

Original article

A new species of *Tetragonopterus* (Characiformes: Characidae) from Central Amazon lowlands, Brazil

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A new species of *Tetragonopterus* is described from lowland rivers of Central Amazon. It differs from congeners by having a vertically-oriented patch of dark pigmentation limited to posterior portion of the caudal peduncle and by bearing five thin and sharp teeth on dentary, along with other morphometric and meristic features. We hypothesize that the new taxon belongs to the herein named “*Tetragonopterus anostomus* clade” that includes *T. anostomus*, *T. denticulatus*, *T. kuluene*, and *T. juruena*.

Keywords: Biodiversity, Freshwater fishes, South America, Taxonomy, Tetragonopterinae.

Uma espécie nova de *Tetragonopterus* é descrita de rios de terra baixa da Amazônia Central. Ela difere de suas congêneres por possuir uma mancha escura orientada verticalmente, limitada à porção posterior do pedúnculo caudal, e por possuir cinco dentes principais finos e afiados no dentário, além de outras características morfométricas e merísticas. Nós levantamos a hipótese que o novo táxon pertença ao clado *Tetragonopterus anostomus*, o qual inclui *T. anostomus*, *T. denticulatus*, *T. kuluene* e *T. juruena*.

Palavras-chave: América do Sul, Biodiversidade, Peixes de água-doce, Taxonomia, Tetragonopterinae.

Introduction

Species of *Tetragonopterus* Cuvier (1816) are recognizable by the presence of two aligned rows of premaxillary teeth, presence of five tricuspidate to pentacuspidate teeth in the inner row of the premaxilla, complete lateral line that is bent downward anteriorly, or slightly bent as in *T. georgiae* (Géry, 1965), branched laterosensory canal in the sixth infraorbital, a flattened prepelvic area bounded laterally by well-marked angles, absence of predorsal spine and the possession of two or three supraneurals (Eigenmann, 1917; Mirande, 2010; Melo *et al.*, 2011; Silva *et al.*, 2016). The genus encompasses small-sized fishes (maximum 11.2 cm standard length) ranging from the Orinoco basin through most northern South America in the vast portion of the Amazon and Guianas and across the La Plata (except upper rio Paraná) and São Francisco basins and adjacent Atlantic coastal drainages, from lower Amazon basin to rio Itapecuru in northeastern Brazil (Silva *et al.*, 2016).

The alpha taxonomy of *Tetragonopterus* has received effective advances since the description of several new species from craton-derived rivers of the Amazon basin (*i.e.*, Brazilian and Guiana shields) (Melo *et al.*, 2011; Silva, Benine, 2011; Silva *et al.*, 2013; Araujo, Lucinda, 2014).

This progress allowed the conclusion of a comprehensive taxonomic revision containing updated distribution information, redescription of poorly described species, formal descriptions of four new species and a molecular dataset of all mitochondrial lineages (Silva *et al.*, 2016). Such improvement resulted in a total of twelve valid species of *Tetragonopterus*, in which eleven of them were included in the subsequent molecular, time-calibrated phylogeny (Melo *et al.*, 2016). Despite the recent systematic revision and phylogeny, the continuous examination of *Tetragonopterus* collected along various localities along the Amazon basin revealed an undescribed species apparently endemic to lowland rivers of Central Amazon, which we formally describe herein.

Material and Methods

Counts and measurements follow Fink, Weitzman (1974) and Benine *et al.* (2004) and were taken point to point with a digital caliper (precision of 0.1 mm) on the left side of specimens whenever possible. All measurements of standard length (SL) and head length (HL) are expressed as percentage of SL or HL. Principal dentary teeth are the anteriormost similar teeth that decrease gradually followed

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by a series of distinctly smaller teeth. Cleared and stained (c&s) specimen was prepared according to Taylor, Van Dyke (1985). Radiographs were taken using the X-ray system Faxitron LX60 DC12 at LIRP. Vertebral counts included the four vertebrae of the Weberian apparatus and the terminal centrum as a single element. The gill raker centered between ceratobranchial and epibranchial was counted as for the ventral branch. Values in parentheses indicate the number of specimens and asterisks indicate the value of the holotype. Comparative material involves analyzed specimens cited in the taxonomic revision (Silva *et al.*, 2016). Museum abbreviations are: Instituto Nacional de Pesquisas da Amazônia, Manaus (INPA); Laboratório de Biologia e Genética de Peixes, Instituto

de Biociências, Universidade Estadual Paulista, Botucatu (LBP); Laboratório de Ictiologia de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto (LIRP); and Museu de Zoologia da Universidade de São Paulo, São Paulo (MZUSP).

