and dorsal and ventral portions of caudal peduncle bordered by dark pigment and forming a conspicuous reticulated pattern; scales from third and fourth longitudinal



Fig. 2. *Moenkhausia cosmops*, specimen in aquarium, about 2 months after capture. Photo by L. M. Sousa.

scale series often with free scale margin with dense concentration of dark chromatophores, forming irregular series of vertically-elongated blotches over the reticulated pattern. Humeral spot large, well-developed, vertically-elongated, inverted-drop shaped, extending vertically two scale rows above and one scale row below lateral line and horizontally two scale rows, being wider above lateral line. An oblique, blurred dark stripe formed by relatively scattered dark chromatophores, one scale row above, parallel to and extending from anal-fin origin to caudal peduncle. Caudal peduncle blotch conspicuous, variably developed, from a roughly rounded blotch covering caudal peduncle central area and caudal-fin basis to a rectangular blotch covering whole caudal peduncle distal area and caudal-fin basis. All fins with scattered, dark chromatophores, more numerous on dorsal, caudal, anal and adipose-fins.

Colour in life: The following description is based on the examination of several freshly caught

specimens, many of which were kept in captivity. Ground colour beige, darker dorsally; reticulated pattern conspicuous only as two longitudinal, decurved, darkened stripe, two scale rows high, at the level of the lateral line, and a similar stripe at the dorsal area; intervening lateral areas clearer, with reticulated pattern much less evident. Upper lip red; opercle mostly translucent, exposing pinkish-red colour of gills; eye lower half bright blue, upper half bright green, with a bright golden tinge. Dorsal-fin basis brownish; caudal-fin basis yellowish.

Sexual dimorphism: None detected. No bony hooks on fins were found.

Geographical variation: Specimens from the upper rio Paraguai basin possess a slightly higher number of scales between the lateral line and the pelvic fin insertion (3, in all 8 specimens counted) when compared with specimens from the upper rio Tapajós basin (2 or 2.5, in 12 specimens counted). No other meristic, morphometric or colour pattern differences were noticed between specimens from both basins.

Geographical distribution: *Moenkhausia cosmops* is known from tributaries of the upper rio Sepotuba in the rio Paraguai basin and from tributaries of the rio Juruena in the rio Tapajós basin, Mato Grosso state, central Brazil (Fig. 4).

Ecological notes: The type locality, córrego Vinte e Cinco de Maio, is a clearwater, moderately fast flowing, large stream (4-5 m wide, 0.5-2 m deep), with a predominantly sandy bottom. Although clearwater, it had a moderate amount of suspended matter, at least at the time of collecting of the type material, in contrast with the river into which it empties, the crystal-clear rio Papagaio. With the exception of a single specimen collected at the main channel of the stream, all specimens of *Moenkhausia cosmops* were collected at backwaters, near marginal macrophytes. No *Moenkhausia cosmops* were found in the rio Papagaio itself. Specimens MZUSP 78722 were collected in the rio Jubinha, a clear, slightly dark-stained water, moderately large river (c. 8 m wide, 1 m to c. 5 m deep), with a sandy bottom. A large school (> 50 individuals) was seen during snorkelling at the river bank, sheltered among dead, submerged saplings. Only two specimens were collected at this site, at a small marginal sandbank, at dusk. Gut contents of three specimens (MZUSP 93556, 26.3-27.3 mm SL) contained insects (mainly ants), vegetal matter and algae.

