

# Redescription of *Astyanax multidentis* Eigenmann, 1908 (Characiformes: Characidae), a small characid of the Brazilian Amazon

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*Astyanax multidentis* is redescribed based on syntypes and additional specimens from the rio Amazonas at Silves, Amazonas State and Óbidos, Pará State, and the rios Trombetas, Tapajós, Xingú, and Araguaia. *Astyanax multidentis* is distinguished from congeners by the unique combination of five to seven maxillary teeth, 31 to 34 pored lateral-line scales, 20 to 23 branched anal-fin rays, and a dark triangular blotch restricted to the middle caudal-fin rays. *Astyanax multidentis* was collected syntopically with *Jupiaba paranatinga* in the rio Tapajós basin and with *Jupiaba* cf. *essequibensis* in the rio Xingu basin, which have paired anteriorly oriented pelvic-fin spines, a antipredatory mechanism. Based on the external morphological similarity between *Astyanax multidentis* and the two species of *Jupiaba*, their sympatric occurrence, and their distinct phylogenetic position, we interpret this a case of Batesian mimicry.

*Astyanax multidentis* é redescrita com base no exame dos sintipos e espécimes adicionais do rio Amazonas em Silves, AM e Óbidos, PA e rios Trombetas, Tapajós, Xingú e Araguaia. *Astyanax multidentis* distingue-se dos congêneres pela exclusiva combinação de cinco a sete dentes no maxilar, 31 a 34 escamas perfuradas na linha lateral, 20 a 23 raios ramificados na nadadeira anal, e uma mácula triangular escura restrita aos raios medianos da nadadeira caudal. *Astyanax multidentis* foi coletada sintopicamente com *Jupiaba paranatinga* na bacia do rio Tapajós, e com *Jupiaba* cf. *essequibensis* na bacia do rio Xingu, que possuem espinho pélvico voltado para frente, um mecanismo antipredatório. Baseado na similaridade morfológica externa entre *Astyanax multidentis* e estas duas espécies de *Jupiaba*, sua ocorrência simpátrica, e sua distante posição filogenética, nós interpretamos como um caso de mimetismo Batesiano.

**Key words:** *Jupiaba*, Mimicry, Neotropical, Taxonomy.

## Introduction

The family Characidae is the fourth largest family of fishes in the World, with over 1.100 valid species, being smaller only than the freshwater families Cyprinidae, Cichlidae, and the mainly marine Gobiidae (Nelson, 2006; Eschmeyer & Fricke, 2012). Interestingly, contrary to these three families, the Characidae is much more geographically limited, being restricted to South America, from Texas (U.S.A.) to Argentina. The family is experiencing a high annual rate of species description, with 46 new species in 2010, despite the still prevalent poor knowledge about the taxonomy and interrelationships of species. Half of the species of the Characidae were listed as *incertae sedis* by Lima *et al.* (2003). Most of the larger genera, such as *Astyanax* Baird & Girard, *Moenkhausia* Eigenmann, *Hyphessobrycon* Durbin, and *Hemigrammus* Gill, are now considered to be not monophyletic (Lima *et al.*, 2003), with numerous species level problems.

*Astyanax* is the most species rich genus in Characiformes, with approximately 130 valid species (Eschmeyer & Fricke, 2012), of which almost 15% (18 species) were described in the last five years (*e.g.*, Zanata & Camelier, 2008; Marinho & Lima, 2009; Bertaco *et al.*, 2010; Garavello & Sampaio, 2010), and about one-third described in the last 10 years (42 species from 2002 to 2011) (*e.g.*, Azpelicueta *et al.*, 2002; Garutti, 2003; Bertaco & Lucena, 2006). Similarly increasing are the contributions through redescrptions of poorly known species (*e.g.*, Garutti, 2003; Mirande *et al.*, 2006; Garutti & Langeani, 2009; Pavanelli & Oliveira, 2009; Azpelicueta & Loureiro, 2009; Almirón *et al.*, 2010; Bertaco *et al.*, 2010; Bertaco & Lucena, 2010; Soneira *et al.*, 2010).

*Astyanax* is primarily characterized by having two series of teeth on the premaxilla with the inner tooth row consisting of five teeth, complete lateral line, and caudal fin not covered by scales (Eigenmann, 1917; 1921), but has been considered to be not monophyletic for over 40 years (Rosen, 1972;

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Weitzman & Fink, 1983; Weitzman & Malabarba, 1998; Lima *et al.*, 2003). Furthermore, recent phylogenetic analyses based on molecular data, including only very few species (two or three in each study) have also demonstrated the non-monophyletic condition of *Astyanax* (Calcagnotto *et al.*, 2005; Javonillo *et al.*, 2009; Oliveira *et al.*, 2011). In a comprehensive phylogenetic analysis of the Characidae, Miranda (2010) recovered the species of *Astyanax* in three different monophyletic groups with *A. latens* Miranda, Aguilera & Azpelicueta closely related to two species of *Hyphessobrycon* (in the *Hyphessobrycon luetkenii* clade), *A. paris* Azpelicueta, Almirón & Casciotta the sister to a large characid clade, and *Astyanax* spp. (15 species) in what he termed *Astyanax* clade which also includes *Hyphessobrycon anisitsi* (Eigenmann), *Markiana nigripinnis* (Perugia), and *Psellogrammus kennedyi* (Eigenmann). Miranda's (2010) *Astyanax* clade is supported by a single non-exclusive synapomorphy: the presence of one or no maxillary teeth.

