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A new species of annual fish, *Hypsolebias tocantinensis* sp.n. (Cyprinodontiformes: Rivulidae) from the rio Tocantins basin, northeastern Brazil

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Abstract

Hypsolebias tocantinensis n. sp. is described from a temporary pool located in the rio Tocantins basin, Maranhão state Brazil. *Hypsolebias tocantinensis* belongs the *H. flammeus* species-group. It is the first occurrence of genus *Hypsolebias* in Maranhão state. This new species differs from all other species of that group, except *Hypsolebias flammeus* (Costa, 1989), *Hypsolebias multiradiatus* (Costa & Brasil, 1994) and *Hypsolebias brunoi* (Costa, 2003), by male color pattern and by the presence of a metallic blue sheen surrounding the black spots in the female. It differs from *H. flammeus*, *H. multiradiatus* and *H. brunoi* by the shape of the dorsal and anal fins (rounded vs. pointed) and by the orientation of the reddish brown bars in males (diagonal vs. vertical). *Hypsolebias tocantinensis* differs from all other *Hypsolebias* by the presence of, in females, irregular light brown stains on the anal fins and by the pattern of the metallic blue sheen around the black spots (completely surrounding the black spots while in congeners this blue sheen is either absent or present in vertical bars).

Key words: Annual fishes, Neotropical region, temporary pools

Introduction

The systematics of *Simpsonichthys* has substantially changed in the last few years (Costa 1995, 1998, 2006, 2007, 2010). After a phylogenetic analysis based on 116 characters, Costa in 2006 proposed four new taxa as subgenera of *Simpsonichthys* Carvalho, 1959: *Simpsonichthys*, *Hypsolebias*, *Xenurolebias* and *Ophthalmolebias*. *Spectrolebias* Costa & Nielsen, 1997 was also proposed as a subgenus, breaking *Simpsonichthys* into five sub divisions. In 2010 Costa elevated all five subgenera to genus status.

The genus *Hypsolebias* contains four monophyletic groups of species: the *H. notatus* species-group, the *H. magnificus* species-group, the *H. antenori* species-group, and the *H. flammeus* species-group with 42 species currently described (Costa 2012), *Hypsolebias* is now the largest genus of South American annual fishes. They are considered annual fish for living in temporary habitats and resisting desiccation by laying their eggs on the substratum. Annual fish are unique in the fact that their eggs develop very slowly and can go through up to three diapauses, depending on genetic and environmental factors (Myers 1952; Wourms 1972).

Hypsolebias can be found in the Brazilian Cerrado and Caatinga habitats, primarily in the rio São Francisco basin, but with a few species in the rio Jaguaribe and rio Tocantins basins (northeastern Brazil). The species described herein belongs to the *Hypsolebias flammeus* species-group. According to Costa (2007), the *Hypsolebias flammeus* species-group is distinguished from the remaining groups of *Hypsolebias* in having a long posterior process of the supraoccipital (vs. short) and elongated anal fin in females (vs. short).

There are currently eight species described in this group: *Hypsolebias alternatus* (Costa & Brasil, 1994) from temporary pool close to the rio Paracatu, *Hypsolebias brunoi* (Costa, 2003), from the rio Canabrava floodplains,

Hypsolebias delucai (Costa, 2003), from a temporary pool close to the rio Urucuia, *Hypsolebias fasciatus* (Costa & Brasil, 2006), from temporary pools close to the rio Preto (all within the rio São Francisco basin), *Hypsolebias flammeus* (Costa, 1989), from a swamp in the confluence of the rio Bezera and rio Paranã, *Hypsolebias marginatus* (Costa & Brasil, 1996), from a temporary pool near the rio Patos, a tributary of rio Maranhão, *Hypsolebias multiradiatus* (Costa & Brasil, 1994), from temporary pool close to rio Tocantins (all in the rio Tocantins basin), and finally *Hypsolebias longignatus* (Costa 2008), from the floodplains of the rio Pacoti, an isolated coastal drainage of northeastern Brazil.