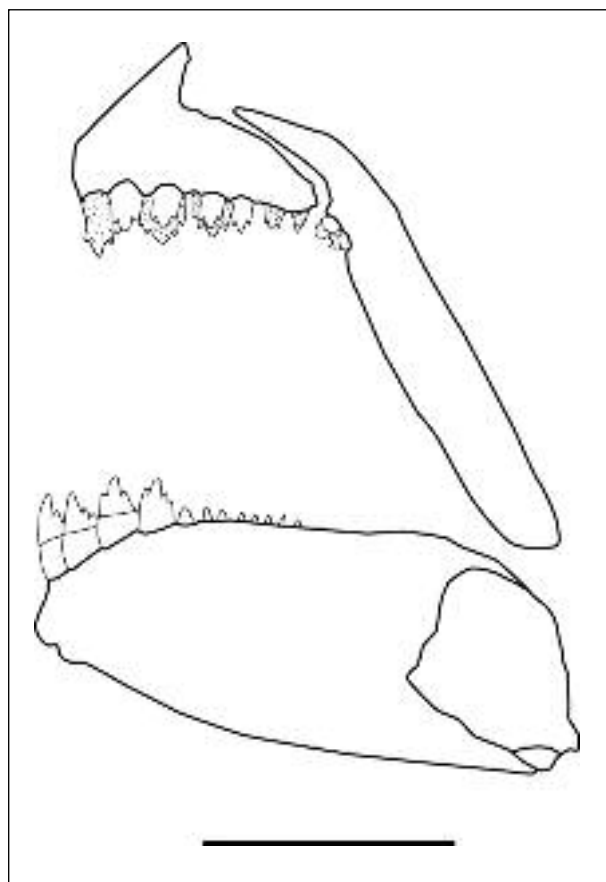


Fig. 3. *Moenkhausia cosmops*, paratype, MZUSP 93495, 36.9 mm SL. Upper and lower jaws, lateral view, left side. Scale bar 1 mm.

Etymology: *Cosmops*, from the Greek *kosmos*, ornament, decoration, and *opos*, *ops*, face, countenance, alluding to the head colour of the new species.

Discussion: Costa (1994) and Lima & Toledo-Piza (2001) discussed a putative monophyletic group within *Moenkhausia*, which included *M. oligolepis*, *M. sanctaefilomenae*, *M. pyrophthalma*, *M. diktyota* and *M. cotinho* (thereafter called “*Moenkhausia oligolepis*/*M. sanctaefilomenae* complex”). This group was defined by four characters of colour pattern: a reticulated ground colour pattern, resulting from the concentration of dark chromatophores along the free margin of the scales, a large dark blotch at the caudal peduncle and caudal-fin basis, a clear area at the caudal peduncle, preceding the peduncular caudal blotch, and red pigmentation on the dorsal portion of the eye. These putative synapomorphies are not, however, present in all species assigned to the group.

Moenkhausia cotinho does not possess a reticulated colour pattern, presenting, instead, longitudinal series of blotches along the dorsal and lateral surfaces of the body, and it is uncertain to us whether or not it possess the red pigmentation on the dorsal portion of the eye. *Moenkhausia diktyota* possesses neither the large dark peduncular blotch nor the clear area preceding the blotch. *Moenkhausia cosmops* probably belongs to this putative monophyletic group, as it possess two of their presumed synapomorphies, i.e., the reticulated colour pattern and the large, dark peduncular blotch. The red pigmentation on the dorsal portion of the eye is actually variable within *Moenkhausia oligolepis*. We have examined living specimens from the rio Culuene (rio Xingu basin) and rio Aripuanã (rio Madeira basin) that lacked the red pigmentation on the dorsal portion of the eye, although most specimens from those areas do possess it. On the