We recently collected specimens of a small-sized characid widely distributed in the rio Tapajós basin which proved to be *Astyanax multidentis* Eigenmann, 1908. This is a poorly known species described more than a century ago and only cited in fish catalogs, or as citations of samples from the rio Paraguay basin. The aim of the present contribution is to redescribe *Astyanax multidentis* based on syntypes and recently collected specimens.

#### Material and Methods

Counts and measurements were taken from seven syntypes and 30 non-type specimens, according to Fink & Weitzman (1974), with the addition of head depth measured at the vertical through the posteriormost tip of bony opercle, and longitudinal scale rows below lateral line counted to the pelvic-fin insertion. Counts are followed by their frequencies in parentheses. Measurements are given as percents of standard length (SL), except for subunits of the head given as percents of head length. Counts of vertebrae, supraneurals, gill-rakers of the first arch, tooth cusps, smaller dentary teeth, procurrent caudal-fin ray and position of the pterygiophores were taken from four cleared and stained (cs) specimens, prepared following Taylor & van Dyke (1985). Vertebral count includes the four vertebrae of the Weberian apparatus and the fused PU1 + U1 as a single element. Counts observed in the syntype series are marked with an asterisk. Meristic data for other species of *Astyanax* were taken for direct examination of specimens (see Comparative material) or from original description or redescrptions (*e.g.*, Eigenmann, 1927; Garutti, 2003; Melo & Buckup, 2006; Pavanelli & Oliveira, 2009).

Institutional abbreviations are: ANSP, Academy of Natural Sciences, Philadelphia; DZSJRP, Departamento de Zoologia e Botânica, Universidade Estadual Paulista "Júlio de Mesquita Filho", Câmpus de São Jose do Rio Preto, São José do Rio Preto; FMNH, Field Museum of Natural History, Chicago; INPA, Instituto Nacional de Pesquisas da Amazônia, Manaus; MCP, Museu de Ciências e Tecnologia da Pontifícia Universidade

Católica do Rio Grande do Sul, Porto Alegre; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge; MNRJ, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro; MZUSP, Museu de Zoologia, Universidade de São Paulo, São Paulo; NMW, Naturhistorisches Museum Wien, Vienna; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

#### Results

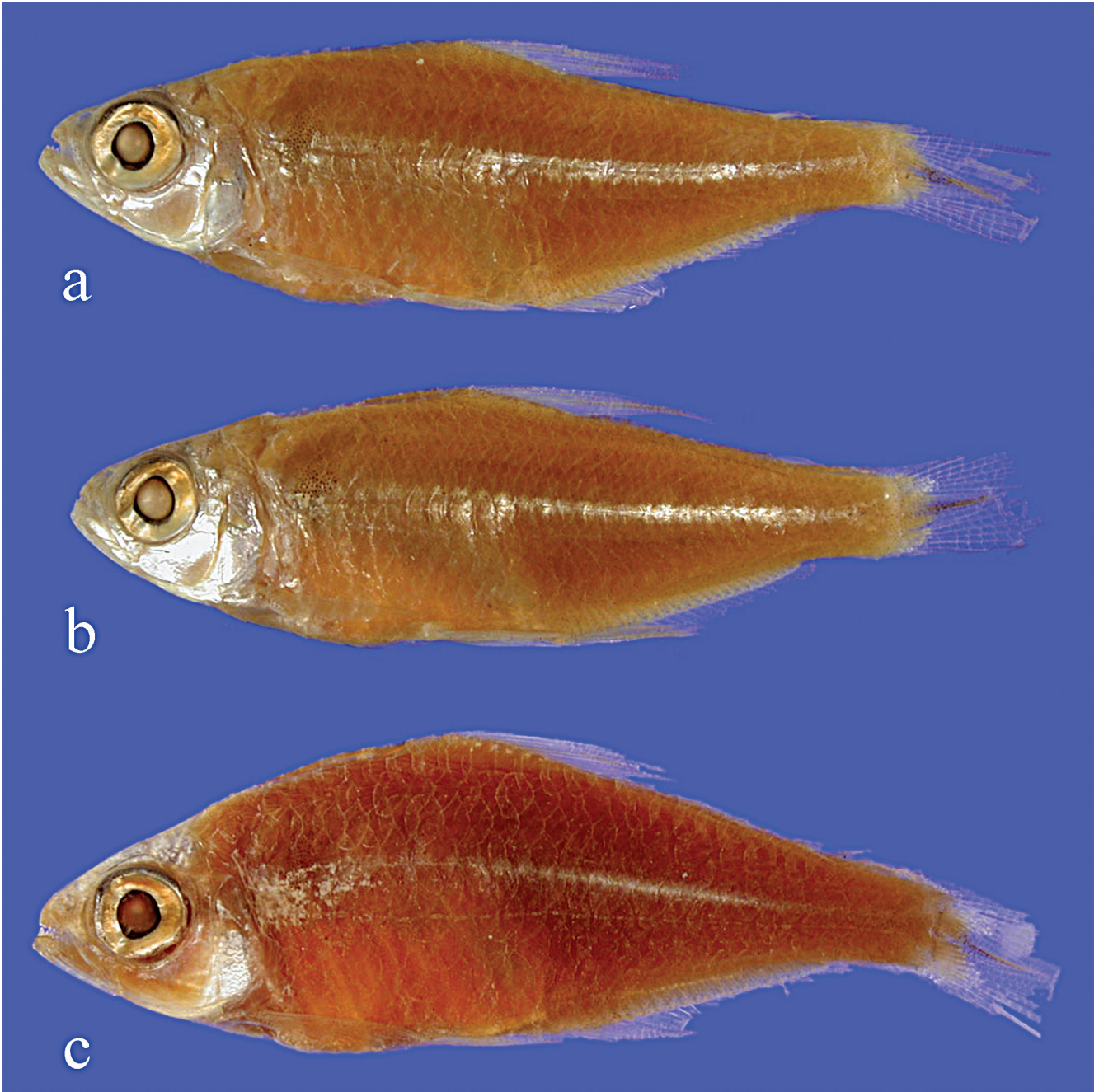
##### *Astyanax multidentis* Eigenmann, 1908