Results

Tetragonopterus manaos, new species

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Figs. 1-3, Tab. 1

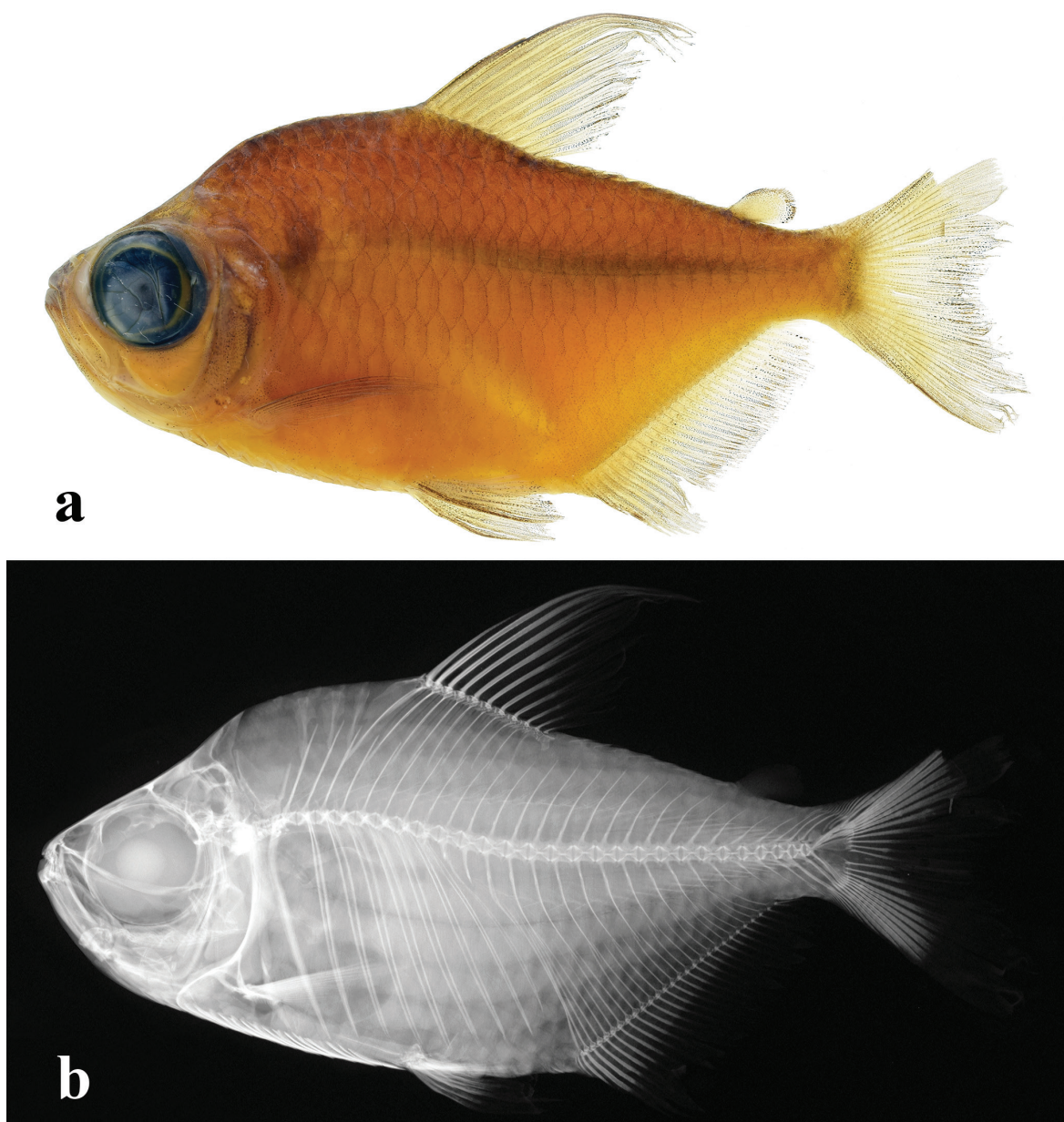


Fig. 1. a. *Tetragonopterus manaos*, holotype, MZUSP 117250, 64.1 mm SL, Brazil, Manaus, Anavilhanas National Park, rio Negro, Amazon basin; **b.** radiograph of the holotype.