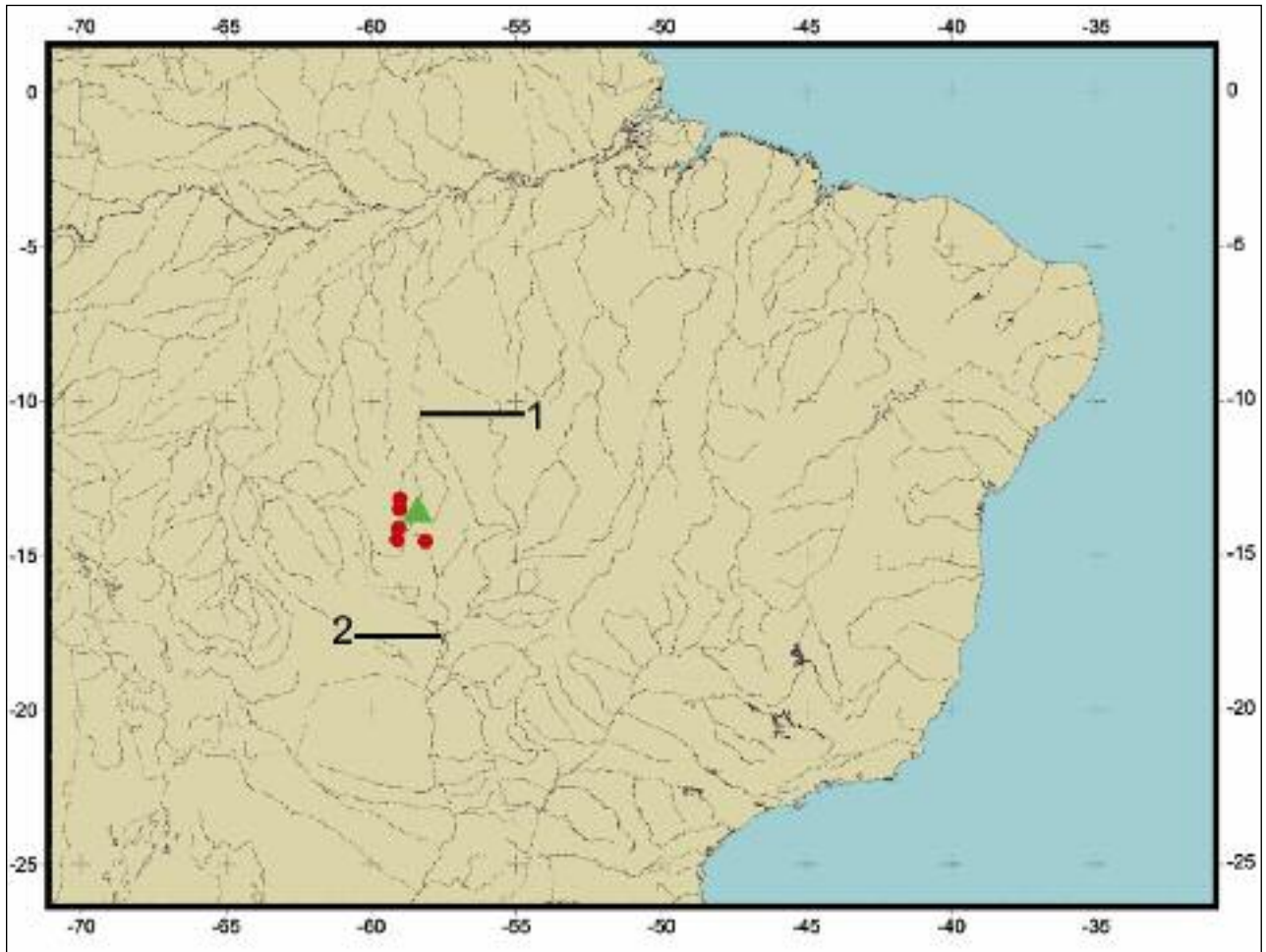


Fig. 4. Map of central and eastern South America showing the distribution of *Moenkhausia cosmops*. A triangle indicates the type-locality. 1 – Rio Juruena; 2 – Rio Paraguai.

other hand, *Moenkhausia oligolepis* specimens from the rio Papagaio drainage, including specimens collected at the type locality of *Moenkhausia cosmops*, consistently lack the red pigmentation on the dorsal portion of the eye. In these specimens, the dorsal portion of the eye was yellowish, while the lower portion was bluish, though not the bright blue present in *Moenkhausia cosmops*. While we have tentatively assigned these specimens to *Moenkhausia oligolepis*, only a thorough analysis of the *Moenkhausia oligolepis*/*M. sanctaefilomenae* complex would provide definitive data.

Another putative synapomorphy pointing out a close relationship between *Moenkhausia cosmops* and the *Moenkhausia oligolepis*/*M. sanctaefilomenae* complex is the shape of the ectopterygoid and palatine bones. Benine (2002, fig. 4a) noticed that a broad ectopterygoid and palatine bones is a putative synapomorphy for a group within *Moenkhausia* including *Moenkhausia sanctaefilomenae*, *M. oligolepis*, *M. cotinho*, *M. levidorsa* and *M. grandisquamis* (Müller & Troschel, 1845). The ectopterygoid and palatine bones of *Moenkhausia cosmops* are similar to the ones found in these species and it is apparently additional evidence for a close relationship between the new species and the *Moenkhausia oligolepis*/*M. sanctaefilomenae* complex.

Contrary to most of its congeners, and similar to *M. diktyota* and *M. pyrophthalma*, *Moenkhausia cosmops* possess an incomplete lateral line. As discussed by Costa (1994) and Lima & Toledo-Piza (2001), it is more reasonable to consider this

reduction of the laterosensorial canal system as homoplastic with the same feature observed in the species of *Hemigrammus* Gill, 1858. However, it is quite possible that some species currently assigned to the latter genus are actually more closely related to the monophyletic group herein recognized. An incomplete lateral line is also documented in some populations of *Moenkhausia sanctaefilomenae* (Eigenmann 1917: 84), *M. oligolepis* (Eigenmann 1917: 80) and *M. cotinho* (Eigenmann 1918: 111).