This group has the widest distribution among the *Hypsolebias* species-groups, with species being found along the tributaries of the upper rio São Francisco basin, and upper and middle rio Tocantins basin. The only exception being *S. longignatus*, found in the rio Pacoti, which is an isolated coastal drainage of northeastern Brazil. The new species herein described is the first *Hypsolebias* found in Maranhão State, in the mid rio Tocantins, in a transitional habitat between the Cerrado (savanna) and the Amazon rain forest, and is by far the most isolated species in the group, found 570 km in a straight line from its closet congener, *H. multiradiatus*. Detailed morphological analyses revealed that these samples belong to a new species that is described herein.

Material and Methods

Measurements were taken point-to-point under a stereomicroscope with a digital caliper to the nearest 0.01mm, on the left side of the specimen whenever possible following Costa (1995, 2007). Measurements are expressed as percentages of standard length (SL), except subunits of the head, which are recorded as percentages of head length (HL).

In the description, each count is followed by its frequency between parentheses. Counts for the holotype are indicated by asterisks. Counts of vertebrae and pleural ribs were taken from radiographs of the holotype and two female paratypes. Terminology for frontal squamation follows Hoedeman (1958) and Costa (2006). For vertebral counts the caudal compound centrum was counted as a single element. Osteological features included in the description are those considered phylogenetically informative by recent studies on *Simpsonichthys* (Costa 2003, 2007). Institutional abbreviations follow Sabaj-Pérez (2010), with addition of UNITAU (Universidade de Taubaté). Comparative material of other rivulids examined in the present study is listed in Costa (2007).

Hypsolebias tocantinensis, new species

(Figs. 1 and 2; Table 1).

Holotype. Deposited at Universidade de Campinas, Campinas, São Paulo, Brazil. (ZUEC 7019) male 38.2mm SL: Brazil, Maranhão, Campestre do Maranhão, temporary pool near rio Lajeado, rio Tocantins basin, 06°-05'-12.43"S, 047°-22'-54.01" W, altitude 133m, 01 April 2011. Col. Arsênio Caldeira Baptista Junior and João Carlos da Cruz.

Paratypes. Deposited at Universidade de Campinas, Campinas, São Paulo, Brazil. (ZUEC 7020), 1 male (37.4mm SL), 7 females (27.7–31.1mm SL), collected with the holotype.

Diagnosis. *Hypsolebias tocantinensis* differs from the remaining species of the *H. flammeus* species-group, except from *H. multiradiatus*, *H. flammeus* (Fig.3), and *H. brunoi* (Fig.4), by the male body color pattern, with reddish brown bars alternating in a bright blue background, by the male's anal fin being bright blue (*vs.* pale yellow or brownish red), and by the presence of a metallic blue sheen surrounding the female's black spots (*vs.* absence of such a pattern). *Hypsolebias tocantinensis* differs from all other *Hypsolebias* by the presence of short extensions in male dorsal and anal fin rays, starting at the 15th ray in the dorsal fin and 7th ray in the anal fin (*vs.* no ray extensions or long extensions in all rays). *Hypsolebias tocantinensis* is unique among the Cynolebiasini by having irregular light brown markings on the female anal fin. Additionally, *H. tocantinensis* differs from *H. flammeus*, *H. multiradiatus* and *H. brunoi* by the angle of the reddish brown bars on the body of the male. Whereas *H. flammeus*, *H. multiradiatus* and *H. brunoi* have vertical bars, in *H. tocantinensis* the bars are slightly diagonal, approximately 15° from vertical.

