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Astyanax biotae, a new species of stream fish from the Rio Paranapanema basin, upper Rio Paraná system, southeastern Brazil (Ostariophysi: Characiformes: Characidae)

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Abstract.—*Astyanax biotae,* a new species of characid, is described from a first-order stream in the Rio Paranapanema basin, upper Rio Paraná system, in the interior of the state of Paraná, southeastern Brazil. The species differs from its congeners in that region in a combination of morphometric and pigmentary features.

Resumo.—*Astyanax biotae,* uma nova espécie de caracídeo é descrita de um riacho de primeira ordem da bacia do Rio Paranapanema, sistema do Alto Rio Paraná, interior do Estado do Paraná, sudeste do Brasil. A espécie descrita difere das demais espécies do gênero *Astyanax* ocorrentes na mesma região por uma combinação de caracteres morfométricos e pigmentares.

Astyanax Baird & Girard includes nearly 90 nominal species of neotropical characid fishes distributed from the southwestern United States to Argentina (Lima et al. 2003:106). The numerous nominal species assigned to *Astyanax,* in conjunction with the lack of a comprehensive treatment of the genus subsequent to Eigenmann (1921, 1927), often makes the identification of species problematic. Furthermore, *Astyanax* as now delimited is likely non-monophyletic, and various species encompassed in the genus as traditionally defined (i.e., characids with two rows of teeth in the upper jaw and with the inner tooth row consisting of five teeth) have been generically reassigned in recent years (e.g., Zanata 1997).

This uncertainty applies even in regions such as the upper Rio Paraná that until recently had been thought to be well known ichthyologically. Evidence from a series of fish groups (Britski & Langeani 1988; Menezes 1988; Vari 1988; Weitzman et al. 1988; Langeani 1990; Menezes 1996a, 1996b; Castro & Casatti 1997) demonstrates that the Rio Paraná system upstream from the now submerged Sete Quedas Falls is an area of endemism (see Castro et al. 2003), a phenomenon likely correlated with the formidable barrier to fish migration presented, until recently, by those falls. The numerous streams and headwaters that contribute to the large rivers of this system are inhabited primarily by fish species of small body sizes (mostly less than 12 cm in standard length). Such small-sized species constitute at least 50% of the described freshwater fish species of South America and typically demonstrate a high degree of geographic endemism (Castro 1999). Such species are highly dependent on riparian vegetation for food, shelter, and reproduction (see Böhlke et al. 1978; Lowe-McConnell 1987), but those habitats are threatened by a number of anthropogenic activities, most notably deforestation and the extensive use

of fertilizers and pesticides in intensive agricultural practices (see Lowe-McConnell 1975, 1987; Menezes et al. 1990; Sabino & Castro 1990; Araújo Lima et al. 1995; Castro & Menezes 1998).

The lacunae in our understanding of the fish diversity within the upper Rio Paraná basin and the possibility of extirpation of as-yet unrecognized species is clearly demonstrated by the species of *Astyanax* in that basin. In their comprehensive overview of the then-known species of *Astyanax* in the upper Rio Paraná basin, Garuti and Britski (2000) recognized seven species of the genus within that river system. Nonetheless, recent collecting efforts in that basin revealed at least two undescribed species of *Astyanax,* one of which is known only from a narrow first-order stream running through a narrow gallery forest that is a remnant of the originally widespread subtropical mesophytic forest of that region. This species, which may be in danger of extinction, is described herein.

Material and Methods

Measurements are given as proportions of standard length (SL) except for subunits of the head that are presented as proportions of head length. Lateral-line scale counts include all pored scales along that series, including scales posterior to the hypural joint. In fin-ray counts, lower-case Roman numerals indicate unbranched rays, and Arabic numerals indicate branched rays. The last anal-fin rays that are joined at the base were counted as one element. Counts for the holotype are indicated in square brackets in the text. Measurements were made following the methods outlined in Fink & Weitzman (1974:1–2) with the addition of head height measured at the vertical at the base of the supraoccipital spine. Cleared and stained specimens were prepared following a modification of the method outlined by Taylor & Van Dyke (1985). Vertebral counts include the four vertebrae associated with the Weberian apparatus.

Stomach contents were analyzed on eight specimens (37.5 to 52.5 mm SL) using the methods of frequency of occurrence and percent composition described by Bowen (1992) and Hynes (1950), respectively. The food items were grouped in broad taxonomic or ecological categories reflecting their origins, with aquatic insects and algae considered autochthonous and terrestrial insects, arachnids, and vascular plants allochthonous.

