

Five new species of genus *Astyanax* Baird & Girard, 1854 from Rio Iguaçú, Paraná, Brazil (Ostariophysi, Characiformes, Characidae)

Garavello, JC.^{a*} and Sampaio, FAA.^b

^aDepartamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos – UFSCar, Rod. Washington Luís, Km 235, CEP 13565-905, São Carlos, SP, Brazil

^bPrograma de Pós-graduação em Ecologia e Recursos Naturais – PPG-ERN, Universidade Federal de São Carlos – UFSCar, Rod. Washington Luís, Km 235, CEP 13565-905, São Carlos, SP, Brazil

*e-mail: garavelo@ufscar.br

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(With 9 figures)

Abstract

Five new species of the Neotropical characiform genus *Astyanax* Baird & Girard are described from Rio Iguaçú at the border of Paraná and Santa Catarina states, southeastern Brazil and *Astyanax gymnogenis* Eigenmann is redescribed. Each new species can be distinguished from all other *Astyanax* species from the upper Rio Paraná basin by exclusive combinations of: tooth shape, number of dental cuspids, distance between third infraorbital and preopercle, number of lateral line scales, longitudinal series of scales, number of gill-rakers and differences from shape of body and head traits. This study proposes the species of genus *Astyanax* from Rio Iguaçú as probably endemic, since all of them are absent from tributaries of the Rio Paraná hydrographic system. The high degree of diversification acquired by those *Astyanax* species in the Iguaçú basin may perhaps be allied to the long isolation period of this river from the Rio Paraná basin caused by the Iguaçú waterfalls. This barrier probably isolated those basins resulting in original groups of Characiformes and then *Astyanax* species, both isolated from one another and both different from their relatives in neighbouring basins.

Keywords: freshwaterfishes, Ostariophysi, taxonomy, Characidae, *Astyanax*, neotropics.

Cinco novas espécies do gênero *Astyanax* Baird & Girard, 1854 do Rio Iguaçú, Paraná, Brasil (Ostariophysi, Characiformes, Characidae)

Resumo

Cinco novas espécies do gênero *Astyanax* Baird & Girard da bacia do Rio Iguaçú na fronteira do Paraná e Santa Catarina, região sudeste do Brasil são descritas e *Astyanax gymnogenis* Eigenmann é redescrita. Cada nova espécie se diferencia das demais do gênero *Astyanax* na bacia do Rio Paraná por combinações únicas de: forma dos dentes, número de cúspides, distância entre o terceiro infraorbital e o pré-opérculo, contagens de escamas da linha lateral, séries longitudinais de escamas, rastros branquiais e diferenças morfométricas na cabeça e tronco. A bacia do Rio Iguaçú apresenta espécies do gênero *Astyanax*, provavelmente endêmicas, e nenhuma delas ocorrendo nos rios da bacia do Rio Paraná. É discutido, neste artigo, se o elevado endemismo de espécies do gênero *Astyanax* nessa bacia hidrográfica estaria relacionado ao longo período de isolamento causado pelas Cataratas do Iguaçú, que separou o Rio Iguaçú do Rio Paraná no passado geológico, diversificando a ictiofauna de Characiformes e diferenciando-a em relação à da bacia do Rio Paraná.

Palavras-chave: peixes de água doce, Ostariophysi, taxonomia, Characidae, *Astyanax*, neotropical.

1. Introduction

The genus *Astyanax* as defined by Baird and Girard (1854) based on *Astyanax argentatus*, was included as “Characini” fishes with an adipose fin present, characterised by an abdominal line not serrate, double rows of teeth on both jaws, flattened and with several conic spines or processes upon their edge; without canine or palatine teeth, dorsal fin above the pelvic fins and with large scales. The last complete revision of *Astyanax* was published by Eigenmann (1921-1927) and included seventy-four species and subspecies distributed from Rio Grande at the Mexico and United States border to south Brazil, Uruguay and Argentina. Eigenmann diagnosed the genus *Astyanax* as “compressed fishes, more or less elongate, rarely reaching a length of 150 mm SL, usually much smaller, but in one instance, *A. maximus*, reaching 200 mm in length; premaxillary with two series of teeth, the first series with several teeth; mandible with strong teeth in front, abruptly minute conical ones on the sides, without conical teeth in a second series; teeth of second series of premaxillary equal or graduated, usually five in number, four in a few species; crowns of premaxillary and mandibular teeth usually ridged and denticulate; maxillary with a few or no (0-10) teeth; caudal naked; lateral line complete; gill-rakers setiform; no predorsal spine”. After this revision by Eigenmann, only a comprehensive summary by Géry (1977) identified more than 60 species, including synonyms considering new subspecies, in a taxonomic proposal on the basis of Eigenmann’s arrangement. Since Eigenmann’s studies, *Astyanax* is considered one of the most speciose genera of order Characiformes. Recently, Lima et al. (2003) considered the genus *Astyanax* as *Incertae Sedis* and with 85 species.

With reference to the upper Rio Paraná above the former Sete Quedas Falls, six nominal species were described, but according to Garutti and Britski (2000), only four could be recognised: *Astyanax paranahybae* Eigenmann, 1911, *Astyanax scabripinnis paranae* Eigenmann, 1914, *Astyanax schubarti* Britski, 1964 and *Astyanax altiparanae* Garutti & Britski, 2000. They also examined the taxonomic status of *Astyanax trierythropterus* Godoy, 1970 and *Astyanax bipunctialbicaudalis* Godoy, 1977, both from Rio Mogi-Guaçu, and examined references to *Astyanax fasciatus* (Cuvier, 1819) and *Astyanax eigenmanniorum* (Cope, 1894) for Rio Paraná. Azpelicueta et al. (2002) and Casciotta et al. (2003) had described new species for this genus from Rio Paraná, Argentina. From south Brazil, Bertaco and Malabarba (2001) describe two species related to *Astyanax scabripinnis* (Jenyns, 1842), one of them from the headwaters of Rio Uruguay. Melo and Buckup (2006) provide a new name for *Tetragonopterus aeneus* Hensel, 1870.

On the other hand, contributions to systematic of genus *Astyanax* in Rio Iguazu comes from Eigenmann (1911b), who studied the Haseman’s ichthyological collection and describe *Astyanax gymnogenis*, the genus *Psalidodon*, and new species for genera *Hypheobrycon* and *Glandulocauda*.

In 1921 and 1927 Eigenmann also cite *Astyanax scabripinnis paranae* and *Astyanax eigenmanniorum* for Rio Iguazu.

In addition, the high endemism shown by the *Astyanax* species in Rio Iguazu above Iguazu waterfalls, has been recognised since Haseman (1911b), who observed the great diversity of Characiformes from Rio Paraná, when compared to the low number of fish families of this order from Iguazu. The Iguazu waterfalls produce a physical isolation between the rivers Iguazu and Paraná. This fact was used by Haseman to explain the absence of a large number of migratory characiform fish species in Iguazu; however, he did not discuss this matter regarding the *Astyanax* species diversification in this basin.

Fifty years later, Garavello (1977), when describing *Apareiodon vittatus*, examined the question of isolation of Rio Iguazu ichthyofauna, mentioning several undescribed species for *Astyanax* in this basin. Godoy (1979), studying fishes from Segredo reservoir at medium Iguazu, gave a short list of species including a reference to an unidentified *Astyanax* species. Menezes and Géry (1983) contributed with the description of *Oligosarcus longirostris*, observing the restriction of this species to above the Iguazu waterfalls. In 1988, Sampaio (unpublished) revised the specific status of the characiform ichthyofauna of Rio Iguazu, including diagnosis for some undescribed *Astyanax* species. After Sampaio, Severi and Cordeiro (1994) compiling Sampaio, catalogued the same *Astyanax* species as recognised by this last author.

Garavello et al. (1997) provided diagnosis for six species of genus *Astyanax* and made mention to *A. bimaculatus* and *A. gymnogenis* from Rio Iguazu. Following on, Almirón et al. (2002) describe *Astyanax ita* from lower Iguazu next to Argentina. At the present time, *Astyanax totae* has been described from Iguazu headwaters by Haluch and Abilhoa (2005); Abilhoa and Duboc (2007) also described *Astyanax varzeae* from headwaters of Rio Negro, and as a final point, Alcaraz et al. (2009) described *Astyanax jordanensis* from Rio Jordão, all three species described as allied to *Astyanax scabripinnis* (Jenyns, 1842).

In the present study we describe five new species for genus *Astyanax* from Rio Iguazu and redescribe *Astyanax gymnogenis* Eigenmann, remarking the references given to: *Astyanax scabripinnis* and *A. eigenmanniorum* by Eigenmann (1921, 1927); *A. altiparanae* by Graça and Pavanelli (2002), and other references to species of *Astyanax* by Ingenito et al. (2004). The present study also examines the high diversity of *Astyanax* species in the Rio Iguazu and puts forward a discussion on the reasons that might have produced an amount of probably endemic *Astyanax* species at Iguazu, and distinguishes them from their relatives from Rio Paraná.

2. Material and Methods

The specimens used in this study are housed in the following institutions: Museu de Zoologia, Universidade de São Paulo, São Paulo (MZUSP); Museu Nacional, Rio de Janeiro (MNRJ); Museu de História Natural Capão

da Imbuia, Curitiba (MHNCI); Field Museum of Natural History, Chicago (FMNH); Academy of Natural Sciences of Philadelphia, Philadelphia (ANSP); California Academy of Sciences Museum, San Francisco (CAS); Nucleo de Pesquisas em Limnologia, Ictiologia e Aqüicultura, Maringá (NUP) and Laboratório de Ictiologia Sistemática, Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, São Carlos (LISDEBE). Type specimens of all new species of genus *Astyanax* herein described are placed at MZUSP, MHNCI, FMNH, NUP and LISDEBE. Institutional abbreviations follow Leviton et al. (1985), with the addition of Laboratório de Ictiologia Sistemática do Departamento de Ecologia e Biologia Evolutiva da Universidade Federal de São Carlos (LISDEBE) and Núcleo de Pesquisas em Limnologia, Ictiologia e Aqüicultura, Maringá (NUP).

Meristic characters were taken under the stereomicroscope, following basically Fink and Weitzman (1974). All teeth of both arcades were counted, but only those of the left side were considered. The number of unbranched fin rays is indicated by Roman characters, and branched rays by Arabic numerals. Gill-rakers were counted on first left branchial arch. The following counts were taken: 1) Number of teeth on premaxillary; 2) Number of teeth on dentary; 3) Number of teeth on maxillary; 4) Number of scales in lateral line; 5) Number of scales in transversal line; 6) Number of circumpeduncular scale series; 7) Number of dorsal-fin rays; 8) Number of pectoral-fin rays; 9) Number

of pelvic-fin rays; 10) Number of anal-fin rays; 11) Number of caudal fin rays; 12) Number of gill-rakers on first left-side branchial arch. Counts were herein utilised for differential diagnosis of all species.

Measurements from specimens were taken with vernier calipers to nearest millimeter. The following sets of dimensions were taken: 1) Standard length: from tip of snout to base of caudal fin; 2) Head length: from tip of snout to posterior margin of opercle; 3) Snout length: from tip of snout to anterior margin of orbit; 4) Predorsal distance: from tip of snout to anterior base of first dorsal ray; 5) Preanal distance: from tip of snout to base of anal fin insertion; 6) Length of base of adipose fin; 7) Caudal peduncle depth: shorter distance from caudal peduncle; 8) Head depth: taken at occipital region; 9) Body depth: at dorsal fin origin; 10) Orbital diameter: taken horizontally; 11) Interorbital width: taken between eyes; 12) Mouth width: width of lower jaw. Those measurements were useful in meristic comparisons and they are expressed as proportions of body and head length inside diagnosis and in Tables 1, 2 and 3.

Type-material examined: *Astyanax scabripinnis paranae* Eigenmann, *Tetragonopterus eigenmanniorum* Cope, *Astyanax ribeirae* Eigenmann, *Astyanax paranahybae* Eigenmann, *Astyanax gymnogenis* Eigenmann; *Astyanax hasemani* Eigenmann; *Astyanax bimaculatus novae* Eigenmann; *Astyanax bimaculatus paraguayensis* Eigenmann; *Astyanax schubarti* Britski; *Astyanax unicus* Travassos

Table 1. Morphometric and meristic data of *Astyanax gymnogenis* and *Astyanax longirhynchus* stated as percents of SL and HL.