Fig. 2. *Tetragonopterus manaos*, paratype, MZUSP 123507, 62.8 mm SL, Brazil, Manaus, Anavilhanas National Park, rio Negro, Amazon basin.

Tab. 1. Morphometric data of *Tetragonopterus manaos*. Range includes holotype. SD = Standard deviation.

	Holotype	N	Range	Mean	SD
Standard length (mm)	64.1	28	54.6-81.6	65.4	-
Percentages of standard length					
Body depth	49.5	28	47.5-54.9	52.4	2.0
Predorsal length	50.9	28	49.0-53.0	50.8	0.9
Prepectoral length	32.1	28	30.5-34.6	32.1	0.9
Prepelvic length	54.1	28	50.4-56.7	54.0	1.5
Preanal length	69.5	28	68.7-75.9	73.3	1.9
Caudal-peduncle depth	11.1	28	10.4-12.2	11.5	0.4
Caudal-peduncle length	6.2	28	4.3-7.1	6.0	0.7
Pectoral-fin length	26.2	28	19.2-27.2	25.8	1.9
Pelvic-fin length	19.4	28	14.1-22.4	19.1	2.1
Dorsal-fin length	39.8	27	26.7-42.3	38.4	2.9
Length of dorsal-fin base	18.1	28	16.3-21.5	19.2	1.0
Anal-fin length	18.4	22	15.6-22.3	19.5	2.0
Length of anal-fin base	35.5	28	30.8-35.6	34.1	1.3
Distance from eye to dorsal-fin origin	37.4	28	35.4-40.1	37.8	1.2
Distance from dorsal-fin origin to caudal-fin base	55.3	28	51.6-58.8	54.1	1.7
Head length	31.0	28	28.8-32.3	30.5	0.9
Head depth	41.6	28	35.5-45.1	41.7	2.1
Percentages of head length					
Snout length	18.9	28	16.7-23.8	19.9	1.7
Maxillary length	55.3	28	50.3-57.3	53.6	2.0
Horizontal orbital diameter	44.2	28	43.6-50.5	46.8	1.9
Least interorbital width	33.0	28	30.9-36.7	33.7	1.6