Specimens of *Moenkhausia cosmops* fixed in formalin rapidly lose the bright green and blue eye colouration, as well as the pinkish-red colour of the gill filaments seen through the opercle. The red pigmentation present in the upper lip remains in specimens preserved in formalin, but rapidly disappears when the specimens are transferred to ethanol, probably due to the dissolution of the carotenoid pigments. Preserved *Moenkhausia cosmops* specimens are very similar to specimens of *M. oligolepis* and *M. sanctaefilomenae*, being diagnosed mainly by the absence of the clear area preceding the dark peduncular blotch, by the presence of a blurred, oblique stripe at the caudal peduncle, an incomplete lateral line (cf., however, the previous paragraph) and lower transverse scale counts (2-3 vs. 3-4, respectively). The discovery of *Moenkhausia cosmops* highlights the importance of proper documentation of the living colour pattern in Characidae (which is, as noticed above, not equivalent to documenting colour pattern in specimens preserved in formalin, even if freshly pre-



Type locality of *Moenkhausia cosmops*: Córrego Vinte e Cinco de Maio, Sapezal, Mato Grosso, Brazil. Photo by F. C. T. Lima.

served). Without such documentation, specimens of *Moenkhausia cosmops* would probably be identified as individuals of *M. oligolepis* or *M. sanctaefilomenae* with interrupted lateral lines.

The upper portion of the rio Tapajós basin (i.e., the portion of the drainage above the confluence of the rio Juruena and the rio Teles Pires) has been systematically sampled for fish only in the last few years. These recent surveys revealed a highly endemic ichthyofauna (see Carvalho & Bertaco 2006 for a partial list of fish species presumably endemic from the area). However, little has been said about the biogeographical relationships between the upper rio Tapajós and neighbouring river drainage basins. The presence of *Batrochoglanis melanurus* Shibatta & Pavanelli, 2005 (Pseudopimelodidae) in the upper rio Paraguai basin was suggested to be indicative of capture of a headwater previously draining the upper rio Tapajós into the upper rio Paraguai basin, since its nearest congeners occur in the Amazon basin (Shibatta & Pavanelli 2005). Hubert & Renno (2006: 1425, fig. 8) inferred that a “dispersal route” has taken place between the upper rio Tapajós and the upper rio Paraguai basins, which, according to them, was suggested by the presence of shared fish species between those areas. However, it is uncertain how those authors have reached that conclusion, given the fact that none of the references listed by them as sources for the distributional data on fish used in their Parsimony Analysis of Endemicity (PAE) mention any fish species exclusively shared between both areas. Except for Shibatta & Pavanelli (2005) and the unsubstantiated claims by Hubert & Renno (2006), there is no other published evidence indicating an area relationship between both river basins. The occurrence of *Moenkhausia cosmops* in both upper rio Tapajós and upper rio Paraguai basins appears to be the first documented case of a fish species exclusively shared between both basins. Actually, extensive recent collections in the upper rio Paraguai revealed that several fish species previously only known from the upper rio Tapajós area also occur at the upper rio Paraguai. These are: *Leporinus octomaculatus* Britski & Garavello, 1993 (Anostomidae), *Moenkhausia phaeonota* Fink, 1979 and *Hyphessobrycon vilmae* Géry, 1966 (Characidae), *Aequidens rondoni* (Miranda-Ribeiro, 1918) (Cichlidae), an undescribed species of *Pyrrhulina* (Lebiasinidae; A. Ferreira-Netto, pers. comm.) and an unidentified, apparently undescribed, species of *Crenicichla*

(Cichlidae). cursory comparisons between specimens from both river basins of all these species failed to reveal any differences. There is, however, a similar case to *Batrochoglanis melanurus*, where a species occurring at the upper rio Paraguai appears to possess its sister-taxa at the rio Tapajós basin: an undescribed species of *Utiaritichthys* Miranda-Ribeiro, 1937 (Characidae), which is apparently closely related to *U. sennaebregai* Miranda-Ribeiro, 1937, from the upper rio Tapajós basin. The extensive divide between the upper rio Paraguai and upper rio Tapajós basins lies at the highlands of the Serra dos Parecis, a relatively flat plateau at the western border of the Brazilian shield. Events of river capture in an apparently recent past probably explain the occurrence of a shared fish fauna in both headwaters. This putative recent ichthyofaunal interchange illustrates once more the complexity of the evolution of the current distribution patterns of the South American freshwater fish fauna.