(mm)	<i>Astyanax gymnogenis</i> (n = 14)				<i>Astyanax longirhynchus</i> (n = 16)			
	Holotype	Range	Mean	SD	Holotype	Range	Mean	SD
Standard length (SL)	66.5	138.8-146.5	143.6	3.490	156.9	86.3-186.0	146.6	4.808
Percents of standard length								
Body depth	37.0	35.7-39.0	36.8	1.534	53.6	31.9-39.9	34.9	3.488
Head length	27.0	22.9-25.1	24.0	0.915	41.0	25.6-26.5	26.1	0.419
Predorsal distance	43.0	51.7-54.1	52.7	1.059	72.0	46.2-53.9	49.3	3.301
Pectoral-fin length	18.9	19.6-20.1	19.9	0.204	31.8	17.2-20.4	19.1	1.528
Pelvic-fin length	12.3	15.0-15.3	15.1	0.156	22.2	14.2-18.5	15.5	2.025
Percents of head length (HL)								
Orbital diameter	11.9	24.4-26.1	25.2	0.876	8.0	19.5-26.9	22.5	3.114
Snout length	51.5	26.8-30.4	28.8	1.616	13.3	6.3-16.8	12.1	2.476
Interorbital width	36.6	35.2-37.8	36.9	1.213	10.2	24.9-36.5	30.6	5.259
Maxillary length	26.6	25.3-27.8	26.7	1.040	16.8	38.6-43.4	41.1	2.001
Lower jaw length	28.7	38.7-43.1	41.0	2.112	18.0	40.4-48.3	44.3	3.253
Meristic								
Number of premaxillary teeth in two series	3	2-4 external	3.8	0.500	4	3-4 external	3.6	0.496
	5	5 internal			5	5 internal		
Number of maxillary teeth	2	1-3	1.8	0.957	2	2-3	2.3	0.987
Number of longitudinal series of scales	38	39-41	40	0.816	43	41-44	42.6	0.898
Number of vertical series of scales: upper/lower	6/6	6-7(7)/4-6(5)			7/6	7/6-5		

Table 2. Morphometric and meristic data of *Astyanax minor* and *Astyanax bifasciatus* expressed as percents of SL and HL.

(mm)	<i>Astyanax minor</i> (n = 74)				<i>Astyanax bifasciatus</i> (n = 86)			
	Holotype	Range	Mean	SD	Holotype	Range	Mean	SD
Standard Length (SL)	89.0	60.5-93.8	79.3	6.641	86.0	49.8-125.0	83.4	1.705
Percents of standard length								
Body depth	39.6	35.8-44.9	40.5	2.131	32.1	35.2-42.5	38.5	1.601
Head length	21.9	22.0-25.4	23.3	0.748	20.4	22.6-26.7	24.2	0.832
Predorsal distance	48.6	44.8-55.6	51.5	1.823	44.0	48.4-55.3	50.5	1.178
Pectoral-fin length	19.4	18.6-23.8	21.4	1.159	19.8	20.7-25.7	22.9	0.981
Pelvic-fin length	13.8	14.4-19.7	17.0	1.424	16.6	15.3-19.9	17.4	0.956
Percents of head length (HL)								
Orbital diameter	7.0	31.6-40.9	34.7	1.842	5.8	33.0-41.5	36.2	1.726
Snout length	5.8	21.9-27.8	24.7	1.089	20.8	21.6-28.4	25.3	1.272
Interorbital width	7.2	31.1-40.3	36.1	1.840	7.2	31.7-40.2	35.9	1.786
Maxillary length	6.8	21.3-27.9	24.3	1.189	6.0	22.5-27.5	24.8	1.139
Lower jaw length	5.8	35.4-44.2	39.2	1.812	7.6	33.1-43.4	39.9	1.544
Meristic								
Number of premaxillary teeth in two series	5	4-6 external	5.3	0.528	4	3-6 external	4.1	0.0435
	5	5 internal			5	5 internal		
Number of maxillary teeth	1	0-2	0.9	0.366	1	1-2	1	0.167
Number of longitudinal series of scales	37	36-39	37	0.676	37	36-40	37.5	0.767
Number of vertical series of scales: upper/lower	6/5	6-7(6)/5-6(6)			6/5	6-7/4-6 (5)		

Table 3. Morphometric and meristic data of *Astyanax serratus* and *Astyanax dissimilis* expressed as percents of SL and HL.

(mm)	<i>Astyanax serratus</i> (n = 22)				<i>Astyanax dissimilis</i> (n = 35)			
	Holotype	Range	Mean	SD	Holotype	Range	Mean	SD
Standard length (SL)	85.9	46.5-124.1	91.3	2.026	65.0	30.2-93.0	62.9	1.634
Percents of standard length								
Body depth	23.7	34.2-39.7	36.3	1.797	27.6	32.0-46.9	37.7	3.731
Head length	21.0	20.2-28.8	27.0	1.073	17.4	24.0-27.9	26.1	0.872
Predorsal distance	40.0	49.0-54.5	51.2	1.429	34.0	49.3-54.4	51.6	1.144
Pectoral-fin length	16.9	16.9-21.7	19.8	1.142	14.0	18.0-25.6	22.2	1.594
Pelvic-fin length	14.5	14.5-18.7	16.3	1.110	10.5	13.4-18.9	16.5	1.227
Percents of head length (HL)								
Orbital diameter	5.7	24.1-36.4	28.7	2.749	6.2	28.7-41.9	35.4	3.275
Snout length	6.0	21.2-28.3	25.7	1.606	5.0	22.0-28.2	24.5	1.394
Interorbital width	7.6	35.0-43.9	40.2	2.038	5.5	33.1-39.4	36.0	1.607
Maxillary length	8.6	23.8-30.3	27.4	1.526	6.2	24.3-29.2	26.7	1.097
Lower jaw length	5.9	43.9-48.9	45.9	1.381	4.8	38.8-45.2	41.8	1.572
Meristics								
Number of premaxillary teeth in two series	4	3-5 external	4.0	0.309	4	3-5 external	4.0	0.273
	5	5 internal			5	4-5 internal		
Number of maxillary teeth	1	1-4	2.3	0.716	1	1-3	1.2	0.457
Number of longitudinal series of scales	35	36-40	38.1	1.136	36	36-38	36.6	0.631
Number of vertical series of scales: upper/lower	7/5	7/5-6 (5)			6/5	5-7 (6)/5-6		

and Santos; *Astyanax altiparanae* Garutti and Britski, *Psalidodon gymnodontus* Eigenmann and *Astyanacinus goyanensis* Ribeiro.

3. Systematic Account

3.1. Provisional key for the six species of genus *Astyanax* herein described from Rio Iguaçú, above Iguaçú waterfalls

1. Teeth cusps in internal premaxillary series disposed in a straight line in ventral view; larger dentary teeth tricuspid; a dark brown vertically elongated humeral blotch; usually 6 gill-rakers on first epibranchial and 10-11 on hypobranchial arch (2)

1'. Teeth cusps in internal premaxillary series forming an arch, with a concave frontal surface in ventral view; larger dentary teeth with more than three cusps; humeral dark brown blotch almost circular or slightly horizontally elongated; usually 7-9 gill-rakers on first epibranchial and more than 13 on hypobranchial arch (3)

2. Margin of third infraorbital close to margin of preopercle, leaving a narrow naked area between these bones less than 1/5 of the depth of third infraorbital; teeth in external premaxillary series with only 3 cusps; maxillary bone short, forming a right angle with premaxillary when mouth is closed; a horizontally elongate dark brown caudal spot present

Astyanax gymnogenis Eigenmann

2'. Margin of third infraorbital distant from margin of preopercle, leaving a wide naked area between these bones, varying from 1/5 to 1/3 depth of third infra-orbital; teeth in external premaxillary series usually pentacuspitate; lateral cusps minute in non-symphysal teeth; maxillary bone long, forming an obtuse angle with premaxillary when mouth is closed

Astyanax longirhinus n. sp.

3. Margin of third infraorbital close to margin of preopercle, leaving a nude area between these bones narrower than 1/5 of depth of third infraorbital bone; internal premaxillary series usually 5 or 6 penta or heptacuspitate; humeral blotch narrow, vertically elongate (4)

3'. Margin of third infraorbital bone isolated from preopercle margin by a large nude area, 1/5 or 1/3 of infraorbital depth; usually 4 pentacuspitate teeth on internal premaxillary series; humeral blotch horizontally elongate or inconspicuous; lateral line usually 36 to 39 scales; humeral blotch oval or circular (5)

4. Cusps of non-symphysal teeth in premaxillary internal series in straight line or in slightly concave arch in ventral view; usually more than 2 maxillary teeth; external premaxillary series with 4 to 6 teeth, penta to heptacuspitate; premaxillary internal series with 5 teeth; first branchial arch usually 21 (9 + 13) to 29 (12 + 16) gill-rakers; a brown narrow and vertically elongate humeral blotch

Astyanax minor n. sp.

4'. Cusps of non-symphysal teeth in premaxillary internal series, forming a very concave arch in ventral

view; 1 or 2 maxillary teeth; premaxillary external series 3 to 6 pentacuspitate teeth; premaxillary internal series 4 or 5 pentacuspitate teeth; first branchial arch with 18 (7 + 11) to 23 (10 + 13) gill-rakers; two humeral brown blotches vertically elongated: first with upper portion large, followed by a post-humeral blotch diffuse and inconspicuous

Astyanax bifasciatus n. sp.

5. Humeral dark brown blotch almost oval, with a narrow vertical prolongation; mandible robust; interorbital distance almost one times in SL; bony orbital diameter almost 1.5 times interorbital distance; maxillary usually with 2 teeth; anal fin usually iii,16 or 17; lateral line 38 or 39 scales

Astyanax serratus n. sp.

5'. Humeral blotch light brown, vertically oval; mandible slender; interorbital distance almost 1.5 in SL; bony orbital diameter almost one times in interorbital distance; maxillary usually with 1 teeth; anal fin usually with iii,18 to 20 rays; lateral line usually with 36 or 37 scales

Astyanax dissimilis n. sp.

3.2. *Astyanax gymnogenis* Eigenmann, 1911 (Figures 1 to 3)

Astyanax gymnogenis Eigenmann, 1911:179. Type-locality: Rio Iguaçú, Porto União, Paraná, Brazil;

Astyanax gymnogenis: Fowler, 1948: 51 (ref.); Godoy, 1979: 11 (ref.); Godoy, 1979: 15 Figure 4 (*lapsus calami*); Severi and Cordeiro, 1994: 17 (description translated from Eigenmann, 1911); Garavello et al., 1997: 71 (diagnosis and reference for Rio Iguaçú);

Astyanax scabripinnis paranae Eigenmann, 1927: 314 (in part): 39 paratypes of *Astyanax scabripinnis paranae*:



Figure 1. Lateral view of *Astyanax gymnogenis*, Holotype, FMNH 54707, 66.5 mm SL.



Figure 2. Lateral view of *Astyanax gymnogenis*, Cotype, FMNH 54708, 65.2 mm SL.



Figure 3. Lateral view of *Astyanax gymnogenis* Eigenmann, specimen LISDEBE 2619, 130.0 mm SL.

FMNH 105094, 1; FMNH 105095, 38; FMNH 105096, 1; FMNH 105097, 195 from Serrinha, Rio Iguaçú, J. D. Haseman, 22 Dec 1908 and FMNH 57359, 25, Porto União da Vitória, Rio Iguaçú, inundated margins, swamps and lagoon; Fowler, 1948: 59 (reference, Rio Iguaçú); Godoy, 1979: 11 (reference, Rio Iguaçú).

Astyanax sp. A: Sampaio, 1988 (unpublished: 24 Figure 2); Severi and Cordeiro, 1994:19 (compilation from Sampaio, 1988): Rio Timbó and Rio Iguaçú.

Diagnosis: *Astyanax gymnogenis* can be separated from all other *Astyanax* from Rio Iguaçú by the combination of the following characters: third infraorbital narrow, leaving a broad naked area between its border and preopercle corresponding to approximately one third depth of the bone; 5 premaxillary large teeth in the inner series all in a straight line in ventral view; symphyseal pair bicuspid; maxillary short in relation to premaxillary, with 1 to 3 teeth, forming a right angle with premaxillary when mouth is closed; all other premaxillary (both series) teeth and larger (anterior) dentary teeth tricuspid; first branchial arch with 6 gill-rakers in epibranchial and 10 or 11 in lower branch (ceratobranchial + hypobranchial); presence of a vertically elongated humeral dark brown blotch and a horizontally elongated dark caudal brown spot.