Description. Morphometric data presented in Table 1. Largest specimen examined 38.25mm SL. Body relatively deep, compressed, greatest body depth at level of pelvic fin base. Snout blunt. Urogenital papilla cylindrical and very short in males, pocket-shaped in females. Dorsal profile convex from snout to end of dorsal fin base, slightly concave or straight on caudal peduncle. Ventral profile convex from lower jaw to the end of anal fin base, nearly straight on caudal peduncle. Eyes positioned on upper portion of side of head.

TABLE 1. Morphometric and Meristic data for the holotype (H) and paratypes of *Hypsolebias tocantinensis*.

	H		Paratypes
	Male	Male n=1	Females n=7
Standard length (mm)	38.2	37.4	27.7–31.2
Percents of standard length			
Body depth	35.3	30.5	25.9–29.9
Caudal peduncle depth	13.0	11.7	10.5–12.2
Pre-dorsal length	44.7	42.7	53.9–60.4
Pre-pelvic length	43.0	39.3	45.8–49.9
Length of dorsal-fin base	38.5	35.3	21.2–24.2
Length of anal-fin base	34.8	35.3	21.8–25.6
Caudal-fin length	28.1	26.7	25.2–28.8
Pectoral-fin length	21.5	24.2	19.2–21.8
Pelvic-fin length	8.3	9.6	8.8–10.8
Head length	29.4	28.3	25.6–29.1
Percents of head length			
Head depth	84.4	92.4	90.1–94.9
Head width	63.2	61.6	60.0–68.2
Snout length	11.9	11.2	11.2–14.1
Lower jaw length	18.1	16.0	15.0–18.7
Eye diameter	27.9	23.6	30.5–33.1
Counts			
Dorsal fin	20	19	13–15
Caudal fin	21	26	21–23
Anal fin	22	21	17–19
Pelvic fin	6	6	6
Pectoral fin	14	14	12–13
Meristic			
Scales in longitudinal series	25	25	24–25
Scales in transversal series	13	12	11
Horizontal scales around caudal peduncle	13	12	13

Tip of dorsal and anal fin rounded in males and females. Short filamentous ray extensions from 15th ray on dorsal fin and 7th ray on anal fin in males; filaments absent in females.

Dorsal and anal fin unbranched in males and females. Caudal fin rounded. Pectoral fin elliptical. Posterior margin of each pectoral fin reaching vertical through base of fifth or sixth anal-fin ray in males, and between pelvic fin and urogenital papilla in females. Tip of each pelvic fin reaching base of first anal-fin ray in males and females. Pelvic fin bases close to each other. Dorsal-fin origin between origins of pelvic- and anal-fins in males; anal-fin origin on vertical through base of fourth dorsal-fin ray. Dorsal-fin origin posterior to anal-fin origin in females, on vertical through base of third anal fin ray. Dorsal fin origin between neural spines of vertebrae 6 and 7 in males, and neural spines of vertebrae 10 and 11 in females. Anal fin origin at 7th pleural ribs of vertebrae in males, and pleural ribs of vertebrae 9 in females. Dorsal-fin rays 19–20 in males, 13–15 in females, anal-fin rays 21–22 in males, 17–19 in females, caudal-fin rays 21–26, pectoral-fin rays 12–14, pelvic-fin rays 5.



FIGURE 1. *Hypsolebias tocantinensis*, male, holotype, 38.2 mm SL: Brazil, Maranhão, flooded areas close to rioLajeado.rio Tocantins basin.



FIGURE 2. *Hypsolebias tocantinensis*, female, paratype, 31.1 mm SL: Brazil, Maranhão, flooded areas close to rioLajeado.rio Tocantins basin.

Frontal squamation E-patterned; E-scales overlapping medially; no row of scales anterior to H-scale; supraorbital scales 2. Longitudinal series of scales 24–25; transverse series of scales 11–13; scale rows around caudal peduncle 12–13. Small papillae contact organ only on inner surface of three dorsal-most rays of pectoral fins in males, absent in scale of flank and ventral portion of opercular area. Total vertebrae 26–27.