Comparative material examined: *Moenkhausia cotinho*: MZUSP 59963, 43; MZUSP 55125, 43; rio Negro basin. MZUSP 21885, 31; rio Tapajós basin. *Moenkhausia diktyota*: MZUSP 85036, 39; rio Negro basin. *Moenkhausia oligolepis*: MZUSP 4915, 9; MZUSP 18199, 1; rio Tocantins basin. MZUSP 91708, 4; MZUSP 30311, 19; rio Xingu basin. MZUSP 93512, 84; MZUSP 93521, 229; rio Tapajós basin. MZUSP 81305, 4; MZUSP 81527, 4; rio Negro basin. MZUSP 17400, 8; rio Solimões basin. MZUSP 38264, 21; Nickerie River basin. *Moenkhausia pyrophthalma*: MZUSP 92292, 2; MZUSP 91294, 1; rio Tocantins basin. *Moenkhausia sanctaefilomenae*: MZUSP 90464, 38; MZUSP 91116, 4; rio Paraguai basin. MZUSP 17246, 1; MZUSP 17257, 3; rio Paraná basin; MZUSP 80131, 1; MZUSP 58272, 1; MZUSP 16870, 1; rio São Francisco basin.

ACKNOWLEDGEMENTS

For help in the field, or for donating specimens used in this study, we would like to thank O. Froehlich, G. Borges, J. Nakagaki, F. Marques, C. M. C. Leite, N. E. Silva and K. de Silimon. We are grateful to the former Conservation International staff R. Lourival, E. Guimarães, J. R. Montambault and M. Harris for logistical support during the AquaRAP Sepotuba expedition in 2002, when the new species was discovered. Specimens were collected under collecting permits IBAMA-Diren 045/99 and Difap/Ibama 104/2006. Leandro M. Souza took the pictures of the living specimens

and, with José L. Birindelli, cared for the specimens kept alive in an aquarium at the laboratory. Eduardo G. Baena radiographed the specimens and prepared figures 3 and 4. Zilda M. S. Lucena and V. Bertaco loaned specimens under their care. Ricardo Benine provided useful suggestions on the manuscript. Financial support was provided by Instituto Socioambiental (FCTL) and CNPq (HAB).