##### Figs. 1-4

*Astyanax multidentis* Eigenmann, 1908: 98 [Óbidos and Silva (=Silves), Lake Saraca].- Eigenmann, 1910: 434 [citation].- Eigenmann, 1921: plate 50, fig. 4 [illustration].- Eigenmann, 1927: 323 [literature compilation].- Eigenmann, 1927: 328 [literature compilation; considered to be allied to *A. guianensis*].- Fowler, 1943: 3 [similarity to *A. chaparæ*].- Fowler, 1948: 55-56 [literature compilation; in part, not rio Paraguay].- Géry, 1977: 426 [identification key].- Vari & Howe, 1991: 7 [catalogue of type specimens].- Lima *et al.*, 2003: 111 [literature compilation].- Lima *et al.*, 2007: 46 [literature compilation].

**Diagnosis.** *Astyanax multidentis* is distinguished from all congeners except *A. angustifrons* (Regan), *A. aurocaudatus* Eigenmann, *A. gisleni* Dahl, *A. goyanensis* (Miranda Ribeiro), *A. guaporensis* Eigenmann, *A. guianensis* Eigenmann, *A. henseli* Melo & Buckup, *A. leopoldi* Géry, Planquette & Le Bail, *A. nasutus* Meek, *A. nicaraguensis* Eigenmann, *A. superbus* Myers, and *A. totae* Haluch & Abilhoa by having five to seven maxillary teeth (*vs.* less than five). *Astyanax multidentis* is distinguished from the aforementioned species, except *A. angustifrons*, *A. guaporensis*, *A. guianensis*, *A. leopoldi*, *A. nicaraguensis*, and *A. totae* by having 31 to 34 pored lateral-line scales (*vs.* more than 34). *Astyanax multidentis* is distinguished from *A. totae* and *A. nicaraguensis* by having 20 to 23 branched anal-fin rays (*vs.* 15 to 18 and 24 to 29, respectively); from *A. angustifrons* and *A. leopoldi* by the absence of a dark blotch on the caudal peduncle (*vs.* presence); and from *A. guaporensis* and *A. guianensis* by having a dark triangular blotch on middle caudal-fin rays (*vs.* middle caudal-fin rays hyaline).

**Description.** Morphometrics presented in Table 1. Overall body size small (largest examined specimen 52.8 mm SL). 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 from that point to tip of supraoccipital spine. Dorsal profile of body slightly convex along predorsal region, straight and posteroventrally inclined along dorsal-fin base, straight to slightly convex from terminus of dorsal-fin base to adipose-fin origin, and concave along caudal peduncle. Ventral profile of head and body convex from tip of lower jaw to anal-fin



**Fig. 1.** *Astyanax multidentis*: (a) syntype, MCZ 89559, 29.2 mm SL, rio Amazonas at Óbidos, (b) syntype, MCZ 89559, 30.0 mm SL, rio Amazonas at Óbidos, (c) MCZ 20826, 36.3 mm SL, rio Amazonas at Óbidos.

origin, straight and posterodorsally inclined along anal-fin base, and concave along caudal peduncle.

Jaws equal, mouth terminal. Premaxillary teeth in two rows (Fig. 3). Outer row with 2\*(3), 3\*(23), 4\*(8), or 5\*(2) tricuspid teeth. Inner row with 5\*(32) or 6 (2) tri- to pentacusp teeth. Tip of maxilla slightly posterior of vertical through anterior margin of eye, with 5\*(21), 6 (9), or 7 (8) uni- to tetracusp teeth. Dentary with 4\* large pentacusp, one tricuspid and series of 6-10 small uni- to tricuspid teeth. Central median

cusp in all teeth longer than lateral cusps. Branchiostegal rays 4. First gill arch with 2 (2) or 3 (2) hypobranchial, 9 (2) or 10 (2) ceratobranchial, 1 intermediate cartilage, and 6 (3) or 7 (1) epibranchial gill rakers. Each gill raker with small denticles on its length.

Scales cycloid, with few *radii* on posterior border. Lateral line straight to slightly curved ventrally, with 31\*(2), 32\*(3), 33\*(18) or 34 (14) perforated scales from supracleithrum to caudal-fin base. Longitudinal scale rows between dorsal-fin





**Fig. 2.** *Astyanax multidentis*: (a) MZUSP 96606, 44.6 mm SL, rio Peixoto de Azevedo, tributary of rio Teles Pires, (b) MZUSP 99818, 29.5 mm SL, rio Teles Pires, (c) MZUSP 94171, 25.7 mm SL, rio Culuene, tributary of rio Xingu, (d) MZUSP 52228, 25.2 mm SL, rio Água Fria, rio Araguaia basin.