Coloration in life (Figs. 1–2). Males. Diagonally positioned 8–9, reddish brown bars alternating with a bright blue background. Head with dorsal and pre-dorsal areas light red. Opercular area greenish with a metallic blue tinge. Black transversal stripe crossing eyes vertically, iris light yellow. Dorsal fin with irregularly branching, reddish brown bars alternating with light blue blotches and spots. Caudal fin light blue with 4–5 reddish brown bars, with the first two bars irregularly branched. Anal fin with 5 reddish brown bars, in-line with bars on body,

alternating with light blue stripes. Pectoral fins hyaline. Pelvic fins reddish brown. Females. Body sides light gray, with faint gray bars between the black spot and caudal fin. One or two black elliptical spots surrounded by metallic blue color, golden on ventral area. Opercular region light metallic green. Iris light yellow, with dark gray stripe through center of eye. Dorsal fins hyaline, anal fin hyaline with irregular reddish brown markings. Pectoral, pelvic and caudal fins hyaline.



FIGURE 3. *Hypsolebias flammeus* from temporary pool close to rio Paranã, Brazil, Goiás (14°02'14.21"S 46°50'57.85"W), rio Tocantins basin.

Distribution (Fig.5). Known only from the type-locality, a flooded area close to the rio Lajeado, rio Tocantins basin, Maranhão state, Brazil.

Habitat (Fig.6). The temporary pool is located in a flooded area about 200 m from the rio Lajeado, in Campestre do Maranhão. The pool has been altered from its original state as it was cut in half by an interstate highway (Belém-Brasília, BR-010). Average depth of the pool is 1m, with deepest portions about 1.5m, with as lightly acid pH (6.4) and low electric conductivity (0,05µs). The substrate is composed of clay and sand with slightly dark water. The temperature on the water surface was approximately 27°C and, in the deepest portion and banks, approximately 21°C. The region's annual average temperature is 26°C, with maximum of 38.2°C and minimum of 20.6°C. The region has an annual average rainfall of 1400mm per year, with a rainy season from November to March. Marginal vegetation is composed primarily of grass for cattle pasture (altered from Amazonian Rain Forest). Aquatic vegetation is composed essentially of grass tufts, *Echinodorus sp.* and *Nynphea sp.* At the same locality two other rivulids were also found, *Pituna compacta* and *Plesiolebias filamentosus*, with *Hypsolebias tocantinensis* being the least abundant. This locality demonstrates the amazing ability annual fish have to survive in adverse conditions; even with the habitat being cut by a major road and having its vegetation completely altered, the pool was sustaining a very healthy population of fishes, with very large number of *Pituna compacta* and *Plesiolebias filamentosus*. The lower occurrence of *H. tocantinensis* in this locality might be related to the pool's cycle, as the collection was done at the beginning of the dry season and the water level was already receding. Individuals of *Hypsolebias* spp. present an accelerated metabolism and normally start dying even before the pool dries out. The accelerated metabolism is even more accentuated in males, which can be observed in several other locations where *Hypsolebias* and *Cynolebias* occur (Nielsen, 2008).



FIGURE 4. *Hypsolebias brunoi* from a temporary pool close to ribeirão Canabrava, Brazil, Goiás, near the city of Vila Boa (15°03'0.4"S 47°04'3.3"W), rio Tocantins basin.



FIGURE 5. Geographic distribution of members *Hypsolebias* from rio Tocantins basin.

Behavior in captivity. Specimens of the new species demonstrated to be very pacific and not too prolific. Agonistic behavior was not observed among males, females or between males and females. No fighting was ever observed, with all specimens maintaining their fins intact for the duration of the observation period.

Etymology. The name *tocantinensis* is in reference to the occurrence of the new species in the rio Tocantins basin.

Discussion

Hypsolebias tocaninensis is defined by two autapomorphies, i.e., the second pharyngobranchial longer than wide, and shorter lateroventral process of the hyomandibulae (Costa 2006, 2007).