The following institutional abbreviations are used: LIRP—Laboratório de Ictiologia de Ribeirão Preto, Departamento de Biologia da Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, Brazil; MZUSP—Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil; and USNM—National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.

Astyanax biotae, new species
Fig. 1, Table 1

Astyanax sp. 2. Castro et al., 2003:13, 20, 21, fig. 6.6 [Brazil, Paraná, Rio Paranapanema basin; ecology].

Holotype.—LIRP 4009, 49.8 mm SL; Brazil, Paraná State, upper Rio Paraná system, Rio Paranapanema basin, Município de Diamante do Norte, Fazenda Água Mole, Córrego Água Mole (22°38′31.7″S, 52°48′59.0″W); collected by Ricardo M. C. Castro, Hertz F. Santos, Ricardo C. Benine, Katiane M. Ferreira, and Flávio C. T. Lima, 7 August 2000 (station PPA029).

Paratypes.—LIRP 2734, 15 specimens, 27.5–52.3 mm SL; LIRP 4021, 2 cleared and stained specimens, 51.3–52.5 mm SL; USNM 373492, 15 specimens, 31.2–52.2 mm SL; MZUSP 79807, 10 specimens, 32.4–45.6 mm SL; LIRP 4276, 34 specimens, 33.0–47.4 mm SL; collected with holotype.

Diagnosis.—*Astyanax biotae* is readily distinguished from all congeners in the upper Rio Paraná basin in having the terminus

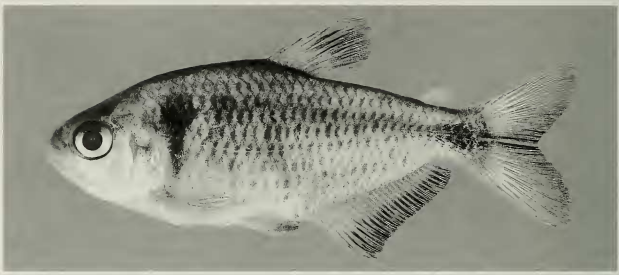

Fig. 1. *Astyanax biotae,* new species, holotype, LIRP 4009, 49.8 mm SL. Brazil, Paraná, upper Rio Paraná system, Rio Paranapanema basin, Município de Diamante do Norte, Fazenda Água Mole, Córrego Água Mole (22°38′31.7″S, 2°48′59.0″W).

of the base of the dorsal fin situated along the vertical through the base of the first or second branched anal-fin ray, versus through the origin of the anal fin (*A. fasciatus, A. trierythropterus*) or in the area of the vent (*A. altiparanae, A.* cf. *eigemanniorum, A. paranahybae, A. scabripinnis,* and *A. schubarti*). Furthermore, *A. biotae* has a distinct overall reticulate pattern formed by dark pigmentation on the exposed portion of the scales versus the lack of such a pigmentation pattern in all of the

Table 1.—Morphometric values for holotype and 30 paratypes of *Astyanax biota.* Standard length is expressed in millimeters; measurements 1–15 as percentages of standard length; 16–21 as percentages of head length.

	Holotype	Paratypes	Mean	*SD*
Standard length	49.8	27.5–52.3	44.20	6.11
1. Greatest body depth	34.7	34.7–41.8	38.68	1.83
2. Snout to dorsal-fin origin	54.5	50.4–56.9	53.86	1.32
3. Length of base of dorsal fin	13.3	12.3–15.1	13.55	0.69
4. Posterior terminus of dorsal fin to adipose fin	24.5	19.3–24.5	22.92	1.30
5. Posterior terminus of dorsal fin to caudal-fin base	38.4	35.6–41.9	37.39	1.30
6. Snout to origin of pelvic fin	49.6	45.7–49.8	48.33	0.98
7. Snout to anus	60.0	54.6–61.3	58.35	1.63
8. Snout to origin of anal fin	65.1	61.4–66.8	64.07	1.44
9. Length of base of anal fin	31.6	29.1–39.6	32.09	1.95
10. Length of caudal peduncle	10.4	9.4–12.8	11.31	1.29
11. Length of longest dorsal-fin ray	27.3	26.8–30.8	28.21	1.19
12. Length of first pectoral-fin ray	21.3	19.2–24.4	22.01	1.25
13. Length of first pelvic-fin ray	16.5	16.0–19.2	17.44	0.82
14. Least depth of caudal peduncle	12.0	10.9–13.7	12.40	0.55
15. Head length	27.7	25.4–28.7	27.23	0.86
16. Head height	94.2	94.2–113.5	102.15	4.40
17. Snout length	26.8	23.5–29.3	25.86	1.53
18. Gape width	29.0	26.3–34.8	30.59	1.88
19. Orbital diameter	31.9	31.9–40.0	34.85	2.17
20. Postorbital head length	42.8	35.1–43.6	39.72	2.13
21. Interorbital width	37.0	34.8–40.9	38.12	1.70