**Table 1.** Morphometric data of *Astyanax multidentis*. SD for Standard Deviation.

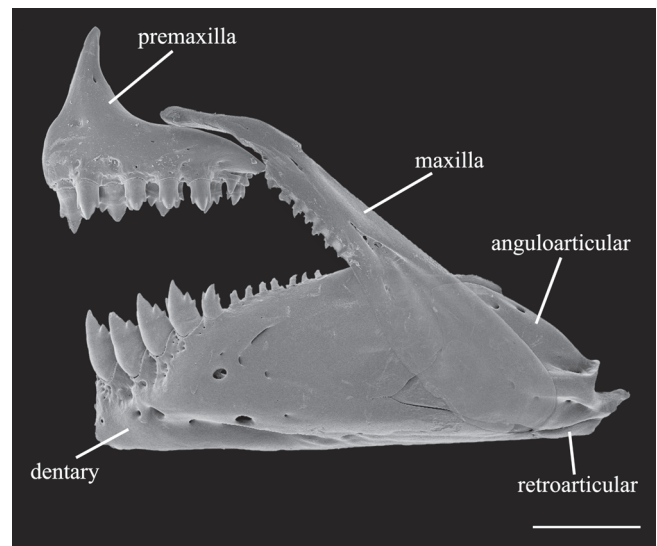
	Syntypes		Non-type specimens		Mean	SD
	N	Range	N	Range		
Standard length (mm)	7	28.5 - 30.7	30	32.7 - 48.8		
	Percentages of standard length					
Depth at dorsal-fin origin	7	29.4 - 32.8	30	29.6 - 36.6	32.6	1.9
Snout to dorsal-fin origin	7	47.2 - 51.2	30	47.8 - 50.4	49.2	0.7
Snout to pectoral-fin origin	7	26.4 - 28.1	30	25.5 - 30.0	27.3	0.9
Snout to pelvic-fin origin	7	44.7 - 48.0	30	46.1 - 50.4	48.1	1.1
Snout to anal-fin origin	7	58.3 - 65.3	30	60.4 - 66.4	63.6	1.6
Caudal-peduncle depth	7	9.0 - 10.7	30	9.0 - 11.3	9.9	0.6
Caudal-peduncle length	7	10.6 - 12.4	30	9.8 - 13.0	11.7	0.7
Pectoral-fin length	6	18.0 - 24.2	30	20.6 - 24.2	22.0	0.9
Pelvic-fin length	6	15.1 - 17.4	30	16.1 - 19.4	17.5	0.8
Dorsal-fin length	5	26.0 - 30.6	30	26.7 - 31.8	29.4	1.1
Dorsal-fin base length	7	13.7 - 17.2	30	13.0 - 15.8	14.4	0.7
Anal-fin lobe length	2	13.0 - 17.1	29	19.1 - 22.3	20.8	0.9
Anal-fin base length	6	27.1 - 33.1	30	26.6 - 30.4	28.4	1.0
Eye to dorsal-fin origin	7	33.1 - 36.2	30	33.0 - 36.2	34.0	0.8
Dorsal-fin origin to caudal-fin base	5	52.1 - 56.9	30	52.5 - 55.4	54.1	0.7
Head depth	7	22.4 - 26.6	30	24.2 - 27.3	25.5	0.7
Head length	7	25.4 - 27.0	30	25.2 - 27.6	26.8	0.6
	Percentages of head length					
Horizontal eye diameter	7	38.3 - 44.7	30	40.9 - 47.0	43.3	1.5
Snout length	6	22.4 - 26.0	30	23.4 - 26.9	25.5	1.2
Interorbital width	7	25.3 - 30.0	30	27.8 - 30.2	28.9	0.7
Upper jaw length	7	37.7 - 41.6	30	37.8 - 44.2	41.3	1.6

origin and lateral line 5 (33) or 6 (4). Longitudinal scale rows between lateral line and pelvic-fin origin 3\*(3), 4\*(28) or 5\*(6). Predorsal scales 8 (1), 9 (18), or 10\* (14) in one series. Row of 5 (8), 6 (8), 7 (9), or 8 (3) scales at base of anteriormost anal-fin rays. Circumpeduncular scale rows 14. Caudal fin with scales along basal one-sixth of upper lobe and basal one-fourth of lower lobe.

Pectoral-fin rays, 11\*(2), i, 12\*(9), i, 13 (15), i, 14 (7), or i, 15 (1). Tip of adpressed fin at pelvic fin-origin or falling slightly short of that point. Pelvic-fin rays i, 7\*(33) or i, 8 (1). Tip of adpressed fin at anal-fin origin or falling slightly short. Supraneurals 3 (1) or 4 (3). Dorsal-fin origin at middle of SL and slightly posterior to vertical through pelvic-fin origin. Dorsal-fin rays ii, 9. First unbranched ray about one-half length of second unbranched ray. Base of last dorsal-fin ray slightly anterior to vertical through anal-fin origin. First dorsal-fin pterygiophore inserted behind neural spine of 5<sup>th</sup> vertebra. Adipose-fin origin at vertical through base of 16<sup>th</sup> to 18<sup>th</sup> branched anal-fin rays. Anal-fin rays iv, 20 (1), iv, 21\*(17), iv, 22 (12), or iv, 23\*(4). First anal-fin pterygiophore inserted behind haemal spine of 12<sup>th</sup> (3) or 13<sup>th</sup> (1) vertebra. Caudal-fin rays i, 9, 8, i\*. Caudal fin forked, with lobes of similar size. Dorsal procurrent caudal-fin rays 11 (3) or 12 (1); ventral procurrent caudal-fin rays 11 (4). Total vertebrae 32 (4): precaudal vertebrae 15 and caudal vertebrae 17.