Description: Morphometric and meristic data are available in Table 1. Standard length ranging between 138.8 to 146.5 mm. Body elongate and laterally compressed; greatest body depth: 35.7 to 39 mm, situated slightly anterior to dorsal-fin origin; predorsal profile concave from region just above eye to end of occipital process, convex from this point to dorsal fin origin. Dorsal fin base in a straight line; postdorsal profile slightly convex to adipose fin; ventral profile of head almost straight, strongly convex from pectoral origin to anal fin origin; anal fin base in a straight line. Head length: 22.9 to 25.1 mm. Snout pointed; snout length: 26.8 to 30.4 mm. Mouth small, terminal; upper jaw protrude slightly beyond lower jaw. Lower jaw delicate, length: 38.7 to 43.1 mm. Maxillary wide and long, maxillary length: 25.3 to 27.8 mm, reaching a vertical line through anterior border of pupil, forming a right angle with premaxillary when mouth is closed. Eye small, bony orbital diameter: 24.4 to 26.1 mm. Interorbital distance: 35.2 to 37.8 mm. Third infraorbital narrow, leaving a broad naked area between its posterior margin and preopercle, depth corresponding approximately one third of this

bone. Gill-rakers moderate in size; first branchial arch: 6 rakers in epibranchial and 10-11 in ceratobranchial + hypobranchial.

Premaxillary teeth in two series; external series with: 2-4 tricuspid teeth; internal with 5 teeth; teeth at symphysis bicuspid, others tricuspid. Maxillary with 1-3 teeth; teeth slightly compressed: 1 to 3 cusps. Dentary with 4 large anterior tricuspid teeth, followed ahead with a smaller tricuspid tooth and several minute teeth with 2 or 3 cusps.

Dorsal-fin ii, 8-9. Its origin nearer tip of snout than caudal-fin origin; predorsal distance: 51.7 to 54.1 mm. Pectoral fin i, 12-13. Pectoral fin short, length: 19.6 to 20.1 mm, not reaching pelvic-fin origin, with 3 scales between tip of pectoral fin longest ray and pelvic-fin origin. Pelvic fin i, 7-8 rays, short, 15.0 to 15.3 mm in length, not reaching anal-fin origin; distance between tip of pelvic fin longest ray and anal-fin origin approximately half pectoral-fin length; pelvic-fin origin just anterior to dorsal-fin. Anal-fin: iii, 18-20 rays; origin posterior to vertical through posterior end of dorsal-fin base. No hooks in anal and pelvic-fin rays.

Lateral line 39-41 perforated scales. Scales above lateral line 7; scales below lateral line 5. Longitudinal scale series around caudal peduncle: 16; an axillary scale dorsal to pelvic-fin origin, near one fourth of pelvic-fin length; scale sheath at first third of anal-fin base. Occipital process: 3 scales in each side; predorsal series: 13 scales and preventral scales not forming in regular series.

Color in alcohol: Ground color range from creamy yellow to pale brown; ventral region pale brown with few chromatophores. Chromatophore concentration gradually increases from lateral line to dorsal region. Dorsal region dark, a vertical humeral light brown blotch and a horizontal lateral stripe slightly silvery, inconspicuous and pale at origin, increasingly darker posteriorly fused to caudal spot; caudal spot present at posterior end of caudal-peduncle and base of caudal-fin rays, extending to end of mid caudal-fin rays. Dorsal portion of eye above pupil darkish; pectoral and pelvic fins whitish; dorsal fin slightly darker due to chromatophore concentration; anal fin whitish except its margin; caudal-fin marginate and with higher chromatophore concentration.

Distribution: All specimens from Rio Timbó, medium and lower Rio Iguaçú.

Comments: The specimens from populations of *A. gymnogenis* here studied have some small differences when compared with holotype and cotype. The caudal spot current in fresh collected specimens is absent in holotype; the predorsal region is rounded forming a keel as in cotype but not in holotype; maxillary with 1 to 3 teeth and only 1 maxillary teeth in *A. gymnogenis* holotype. The distance between pectoral and anal-fin origins is greater than distance between anal-fin origins to base of caudal fin. In cotype of *A. gymnogenis* these measurements are equidistant. Also orbital diameter in fresh specimens is narrow than in the specimens of type series.

Eigenmann (1911) described *Astyanax gymnogenis* based on two specimens from Rio Iguaçú at União da Vitória, central border of Paraná and Santa Catarina. It is possible that differences observed between type specimens and the fresh specimens studied are due to allometric growth rates, which could be considered as specific variation of *A. gymnogenis*. Also the poor conservation status of type material may perhaps correspond to upper described deformation.

Otherwise, the examination of paratype series of *Astyanax scabripinnis paranae* deposited in Field Museum (FMNH 54770) from ichthyological material collected by Haseman at Serrinha, Rio Iguaçú, Paraná, revealed that they comprise two species. From them, 39 specimens proved to be pertinent to *Astyanax gymnogenis* and they were separate from the lot FMNH 54770 of *Astyanax scabripinnis paranae* original series receiving numbers: FMNH 105094 (1 specimen) and 105095 (38 specimens). Also lots FMNH 57359 (25), FMNH 105096 (1) and 105097 (195) from Serrinha, and União da Vitória (Porto União), Paraná, revealed to be valid as *Astyanax gymnogenis* Eigenmann. So, those paratypes of *Astyanax scabripinnis paranae* are herein integrated as *Astyanax gymnogenis*, since specimens have tooth arcades and general features which permit the identification of this last species.

Type material examined: Brazil: Paraná: FMNH 54707, Holotype, 66.5 mm SL, Porto União, Haseman, 1908; FMNH 54708, Cotype, 65.2 mm SL, Porto União, Haseman, 1908; FMNH 57359, 25; FMNH 105094, 1; FMNH 105095, 38; FMNH 105096, 1 and 105097, 195 (paratypes of *Astyanax scabripinnis paranae* not measured): Serrinha, Rio Iguaçú, J. D. Haseman, 22 Dec 1908.

Non type material examined: Brazil: Paraná: Quedas do Iguaçú, Rio Iguaçú: LISDEBE 2617, 54, 71.8-144.4 mm SL, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares, and J. C. Soares, 30 Nov-6 Dec 1989; LISDEBE 2618, 7, 75.3-133.1 mm SL, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares and J. C. Soares, 14-17 Jan 1990. Laranjeiras do Sul: Rio Iguaçú: LISDEBE 2619, 33, 74.8-153.1 mm SL, downstream of Salto Santiago dam, between Laranjeiras do Sul and Chopinzinho, J. C. Garavello, A. S. Soares, R. J. Rodrigues, M. J. Weber and M. M. Paschoa, 5-10 Nov 1990; Candi: LISDEBE 2620, 22, 88.0-119.7 mm SL, Candi, Rio Cavernoso, tributary of Rio Iguaçú near Candi, J. C. Garavello and A. S. Soares, 6 Dec 1998; LISDEBE 2621, 1, 132.3 mm SL, Rio Jordão, tributary of Rio Iguaçú, near Estância Santa Clara, J. C. Garavello, 31 Oct/5 Nov 1989. **Santa Catarina:** Porto União: Rio Timbó: LISDEBE 2622, 1, 146.2 mm SL, Rio Timbó tributary of Rio Iguaçú, at 500 m below the rapids, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surhema collectors, 7-9 Jun 1979; LISDEBE 2623, 3, 63.4-75.5 mm SL, Rio Timbó, approximately 500 m below the rapids, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surhema collectors, 12-14 Sept. 1979; LISDEBE 2624, 1, 120.4 mm SL, Rio Timbó, tributary of Rio Iguaçú, Colônia São Pedro, J. C. Garavello and UFSCar collectors, 18-19 Nov 1986.

3.3. *Astyanax longirhinus* new species (Figure 4)

Astyanax sp. G: Garavello et al., 1997: 73 (diagnosis and reference for Rio Iguaçú).

Holotype: MZUSP 105954, 156.9 mm SL, Rio Iguaçú downstream of Salto Santiago dam, between Laranjeiras do Sul and Chopinzinho, Laranjeiras do Sul, Paraná, Brazil. J. C. Garavello, A. S. Soares, R. J. Rodrigues, M. J. Weber and M. M. Paschoa, 5-10 Nov 1990.

Paratypes: Brazil, Paraná: MZUSP 105955, 1, 182.4 mm SL Rio Iguaçú reservoir of Salto Segredo dam, Nupelia collectors, no date; LISDEBE 2599, 1, 118.9 mm SL, same locality and collectors of holotype; FMNH 105094, 1, 103.5 mm SL, Serrinha, Rio Iguaçú, J. D. Haseman, 22 Dec 1908; FMNH 105095, 38, 6.3-103.3 mm SL, Serrinha, Rio Iguaçú, J. D. Haseman, 22 Dec 1908; NUP 10152, 16, 86.3-186 mm SL, Rio Iguaçú, reservoir of Salto Segredo hydroelectric dam, Nupelia collectors, 11 Jan 1994. **Santa Catarina:** MZUSP 105956, 1, 177 mm SL, Porto União, Rio Timbó, tributary of Rio Iguaçú at Colônia São Pedro, J. C. Garavello, A. S. Soares and J. C. Soares, 20-22 Nov 1986; LISDEBE 2598, 4, 120-149.3 mm SL, Porto União, Rio Timbó, tributary of Rio Iguaçú, Colônia São Pedro: J. C. Garavello, A. S. Soares and J. C. Soares, 20-21 Nov 1986; LISDEBE 2600, 3, 142-148 mm SL, Porto União, Rio Timbó, tributary of Rio Iguaçú, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surhema collectors, 12-14 Sept 1979.

Diagnosis: *Astyanax longirhinus* n. sp. can be distinguished from all other *Astyanax* from Rio Iguaçú by combination of following characters: third infraorbital narrow and deep, not in contact with preopercle, leaving an ample naked area between these bones. Teeth of premaxillary series straight; symphyseal teeth of premaxillary internal series and dentary teeth tricuspid; teeth on premaxillary external series usually tricuspid, with lateral cusps minute when pentacuspoid; remaining teeth in premaxillary internal series pentacuspoid. Maxillary bone long, forming an obtuse angle with premaxillary bone when mouth is closed. Dentary large and provided with 4 large tricuspidate, followed by 3-5 tricuspid or pentacuspoid teeth.

Description: Morphometric and meristic data are presented in Table 1. Standard Length ranging between 86.3-186.0 mm. Body moderately high and elongate, laterally compressed; greatest body depth sited just anterior



Figure 4. Lateral view of *Astyanax longirhinus* new species, Holotype, MZUSP 105954, 156.9 mm SL.

to dorsal-fin origin, ranging between 34.4-59.4 mm. Dorsal profile of head almost straight and elongate; predorsal profile slightly convex from occipital process to origin of dorsal-fin; dorsal fin base straight inclined; postdorsal profile slightly convex from dorsal fin insertion to base of caudal peduncle; caudal peduncle elevated; ventral profile slightly convex from anterior lower jaw to anal opening; anal fin base almost straight.

Head length: 22.3-49.3 mm. Snout thin and elongate; snout length: 6.3-16.8 mm. Eyes in adults, as large as one half of snout length; orbital diameter: 6-10.8 mm. Interorbital distance: 6.2-18.0 mm. Mouth terminal; premaxillary horizontally aligned; maxillary long, somewhat inclined and reaching a vertical line through mid-pupil; maxillary bone forming an obtuse angle with premaxillary when mouth is closed; maxillary length range: 8.6-21.4 mm. Lower jaw narrow, dentary weak, elongate, adjusting under the premaxillary; lower jaw length: 9.0-23.6 mm. Third infraorbital not in contact with preopercle and with a naked area, large as 1/3 of infraorbital between them. First branchial arc: 7 gill-rakers in epibranchial and 9 in lower branch (ceratobranchial + hipobranchial).

Premaxillary teeth disposed in two series. External series with 3-4 large tricuspid teeth; internal series with 5 symmetric teeth; teeth in premaxillary internal series and large teeth on dentary tricuspidate; non-symphysal teeth pentacuspate and with the most lateral cusps very minute and inconspicuous. Maxillary with 2-3 small tricuspid compressed teeth with inconspicuous lateral cusps. Dentary with a single series of 4 tricuspidate symphysal teeth, an extra lateral cusps minute when pentacuspate, followed by a variable number of 3-5 cuspidate teeth decreasing in size.