other species of *Astyanax* that occur in the upper Rio Paraná basin. *Astyanax biotae* and *A. paranahybae* can also be distinguished by the difference in their relative body heights (approximately 35–42% of SL versus 25%, respectively).

Description.—Morphometrics of holotype and paratypes presented in Table 1. Body relatively deep, less so in individuals of less than 30 mm SL; greatest body depth located along vertical through insertion of pelvic fin. Dorsal profile of head distinctly convex from margin of upper lip to vertical through posterior nostril, straight to very slightly convex from that point to tip of supraoccipital spine. Dorsal profile of body slightly to moderately convex from rear of head to origin of dorsal fin, straight and posteroventrally slanted along base of dorsal fin, straight to slightly convex from posterior terminus of base of dorsal fin to adipose fin, and slightly concave along caudal peduncle. Slight middorsal ridge present along predorsal region of body. Body transversely rounded overall dorsally, but somewhat flattened middorsally between posterior terminus of base of dorsal fin and adipose fin. Ventral profile of head strongly convex anteriorly and then slightly convex as far as vertical through posterior margin of eye. Ventral profile of body convex to insertion of pelvic fin, nearly straight but slightly posteroventrally aligned from that point to origin of anal fin, straight to slightly convex and posterodorsally slanted along base of anal fin, straight to slightly concave along caudal peduncle.

Head obtusely rounded anteriorly in lateral profile; mouth terminal, albeit very slightly upturned. Upper jaw with maxilla distinctly posteroventrally angled and extending under orbit as far as vertical through anterior margin of pupil. Nostrils of each side very close together; anterior opening circular, posterior crescent-shaped. Eye relatively large and without distinct adipose eyelid. Median fronto-parietal fontanel extending from mesethmoid to supraoccipital spine; width of fontanel approximately one-fourth of interorbital distance. Infraorbital series complete with third infraorbital by far the largest. All infraorbitals carrying laterosensory canal segments proximate to inner margin of orbital rim. Supraorbital absent. Branchiostegal rays four. Gill-rakers long and setiform; 6+1+11 rakers on outermost gill-arch of 52.5 mm SL cleared and stained specimen.

Description of dentition based on two cleared and stained specimens. Teeth on premaxilla in two rows, with teeth of inner row larger. Inner row with five teeth. Symphyseal tooth of inner series quadricuspid and more elongate than other teeth. Second tooth more massive and pentacuspid. Remaining teeth pentacuspid, with third and fourth teeth somewhat smaller than second tooth, and fifth tooth distinctly smaller than all other teeth in series. Outer row of teeth on premaxilla consisting of four tricuspid teeth arranged in regular series with size of teeth gradually decreasing laterally. Fourth tooth of outer tooth row separated from third tooth by distance twice that separating other teeth of series. Maxilla with single tricuspid or pentacuspid tooth. Dentary with eight to 10 teeth. Anterior five dentary teeth pentacuspid and arranged in single row. First four dentary teeth massive and followed by much smaller fifth tooth. Anterior five dentary teeth followed by gap and then three to five very small, elongate, conical teeth.

Scales cycloid, relatively large, and firmly implanted. Lateral line decurved anteriorly and then nearly straight along midlateral line, completely pored from supracleithrum to base of caudal fin and followed by apparently unossified tubular extension running along membrane between middle rays of caudal fin. Lateral line scales 32 to 35 [34]; scales in transverse series from origin of dorsal fin to lateral line 6 or 7 [6]; scales in transverse series from insertion of pelvic fin to lateral line 4 or 5 [4]; scales in transverse series from origin of anal fin to lateral line 4 or 5 [5]; scales along middorsal line between tip of supraoccipital

process and origin of dorsal fin 10 to 14 [11]; scales along mid-dorsal line between posterior termination of base of dorsal fin and adipose fin 8 to 11 [9]; horizontal scale rows around caudal peduncle 13 to 15 [14].