**Color in alcohol.** Overall ground color yellowish. Opercular area silvery. Lips, anterior portion of maxilla, and dorsal portion of head with small dark chromatophores. Larger chromatophores on upper one-half of opercle. Scales of two or three dorsalmost longitudinal scale rows bordered by dark pigmentation. Humeral blotch conspicuous, vertically

oriented, from one scale row ventral of, and three scale rows dorsal of lateral line, and over three scales horizontally. Lower half of humeral spot often interrupted by clear horizontal area. Clear area between humeral blotch and posterior pigmented area that fades longitudinally. Stripe extending over four or five longitudinal scale rows dorsal to lateral line, and from vertical through 7<sup>th</sup> or 8<sup>th</sup> lateral line scale to caudal peduncle. Dark pigmentation along horizontal septum, approximately from vertical through dorsal-fin origin to caudal peduncle.



**Fig. 3.** Upper and lower jaws of *Astyanax multidentis* (lateral view, right side), MZUSP 96726, 44.3 mm SL. Scale bar 1 mm.



Clear area anterior to caudal-fin base. Pectoral, pelvic and adipose fins with scattered dark chromatophores. First unbranched dorsal-fin ray with dark chromatophores; remaining rays hyaline. Distal portion of interradial membranes of all dorsal-fin rays with scattered dark chromatophores. Anal fin with scattered small chromatophores. Chromatophores frequently concentrated at proximal and distal portions of interradial membranes. Caudal fin with somewhat and sometimes diffuse triangular blotch on middle rays. Anterior margin of blotch straight; posterior pointed. Caudal-fin lobes hyaline or with scattered dark chromatophores.

**Color in life.** Coloration in life similar to described above for preserved specimens, except for dorsal portion of iris red, distal portion of anteriormost rays of dorsal, pelvic and anal fins white, adipose fin red, and caudal fin with pale orange blotch immediately dorsal and ventral to dark median blotch (Fig. 4).

**Sexual dimorphism.** No sexually dimorphic modification was observed.

**Distribution.** *Astyanax multidentis* is known from the rio Amazonas at Silves, State of Amazonas, and Óbidos, State of Pará, and the rios Trombetas, Tapajós, Xingú and Araguaia (Fig. 5).

**Remarks.** During the Thayer Expedition, James collected 40 specimens of small characids at Óbidos, which were kept in a single jar and catalogued as MCZ 20840. Eigenmann (1908, 1918, 1927) recognized two distinct species among these specimens, electing 5 specimens as paratypes of *Hemigrammus microstomus* and 35 as paratypes of *Astyanax multidentis*. Later, the 35 syntypes of *Astyanax multidentis* were removed to MCZ 89559 (the five paratypes

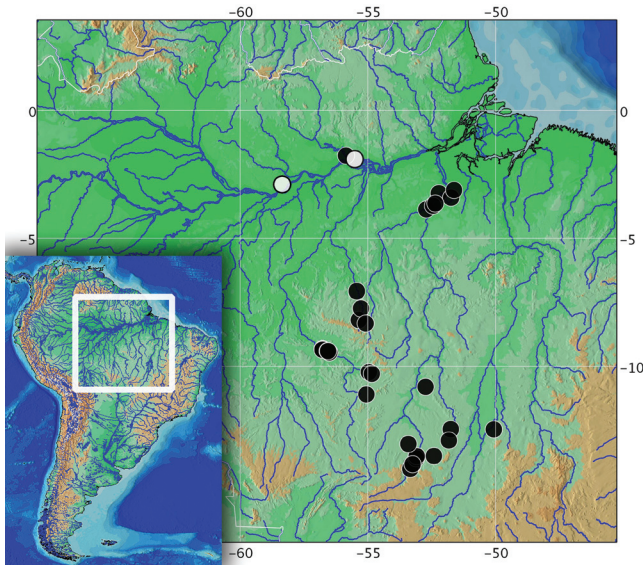
of *Hemigrammus microstomus* remained as MCZ 20840). During this process, the 35 syntypes of *Astyanax multidentis* received the informal number MCZ 21064a, in reference to the other syntype from lago Saraca, catalogued as MCZ 21064. Six of the 35 syntype were then exchanged to USNM (USNM 120244). The others 29 syntypes remained catalogued as MCZ 89559. Thus, the syntypes of *Astyanax multidentis* are MCZ 21064 (1), MCZ 89559 (29) and USNM 12044 (6).

Eigenmann (1927) cited a single specimen (MCZ 20826, Fig. 1c) as “probably identical with” the type specimens of *Astyanax multidentis*. Our examination confirm Eigenmann’s (1927) suggestion that the aforementioned specimen is indeed conspecific with the syntypes of *Astyanax multidentis*.

