



## A new species of *Simpsonichthys* (Cyprinodontiformes: Rivulidae) from the rio São Francisco basin, northeastern Brazil

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### Abstract

*Simpsonichthys lopesi* n. sp. is described from a temporary pool located in the São Francisco river basin. This species is distinguished from remaining species, except *S. adornatus*, by the large number of dorsal fin rays, which makes possible a large dorsal fin base length that begins well anterior to the middle of the body, before the vertical line through the pelvic fin. This species differs from *S. adornatus* by the color pattern of the anal fin, which may have yellow stripes or light dots (vs. small light points), and also by the lower number of dorsal fin rays.

**Key words:** Annual fishes, Neotropical region, temporary pools

### Resumo

*Simpsonichthys lopesi* n. sp. é descrita de uma poça temporária localizada na bacia do rio São Francisco. A espécie distingue-se das demais, exceto *S. adornatus*, pelo grande número de raios da nadadeira dorsal, o que confere grande comprimento da base dessa nadadeira que se inicia muito antes da metade do corpo, antes da nadadeira pélvica. Difere de *S. adornatus* pelo padrão de colorido da nadadeira anal, que pode apresentar listras amareladas ou manchas claras (vs. pequenas pintas claras), e também pelo menor número de raios da nadadeira dorsal.

### Introduction

*Simpsonichthys* Carvalho, 1959 is the South American annual fish genus with the highest number of species. The 53 species (Nielsen 2008; Costa 2008; Costa & Brasil 2008) occur mostly in the Central and Northern regions of Brazil, in the São Francisco, Araguaia-Tocantins, Paraná-Paraguai, Xingú and Madeira river basins.

According to Costa (2006), *Simpsonichthys* species are characterized by their small pointed process on the dorsal portion of the palatine, unbranched rays on the tip of the dorsal and anal fins in males, and overlapping E-scales. They are considered annual fishes for living in temporary habitats and resist desiccation by laying their eggs on the substratum. Their eggs develop slowly and undergo stages of developmental arrest or diapause (Myers 1952; Wourms 1972).

The systematics of *Simpsonichthys* has been frequently modified in the last few years (Costa 1995; 1998; 2006). After a phylogenetic analysis based on 116 characters, five subgenera were proposed by Costa (2006): *Simpsonichthys*, *Spectrolebias*, *Xenurolebias*, *Ophthalmolebias* and *Hypsolebias*. The subgenus *Hypsolebias* contains four monophyletic groups of species: *S. notatus*, *S. magnificus*, *S. antenori* and *S. flammeus* groups. The *S. magnificus* group is especially relevant here, for it includes six species that are all from the rio São

Francisco basin (Costa 2006). Among the species is *S. adornatus*, which has an elongated dorsal fin that begins anterior to the pelvic fin. Recently, specimens of *Simpsonichthys* with this same characteristics were collected but in a different locality from the known range of *S. adornatus*. 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 0.1mm on the left side of the specimen following Costa (1995; 2007). Measurements are expressed as percents of standard length (SL), except subunits of the head, which are recorded as percents of head length (HL).

In the description, each count is followed by its frequency in parentheses, and counts for the holotype are indicated by an asterisk. Counts of vertebrae, pleural ribs, branchiostegal rays, anal fin proximal and distal radials, and procurrent caudal fin rays were based on four cleared and stained (c&s) specimens (two males and two females) prepared according to Dingerkus and Uhler (1977). Frontal squamation followed 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 in recent studies on *Simpsonichthys* (Costa 2003; 2007).

Institutional abbreviations follow Leviton *et al.* (1985), with addition of MZUEL (Museu de Zoologia da Universidade Estadual de Londrina).