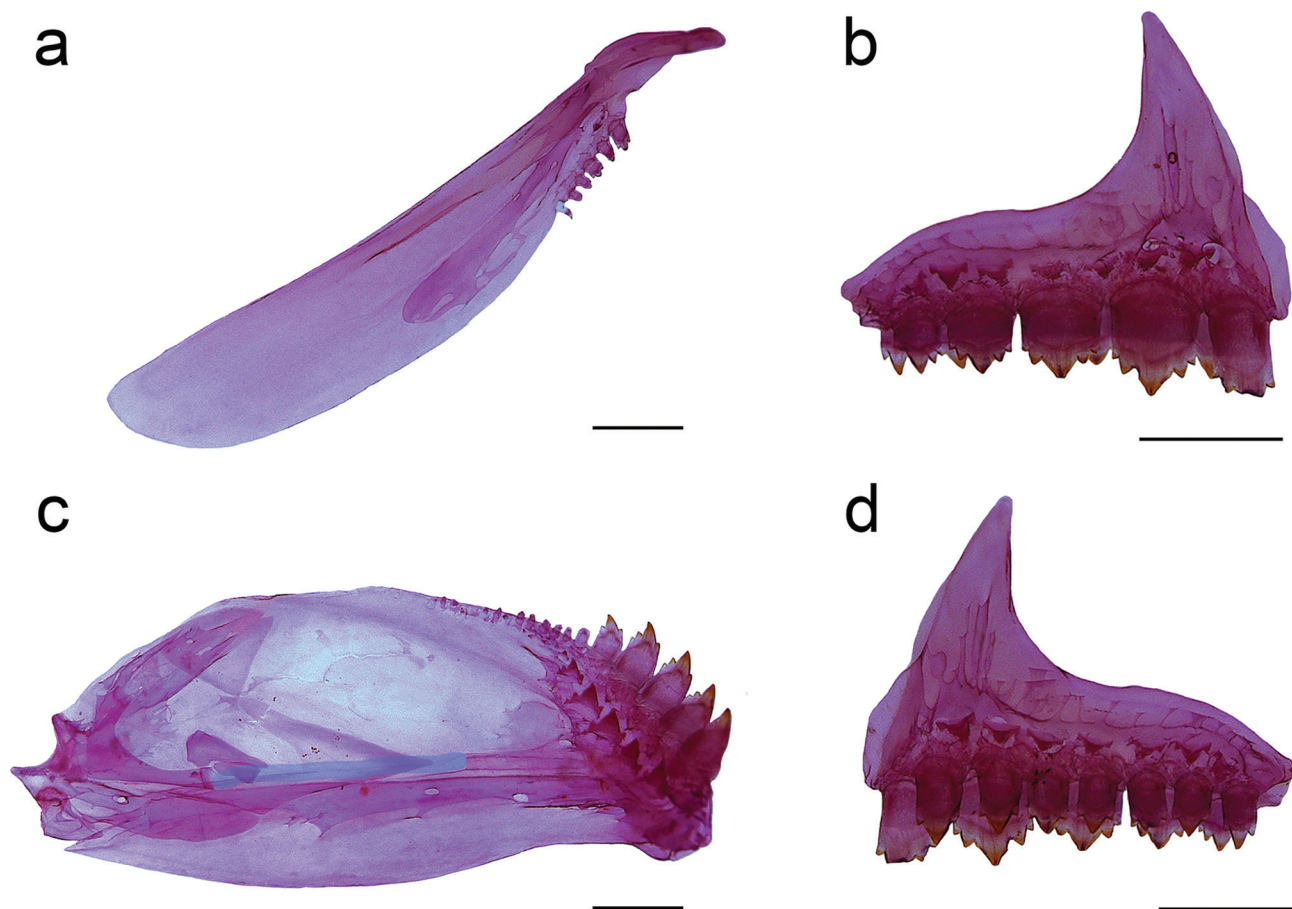


Fig. 3. Left side dentition of *Tetragonopterus manaos*, MZUSP 121680, paratype, 56.1 mm SL. Medial view of **a.** maxilla, **b.** premaxilla, **c.** dentary, and **d.** lateral view of premaxilla. Scale bars = 1 mm.

Holotype. MZUSP 117250, 64.1 mm SL, radiographed, Brazil, Amazonas, Manaus, Anavilhanas National Park, igapó of rio Negro, approximately 02°42'S 60°45'W, Mar-Apr 1980, M. Goulding.

Paratypes. All from Brazil. INPA 25533, 1, 80.4 mm SL, Amazonas, Presidente Figueiredo, Cachoeira Morena, rio Uatumã, 02°07'24.0"S 59°19'49.0"W, 24 Apr 2005, E. G. Ferreira & S. Amadio. INPA 44352, 1, 54.6 mm SL, Amazonas, Iranduba, Sítio Santa Marta, rio Negro, 03°06'23.0"S 60°19'07.0"W, 31 May 2014, D. A. Bastos. INPA 18708, 2, 60.2-63.6 mm SL, Amazonas, Tefê, Toco Preto, rio Tefê, 03°47.31'S 64°59.91'W, 21 Oct 1999, W. G. R. Crampton. LBP 24888, 2, 62.8-69.1 mm SL, Amazonas, Manaus, Anavilhanas, igapó, rio Negro, 02°42'0.0"S 60°45'0.0"W, Aug 1980, M. Goulding. MZUSP 56523, 1, 55.3 mm SL, Pará, Oriximiná, rio Trombetas, 01°49'42.0"S 55°48'41.0"W, 24 Oct 1994, O. T. Oyakawa *et al.* MZUSP 121680, 12, 1 c&s, 56.1-78.2 mm SL, Amazonas, Manaus, Anavilhanas National Park, igapó, rio Negro, approximately 02°42'S 60°45'W, Aug 1980, M. Goulding. MZUSP 123507, 7, radiographed, 62.8-81.6 mm SL, same data as holotype.