Examinations of the type series of *Moenkhausia collettii* deposited at the NMW revealed that part of the syntypes from Óbidos (NMW 57382, 5), is conspecific with *Astyanax multidentis*. *Astyanax multidentis* can be promptly distinguished from *Moenkhausia collettii* by having a the middle caudal-fin rays dark (vs. middle caudal-fin rays hyaline), 5 to 7 maxillary teeth (vs. 1 to 3), scales restricted to the base of the caudal fin, along basal one-sixth of upper lobe and basal one-fourth of lower lobe (vs. along one-fourth of the upper lobe and half of the lower lobe) and by the absence of a black line on the anal-fin base (vs. presence). Since the type series of *Moenkhausia collettii* is composed of more than one species, a lectotype designation of that species is in need. However, this is beyond of the scope of the present contribution, as it should be done in a separate study about the taxonomy and distribution of *M. collettii*. Noteworthy to say that Steindachner (1882) described the maxilla as edentulous in the original description of *M. collettii* and also illustrated a specimen with middle caudal-fin rays hyaline, features not present in specimens of *Astyanax multidentis*.



**Fig. 4.** *Astyanax multidentis*, photographed live, MZUSP 91955, ca. 25 mm SL, rio Culuene, tributary of rio Xingu (photo by Leandro Sousa).



**Fig. 5.** Distribution of *Astyanax multidens* in the rio Amazonas basin. White circle represent the type localities.

Although Bertoni (1939) and Fowler (1948) mentioned *Astyanax multidens* for the upper rio Paraguay, their reports are doubtful since the extensive material analyzed from that drainage do not have any specimens of *Astyanax multidens*. Géry (1977: 426) also mentioned *Astyanax multidens*, referring it to his “*Astyanax-paucidens* group”, which also includes other poorly known species such as *A. scintillans* Myers, 1928, *A. guaporensis*, *A. guianensis*, *A. paucidens* (Ulrey, 1894), *A. gracilior* Eigenmann, 1908, *A. kennedyi* Géry, 1964, and *A. essequibensis* Eigenmann, 1909 [= *Jupiaba essequibensis*].

**Material examined. Brazil.** ANSP 191047, 5, 34.2-41.8 mm SL; DZSJRP 12546, 5, 32.4-44.1 mm SL; INPA 33987 5, 33.0-44.3 mm SL; MCP 44598, 5, 31.7-43.3 mm SL; MNRJ 37225, 5, 31.8-43.3 mm SL; MZUSP 96606, 75, 27.3-45.3 mm SL, Mato Grosso, Peixoto de Azevedo, rio Peixoto de Azevedo, tributary of rio Teles Pires, rio Tapajós basin, 10°13'14"S 54°58'2"W. MCZ 21064, 1, 29.9 mm SL, syntypes of *Astyanax multidens* Eigenmann, 1908, “Silva, Lake Saraca” (=Amazonas, lago Saraca at Silves, 2°53'S 58°21'W). MCZ 89559, 29; USNM 120244, 6, 26.1-30.6 mm SL, syntypes of *Astyanax multidens* Eigenmann, 1908, “Óbidos”, (=Amazonas, Óbidos, rio Amazonas, 1°52'S 55°30'W). MCZ 20826, 1, 36.3 mm SL, same data as MCZ 89559. MZUSP 5454, 12, 32.5-37.0 mm SL, Pará, Oriximiná, rio Trombetas basin. MZUSP 52228, 27, 24.8-29.9 mm SL, Tocantins, Sandolândia, rio Água Fria, rio Araguaia basin. MZUSP 74635, 10, 16.2-24.8 mm SL, Mato Grosso, São José do Xingu, rio Preto, tributary of rio Xingu. MZUSP 91706, 23, 16.2-33.9 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu. MZUSP 91215, 2, 21.9 and 25.8 mm SL, Mato Grosso, Bom Jesus do Araguaia, rio Suiazinho, tributary of rio Suiá-Miçu, rio Xingu basin, 12°27'25"S 51°45'35"W. MZUSP 91226, 1, 20.7 mm SL, Mato Grosso, Canarana, rio Sete de Setembro, tributary of rio Xingu, 13°30'19"S 52°24'57"W. MZUSP 91369, 2, 22.3 and 22.7 mm SL, Mato Grosso, Gaúcha do Norte, rio Curisevo, tributary of rio Xingu, 13°2'5"S 53°25'19"W. MZUSP 91738, 2, 25.0 and 25.6 mm SL,