Dorsal-fin ii, 9 rays: 13.5-35 mm in the longest ray; dorsal-fin origin more distal from the tip of snout than the base of caudal fin rays. Pectoral-fin: 17.5-32.0 mm long, not reaching the pelvic fin origin, and covering eighth scales of body when adpressed; i, 11 branched rays. Pelvic fin 1,7 rays: 16.0-27.0 mm long, not reaching anal fin base; situated slightly after the vertical through dorsal fin origin and covering anal opening when adpressed. Anal fin ii (iii), 18-20 rays: 9.5-22.8 mm; anal fin origin at vertical through tip of dorsal fin. No hooks in pelvic and anal fins. Lateral line 41-44 perforated scales; scales above lateral line 7 and under, usually 6. Longitudinal series of scales around caudal peduncle: 16; axillary scale dorsal to origin of pelvic-fin. Scale sheat in base of anterior anal-fin rays. Occipital process covered with 3 scales in each side. Scales of predorsal, postdorsal, preventral and preanal regions not formed in regular series.

Color in alcohol: Ground color creamy yellow; ventral region yellowish, with chromatophore concentration increasing gradually towards dorsal region; dorsal region slight brown with a large dark brown humeral bar vertically running by almost entire body depth; a conspicuous horizontal lateral silvery stripe as large as two series of scales running above lateral line, from posterior opercular region to end of caudal fin. A dark brown fine line running from ending

caudal peduncle to beyond mid caudal fin rays, following the silvery stripe. Pectoral and pelvic fins yellowish; anal fin slightly brown with chromatophores concentrated at margins and membranes of anterior rays; dorsal and caudal fin rays slightly darker than the remaining fin.

Color in life: Ground color slight brown at dorsum, a conspicuous dark brown vertical humeral blotch, and a large horizontal shine metallic silvery bar along lateral line. Abdomen yellow, sometimes orange at caudal fin, which is yellow or especially orange. Dorsal and pelvic fins yellowish; caudal and anal fins rays darker than others.

Etymology: The name *longirhinus* after Latin, *longi* = elongated and Greek, *rhinos* = nose. Meaning: long nose, in allusion to an elongated snout of this species, distinctive in *Astyanax*.

Distribution: This species is only known from medium and lower Iguaçú Basin.

Comments: With reference to Iguaçú species of *Astyanax* herein described, only *Astyanax longirhinus* and *Astyanax gymnoensis* has teeth on internal tooth series of premaxilla forming a straight line. It differs from remaining Iguaçú *Astyanax* species that have teeth of internal tooth series with small cusps forming an arch.

3.4. *Astyanax minor* new species (Figure 5)

Astyanax eigenmanniorum Eigenmann, 1921: 310 (in part): specimens FMNH 54740, 74, from the locality of Rio Iguaçú, Porto União, Santa Catarina, J. D. Haseman, 1908.

Astyanax eigenmanniorum Fowler, 1948: 44 (reference in part, Iguaçú basin).

Astyanax sp. C: Sampaio, 1988 (unpublished: 40, Figure 5); Severi and Cordeiro, 1994: 23 (compilation from Sampaio, 1988: Iguaçú basin); Garavello et al., 1997: 72 (diagnosis and reference for Rio Iguaçú); Ingenito et al., 2004:29 (identification key).

Holotype: MHNCI 3028, 89.0 mm SL, Type-locality: Rio Mato Grande, Águas Claras, Piraquara, Paraná, Brazil, J. C. Ribeiro and A. Matos Prado, Jun 1983.

Paratypes: Brazil, Paraná: MZUSP 105957, 6, 69-85.2 mm SL, São José, dos Pinhais, Rio Iguaçú, marginal ponds, J. C. Garavello and F. A. A. Sampaio, 29 Dec 1984; MZUSP 105958, 4, 15.7-42.9 mm SL, Araucária, ribeirão das Onças at Contenda - Araucária border, N. A. Menezes, S. H. Weitzman and F. A. A. Sampaio, 3 April 1985;



Figure 5. Lateral view of *Astyanax minor* new species, Holotype, MHNCI 3028, 89.0 mm SL.

- MZUSP 105959, 8, 65.0-78.7 mm SL, São José dos Pinhais, flooded marginal pools of Rio Iguaçu, J. C. Garavello and F. A. A. Sampaio, 27 Dec 1984; MHNCI 12333, 16, 63.7-79.3 mm SL, Curitiba, Rio Iguaçu, Parque Regional do Iguaçu, Cerdeira, Silva and J. C. Ribeiro, 28-30 April 1981; MHNCI 3381, 1, 76.5 mm SL, Piraquara, Rio Piraquara, J. C. Ribeiro and Dambros, Aug 1983; MHNCI 12334, 5, 70.9-76.8 mm SL, Piraquara, Rio Itaquí, A. M. Cordeiro and J. C. Ribeiro, 9 Oct 1986; MHNCI 863, 1, 54.4 mm SL, Araucária, Rio Iguaçu, R. Langue and Palmeira, Jun 1960; MHNCI 3034, 1, 50.6 mm SL, Araucária, Rio das Onças, J. C. Ribeiro and A. M. Prado, May 1983; MHNCI 3078, 3085, 3088, 3089, 4, 56.1-61 mm SL, Agudos do Sul, Rio da Várzea, J. C. Ribeiro and A. M. Prado 22 April 1983; MHNCI 12335, 1, 83.5 mm SL, Agudos do Sul, Rio da Várzea, J. C. Ribeiro, A. M. Prado and Dambros, 18 Nov 1983; MHNCI 3096-3098, 3104-3108, 3111, 3113, 3116, 3120, 3122, 3123, 3129, 14, 61.7-78.3 mm SL, Agudos do Sul, Rio da Várzea, Mandirituba, J. C. Ribeiro and A. M. Prado, Jun 1983; MHNCI 12336, 2, 74.4 and 89.1 mm SL, Palmas, Rio Iguaçu, approximately 4-5 km downstream from the confluence with Rio Iratim, W. B. Wosiacki and Germano, 6-12 Jun 1987; MHNCI 12337, 3, 71.2-77.4 mm SL, Pinhão, Rio Iguaçu, near confluence with Rio dos Touros, A. M. Cordeiro and W. B. Wosiacki, 4-10 May 1987; MHNCI 12338 3, 69.2-73.1 mm SL, Araucária, Rio Passauna, J. C. Ribeiro, 23 Sept 1986; MHNCI 12339 1, 61.2 mm SL, Araucária, Rio Passauna, main river, A. M. Cordeiro and J. C. Ribeiro, 30 Nov 1986; LISDEBE 2601, 3, 35.4-85.7 mm SL, Piraquara, Rio Irai, bridge at Encanamento Road, J. C. Garavello and F. A. A. Sampaio, 27 Dec 1984; LISDEBE 2602, 2, 71.9 and 80 mm SL, São José dos Pinhais, Rio Irai, near Encanamento Road, J. C. Garavello and UFSCar collectors, 3 April 1985; LISDEBE, 2603, 2, 27.7 and 37.2 mm SL, riacho Serrinha, Engenheiro Bley, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 12 Nov 1980; LISDEBE 2604, 4, 65.1-72.6 mm SL, Rio Negro, Mafra at Rio Negro border of Santa Catarina, J.C. Garavello and UFSCar collectors, 2 April 1985; LISDEBE 2605, 2, 84.3 and 90 mm SL, União da Vitória, Rio Iguaçu, Surehma, 10-13 Jun 1979; LISDEBE 2606, 171, 66-90 mm SL, São José dos Pinhais, Rio Iguaçu, marginal ponds at Avenida Marechal Floriano Peixoto, in front of the access to Parque Regional do Iguaçu, J. C. Garavello and UFSCar collectors, 27-28 Dec 1984; LISDEBE 2607, 13, 42.4-83.6 mm SL, São José dos Pinhais, Rio Iguaçu, marginal ponds at Avenida das Torres, vicinity of Reserva de Cambuí, J. C. Garavello and UFSCar collectors, 29 Dec 1984; LISDEBE 2608, 1, 78.5 mm SL, Quedas do Iguaçu, Rio Iguaçu, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares and J. C. Soares, 30 Oct/6 Nov 1989; LISDEBE 2609, 4, 79.4-96 mm SL, Quedas do Iguaçu, Rio Iguaçu, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares and J. C. Soares, 14-17 Jan 1990; LISDEBE 2610, 16, 7-81.8 mm SL, Rio Iguaçu, downstream of Salto Santiago dam, Laranjeiras do Sul, J. C. Garavello, A. S. Soares, R. J. Rodrigues, M. J. Weber and M. M. Paschoa, 5-11 Nov 1990; LISDEBE 2611, 2, 32.6-34.5 mm SL, São José dos Pinhais, Rio Irai, tributary of Rio Iguaçu, near the Encanamento Road, J. C. Garavello and F. A. A. Sampaio, 3 April 1985; LISDEBE 2612, 8, 34.8-38.9 mm SL, Curitiba, Rio Irai, on road Curitiba to Paranaguá, km 6, J. C. Garavello, 28 Nov 1981. **Santa Catarina:** FMNH 54740, 74, 28-108. 2 mm SL, Porto União, Rio Iguaçu, J. D. Haseman, 29 Dec 1912; MZUSP 105960, 6, 61.6-70.5 mm SL, Rio Canoinhas, continuation of the Mafra to Itaipópolis highway, km 219, N. A. Menezes, S. H. Weitzman and F. A. A. Sampaio, 2 April 1985; LISDEBE 2613, 1, 93.6 mm SL, Porto União, Rio Timbó, tributary of Rio Iguaçu, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 12-14 Sept 1979; LISDEBE 2614, 6, 78.2-91.4 mm SL, Porto União, Rio Timbó, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surehma collectors. 16-21 Nov 1980; LISDEBE 2615, 3, 64.2-70.3 mm SL, Porto União, Rio Timbó, Colônia São Pedro, J. C. Garavello, J. M. M. Gomes and Surehma collectors, undated; LISDEBE, 2616, 2, 69 and 73.7 mm SL, Porto União, Rio Timbó, tributary of Rio Iguaçu, Colônia São Pedro, J. C. Garavello and F. A. A. Sampaio, 18-21 Nov 1986.
- Diagnosis:** *Astyanax minor* is distinguished from *Astyanax* by combination of following characters: infraorbital 3 deep but not in contact with preopercle, leaving a narrow naked area between its border and preopercle; premaxillary external series with 4-6, usually 5 or 6 pentacuspids or heptacuspids teeth; first branchial arch 9-12, usually 10 rakers in upper branch and 13-16, usually 14 or 15 rakers in lower branch; a narrow and elongated vertical humeral bar.
- Description:** Morphometric and meristic data are presented in Table 2. Standard Length: between 60.5-93.8 mm. Body moderately elongate and laterally compressed. Greatest body depth slightly anterior to dorsal-fin origin: 35.8-44.9 mm; predorsal profile concave or moderately concave at base of occipital process; convex from occipital process to dorsal-fin origin; dorsal-fin base straight inclined; postdorsal profile slightly convex in straight line. Ventral profile convex, forming a continuous line from dentary to anal-fin; anal-fin base, a straight line or little convex.
- Head length: 22.0-25.4 mm. Snout small, delicate and somewhat pointed; snout length: 21.9-27.8 mm, much smaller than eye; orbital diameter: 31.6- 40.9 mm. Mouth small and terminal; maxillary delicate: 21.3-27.9 mm, not reaching a vertical line through mid-pupil. Lower jaw length: 35.4-44.2 mm. Third infraorbital deep but not in contact with preopercle, leaving a narrow naked area between its border and preopercle. Gill-rakers moderate in size; first branchial arch with 9-12, usually 10 rakers in epibranchial, and 13-16, usually 14 rakers in ceratobranchial + hipobranchial.
- Premaxillary teeth armed with two series. External series with 4-6, usually 5 pentacuspids or heptacuspids teeth with the combinations: 5/5, 6/5 and 6/6. Internal series with 5 teeth; teeth at symphysis asymmetric, with 5-6 cusps: proximal cusp very small, second cusp largest, followed by small cusps; other teeth symmetrical or nearly

asymmetrical, with 7-9 cusps; cusps forming an arch with concave frontal surface in ventral view. Maxillary with 0-2, usually 1 heptacuspoid tooth; most frequent combination 1/1, occasionally 1/0, and rarely 2/0, 2/1 or 2/2. Dentary with a single series of 4 large incisors with 7-9 cusps, followed by 2 abruptly smaller pentacuspoid teeth and a variable number of minute usually tricuspoid teeth; teeth slightly asymmetrical due to a slight inclination to distal side and sometimes with an extra cusp on distal region.