### *Simpsonichthys lopesi*, new species

(Figs. 1–3; Table 1)

**Holotype.** MZUSP 103102, male 33.3mm SL, City of Muquém de São Francisco, locality of Javi, temporary pool near the riacho de Santana, rio São Francisco basin, 12°12'04.6"S, 43°39'27.8"W, 20.iii.2008. Col. Rogério dos Reis Suzart, Amer Faour Martín, Walber Stepple Hiluey.

**Paratypes.** MZUSP 103103, 2 males (45.8–31.7mm SL), 3 females (31.6–22.3mm SL), same data from holotype. MZUEL 5177, 5 males (41.0–23.1mm SL, 2 C&S), 8 females (34.5–17.8mm SL, 2 C&S), same data from holotype.

**Diagnosis:** *Simpsonichthys lopesi* differs from remaining congeneric species, except *S. multiradiatus* and *S. adornatus*, because of the elongated dorsal fin base length of males that begins well anterior to the vertical line through the middle of the body, before pelvic fin origin. *Simpsonichthys lopesi* differs from *S. multiradiatus* by the color pattern of its body and anal fin without transverse stripes (vs. with red transverse stripes). *Simpsonichthys lopesi* differs from *S. adornatus* by the variable color pattern of its anal fin, with males presenting yellow and dark stripes or dark color with unlined yellow spots (vs. small blue spots). Males of *S. lopesi* generally have a lower number of rays on the dorsal fin compared to males of *S. adornatus* (22–30 vs. 28–32), higher predorsal length (34.3–38.8% SL vs. 28.3–34.4%), higher dorsal-fin base length (45.9–53.7% SL vs. 54.0–60.3%), lower anal fin base length (36.3–41.7% SL vs. 43.4–48.2%), lower head depth (75.9–98.5% HL vs. 106.8–113.8%), and bigger snout length (19.2–27.0% HL vs. 11.4–14.6%). Females of *S. lopesi* differ from females of *S. adornatus* by having a lower body depth (22.1–32.7% SL vs. 34.3–36.8%), lower caudal peduncle depth (11.2–14.3 vs. 14.1–15.2), lower head depth (77.5–97.9% HL vs. 98.3–108.9), lower head (57.3–72.3% HL vs. 73.7–78.2%), and bigger snout length (17.9–20.9% HL vs. 12.3–14.9%).

**Description.** Morphometric data are presented in Table 1. Largest specimen examined 45.8mm SL. Body relatively high. 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 end of anal fin base, nearly straight on caudal peduncle. Body deep, compressed, greatest body depth at level of pelvic fin base. Eyes positioned on dorsal portion of side of head. Snout blunt. Urogenital papilla cylindrical and short in males, pocket-shaped in females.

Tip of dorsal fin pointed in old males and rounded in young; rounded in females; tip of anal fin rounded in both sexes. Short filamentous ray on tip of dorsal fin in males, reaching vertical through base of caudal fin; filaments absent in anal fin. Dorsal fin rays unbranched except in one male and two females with two branched rays under the filamentous ray on tip of dorsal fin. Caudal fin rounded. Pectoral fins elliptical. Posterior margin of each pectoral fin reaching vertical through base of first, second or fourth anal-fin rays in males, and between pelvic fin and urogenital papilla in females. Tip of each pelvic fin reaching base of first or second anal-fin ray in males and base of first anal fin ray in females. Pelvic fin bases in close proximity. Dorsal fin origin previous to pelvic fin origin in males, anal fin origin on vertical through base of third dorsal fin ray; dorsal fin origin posterior to anal fin origin in females, on vertical through base of third and fifth anal fin ray; one female with dorsal fin origin anterior to anal fin. Dorsal fin origin between neural spines of vertebrae 3 and 5 in males, and neural spines of vertebrae 10 and 12 in females. Anal fin origin between pleural ribs of vertebrae 6 and 8 in males, and pleural ribs of vertebrae 8 and 10 in females. Dorsal fin rays 22(1), 25(2)\*, 26(1), 27(1), 28(1) and 30(1) in males, 11(1), 15(4), 16(5) and 17(1) in females; anal fin rays 21(3) and 22(5)\* in males, 18(1), 19(6), 20(3) and 21(1) in females; caudal fin 20(1), 21(6)\*, 22(4), 23(1), 24(7) and 25(1); pectoral fin rays 10(1), 11(9), 12(8)\* and 13(1); pelvic fin rays 4(3), 5(8) and 6(6)\*.