Mato Grosso, Paranatinga, rio Culuene, 13°50'21"S 53°15'13"W. MZUSP 91800, 2, 22.9 and 32.0 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 14°0'32"S 53°20'46"W. MZUSP 91955, 54, 14.9-25.1 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°49'S 53°15'W. MZUSP 94171, 3, 20.4-26.8 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°50'S 53°15'W. MZUSP 94251, 11, 18.5-23.8 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°50'22"S 53°14'59"W. MZUSP 94284, 20, 18.8-24.5 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°35'49"S 53°6'35"W. MZUSP 94339, 46, 17.0-27.4 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°30'51"S 53°5'49"W. MZUSP 94410, 4, 17.0-17.3 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°25'48"S 53°2'24"W. MZUSP 95689, 37, 15.7-26.8 mm SL, Mato Grosso, Paranatinga, ribeirão da Anta, tributary of rio Culuene, rio Xingu basin, 13°30'53"S 53°5'34"W. MZUSP 95954, 2, 30.4 and 31.3 mm SL, Mato Grosso, Itaúba, Teles Pires drainage, tributary of rio Renato, rio Tapajós basin, 11°5'42"S 55°3'54"W. MZUSP 96726, 133, 24.4-39.5 mm SL, 2 cs, 34.4 and 34.8 mm SL, Mato Grosso, Paranaíta, rio Teles Pires, near ferryboat of road MT-416, rio Tapajós basin, 9°27'7"S 56°30'46"W. MZUSP 96727, 88, 25.7-37.7 mm SL, Mato Grosso, Paranaíta, marginal remaining lagoons from mining activities, rio Tapajós basin, 9°25'44"S 56°32'36"W. MZUSP 96730, 26, 31.9-38.9 mm SL, Pará, Jacareacanga, rio Teles Pires downstream of Sete Quedas rapids, rio Tapajós basin, 9°19'1"S 56°46'47"W. MZUSP 96745, 29, 33.1-48.5 mm SL, Mato Grosso, Peixoto de Azevedo, tributary of right margin of rio Peixoto de Azevedo, rio Tapajós basin, 10°17'14"S 54°50'57"W. MZUSP 96907, 43, 19.0-25.9 mm SL, Mato Grosso, Paranatinga, córrego do Lício, tributary of rio Culuene, rio Xingu basin, 13°50'22"S 53°14'59"W. MZUSP 97205, 2, 24.1 and 24.8 mm SL, Pará, Altamira, rio Curuá, tributary of rio Iriri, rio Xingu basin, 8°19'7"S 55°5'23"W. MZUSP 97249, 185, 25.3-52.8 mm SL, 2 cs, 44.2 and 44.3 mm SL, Pará, Novo Progresso, rio Jamanxim, tributary of rio Tapajós, about 30 km from Castelo dos Sonhos, 8°11'4"S 55°21'28"W. MZUSP 97307, 37, 26.6-41.7 mm SL, Pará, Novo Progresso, rio Jamanxim, tributary of rio Tapajós, near village of Mil, 7°43'51"S 55°16'36"W. MZUSP 97407, 13, 22.8-23.5 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu, 13°49'46"S 53°15'6"W. MZUSP 97475, 34, 26.1-33.4 mm SL, Pará, Novo Progresso, rio Jamanxim, tributary of rio Tapajós, at beach near city, 7°3'52"S 55°26'28"W. MZUSP 99600, 31, 17.5-35.8 mm SL, Mato Grosso, Paranaíta, left margin of rio Teles Pires, rio Tapajós basin, 9°27'6"S 56°30'44"W. MZUSP 99818, 8, 21.7-30.0 mm SL, Pará, Jacareacanga, rio Teles Pires, downstream of Sete Quedas rapids, rio Tapajós basin, 9°19'56"S 56°46'33"W. MZUSP 99845, 8, 18.6-24.7 mm SL, Pará, Jacareacanga, rio Teles Pires, downstream of Sete Quedas rapids, rio Tapajós basin, 9°18'42"S 56°46'47"W. MZUSP 99960, 16, 22.1-41.0 mm SL, Pará, Jacareacanga, rio Teles Pires, downstream of Sete Quedas rapids, rio Tapajós basin, 9°20'38"S 56°46'42"W. MZUSP 100037, 11, 20.8-31.7 mm SL, Mato Grosso, Paranaíta, rio Teles Pires, upstream of Sete Quedas rapids, rio Tapajós basin, 9°23'53"S 56°34'37"W. MZUSP 100100 (41, 17.9-26.6 mm SL), Pará, Jacareacanga, rio Teles Pires, upstream of Sete Quedas rapids, rio Tapajós basin, 9°24'5"S 56°33'49"W. MZUSP 104495, 9, 18.0-22.9 mm SL, Mato Grosso, ribeirão Cascalheira, rio Turvo, tributary of rio Suiá-Miçu, rio Xingu basin. MZUSP 110938, 2, 26.3 and 28.6 mm SL, Pará, Altamira, rio Iriri, tributary of rio Xingu, at Cachoeira Grande, 3°52'8"S 52°41'52"W. MZUSP 110939, 68, 21.1-31.5 mm SL, Pará, Altamira, rio Xingu, 3°42'32"S 52°27'11"W. MZUSP 110940, 268, 20.5-30.6 mm SL, Pará, Altamira, rio Xingu, 3°38'14"S



52°21'53"W. MZUSP 110941, 1, 30.9 mm SL, Pará, Altamira, rio Xingu, 3°24'39"S 51°44'50"W. MZUSP 110943, 18, 19.8-29.7 mm SL, Pará, Altamira, rio Xingu, 3°14'12"S 52°13'21"W. NMW 57382, 5, syntypes of *Tetragonopterus collettii* Steindachner, 1882, 27.8-31.0 mm SL, Óbidos.

### Discussion

*Astyanax multidentis* does not belong to Miranda's (2010) *Astyanax* clade for having five to seven maxillary teeth, and thus lacking the unique synapomorphy of that clade (*i.e.*, none or one maxillary teeth). Based on external similarities, *Astyanax multidentis* most closely resembles *A. guaporensis* and *A. guianensis*. The latter two species also possess somewhat diamond-shaped body, two vertically oriented humeral blotch and no dark blotch on caudal peduncle, five or more teeth on maxilla, and relatively few pored scales on lateral line (33 to 36).