Dorsal-fin ii, 8-10 rays; closer to tip of snout than caudal-fin origin. Pectoral-fin i, 10-14 ray; pectoral-fin length: 18.6-23.8 mm, not reaching pelvic-fin origin. Pelvic fin i, 7-8 rays. Pelvic-fin small: 14.4-19.7 mm, not reaching anal-fin origin; pelvic-fin origin slightly anterior to vertical line crossing through the dorsal-fin origin. In males, first through fifth branched rays with hooks on the ventral surface of posterior branch. Anal-fin: iii, 16-23 rays; anal-fin origin posterior to vertical line through the end base of dorsal-fin. Males with posterior unbranched ray and anterior branched rays with hooks. Hooks located on both sides of posterior surface of unbranched ray. Hooks on both sides of posterior main branch and only in posterior surface of branched rays; hooks larger and more numerous on surfaces of anterior branched rays, posterior rays without hooks.

Lateral line 36-39 perforated scales. Scales above lateral line with 6-7, usually 6; scales below lateral line usually 5-6. Longitudinal scale series around caudal peduncle: 15-17, usually 16 scales. An axillary scale located dorsally to pelvic-fin origin. Scale sheath present at anterior anal-fin-rays base. Occipital process with 3 sometimes, 4 scales on each side; scales at predorsal and preanal regions not formed in regular series.

Color in alcohol: Body ground color creamy yellow and ventral region light grey Chromatophore concentrations gradually increase from lateral line to dorsal region. A narrow, vertically elongated brown blotch on humeral region. An inconspicuous horizontal lateral stripe, faint at origin, increases dark to posterior end, where it fuses to a dark caudal spot. Caudal spot present at caudal peduncle and base of caudal-fin rays extending to mid caudal-fin rays to their ends; anal and caudal fin margins darker than rest of fin due to larger chromatophore concentration.

Color in life: Body silvery bright shined with the ventral region almost white; dorsal region slightly darker than the ventral region. A humeral bar vertically elongated a horizontal lateral stripe, and caudal spot much fainter than in preserved specimens. Fins hyaline; dorsal, adipose, caudal, anal, and pelvic fins slightly yellow; pectoral fins colourless.

Etymology: From Latin the name *minor* = small, in allusion to small body size of this species, when compared with remaining species of *Astyanax* from Iguacu basin.

Sexual dimorphism: Anal-fin and pelvic-fin hooks present only in small specimens, only in males to 60.5 mm SL. Females larger than males; snout length and body depth proportionally larger in females; orbital diameter, length of anal, pectoral and pelvic fins larger in males.

Distribution: This species is known only from upper Iguacu basin, found mostly in localities situated upstream of confluence with Rio Jordão.

Comments: Specimens of *Astyanax minor* were also compared with primary types of *Tetragonopterus eigenmanniorum* Cope, (ANSP 21598, 21599-21601 and 21267 and 21268). These two species showed differences on number of scales on lateral line: while *minor* has 36-39 perforated scales in lateral line, *eigenmanniorum* has only 32. With reference to the number of gill-rakers, *A. minor* is a form of *Astyanax* with 24-28 gill-rakers in first branchial arch, while *A. eigenmanniorum* only retains the regular count up for the genus: 15 to 20. Also the specimens identified by Eigenmann (1921: 310, FMNH 54740, 74 specimens from "Porto União, Rio Iguassu, Haseman, 29 Dec 1908") as *A. eigenmanniorum* was examined, and we conclude that those 74 specimens are, in fact, *A. minor*, and they are included in type series of this species herein described. So *A. minor* differ from *A. eigenmanniorum* and the presence of *eigenmanniorum* in the Iguacu basin is here put in doubt, for despite strong collecting efforts, it has never been encountered in this basin.

3.5. *Astyanax bifasciatus* new species (Figure 6)

Astyanax fasciatus (non Cuvier, 1819: 352): Godoy, 1979: 11 (misidentification).

Astyanax sp B: Sampaio, 1988 (unpublished: 29, Figure 3); Severi and Cordeiro, 1994: 21 (compilation from Sampaio, 1988), Iguacu basin; Garavello, Pavanelli and Suzuki, 1997: 72 (diagnosis and reference for Rio Iguacu); Ingenito et al., 2004:29 (identification key).

Holotype: MZUSP 105961, female 86.0 mm SL, type locality: Rio Iguacu, marginal ponds at Avenida das Torres, at side of Reserva do Cambuí, São José dos Pinhais, Paraná, Brazil, J. C. Garavello and F. A. A. Sampaio, 27-29 Dec 1984.

Paratypes: Brazil, Paraná: MZUSP 105962, 25, 66.0-90.5 mm SL; same data as Holotype; MZUSP 105963, 3, 22.0-34.0 mm SL, Rio das Onças, Araucária-Contenda border, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 3 April 1985; MZUSP 105964, 4, 21.5-27 mm SL, Agudos do Sul, Rio da Várzea, Campo do Tenente, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 3 April 1985; MHNCI 3016 and 3022, 2, 55.0-74.3 mm SL, Piraquara, Rio Mato Grande, J. C. Ribeiro and A.



Figure 6. Lateral view of *Astyanax bifasciatus* new species, Paratype, LISDEBE 2645, 115.0 mm SL.

M. Prado, April 1983; MHNCI 12340, 1, 59 mm SL, Curitiba, Rio Iguaçú, Iguaçú, Regional Park, Cerdeira, Silva and J. C. Ribeiro, 28-30 Apr 1981; MHNCI 334 1, 98.3 mm SL, Araucária, Rio Iguaçú, R. Lange, Oct 1953; MHNCI 12341, 1, 70 mm SL, Araucária, Rio Iguaçú, R. Lange and Palmeira, May 1960; MHNCI 12342, 1, 71 mm SL, Agudos do Sul, Rio da Várzea, J. C. Ribeiro, M. Prado and A. Dambros, 18 Nov 1983; MHNCI 12343, 4, 70-78 mm SL, Araucária, Rio Itaquí, A. M. Cordeiro and J. C. Ribeiro, 9 Oct 1986; MHNCI 12344, 5, 86.5-94.5 mm SL, Palmas, Rio Iguaçú, 4-5 km downstream from confluence with Rio Iratim, W. B. Wosiacki and Germano, 6-12 Jun 1987; MHNCI 12345, 7, 84.5-96.6 mm SL, Pinhão, Rio Iguaçú, near confluence with Rio dos Touros, A. M. Cordeiro and W. B. Wosiacki, 4-10 May 1987; LISDEBE 2638, 10, 45.0-95.5 mm SL, Piraquara, Rio Iraí, tributary of Rio Iguaçú, J. C. Garavello, F. A. A. Sampaio and UFSCar collectors, 27 Dec 1984; LISDEBE 2639, 1, 79.5 mm SL, São José dos Pinhais, Rio Iraí tributary of Rio Iguaçú, near Encanamento Road, J. C. Garavello, F. A. A. Sampaio and UFSCar collectors, 3 April 1985; LISDEBE 2643, 58, 75.2-121 mm SL, Quedas do Iguaçú, Rio Iguaçú, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares and J. C. Soares, 30 Oct-6 Nov, 1989; LISDEBE 2644, 25, 93.6-125.0 mm SL, Laranjeiras do Sul, Rio Iguaçú, downstream of Salto Santiago dam between Laranjeiras do Sul and Chopinzinho, J. C. Garavello, A. S. Soares, J. C. Soares, R. J. Rodrigues, M. J. Weber and M. M. Paschoa, 5-10 Nov, 1990; LISDEBE 2645, 47, 72.9-129.2 mm SL, Quedas do Iguaçú, Rio Iguaçú, downstream of Salto Osório dam, J. C. Garavello, A. S. Soares and J. C. Soares, 30 Oct-6 Nov, 1989; LISDEBE, 2646, 7, 66.5-91 mm SL, same data as Holotype LISDEBE 2647, 43, 58.6-92.5 mm SL, São José dos Pinhais, Rio Iguaçú, marginal ponds at Marechal Floriano Peixoto avenue, in front of the access to Parque Regional do Iguaçú, UFSCar collectors, 27 Dec 1984. **Santa Catarina:** MZUSP 105965, 5, 18.5-60.0 mm SL, Mafra, Rio Butiá, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 2 April 1985; MHNCI 142 and 143, 2, 105-109 mm SL, Avencal, Rio Negro, at Mafra-Rio Negro border, R. Lange, Jul 1943; LISDEBE 2640, 11, 71.2-112 mm SL, Rio Negro, near bridge on Highway BR-116, Santa Catarina/Paraná State border, F. A. A. Sampaio, 2 April 1985. Porto União, Colônia São Pedro: LISDEBE 2641, 3, 72.5-107 mm SL, Rio Timbó, approximately 500 m below rapids, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 7-9 Jun 1979; LISDEBE 2642, 3, 82.3-93.3 mm SL, Rio Timbó, tributary of Rio Iguaçú, J. C. Garavello, F. A. A. Sampaio and UFSCar collectors, 18-21 Nov 1986; LISDEBE 2648, 17, 65.5-116.6 mm SL, Rio Timbó, tributary of Rio Iguaçú, J. C. Garavello and UFSCar collectors, 20-21 Nov 1986.

Diagnosis: *Astyanax bifasciatus* can be distinguished from all other *Astyanax* from the Iguaçú basin by the combination of the following characters: infraorbital 3 deep, but not in contact with preopercle, leaving a narrow naked area between border and preopercle; premaxillary external series with 4 (rarely 5) pentacuspoid teeth; non-symphysial

teeth in premaxillary internal series heptacuspoid; vertical humeral bar with dorsal portion much wider than ventral portion; a faint and diffuse "post-humeral" spot; lateral line with 36-40 scales, usually 37 or 38; first branchial arch with 7-9, usually 8, rakers in upper branch and 10-13, usually 12, rakers in lower branch.

Description: Morphometrics and meristics data are presented in Table 2. Standard Length: 49.8-125 mm. Body moderately elongate, compressed laterally. Greatest body depth: 35.2-42.5 mm, slightly anterior to dorsal-fin origin. Predorsal profile convex from occipital process to dorsal-fin origin; base of dorsal-fin almost straight and postdorsal profile almost convex; ventral profile of head forming a continuous curve from lower jaw to pelvic-fin origin; usually straight from ventral fin to anal-fin origin; anal-fin base straight.

Head length: 22.6-26.7 mm. Snout short, snout length: 21.6-28.4 mm, much smaller than eye; orbital diameter 33.0-41.5 mm. Mouth terminal; maxillary long and narrow: 22.5-27.5 mm, reaching a vertical line through mid-pupil. Lower jaw delicate: 33.1-43.4 mm. Third infraorbital large but not in contact with preopercle, leaving a narrow naked area between its border and preopercle. Gill-rakers moderate in size; epibranchial of the first branchial arch: 7-9, usually 8 rakers and 10-13, usually 12 in ceratobranchial + hipobranchial.

Premaxillary teeth in two series; external series with 3-6 pentacuspoid teeth, usually 4; observed combinations: 4/4, 5/4 or 6/4, rare 4/3 or 3/3. Internal series usually with 5 pentacuspoid teeth, rarely 4; teeth at symphysis asymmetric: proximal cusp small, second cusp largest, following cusps gradually smaller; other teeth symmetrical, in ventral view cusps form an arch with concave frontal surface. Maxillary with 0-2, usually 1 pentacuspoid and compressed tooth; observed combinations: 1/1, 1/0 or 2/1. Dentary with a single series of 4 or 5 large pentacuspoid incisors followed by 1 or 2 abruptly smaller pentacuspoid teeth and a variable number of minute teeth with 1 or 2 cusps. Larger teeth symmetrical or slightly asymmetrical; tooth asymmetry due to an extra cusp on distal side or slight inclination to distal side or both.

Dorsal-fin with ii, 9-10 branched rays; dorsal-fin origin usually closer to tip of snout than to caudal-fin origin; pectoral-fin i, 11-14 rays; pectoral-fin length: 20.7-25.7 mm, in smaller specimens pectoral fin reaches or approaches pelvic-fin origin; in larger specimens its tip ends 1 or 2 scales in front of pelvic-fin origin. Pelvic fin short: I, 7-8 rays: 15.3-19.9 mm, reaching anus but not anal-fin origin; its origin slightly anterior to dorsal-fin origin. In males, first through fifth branched rays with slightly antrorse hooks on the ventral surface of posterior branch. Anal-fin: iii, 19-24 rays; anal-fin origin posterior to vertical line drawn ventrally from end of dorsal-fin base. In males, posterior unbranched ray and anterior branched rays with hooks. Hooks on unbranched ray on both sides of posterior surface; hooks on branched rays on both sides of posterior main branch and posterior branch only; anterior branched rays with larger and more numerous hooks; posterior rays

without hook. Anal-fin hooks slightly recurved; smaller and weaker than pelvic-fin hooks.