Species of *Hypsolebias* follow a certain pattern in their distribution, this being related to the course of the river, and to pools being placed in a flat region near its margins. When there is intense flooding, when it is possible for river levels to rise more than 10 meters above normal, the opportunity is ripe for annual Rivulidae to disperse by settling in new pools. Thus, species distribution is related to the course of the river (Nielsen, 2008).



FIGURE 6. Type locality of *Hypsolebias tocantinensis* near rio Lajeado, rio Tocantins basin.

This distribution of groups could also be related to the course of rivers in past eras. This possibility justifies using these fishes as biographic indicators. In other words, we could, through an analysis of their distribution, corroborate former geological formations. The cladogram of phylogenetic relations among cynolebiasine (Costa, 2010) depicts the close proximity of *H. multiradiatus*, *H. flammeus* and *H. bruno*i within *H. flammeus* species-group.

Males of *H. tocantinensis* differ from males of *H. multiradiatus* by having a lower number of reddish brown bars on body (8 or 9 vs. 12 or 14); lower number of reddish brown bars on anal fin (4 or 5 vs. 6 or 7); different color pattern in the dorsal fin (spotted in *H. multiradiatus* vs. spots and bars in *H. tocantinensis*); caudal and dorsal fins rounded (vs. subtruncate); different belly coloration (with reddish brown bars on a light blue background in *H. tocantinensis* vs. pale orange in *H. multiradiatus*); round anal fin (vs. spatula-shaped), lower number of reddish brown bars in the caudal fin (4 vs. 5 or 6), lower number of scales in longitudinal series (25 vs. 26 or 27), lower body depth (30.5–35.3% SL vs. 36.9–38.0), lower caudal peduncle depth (11.7–13.0% SL vs. 13.6–15.8), lower prepelvic length (39.3–43.0% SL vs. 45.0–47.6), lower length of dorsal-fin base (35.3–38.5 % SL vs. 42.9–44.6), lower caudal-fin length (26.7–28.1% SL vs. 29.2–34.3), lower head depth (84.4–92.4% HL vs. 100.5–111.2), lower head width (61.6–63.2% HL vs. 63.9–68.5), lower eye diameter (23.6–27.9% HL vs. 28.6–34.4), number of vertebrae to anal-fin origin (9–10 vs. 7–8), dorsal-fin origin of vertebra (8–9 vs. 5–7), males with a low number of rays on the dorsal fin (19–20 vs. 25–28), lower numbers of rays on the anal-fin (21–22 vs. 23–28), and dorsal-fin origin between pleural ribs of vertebrae 8 and 9 (vs. 5 and 7 in *H. multiradiatus*).

Females of *H. tocantinensis* differ from females of *H. multiradiatus* by having a lower body depth (25.9–29.9% SL vs. 32.6–38.0%), lower length of dorsal-fin base (21.2–24.2% SL vs. 25.4–27.7%), lower caudal peduncle depth (10.5–12.2% SL vs. 13.1–14.8%), lower caudal-fin length (25.2–28.8% SL vs. 30.3–31.6%), lower pectoral-fin length (19.2–21.8% SL vs. 22.4–25.7%), lower head length (25.6–29.1% SL vs. 30.4–31.1%), lower

head depth (90.1–94.9% HL vs. 97.8–106.8), higher predorsal length (53.9–60.4% SL vs. 53.1–56.6%), lower number of dorsal-fin rays (13–15 vs. 17–21), lower number of anal-fin rays (17–19 vs. 23–28), and fewer scales in longitudinal series (24–25 vs. 26–27).