Vertebrae 32(3), 33 (17), or 34 (7) [33].

Dorsal-fin rays ii,9 [ii,9]; anal-fin rays ii to iv,22 to 26 [iii,24]; total number of anal-fin rays 24 to 30 [28]; pectoral-fin rays i,10 to 12 [i,12]; pelvic-fin rays typically i,7, with i,6 in three specimens, and i,4 in both fins in one apparently anomalous individual [i,7]; some specimens with anteriorly directed hooks on dorsal surface of pelvic-fin rays in adpressed fin; principal caudal-fin rays 10/9 [10/9].

Dorsal-fin margin distally rounded to slightly truncate; first unbranched ray approximately 40% length of second unbranched ray. Dorsal-fin origin situated at vertical approximately at middle of SL. Origin of adipose fin located slightly anterior of vertical through posterior terminus of base of anal fin. Pectoral fin relatively well developed, profile distinctly acute in adpressed fin. Tip of pectoral fin extending to, or falling slightly short of, vertical through insertion of pelvic fin. Profile of expanded pelvic fin pointed, with lateral rays longest. Insertion of pelvic fin located distinctly anterior to vertical through origin of dorsal fin. Tip of adpressed pelvic fin extending to origin of anal fin. Distal margin of anal fin ranging from somewhat concave to straight, with third unbranched and first and second branched rays longest and subequal or first through third branched rays longest; subsequent branched rays gradually decreasing in length. Caudal fin forked with lobes rounded.

Color in life.—Description based on color transparencies of live holotype (see also Castro et al., 2003:fig 6.6). Overall coloration silvery-brownish with silvery highlights on scales, particularly in abdominal region. Basal region of exposed portions of scales darker, particularly along regions slightly dorsal of midlateral line. Iris, anteroventral portions of infraorbital region, lower jaw, and ventral regions of head silvery. Iris with green highlights. Dark pigmentation as in preserved specimens.

Coloration in alcohol.—Overall ground color of specimens fixed in formalin yellowish-brown on body, with guanine still present on ventral portion of head and on abdomen. Snout and dorsal portion of head relatively dark. Middorsal and immediately adjoining portions of body dark. Distinct, ventrally attenuated humeral spot extending from approximately two scales ventral of dorsal midline to about one scale dorsal of horizontal through insertion of pectoral fin. Scales of lateral surface of body posterior of humeral mark with dark pigmentation field on exposed portion of each scale. Dark spots forming irregular, discontinuous dark stripe along midlateral surface of body. Caudal peduncle with distinct, anteriorly-attenuating, dark mark.

Dorsal, anal, and caudal fins with interradial membranes covered with small dark chromatophores. Dorsal fin with dark pigmentation on interradials more prominent on distal one-half of central rays of fins, particularly in larger individuals. Dark pigmentation on caudal fin particularly well developed along middle rays of fin. Anal fin with dark pigmentation distinctly more developed on distal half of fin in some individuals; otherwise pigmentation of uniform intensity across fin. Adipose fin often freckled with small dark spots. Pectoral and pelvic fins with small dark spots along fin-ray margins and on membranes.

Etymology.—The species name, *biotae*, is in recognition of the important pioneering role of the "BIOTA/FAPESP—The Virtual Biodiversity Institute Program" (www.biota.org.br/) in the inventory, conservation, and sustainable use of the biodiversity resources of the State of São Paulo, Brazil. This special research program of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) supported the collecting efforts that yielded all known specimens of the species.

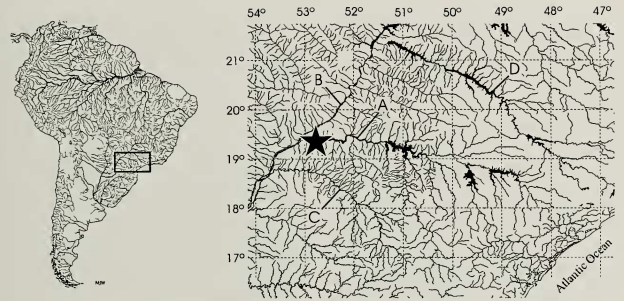

Fig. 2. Map of the upper Rio Paraná basin showing type locality for *Astyanax biotae* (star) and major river systems in the basin; A = Rio Paranapanema; B = Rio Paraná, C = Rio Uruguay, D = Rio Tietê.