Diagnosis. *Tetragonopterus manaos* is distinguished from all congeners, except *Tetragonopterus ommatus* Silva, Melo, Oliveira, Benine (2016) by having a vertically-oriented patch of dark pigmentation limited to the posterior portion of the caudal peduncle (*vs.* mark centered on the caudal peduncle). *Tetragonopterus manaos* differs from *T. ommatus* by the number of maxillary teeth 4-6 (*vs.* 7-8), by having thinner and sharper dentary teeth (*vs.* more robust dentary teeth), and by the greatest body depth 47.5-54.9% of SL (*vs.* 42.1-44.7% of SL). *Tetragonopterus manaos* further differs from all congeners, except *T. anostomus* Silva, Benine (2011), *T. denticulatus* Silva, Melo, Oliveira, Benine (2013), *T. juruena* Silva, Melo, Oliveira, Benine (2016), *T. kuluene* Silva, Melo, Oliveira, Benine (2016), and *T. rarus* (Zarske, Géry, Isbrücker, 2004), by the presence of five principal, sharper teeth on dentary (*vs.* three to four robust teeth). Moreover, the new species differs from *T. anostomus* by having a terminal mouth (*vs.* subsuperior mouth) (*sensu* Silva *et al.*, 2016). In addition, *T. manaos* differs from *T. anostomus* and *T. araguaiensis* Silva, Melo, Oliveira, Benine (2013) by the number of gill rakers on the lower (13-15) and upper (8-10) limbs of

the first gill arch (*vs.* 17-20 and 10-13, respectively); it differs from *T. kuluene* by having two humeral dark marks (*vs.* one humeral dark mark); it differs from *T. argenteus* Cuvier (1816) by having 7-9 predorsal scales (*vs.* 11-18); it differs from *T. chalceus* by bearing five thinner and sharper dentary teeth (*vs.* four robust teeth); it differs from *T. carvalhoi* Melo, Benine, Mariguela, Oliveira (2011) by the presence of a vertically-oriented dark mark on the caudal peduncle (*vs.* a lozenge-shaped dark mark); it differs from *T. rarus* and *T. georgiae* by the presence of 3.5 scale rows between lateral line and pelvic-fin origin (*vs.* 4.5-5); it differs from *T. juruena* by having 13-15 rakers on the lower limb of the first gill arch (*vs.* 10-12); it differs from *T. rarus* by the absence of dark longitudinal stripes on the lateral surface of the body (*vs.* presence).

Description. Morphometric data summarized in Tab. 1. Compressed body, proportionally deep. Greatest depth at dorsal-fin origin. Dorsal profile slightly convex from snout tip to vertical through middle of orbit and slightly concave from this point to end of occipital process. Convex from end of occipital process to dorsal-fin origin and slightly convex along dorsal-fin base. Slightly convex from rear of dorsal-fin base to rear of adipose fin. Caudal peduncle with slightly concave dorsal and ventral profiles. Ventral profile convex from lower lip to pelvic-fin origin; straight from this point to anal-fin origin and straight along anal-fin base.

Snout shorter than orbital diameter. Mouth terminal with premaxillary teeth in two rows. Outer row with 5(2), 6(13), 7*(12) or 8(1) teeth with three cusps. Inner row with 4(1), 5*(24) or 6(3) teeth with three or five cusps. Maxilla with 4(3), 5*(16) or 6(9) teeth with three cusps. Dentary bearing 5(28) anterior most principal teeth with five cusps, followed by a series of small tricuspidate or conic teeth (Fig. 3).

Dorsal-fin rays ii,9(28). First unbranched dorsal-fin ray shorter than second one. Dorsal-fin origin at middle of the body in SL. Anal-fin rays ii,27(1); iii,25(1); iii,27(5); iii,28(2); iii,29(2); iv,26*(3); iv,27(4); iv,28(1); v,26(2); v,27(5); v,28(1) or v,29(1). Posterior unbranched anal-fin rays and anterior branched rays slightly longer than following rays. Anal-fin origin at vertical through two scales posterior to last branched dorsal-fin ray. Pectoral-fin rays i,12(4); i,13*(23) or i,15(1). Tip of adpressed pectoral fin reaching two scales posterior to pelvic-fin origin. Pelvic-fin rays i,7*(23); ii,6(1) or ii,7(4). Pelvic-fin origin located at vertical through dorsal-fin origin. Distal margin of pelvic fin angled, anterior rays longest. Tip of adpressed pelvic fin not reaching the anal-fin origin.