Males of *H. tocantinensis* differ from males of *H. flammeus* by having their bellies with the same coloration as the rest of the body (vs. a pale yellow belly in *H. flammeus*) branching bars in the dorsal and anal fins (vs. continuous bars); 5 bars in the anal fin (vs. 7 bars), all diagonally positioned as extensions of the bars on the body (vs. 2 diagonal and 5 vertical bars in *H. flammeus*); short fin ray extensions starting only at the 15th ray in the dorsal fin and only at the 7th ray in the anal fin (vs. long extensions on all dorsal and anal fin rays); slender body depth (30.5–35.3% SL vs. 38.9–40.3), lower caudal peduncle depth (11.7–13.0% SL vs. 14.0–15.1), lower prepelvic length (39.3–43.0% SL vs. 46.5–49.8), lower length of anal-fin base (34.8–35.3% SL vs. 36.6–42.6), lower caudal-fin length (26.7–28.1% SL vs. 35.6–39.7), lower pectoral-fin length (21.5–24.2% SL vs. 24.8–29.7), lower head length (28.3–29.4% SL vs. 30.7–31.9), lower eye diameter (23.6–27.9% HL vs. 30.4–36.2), and fewer numbers of scales in longitudinal series (25 vs. 26–27).

Females of *H. tocantinensis* differ from females of *H. flammeus* by possessing a lower body depth (25.9–29.8% SL vs. 33.2–35.3%), lower caudal peduncle depth (10.5–12.2% SL vs. 12.6–13.9%), lower caudal-fin length (25.2–28.8% SL vs. 33.6–37.8%), lower pectoral-fin length (19.2–21.8% SL vs. 25.7–26.4%), numbers of dorsal-fin rays (13–15 vs. 15–18), and fewer scales in longitudinal series (24–25 vs. 26–27). *H. tocantinensis* has one or two black spots in the center of the body surrounded by a metallic blue sheen, while *H. flammeus* has one to three black spots, alternating with vertically elongate metallic blue spots.

Males of *H. tocantinensis* differ from males of *H. brunoi* by having branched bars in the dorsal and anal fins (vs. unbranched bars); short fin ray extensions starting only at the 15th ray in the dorsal fin and only at the 7th ray in the anal fin (vs. long extensions on all dorsal and anal fin rays); slender body depth (30.5–35.3% SL vs. 36.1–37.5), lower caudal peduncle depth (11.7–13.0% SL vs. 14.8–15.2), lower pre-dorsal length (42.7–44.7% SL vs. 47.0–49.1), lower prepelvic length (39.3–43.0% SL vs. 45.5–47.6), lower caudal-fin length (26.7–28.1% SL vs. 32.9–34.5), lower pectoral-fin length (21.5–24.2% SL vs. 23.9–25.5), lower head length (28.3–29.4% SL vs. 30.4–31.5), lower head depth (84.4–92.4% HL vs. 98.6–107.0), lower snout length (11.2–11.9% HL vs. 11.7–14.4), lower eye diameter (23.6–27.9% HL vs. 32.5–34.8), and greater numbers of scales in transverse series (12–13 vs. 10).

Females of *H. tocantinensis* differ from females of *H. brunoi* by possessing a lower body depth (25.9–29.9% SL vs. 34.8–36.4%), lower caudal peduncle depth (10.6–12.2% SL vs. 12.9–13.8%), lower prepelvic length (45.8–49.9% SL vs. 52.4–54.0%), lower caudal-fin length (25.2–28.8% SL vs. 32.0–36.3%), lower pectoral-fin length (19.2–21.8% SL vs. 24.2–27.2%), and greater numbers of scales in transverse series (11 vs. 10). *H. tocantinensis* has one or two black spots in the center of the body surrounded by metallic blue color, while *H. brunoi* has one to three black spots, alternating with vertically elongate metallic blue spots.

The purported phylogenetic affinity among *H. tocantinensis*, *H. multiradiatus*, *H. flammeus* and *H. brunoi* is consistent with their geographical distribution along the rio Tocantins basin. However, the type locality of *H. tocantinensis* is 570 km away from the closest species in the group (*H. multiradiatus*), which may suggest that other populations, or even other species of this genus, might occur within that range.

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