Lateral line 36-40 perforated scales, usually 37 or 38. Scales above lateral line 6-7; scales below lateral line usually 5, rarely 4 or 6; longitudinal series of scales around caudal peduncle 15 or 16. Axillary scale long, reaching from dorsal to pelvic-fin origin. Scale sheath present at anterior anal-fin-rays base. Occipital process with 3 scales on each side; scales in predorsal, preventral, and preanal regions not in regular series.

Color in alcohol: Ground color of body varying from creamy to whitish; ventral region pale brown with less chromatophore concentration, that gradually increases from lateral line to dorsal region; dorsal region dark with a vertical humeral bar present; its dorsal portion much wider than ventral portion; a faint and diffuse "post-humeral" spot, posterior to humeral bar, at origin of the horizontal lateral stripe. Horizontal stripe inconspicuous at origin, and increasingly darker to posterior end; it fuses to a dark caudal spot; pelvic and anal fins reddish. Caudal spot at caudal peduncle and base of caudal-fin rays, extending to mid caudal-fin rays to their ends.

Color in life: Body silvery, sometimes slightly golden; ventral region pale, almost white; dorsal portion of eye, above pupil, red; the humeral bar, the post-humeral spot and the horizontal lateral stripe, more conspicuous than in preserved specimens. Fins hyaline: dorsal and pectoral fins slightly yellow; caudal fin with a slight orange color; anal-fin and caudal-fin margins slightly darker than remaining fin due to higher chromatophore concentration. Aquarium specimens, when disturbed, fins may acquire stronger color: caudal may reach a reddish color, pelvic fin orange and anal vary from orange, at anterior half to yellow at posterior section.

Etymology: The name *bifasciatus* from Latin *bis* = double and *fascia* = stripe; transverse bars crossing other bars, in allusion to two vertical dark brown bars crossing humeral region.

Sexual dimorphism: Anal and pelvic fin hooks present only in males; smaller specimens (near 49.8 mm SL) also bearing hooks. Females grow larger than males; lower jaw proportionally larger in females; orbital diameter and pelvic-fin length proportionally larger in males.

Distribution: This species is known only from the Iguacu basin with large distribution.

3.6. *Astyanax serratus* new species (Figure 7)

Astyanax sp. D: Sampaio, 1988 (unpublished: 50; Figure 7); Severi and Cordeiro, 1994: 25; figure (compilation from Sampaio, 1988), Rio Iguacu; Garavello, Pavanelli and Suzuki, 1997: 72 (diagnosis and reference for Rio Iguacu); Ingenito et al., 2004:29 (identification key).

Holotype: MHNCI 12346, male 86.0 mm SL, Rio da Várzea, Agudos do Sul, Paraná, Brazil, J. C. Ribeiro, A. M. Prado and A. Dambros, 18 Nov 1983.

Paratypes: **Brazil, Paraná:** MHNCI 12347, 7, 52.0-70.2 mm SL, same data as holotype; MHNCI 12348, 3, 37.5-70.2 mm SL, Curitiba, Rio Barigui (lago Barigui),



Figure 7. Lateral view of *Astyanax serratus* new species, Holotype, MHNCI 12346, 86.0 mm SL.

A. M. Cordeiro and J. C. Ribeiro, 8 Aug 1986; MHNCI 3033, 1, 60.5 mm SL, Araucária, Rio das Onças; J. C. Ribeiro and A. M. Prado, May 1983; MZUSP 105966, 1, 38.8 mm SL, Lapa, Rio dos Patos, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 3 April 1985; LISDEBE 2625, 2, 110.3 and 111.2 mm SL, São Mateus, Rio Iguacu, near the confluence with Rio Potinga, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 8-9 April 1980; LISDEBE 2626, 5, 78.3-107.5 mm SL, Quedas do Iguacu, Rio Iguacu, downstream Salto Osório dam, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 13-15 Nov 1980; **Santa Catarina:** MHNCI 173, 1, 120 mm SL, Rio Negro, Avencal, N. Firigote, Oct 1943; Porto União, Colônia São Pedro: MZUSP 105967, 3, 82.0-100.4 mm SL, Rio Timbó, approximately 500 metres below rapids, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 7-9 Jun 1979; MZUSP 105968, 6, 79.5-108 mm SL, Rio Timbó, approximately 500 metres below rapids, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 12-14 Sept 1979; LISDEBE 2627, 1, 86.5 mm SL, Rio Timbó, approximately 500 metres below rapids, J. C. Garavello, J. M. M. Gomes and Surehma collectors, 16-21 Nov 1979; LISDEBE 2628, 1, 95.5 mm SL, Rio Timbó, tributary of Rio Iguacu, J. C. Garavello and UFSCar collectors, 20-21 Nov 1986.

Diagnosis: *Astyanax serratus* n. sp. can be distinguished from all other *Astyanax* from Iguacu basin by combination of the following characters: infraorbital 3 narrow and deep but not in contact with preopercle, leaving a naked area approximately 1/5 of height between border and preopercle; premaxillary external series with 2-5, usually 4 tricuspid teeth; non-symphysial teeth in premaxillary internal series pentacuspoid; maxillary with 0-4, usually 2 teeth; humeral spot rounded and dark, frequently with a weak and narrow vertical downward prolongation.

Description: Morphometric and meristic data are presented in Table 3. Standard length ranging between: 6.5-124.1 mm. Body elongate, compressed laterally. Greatest body depth: 34.2-39.7 mm, situated slightly anterior to dorsal-fin origin; predorsal profile of head slightly concave to occipital process; convex from occipital process to dorsal-fin origin; base of dorsal-fin almost straight. Postdorsal profile a straight line or slightly convex to caudal peduncle; ventral profile forming a continuous curve from lower jaw to anal-fin origin; anal-fin base almost straight.

Head length: 25.2-28.8 mm. Snout small and short, snout length: 21.2-28.3 mm. Eye small, slightly larger than snout; bony orbital diameter: 24.1-36.4 mm. Mouth small and terminal; maxillary long and narrow, its length: 23.8-30.3 mm, reaching a vertical line through eye pupil. Lower jaw relatively large and robust, its length: 43.9-48.9 mm. Third infraorbital bone narrow and deep but not in contact with preopercle, leaving a naked area between its border and preopercle; width of naked area variable, usually corresponding to 1/5 of height of infraorbital bone. Gill-rakers moderate in size; first branchial arch with: 8-9, usually 8 rakers, in epibranchial and 11-13, usually 12 in ceratobranchial + hipobranchial.

Premaxillary teeth in two series, external series with 2-5 tricuspid teeth, usually 4; observed combinations: 4/4, few 4/3, rare 3/3, 4/2 or 5/4 teeth formulae. Internal series with 5 teeth; teeth at symphysis tetracuspid and asymmetric: proximal cusp small, second cusp largest, and following cusps gradually smaller; other teeth pentacuspid and symmetrical; in ventral view cusps forming an arch with concave frontal surface. Maxillary: 0-4, usually 2 tricuspid teeth; most frequent combination observed: 2/2, few 3/3 or 2/1; dentary with a single series of 4 large pentacuspid incisors sometimes with a small extra cuspid, followed by a variable number of abruptly smaller tricuspid teeth. Larger teeth gradually decreasing in size, but the insertion of second tooth is lower than insertion of third tooth, thus its largest cusp does not reach a line through the largest cusps of symphysal tooth and third tooth.

Dorsal-fin ii, 8-9, usually 9 rays. Dorsal-fin origin normally closer to tip of snout than to caudal-fin origin; pectoral-fin i, 11-13, usually 12 rays; pectoral-fin not reaching pelvic-fin origin; pectoral fin length: 16.9-21.7 mm. Pelvic-fin with i, 6-8, usually 7 rays; pelvic fin small, its length: 14.5-18.7; in smaller specimens pelvic fins reaches anal-fin origin, in larger specimens it reaches the anal pore but not beyond that point; pelvic-fin origin slightly anterior to dorsal-fin origin. In males, branched rays of pelvic-fin with small, slightly antrorse hooks on ventral surface of ray; only one hook per ray-segment. Anal-fin iii, 16-20, usually 16-17 branched rays; anal-fin origin posterior to vertical line through end of dorsal-fin base. In males, posterior unbranched ray and anterior branched rays with small and slightly recurved hooks; hooks on unbranched ray placed on both sides of posterior surface; hooks on both sides of main branch and on posterior branch; hooks larger and more numerous on anterior rays, posterior rays without hooks. Anal-fin hooks smaller and weaker than pelvic-fin hooks; only one hooks for each ray segment.

Lateral line 36-40 perforated scales. Scales above lateral line 6-7; scales below lateral line 5-6; longitudinal series of scales around caudal peduncle 16-20; an axillary scale dorsal to pelvic-fin origin; scale sheath at anterior anal-fin-rays base; origin of caudal fin scaled. Predorsal region usually with a regular series of 11-14 scales; scales in preventral region not forming regular series.

Color in alcohol: Ground color creamy yellow; ventral region pale, with few chromatophores; chromatophore

concentration gradually increases from lateral line to dorsal region. A dark and circular humeral spot sometimes a weak and narrow vertical prolongation; a horizontal lateral stripe inconspicuous and faint at origin and increasingly darker to posterior end, where it fuses to dark caudal spot; lateral stripe with a silvery shine in some specimens Caudal spot extending to tips of mid caudal-fin rays. Pectoral and pelvic fins hyaline and with few chromatophores; dorsal, anal and caudal fins greyish, dark along the fin-membrane, between fin-rays; anterior and marginal regions of anal fin darker than remaining fin.

Color in life: Body silvery; humeral spot faint, sometimes inconspicuous; fins hyaline, sometimes with a slight yellowish tone.

Etymology: The name *serratus* from Latin: *serra*, *serratis* = serrae is given in allusion to numerous fin hooks on pelvic-fin of males, resembling the profile of a serrae.

Sexual dimorphism: Anal and pelvic-fin hooks present only in males; only one male without pelvic-fin hooks; smaller specimens (near 46.4 mm SL) with hooks; females usually larger in SL than males; lower jaw slight larger in females; maxillary bone, orbital diameter, pectoral-fin, pelvic-fin and anal-fin length proportionally larger in males.

Distribution: This species is known only from Rio Iguaçú where it is widely distributed.

3.7. *Astyanax dissimilis* new species (Figure 8)

Astyanax sp. E: Sampaio, 1988 (unpublished: 60 Figure 9); Severi and Cordeiro, 1994: 27 (compilation from Sampaio, 1988), Rio Iguaçú and tributaries; Garavello, Pavanelli and Suzuki, 1997: 73 (diagnosis and reference for Rio Iguaçú); Ingenito et al., 2004:29 (identification key).

Holotype: MZUSP 105969, male 62.8 mm SL, Type locality: Rio Canoinhas, tributary of Rio Iguaçú near the bridge on highway BR 280 from Mafra to Itaiópolis, Canoinhas, Santa Catarina, Brazil; N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 2 April 1985.

Paratypes: Brazil, Santa Catarina: MZUSP 105970, 32, 28.6-74.7 mm SL, same data as holotype; MHNCI 151, 1, 88.6 mm SL, Rio Negro, Avenal, Firigote, October 1943. Porto União, Colônia São Pedro: LISDEBE 2629, 3, 77.5-79.9 mm SL, Rio Timbó, J. C. Garavello, J. M. M.



Figure 8. Lateral view of *Astyanax dissimilis* new species, Holotype, MZUSP 105969, 62.8 mm SL.