Scales large and cycloid. Lateral line complete 28(3), 29(10), 30(6), 31*(6) or 32(3) pored scales; anterior portion distinctly bent downward. Predorsal scales 7*(2), 8(21) or 9(5). Scale rows between dorsal-fin origin and lateral line 6(28). Scale rows between lateral line and

pelvic-fin origin 3.5(28). Scale rows around caudal peduncle 10(4), 11(4), 12*(11) or 13(6). Anal-fin base covered by up to four rows of small scales. Few scales covering the base of caudal-fin lobes.

First gill arch with 13(6), 14(12) or 15*(8) rakers on lower limb and 8*(9), 9(12) or 10(5) rakers on upper limb. Total vertebrae 30(1) or 31*(7). Supraneurals 2(1) or 3*(7) (Fig. 1b).

Color in alcohol. Overall ground coloration yellowish tan. Dorsolateral portions of head and body darkly pigmented. Dorsolateral portion of body with few chromatophores along distal margins of scales. Ventrolateral portion of body unpigmented. Two pale brown humeral spots vertically elongate and separated by one and half scales from each other. Each humeral mark covering two to three scales vertically and two or three scales horizontally. Anterior humeral mark more evident than the posterior humeral mark; anterior mark separated by one and half or two scales from posteriormost margin of opercular bone. Caudal peduncle with a ventrally-oriented patch of dark pigmentation limited to posterior portion of caudal peduncle; dark mark often quite faint. Midlateral silver stripe broad, extending from supracleithrum to caudal peduncle. Distal portions of anal, dorsal, adipose and caudal, and more lateral rays of pectoral and pelvic fins densely scattered by dark chromatophores. Unbranched rays of all fins outlined by dark chromatophores (Figs. 1a, 2).

Sexual dimorphism. Secondary sexual characters were not found in any analyzed specimen of *Tetragonopterus manaos*.

Geographic distribution. *Tetragonopterus manaos* is known from the Central Amazon in the lower sections of Tefé, Negro, Uatumã and Trombetas rivers, near the mainstream of rio Amazonas (Fig. 4).

Etymology. The specific name *manaos* is in reference to the Manaós, indigenous tribe that inhabited the lower rio Negro, which includes the type-locality of the new species. A noun in apposition.

Conservation status. Given the wide-ranging occurrence area throughout Central Amazon, the good environmental conditions and the lack of significant threats along most of the sampled localities, *Tetragonopterus manaos* should be categorized as Least Concern (LC) under the categories and criteria of the International Union for Conservation Nature (IUCN Standards and Petitions Subcommittee, 2017). Furthermore, sampled localities are proximate to several governmental protection zones, such as the Tefé National Forest, Anavilhanas National Park, Uatumã Biological Reserve, and Saracá-Taquera National Forest, northern Brazil.