Common name.—Brazil, Paraná, Diamante do Norte: "Lambari" a name also generically applied to all other species of *Astyanax* and other small characids in southeastern Brazil.

Distribution.—Known only from the type locality in the region called the Pontal do Paranapanema.

Ecology.–The sample of *Astyanax biota* was collected during the winter dry season in the Córrego Água Mole (see Castro et al. 2003:fig. 5.6), a first-order stream running through a narrow, not very dense gallery forest within an extensive cattle grazing area, at an elevation of approximately 300 m above sea level. This location lies within what was originally an extensive subtropical mesophytic forest in southern and southeastern Brazil (Huek & Seibert 1981). The width of the stream varied between 0.7–1.0 m and the depth between 0.17–0.40 m, with a current speed of approximately 0.2 $m.s^{-1}$. The marginal vegetation was dominated by grasses of the family Cyperacea (*Fimbristylis* sp.) and ferns (Pterydophyta) of the family Polypodiaceae. Water temperature was 18.6°C; pH 8.7; dissolved oxygen 10.6 $mg.l^{-1}$; conductivity 17 $S.cm^{-1}$; and horizontal water transparency 0.4 m.

Collecting efforts along an 100 m long stretch of the stream yielded seven fish species in addition to *Astyanax biotae*: *Callichthys callichthys, Corydoras aeneus, Crenicichla britskii, Gymnotus* cf. *inaequilabiatus, Gymnotus* cf. *sylvius, Rhamdia quelen,* and *Phalloceros caudimaculatus. Astyanax biotae* was the most abundant species in the sample (approximately 70% of the 110 specimens in the sample) and the second largest contributor to the fish biomass (approximately 31% of the total collected fish biomass) after *Rhamdia quelen* (approximately 53%). These values clearly indicate the ecological importance of *Astyanax biotae* at this site.

Although our food analysis results are derived from a single collecting event, the stomach content analysis of eight individuals (37.5 to 52.5 mm SL; one with an empty stomach) clearly demonstrates that *Astyanax biotae* feeds primarily on arthropods (approximately 80% of the diet composition), with debris and seeds of vascular plants (approximately 15%) and filamentous algae (approximately 6%) significantly

less important in the diet. Aquatic insects (mostly aquatic larvae of the Chironomidae followed in order by aquatic larvae of the aquatic Coleoptera, aquatic larvae of the Plecoptera and Trichoptera (equal amounts of each), nymphs of the Ephemeroptera, naiads of the Odonata, and a single adult of the aquatic Hemiptera) and terrestrial insects (primarily worker ants, Formicidae; followed by worker termites, Isoptera, and adult terrestrial Coleoptera) account for approximately 30% of the ingested arthropods, followed by distinctly lower numbers of arachnids (mostly spiders, Aranae, and a pseudoscorpion). Overall, approximately 55% of the items in the stomachs of *A. biotae* were allochthonous and 45% were autochthonous, a clear indication of the importance of the riparian vegetation as a food source for this species of *Astyanax.* One of the examined specimens, a 52.5 mm SL female (USNM 373492) with a greatly distended abdomen was found to contain approximately 350 roundish, well-developed, deep yellow oocytes 0.7–0.8 mm in diameter.

Comparative material examined.—*Astyanax altiparanae,* LIRP 35, 126 specimens, 43.0–80.1 mm SL; USNM 373491, 10 specimens, 41.1–79.9 mm SL. *Astyanax* cf. *eigenmanniorum,* LIRP 3401, 10 specimens, 55.0–70.8 mm SL; USNM 373495, 10 specimens, 48.5–68.3 mm SL. *Astyanax fasciatus,* LIRP 32, 28 specimens, 42.0–93.5 mm SL; USNM 373493, 10 specimens, 45.7–83.8 mm SL. *Astyanax schubarti,* MZUSP 4263, holotype, 82.9 mm SL; MZUSP 4264, 1 paratype, 90.4 mm SL. *Astyanax scabripinnis,* LIRP 124, 562 specimens, 19.1–75.0 mm SL; USNM 373494, 10 specimens, 36.5–74.8 mm SL. *Astyanax trierythriopterus,* LIRP 2017, 138 specimens, 26.3–41.2 mm SL; USNM 373496, 10 specimens, 27.8–41.1 mm SL.

Acknowledgments

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