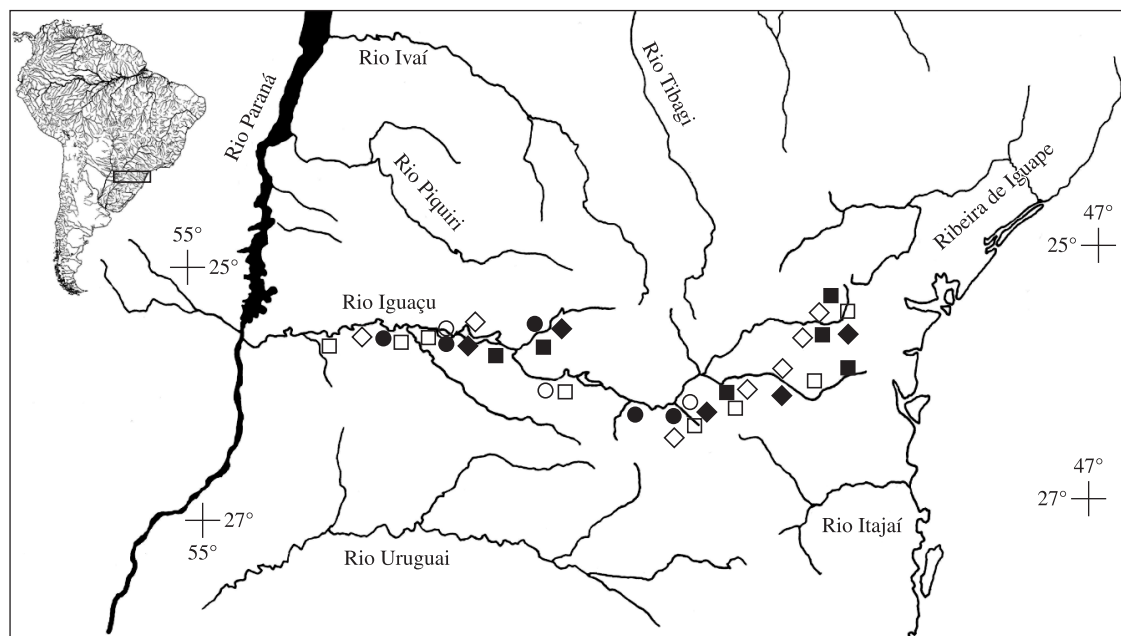


Figure 9. Map of Rio Iguazu drainage, Paraná, Brazil, showing distribution of *Astyanax gymnogenis* (black circle), *Astyanax longirhinus* (white circle), *Astyanax minor* (black square), *Astyanax dissimilis* (white square), *Astyanax serratus* (black diamond) and *Astyanax bifasciatus* (white diamond). Symbols may represent more than one sample. Main rivers: Rio Iguazu; Rio Chopim; Rio Negro and Rio Timbó

Gomes and Surehna collectors, 7-9 Jun 1979; LISDEBE 2630, 15, 76.3-101.1 mm SL, Rio Timbó, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 16-21 Nov 1980; LISDEBE 2631, 2, 64.1-67 mm SL, Rio Timbó, J. C. Garavello, J. M. M. Gomes and Surehna collectors, undated; LISDEBE 2632, 2, 96.3-129.4 mm SL, Rio Timbó, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 12-14 Nov 1979. **Paraná:** MHNCI 3029 and 3030, 2, 86-89.4 m SL, Piraquara: Rio Mato Grande, tributary of Rio Iguazu, Águas Claras, J. C. Ribeiro and A. M. Prado, Jun 1983; MHNCI 3379, 1, 95.9 mm SL, Rio Piraquara, J. C. Ribeiro and A. Dambros, Aug 1983; MHNCI 12349, 3, 63.0-67.7 mm SL, Araucária: Rio Itaquí, A. M. Cordeiro and J. C. Ribeiro, 9 Oct 1980; MHNCI 12350, 1, 74.2 mm SL, Rio Passaúna, A. M. Cordeiro and J. C. Ribeiro, 23 Sept 1986; MHNCI 12351, 1, 49.6 mm SL, Rio Guajuvira, J. C. Ribeiro and A. M. Prado, May 1983; MZUSP 105971, 3, 25.6-55.5 mm SL, Ribeirão das Onças, near road BR 476 at Araucária-Contenda border, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 3 April 1985; LISDEBE 2633, 31, 18.5-32.4 mm SL, Engenheiro Bley, riacho Serrinha, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 12 Nov 1980; MZUSP 105972, 14, 26.9-53.6 mm SL, Lapa, Rio dos Patos tributary of Rio da Várzea near bridge of Road BR 427, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 3 April 1985; Agudos do Sul: MHNCI 12352, 1, 46.8 mm SL, Rio da Várzea, J. C. Ribeiro and A. M. Prado, 22 April 1983; MHNCI 12353, 11, 48.5-93.1 mm SL, Rio da Várzea, J. C. Ribeiro, A. M. Prado and A. Dambros, 18 Nov 1983; MHNCI 3099-3103, 3105, 3109, 3114, 3115, 3117, 3121, 3126, 3128; 3130,

3132, 3133 16, 66.2-79.2 mm SL. Mandirituba: Rio da Várzea, J. C. Ribeiro and A. M. Prado, Jun 1983; MHNCI 3094, 3119, 3120, 3125, 3127, 5, 48.2-49.1 mm SL, Rio da Várzea, Ribeiro and Prado, Jun 1983; LISDEBE 2634, 45, 23.9-69.9 mm SL, ribeirão Vermelho at bridge in BR 116, km 178, Campo do Tenente-Quitandinha border, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 2 April 1985; MZUSP 105973, 3, 63.9-69.8 mm SL, Mafra, Rio Negro, at bridge of BR-116, Paraná and Santa Catarina border, N. A. Menezes, S. Weitzman and F. A. A. Sampaio, 2 April 1985; MHNCI 12354, 1, 98.3 mm SL, Pinhão, Rio Iguazu, near the confluence with Rio dos Touros, A. M. Cordeiro and W. B. Wosiacki, 4-10 May 1987; LISDEBE 2635, 6, 43.5-59.9 mm SL, Porto Lupion, Rio Iguazu, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 15-21 Jun 1979; LISDEBE 2636, 3, 102.9-135.8 mm SL, Quedas do Iguazu downstream of Salto Santiago dam, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 13-15 Nov 1980; LISDEBE 2637, 4, 77.3-99 mm SL, Porto Lupion, Rio Iguazu, J. C. Garavello, J. M. M. Gomes and Surehna collectors, 15-21 Jun 1979; NUP 10151, 5, 69.8-104.1 mm SL, Rio Iguazu, Salto Segredo, Nupelia collectors, 11 Jan 1994.

Diagnosis: *Astyanax dissimilis* n. sp can be separated from all other *Astyanax* from the Iguazu basin by the following combination of characters: infraorbital 3 not in contact with pre-opercle, leaving a naked area corresponding to approximately 1/5-1/4 the height of infraorbital 3; premaxillary external series with 2-5, usually 4 tricuspid teeth; non-symphysal teeth in premaxillary internal series with 5 cusps forming an arch in ventral view; maxillary

with 0-3, usually 1 tooth; faint, narrow and elongate vertical humeral bar present.

Description: Morphometric and meristic data are presented in Table 3. Standard length ranging between 38.2-93.0 mm. Body moderately elongate compressed laterally. Greatest body depth: 32.0-46.9 mm, situated slightly anterior to dorsal fin origin. Dorsal profile varying from straight to slightly concave at head; predorsal profile convex from occipital process to dorsal-fin origin; dorsal-fin insertion straight; postdorsal profile convex; ventral profile forming a continuous and somewhat pronounced curve from anterior lower jaw to anal-fin origin; anal-fin base straight.

Head length: 24.0-27.9 mm. Snout small, snout length: 22.0-28.2 mm. Eyes larger than snout; orbital diameter: 28.7-41.9 mm. Interorbital distance: 33.1-39.4 mm. Mouth terminal; maxillary long and narrow, reaching a vertical line through mid-pupil; maxillary length: 24.3-29.2 mm. Lower jaw delicate, lower-jaw length: 38.8-45.2 mm. Third infraorbital bone not in contact with preopercle; naked area between the two bones variable, usually corresponding to 1/5 to 1/4 of the height of infraorbital bone. Gill-rakers moderate in size; first branchial arch: 7-9, usually 8 rakers in epibranchial, and 11-12 rakers in ceratobranchial + hipobranchial.

Premaxillary teeth disposed in two series. External series: 2-5 tricuspid teeth, normally 4; most observed combinations 4/4 and few 4/3 dental formulae. Internal series: 4-5 teeth, usually 5; teeth at symphysis pentacuspoid and asymmetric: proximal cusp small, second cusp is the largest, following cusps gradually smaller than second; other teeth in internal series pentacuspoid and usually symmetrical but sometimes with one or two extra cusps; in ventral view cusps forming an arch with concave frontal surface. Maxillary: 0-3 teeth, usually one pentacuspoid tooth; most observed combinations: 1/1, few 2/2 and 2/1. Dentary with a single series of 4 large pentacuspoid, sometimes hexacuspoid tooth followed by a variable number of abruptly smaller 3-5 cuspid teeth. Larger teeth gradually decreasing in size but the insertion of second tooth is far below the insertion of third; its largest cusp does not reaching a line through largest cusps of symphyseal and third teeth.

Dorsal-fin ii, 8-9 rays; dorsal-fin origin closer to tip of snout than to caudal fin base. Pectoral-fin: i, 11-13, normally 12 rays. Pectoral-fin not reaching pelvic-fin origin; pectoral-fin length: 18-25.6 mm. Pelvic-fin: i, 6-8, usually 7 rays; pelvic-fin length: 13.4-18.9 mm, not reaching anal-fin origin. Pelvic-fin origin situated slightly anterior to dorsal-fin origin. In approximately 25% of the male specimens examined, branched rays with small conical or slightly antrorse hooks on the ventral surface of ray. Anal-fin: iii, 16-21, usually 18 or 19 rays; anal-fin origin posterior to vertical line through end of dorsal-fin base. In males, posterior unbranched ray and anterior branched rays with small conic or slightly recurved hooks; hooks on unbranched ray situated on both sides of posterior surface of ray; hooks on branched rays located only on both sides of posterior surface of main and posterior

branches; hooks larger and more numerous in anterior branched rays; posterior rays with few minute hooks or without hooks at all.

Lateral line 36-38 perforated scales. Scales above lateral line 5-7, usually 6; scales below lateral line 5-6. Longitudinal series of scales around caudal peduncle: 13-16. An axillary scale dorsal to pelvic-fin origin; scale sheath present at anterior base of anal-fin-rays. Occipital process with 3 scales on each side; predorsal region with usually regular series of 10-12 scales; scales in preventral region not forming regular series.

Color in alcohol: Ground color creamy yellow; ventral region pale, chromatophore concentration gradually increases to dorsal region, dorsal surface of head and mid-dorsal region dark; a faint, narrow and elongated vertical humeral brown bar present. A horizontal lateral brown stripe inconspicuous at origin and increasing dark pigment to posterior end is fused to caudal spot; caudal spot situated on caudal peduncle at base of caudal-fin rays; pectoral and pelvic fins nearly whitish and with few chromatophores; dorsal, anal and caudal-fin margins darker than remaining fins, due to higher chromatophore concentration; caudal-fin grayish.

Color in life: Body silvery; a dark humeral brown spot, a horizontal lateral stripe and an inconspicuous caudal spot; fins membrane hyaline or ranging to yellowish.

Etymology: The name *dissimilis* from the Latin *dissimile* = not similar, given in allusion to differences of this species in relation to the remaining species of *Astyanax* herein described.

Sexual dimorphism: Anal-fin and pelvic-fin hooks observed only on males; 75% of males without pelvic-fin hooks; standard length of smaller specimen with hooks: 38.2 mm. Females usually larger than males; snout, lower jaw, interorbital distance and body depth, comparative larger in females; head length, bony orbital diameter, pectoral-fin, pelvic-fin and anal-fin length proportionally larger in males.

Distribution: This species is known only from Iguaçú basin with wide distribution.

4. Discussion

The five new species of genus *Astyanax* herein described and *A. gymnogenis*, proved to be different from the species currently identified as: *A. paranhybae*, *A. fasciatus*, *A. schubarti*, *A. eigenmanniorum*, *A. scabripinnis paranae* and *A. altiparanae* from the upper Rio Paraná basin. They are also different from *Astyanax ribeirae* from Xiririca, Rio Ribeira de Iguape and from *A. ita*, *A. totae*, *A. varzea* and *A. jordanensis* from Rio Iguaçú. The combination of dental structure; number of scales of lateral, transversal, predorsal and preanal series; number of rays of pelvic and anal fins; number of gill-rakers and some body proportions, are responsible for exclusive diagnosis to those Iguaçú species of genus *Astyanax*.

Astyanax longirhinus, *A. bifasciatus*, *A. serratus*, *A. minor*, *A. dissimilis* and *A. gymnogenis* has the internal premaxillary

series of five large teeth on each half premaxillary ramus, a character of historic value to recognize species of genus *Astyanax*. With exception of few anomalous specimens of *A. dissimilis* here studied that have four teeth, the remaining species always showed those five regular teeth on this series in Iguaçú *Astyanax*.

On the other hand, these five large teeth on this series in *A. gymnogenis* and *A. longirhinus* have three cusps straight aligned in the ventral view. *A. minor*, *A. bifasciatus*, *A. serratus* and *A. dissimilis* has this series with penta, hexa or heptacuspids teeth in variable arrangements. Those last species have cusps from each teeth disposed in a semicircle, forming the anterior rim of each teeth. Outside of Iguaçú, this character is shared with *A. scabripinnis paranae*, *A. fasciatus*, *A. schubarti*, *A. altiparanae* and *A. eigenmanniorum* from the upper Rio Paraná basin. A similar arrangement of these teeth cusps was also observed in holotype of *Astyanax paranahybae*. Weitzman and Vari (1986) first described this teeth arrangement in *Astyanax scologaster* from the Rio Negro, Amazon. On the other hand, *A. ribeirae* has penta or hexacuspids teeth with cusps not forming an arch as in species herein discussed.