REFERENCES

- BENINE, R. 2002. *Moenkhausia levidorsa*, a new species from Rio Aripuanã, Amazon basin, Brazil (Characiformes: Characidae). *Ichthyological Exploration of Freshwaters* 13 (4): 289-294.
- BENINE, R. C., CASTRO, R. M. C. & SABINO, J. 2004. *Moenkhausia bonita*: a new small characin fish from the Rio Paraguay basin, Southwestern Brazil (Characiformes: Characidae). *Copeia* 2004 (1): 68-73.
- BERTACO, V. & LUCINDA, P. H. 2006. *Moenkhausia pankiloperyx*, new species from rio Tocantins drainage, Brazil (Ostariophysi: Characiformes, Characidae). *Zootaxa* 1120: 57-68.
- CARVALHO, T. P. & BERTACO, V. A. 2006. Two new species of *Hyphessobrycon* (Teleostei: Characidae) from upper rio Tapajós basin on Chapada Parecis, Central Brazil. *Neotropical Ichthyology* 4 (3): 301-308.
- COSTA, W. J. E. M. 1994. Description of two new species of the genus *Moenkhausia* (Characiformes: Characidae) from central Brazil. *Zoologische Anzeiger* 232: 21-29.
- EIGENMANN, C. H. 1917. The American Characidae [I]. *Memoirs of the Museum of Comparative Zoology* 43 (1): 1-102, pls. 1-8, 12, 14-16, 95, 98, 100-101.
- EIGENMANN, C. H. 1918. The American Characidae [II]. *Memoirs of the Museum of Comparative Zoology* 43 (2): 103-208, pls. 9-11, 13, 17-29, 33, 78-80, 93.
- FINK, W. L. & WEITZMAN, S. H. 1974. The so-called cheirodontin fishes of Central America with description of two new species (Pisces, Characidae). *Smithsonian Contributions to Zoology* 172: 1-46.
- GÉRY, J. 1977. *Characoids of the world*. T.F.H. Publications, Neptune City, 672 pp.
- GÉRY, J. 1992. Description de deux nouvelles espèces proches de *Moenkhausia lepidura* (Kner) (Poissons, Characiformes, Tetragonopterinae), avec une revue du groupe. *Revue Française d'Aquariologie* 19 (3): 69-78.
- GÉRY, J. & ZARSKE, A. 2004. *Moenkhausia heikoi* n.sp., a new tetra (Teleostei: Ostariophysi: Characiformes: Characidae) from the Rio Xingu basin, Brazil, with a supplementary description of the genus type species. *aqua, Journal of Ichthyology and Aquatic Biology* 9 (1): 29-43.
- HUBERT, N. & RENNO, J. F. 2006. Historical biogeography of South American freshwater fishes. *Journal of Biogeography* 33: 1414-1436.
- LIMA, F. C. T. & BIRINDELLI, J. L. O. 2006. A new *Moenkhausia* (Characiformes: Characidae) from the Serra do Cachimbo, Rio Xingu basin, Brazil. *Ichthyological Exploration of Freshwaters* 17 (1): 53-58.
- LIMA, F. C. T., BRITSKI, H. A. & MACHADO, F. A. 2004. New *Knodus* (Ostariophysi: Characiformes: Characidae) from the upper Rio Paraguay basin, Brazil. *Copeia* 2004 (3): 577-582.
- LIMA, F. C. T. & BRITTO, M. R. 2001. New catfish of the genus *Aspidoras* (Siluriformes: Callichthyidae) from the upper rio Paraguai system in Brazil. *Copeia* 2001 (4): 1010-1016.
- LIMA, F. C. T., MALABARBA, L. R., BUCKUP, P. A., PEZZI DA SILVA, J. F., VARI, R. P., HAROLD, A., BENINE, R., OYAKAWA, O. T., PAVANELLI, C. S., MENEZES, N. A., LUCENA, C. A. S., MALABARBA, M. C. S. L., LUCENA, Z. M. S., REIS, R. E., LANGEANI, F., CASATTI, L., BERTACO, V. A., MOREIRA, C. & LUCINDA, P. H. F. 2003. Genera Incertae Sedis in Characidae. In: *Check List of the Freshwater Fishes of South and Central America*. (Eds. R. E. Reis, S. O. Kullander & C. J. Ferraris.): 106-169. Edipucrs, Porto Alegre.
- LIMA, F. C. T. & TOLEDO-PIZA, M. 2001. New *Moenkhausia* (Characiformes: Characidae) from the rio Negro of Brazil. *Copeia* 2001 (4): 1058-1063.
- LUCINDA, P. H. F., MALABARBA, L. R. & BENINE, R. C. 2007. On a new species of the genus *Moenkhausia* Eigenmann (Ostariophysi: Characidae). *Zootaxa* 1525: 61-68.
- MENEZES, N. A. & WEITZMAN, S. H. 1990. Two new species of *Mimagoniates* (Teleostei: Characidae: Glandulocaudinae), their phylogeny and biogeography and a key to the glandulocaudin fishes of Brazil and Paraguay. *Proceedings of the Biological Society of Washington* 103: 380-426.
- SHIBATTA, O. A. & PAVANELLI, C. S. 2005. Description of a new *Batrochoglanis* species (Siluriformes, Pseudopimelodidae) from the rio Paraguai basin, State of Mato Grosso, Brazil. *Zootaxa* 1092: 21-30.
- TAYLOR, W. R. & VAN DYKE, G. C. 1985. Revised procedures for staining and clearing small fishes and other vertebrates for bone and cartilage study. *Cybium* 9: 107-109.
- WILLINK, P. W., FROELICH, O., MACHADO-ALLISON, A., MENEZES, N., OYAKAWA, O., CATELLA, A., CHERNOFF, B., LIMA, F. C. T., TOLEDO-PIZA, M., ORTEGA, H., ZANATA, A. M. & BARRIGA, R. 2000. Fishes of the rios Negro, Negrinho, Taboco, Taquari and Miranda, Pantanal, Brasil: diversity, distribution, critical habitats, and value. In: *A biological assessment of the aquatic ecosystems of the Pantanal, Mato Grosso do Sul, Brasil*. (Eds. P. W. Willink, B. Chernoff, L. E. Alonso, J. R. Montalbault & R. Lourival). 63-81 (Portuguese version: 183-201). Bulletin of Biological Assessment, 18, Conservation International, Washington, D.C.
- ZARSKE, A., GÉRY, J. & ISBRÜCKER, I. J. H. 2004. *Moenkhausia rara* n. sp. – eine neue, bereits bestandsgefährdete Salmmler-Art (Teleostei: Characiformes: Characidae) aus Surinam und Französisch Guyana mit einer ergänzenden Beschreibung von *M. simulata* (Eigenmann in Pearson, 1924). *Zoologische Abhandlungen (Dresden)* 54: 19-30.