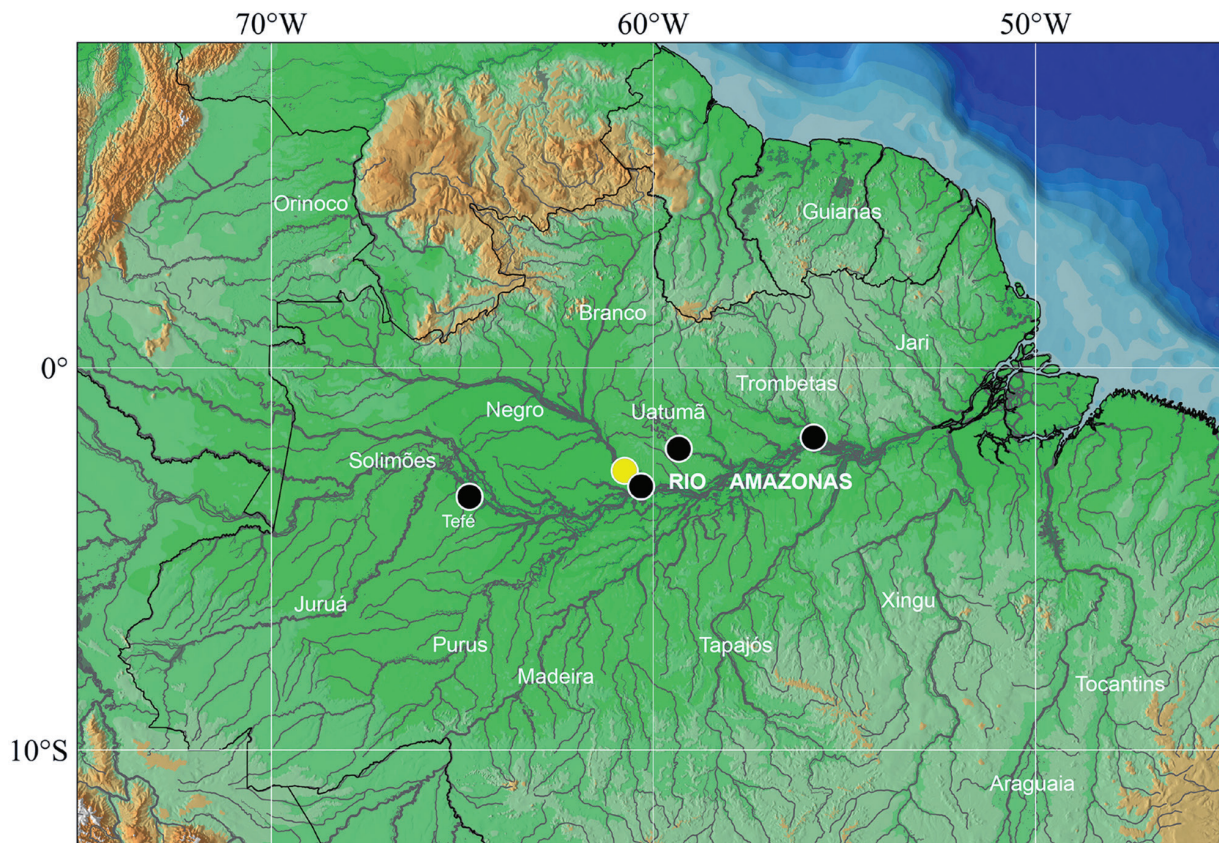


Fig. 4. Map of northern South America showing the distribution of *Tetragonopterus manaos*; yellow circle represents the holotype and black circles represent paratypes.

Discussion

The most recent molecular phylogeny provided support for several monophyletic groups within *Tetragonopterus* (Melo *et al.*, 2016). One of the highly supported clades includes *T. denticulatus* sister to a subclade with *T. anostomus* plus *T. kuluene* (referred there as *T. sp. Xingu*), hereafter named “*T. anostomus* clade”. This three-species clade is morphologically supported by the exclusive possession of numerous (*i.e.*, five or more) and relatively smaller dentary teeth (Silva, Benine, 2011; Silva *et al.*, 2013; 2016). *Tetragonopterus juruena* from the upper rio Tapajós, absent in that phylogeny (Melo *et al.*, 2016), is another species that has the morphological conditions of the “*T. anostomus* clade”. These exclusive morphological features are also evident in *T. manaos*, which allow us to hypothesize that it represents another member of that clade. Nevertheless, interspecific relationships between *T. manaos* and its congeners remain undefined.

Tetragonopterus manaos possesses a vertically-oriented patch of dark pigmentation that is limited to the posterior portion of the caudal peduncle (Figs. 1a, 2), often quite faint in some specimens. A similar condition is also present in *T. ommatus*, a species from the middle rio Tapajós (Silva *et al.*, 2016), which is sister to *T. araguaensis* and not close related to the “*T. anostomus* clade” (Melo *et al.*, 2016).

Therefore, the pigmentation pattern observed in *T. manaos* and *T. ommatus* is likely homoplastic. These two species are distinguished by diagnostic characters (*e.g.*, number of maxillary teeth, number and shape of dentary teeth, and relative body depth) that would support the hypothesis that they are unrelated taxa. However, the nature of these characteristics (teeth shape and number, and caudal peduncle color pattern) is a matter of further comparative research.

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