The external large premaxillary teeth series did not shown the same constancy in teeth counts as internal series, varying in number of teeth and cusps for almost all studied species. *A. gymnogenis* and *A. longirhinus* has 3 or 4 large teeth (2 in few specimens) with three cusps, except for a few specimens of *A. longirhinus* that showed an additional and inconspicuous pair of lateral cusps on inner teeth of this series.

In addition, the dentary teeth of all species exhibit four large teeth on each side, followed by small teeth abruptly reduced in size and decreasing regularly to inner part of bone. This is another important character for diagnosing *Astyanax*, as described by Eigenmann (1921) and discussed by Gery et al. (1996). The symphyseal pair of dentary teeth in *A. gymnogenis* and *A. longirhinus* is large and tricuspidate. *A. minor*, *A. bifasciatus*, *A. dissimilis* and *A. serratus* always showed this large pair of dentary teeth with more than three cusps. Also the species from upper Rio Paraná basin and *A. ribeirae* has this last configuration in their dentary teeth.

An examination of *Astyanacinus goyanensis* Ribeiro paratypes that has a minimum of eight teeth on each maxillary branch, permits a sure diagnosis for all Iguaçú *Astyanax* herein described. Also, the species from the upper Paraná basin, *A. fasciatus*, *A. schubarti*, *A. paranahybae*, *A. eigenmanniorum* and *A. scabripinnis paranae*, always showed more than one tooth on the maxillary bone. *A. altiparanae* as described by Garutti and Britski (2000), have maxillary teeth absent. *A. gymnogenis* and *A. longirhinus* has tricuspid maxillary teeth, similar to that from premaxillary ramus; *A. bifasciatus* and *A. serratus* has pentacuspids maxillary teeth, contrasting with the hexa and heptacuspids maxillary teeth respectively display by *A. dissimilis* and *A. minor*.

The new Iguaçú species and *A. gymnogenis* also showed some variation related to the size of the third infraorbital

bone. As assumed by Weitzman and Vari (1986) with *Astyanax scologaster*, which has infraorbitals not in contact with the sensory tube of preopercle, the infraorbital bones were described as a complete series for genus *Astyanax*. So, *A. longirhinus*, *A. dissimilis* and *A. serratus* has the third infraorbital narrow and distant from preopercle, with a large nude area near 1/5 to 1/3 of infraorbital depth. Otherwise, *A. gymnogenis* has a narrow nude area less than 1/5 of infraorbital depth between these bones that is similar in *A. minor* and *A. bifasciatus*.

The gill-rakers, with the exception of *A. gymnogenis* and *A. longirhinus*, remained moderate in size and in low counts. It was always counted at the first left branchial arch, registering usually 6 in the epibranchial and 10 (11) in lower branch (ceratobranchial + hipobranchial), carrying a total of 16 (17) gill-rakers on each first arch. On the other hand, *A. minor* with 9 (10) on the epibranchial and 13 (14) on lower branch, is distinguished from the remaining species by their large counts, 22-24 gill-rakers on first branchial arch. *A. bifasciatus* with: 7 (8) and 10 (11-12), total of 17 to 20 gill-rakers; *A. serratus*: 8 and 11 (12) and *A. dissimilis*: 7 (8) and 11 (12) also sum 17 to 20 gill-rakers. So, only *A. gymnogenis* and *A. longirhinus* have low number of gill-rakers, contrasting with *A. serratus*, *A. bifasciatus*, *A. dissimilis* and *A. minor*.

The dorsal fin with ii, 8 (9) rays remained constant for all species and it seems to be a pattern for dorsal-fin rays count for all *Astyanax* species from Rio Paraná basin. Pectoral-fin rays varies from i, 12 (13) rays, showing a conservative pattern for all species of *Astyanax* studied. Pelvic-fin with i, 7 (8) rays was verified for all species that always repeat this formulae. The anal-fin rays varied from iii, 16-20 in *A. gymnogenis* and *A. longirhinus* to iii, 16-23 in *A. minor*; iii, 19-24 in *A. bifasciatus* and iii, 16-24 in *A. serratus* and *A. dissimilis*.

Small hooks on rays of anal-fin are described from males of *A. minor* on posterior unbranched and anterior branched rays. Also, male of *A. bifasciatus* have hooks on posterior unbranched ray and on both sides of anterior branched rays of anal fin. Small and recurved hooks were also encountered on male anal-fin near to posterior margin of unbranched ray and both sides of anterior branched rays in *A. serratus* and *A. dissimilis*. On the other hand, no hooks were found on male anal-fin rays of *A. gymnogenis* and *A. longirhinus*. Those hooks on the anal-fin of these species perform the sexual dimorphism current in species of genus *Astyanax* as a whole.

Scales in lateral line varied from: 36-40 in *A. bifasciatus* to 36-38 (39) in *A. serratus*, *A. minor* and *A. dissimilis*. The species *A. gymnogenis* have 38, (39)-40 (41) and *A. longirhinus*: 41-44 scales in lateral line. The transversal scale series varied from 6 (7) series above and 5 series under lateral line. Caudal peduncle with 16 circumpeduncular series was coincident in all species studied. Other Iguaçú species as *A. ita* include 34-36 scales on lateral line; 4.5/1/6 series of scales on transversal line, while *A. totae* have 34-38 scales on lateral line and 6/1/4 series on transversal line. *A. varzeae* comprise 37-42 scales on lateral line and 6/1/5

series of scales on transversal line, while *A. jordanensis* have 35-38 scales on lateral line and 5-6/5 scale series on transversal line. All those last species was described as very similar to *A. scabripinnis*. They may be easily distinguished from the Iguaçú species here described by the combination of scale counts and tooth structure. The teeth structure in *A. ita* is characterised by the presence of penta to heptacuspidate teeth on each premaxillary and dentary, while *A. totae*, *A. varzeae* and *A. jordanensis* exhibit tri to pentacuspid teeth on premaxillary and dentary ramus.

The color pattern of Iguaçú *Astyanax* includes species with ground color ranging from whitish with belly silvery or hyaline, to creamy-yellow and reddish abdominal region. This reddish ground color pattern was registered mainly in the reproductive period when fishes receive strong melanin apport, well defining their differences in coloration. With the exception of *A. serratus*, no other studied species showed a color pattern including an almost circular or oval humeral dark blotch like *A. altiparanae* from the upper Rio Paraná basin. While *A. longirhinus* and *A. gymnogenis* showed patterns of creamy-yellow with an elongated vertical dark brown bar on the humeral region, *A. bifasciatus* joined orange reddish ground color of their bodies with an evident humeral vertically elongated dark blotch and a second vertical dark brown blotch, sometimes inconspicuous. *A. minor* and *A. dissimilis* on the contrary, show a bright silvery or hyaline coloration common to the majority of *Astyanax* species.

This study revealed *A. gymnogenis* and five new species as probably endemic from the Rio Iguaçú basin. Haseman (1911b) was the first author to discuss derivation of Iguaçú ichthyofauna. He assumed that the Iguaçú waterfalls were old and the current ichthyofauna of Paraná and La Plata river basins and thus, the ichthyofauna of Rio Iguaçú, were not apt to overtake the Iguaçú falls.

The possible endemism showed by *Astyanax* species from Iguaçú is here considered, in relation to their congeners from the upper Rio Paraná basin. Besides evidence coming from the recognised geographical events associated with the isolation occurring since the beginning of the Iguaçú falls, the exchange of ichthyofauna, mainly in headwaters, was assumed by Weitzman et al. (1988). They check the combination of stream capture events taken from upper land areas of Rio Iguaçú, and fluctuation of sea level affecting some lower coastal regions in the past. Furthermore, they posit these facts as the main factors to explain sympatry for *Mimagoniates microlepis* and *M. lateralis* in this area.

Several arrangements of near species from the same genus, sharing different isolated basins in southeastern Brazil, could be considered in this discussion. For example, *Mimagoniates microlepis* and *M. lateralis*; *Corydoras barbatus* and *C. paleatus* as cited by Weitzman et al. (1988); *Oligosarcus longirostris* from Iguaçú and *Oligosarcus* species from southeastern Brazil as discussed by Menezes (1988); *Apareiodon vittatus* from Iguaçú and *A. piracicabae* from upper Rio Paraná as studied by Garavello (1977), and the giant species *Steindachneridion melanodermatum* from

Rio Iguaçú and their relatives in southeastern Brazilian basins as assumed by Garavello (2005).

In view of the recognised allopatry on Tetragonopterinae species in these southeastern basins as considered by Weitzman et al. (1988), and in view of shared ancestors in old flood valleys of the continental shell on the Brazilian coast, we may suggest that the same might have taken place near *Astyanax* species from Rio Iguaçú.

At the present time, the Iguaçú *Astyanax* show similar species in isolated coastal rivers, especially in the Rio Ribeira de Iguape. In fact, the examination of type material of *Astyanax ribeirae* revealed it is similar to *Astyanax minor* herein described. *A. ribeirae* and *A. minor* have an elevated number of tooth cusps and a high number of anal-fin rays: 24-25 (*A. minor*) and 26-28 (*A. ribeirae* - holotype). So, we may assume that ancestral forms of Iguaçú *Astyanax* might be retained from other isolated earlier neighbouring basins in the past.

Other important information from recent palynological studies on Cenozoic deposits of sediment from Tremembé formation, Taubaté, São Paulo needs to be considered. Those sample stratum were redated, advancing to an Oligocenic age by Lima et al. (1985). The Characiform fishes found at this Oligocenic deposit are, according to Malabarba (1998), *Megacheirodon unicus*, *Brycon avus*, *Lignobrycon ligniticus* and *Cyphocharax mosesi*. The question is: those species represent modern lineages of characins? If so, the endemism of Rio Iguaçú *Astyanax*, as with the modern lineages of Characiform fishes, were probably established in this basin earlier than the isolation arising from the formation of the Iguaçú waterfalls.

Consequently, it is plausible to suspect that Tetragonopterinae ichthyofauna that remain isolated at Rio Iguaçú arose from modern species derived in isolation and perhaps gave origin to the *Astyanax* lineage herein described. If this is correct, it is important to understand that this scenario of endemism for *Astyanax* species in Iguaçú is a general event, probably derived from other geographic episodes distinct from pure dispersion.

On the other hand, as indicated by Petri and Fulgoro (1983), the juvenile aspect of several geological regions of Rio Iguaçú, probably shows tectonic reactivation of several "breaks" along the basin. According to these authors, it may produce isolated amounts of water in some discontinuous regions, producing compartmentalisation. If these water supplies have existed for a long time, as Bigarella and Salamuni (1957) observe for the Curitiba basin, many environmental changes might have taken place throughout the Iguaçú basin in the past. Compartmentalizations perhaps brought about dramatic effects on ichthyofauna by introducing significant modifications on the habitat structure. In fact, fishes with reproductive migratory movements could be strongly affected, originating in the simplification of ichthyofauna, as recognised by Lowe McConnell (1975), an event that has always taken place when compartmentalisation occurs.

The evidence of compartmentalisation in Rio Iguaçú is corroborated by other recent descriptions of *Astyanax*

species in this basin, as assumed by: Almiron et al. (2002), Haluch and Abilhoa (2005), Abilhoa and Duboc (2007) and Alcaraz et al. (2009). Some of these species are restricted to headwaters, Haluch and Abilhoa and Abilhoa and Duboc observe, when describing *A. totae* and *A. varzea*. Other species are most frequent at median and low regions of this basin, such as *A. ita*, described by Almiron et al., which seems to be restricted to downwaters of the Iguaçú basin.

This fact may perhaps also explain the slight differences in size of orbital diameter in *Astyanax gymnogenis* populations herein studied in relation to type specimens and samples from other localities. Those populations may perhaps remain in isolation during recent geological times. Consequently, it will not be a surprise if other undescribed *Astyanax* species, derived from isolated populations, are perhaps discovered from other regions of Iguaçú. Furthermore, the major result of compartmentalisation in Iguaçú seems to be the effect on local differentiation of isolated populations, followed by continuing speciation through the basin as a whole. To finalise, a conclusion on this subject would only be possible when perhaps phylogeny of Tetragonopterinae genera in the area could be put forth.

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