Specimens of *Astyanax multidentis* were collected in sandy beaches in the rio Teles Pires and rio Jamaxim in syntopy with specimens of *Jupiaba paranatinga* Netto-Ferreira, Zanata, Birindelli & Sousa (Fig. 6a), and in sandy beaches of the rio Xingu in syntopy with *Jupiaba cf. essequibensis*

Eigenmann (Fig. 6b). The three aforementioned species are very similar in coloration (*e.g.*, dark marking on dorsal and anal fins), body size and shape. However, *Astyanax multidentis* lack all the synapomorphic features of *Jupiaba*, including a modified elongate pelvic bone developed as an anteriorly oriented spine (Zanata, 1997), an antipredatory mechanism (Zanata *et al.*, 2009). Therefore, given the external morphological similarity between the three species, their sympatric occurrence, and their distinct phylogenetic position (considering *Jupiaba* as monophyletic, following Zanata, 1997), we interpret this as a case of Batesian mimicry, comparable to other previously described (Zanata *et al.*, 2009; Zanata & Ohara, 2009).

Three cases of Batesian mimicry including species of *Jupiaba* and a harmless mimetic species were previously reported: *Astyanax anterior* Eigenmann as a mimic of *Jupiaba abramoides* (Eigenmann), *J. anteroides* (Géry) and *J. poranga* Zanata in the rio Tiquié (rio Negro basin) and rio Teles Pires; *Moenkhausia pirauba* Zanata, Birindelli & Moreira as a mimic of *Jupiaba yarina* Zanata and *J. apenima* Zanata in the rio Xingu, rio Tapajós basins (Zanata *et al.*, 2009); and *Moenkhausia* sp. from the rio Madeira basin as a mimic of *Jupiaba citrina* Zanata & Ohara (Zanata & Ohara, 2009). Despite of the high



**Fig. 6.** (a) *Jupiaba paranatinga*, holotype, MZUSP 100855, 37.4 mm SL, rio Teles Pires, tributary of rio Tapajós, (b) *Jupiaba cf. essequibensis*, MZUSP 110952, 36.7 mm SL, rio Xingu; both collected in syntopy with *Astyanax multidentis*.



diversity of the family Characidae, these were the first cases of Batesian mimicry described for the small-sized Characidae. Other cases of Batesian mimicry among Neotropical freshwater fishes involve *Piaractus brachypomus* (Cuvier) and *Pygocentrus cariba* (Humboldt, 1821) (Mago Leccia, 1978), *Corydoras diphyes* Axenrot & Kullander and *Otocinclus mimulus* Axenrot & Kullander, *Corydoras garbei* Ihering and *Otocinclus xakriaba* Schaefer, *Corydoras paleatus* (Jenyns) and *Otocinclus flexilis* Cope and *O. arnoldi* Regan (Axenrot & Kullander, 2003; Lehmann *et al.* 2010), *Brachyrhamdia imitator* Myers and *Corydoras melanisti* Regan (Axenrot & Kullander, 2003).

**Comparative material.** *Jupiaba cf. essequibensis*. **Brazil.** Pará. MZUSP 110952, 11, 34.7-37.4 mm SL, Altamira, rio Xingu, 3°24'39"S 51°44'50"W. *Jupiaba paranatinga*. **Brazil.** Mato Grosso. MZUSP 100855, holotype, 37.4 mm SL, Paranaíta, rio Teles Pires, rio Tapajós basin. MZUSP 95720, 23, 33.0-37.6 mm SL, Paranaíta, rio Teles Pires, rio Tapajós basin. MZUSP 95956, 13, 31.2-33.0 mm SL, Itaúba, rio Teles Pires, rio Tapajós basin. *Astyanax guaporensis*. **Brazil.** Rondônia. FMNH 54709, 38.6 mm SL, holotype of *Astyanax guaporensis* Eigenmann, 1911, rio Guaporé at Maciel, rio Madeira basin. FMNH 54710, 1, 32.0 mm SL, rio Guaporé at Maciel, rio Madeira basin. MZUSP 77888, 1, 30.7 mm SL, Costa Marques, rio Guaporé, rio Madeira basin. *Astyanax guianensis*. **Brazil.** Amapá. MZUSP 104823, 16, 37.4-44.4 mm SL, Laranjal do Jari, rio Jari. **Guyana.** BMNH 1911.10.31.314-8, 5, 32.1-36.5 mm SL, syntypes of *Astyanax guianensis* Eigenmann, 1909, Essequibo river at Warraputa. BMNH 1911.10.31.319-20, 2, 41.8 and 43.3 mm SL, syntypes of *Astyanax guianensis* Eigenmann, 1909, Essequibo river at Warraputa. *Moenkhausia collettii*. **Brazil.** Amapá. MZUSP 73951, 4, 37.7-43.4 mm SL, rio Araguari. Pará. MZUSP 105535, 15, 28.6-36.8 mm SL, Marabá, rio Tocantins, 5°36'47"S 50°26'42"W. Amazonas. NMW 57379, 3, 39.3-50.1 mm SL; NMW 57380, 3, 33.5-48.0 mm SL; NMW 57381, 2, 47.0 and 47.9 mm SL, syntypes of *Tetragonopterus collettii* Steindachner, 1882, Hyavari [= rio Javari, tributary of rio Solimões, 4°21'S 70°2'W].

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