**TABLE 1.** Morphometric data of *Simpsonichthys lopesi*. Low and high measurements include holotype.

	Holotype	Males (n=8)		Females (n=11)	
		Low-high	Mean±SD	Low-high	Mean±SD
Standard length (mm)	33.3	22.6–45.8	30.9±8.7	16.6–34.5	24.67.0
Percents of SL					
Body depth	32.9	31.0–33.7	32.5±1.0	22.1–32.7	29.7±3.9
Caudal peduncle depth	13.2	12.9–14.3	13.7±0.5	11.2–14.3	13.1±0.9
Pre-dorsal length	34.3	34.3–38.8	36.3±1.9	55.6–63.5	60.1±2.1
Pre-pelvic length	41.5	38.6–46.6	42.0±2.7	44.1–52.9	47.52.9
Length of dorsal-fin base	51.0	45.9–53.7	51.0±2.4	18.7–30.3	24.9±3.1
Length of anal-fin base	39.5	36.3–41.7	39.5±1.8	21.7–29.5	26.1±2.8
Caudal-fin length	24.3	24.3–31.8	27.2±2.7	20.4–32.1	27.3±3.5
Pectoral-fin length	20.4	19.5–24.9	22.3±1.8	14.1–24.2	20.5±3.3
Pelvic-fin length	8.0	6.7–9.4	8.2±0.8	7.2–10.3	8.6±0.9
Head length	24.7	24.7–27.3	26.3±0.8	25.1–30.0	27.2±1.2
Percents of HL					
Head depth	92.6	75.9–98.5	89.6±7.5	77.5–97.9	86.6±5.8
Head width	69.6	60.5–72.2	66.1±3.8	57.3–72.3	63.3±5.5
Snout length	27.0	19.2–27.0	22.3±2.7	17.9–20.9	19.6±1.0
Lower jaw length	27.7	21.2–28.5	25.2±2.7	19.3–28.2	22.4±2.6
Eye diameter	32.7	28.2–34.3	31.6±2.0	27.4–34.0	31.7±2.0

Frontal squamation E-patterned; E-scales overlapping medially; no row of scales anterior to G-scale; supraorbital scales 2. Longitudinal series of scales 25(2), 26(5), 27(5) and 28(6)\*; transverse series of scales 10(6), 11(10) and 12(2)\*; scale rows around caudal peduncle 10(3), 11(5), 12(9) and 13(1)\*. Contact organ on each scale of flank and ventral portion of opercle in males. Small papillae contact organ on inner surface of three dorsalmost rays of pectoral fins in males.

Basihyal sub triangle, its width about 50% of length; basihyal cartilage about 25% of total length of basihyal. Six branchiostegal rays. Second pharyngobranchial teeth 3–4. Gill-rakers on first branchial arch 2+7. Vomerine teeth absent. Dermosphenotic absent. Ventral process of posttemporal long. Total vertebrae 26(1) and 28(3).

**Coloration in life.** Males (Figs. 1 and 2). The color pattern of the trunk in newly collected specimens is yellowish white, slightly red. Head with dorsal and pre-dorsal areas reddish-yellow. Opercular area light yellow with an iridescent blue reflex. Black transversal stripe crossing eyes vertically. About three series of

iridescent blue spots lined on flank. Dorsal-fin with yellow base becoming dark brown posteriorly. Oblique light yellow stripes on anterior dorsal-fin area that continuous as spots posteriorly; about 8 to 10 series of stripes and spots lined obliquely. Anal-fin color golden-yellow, with a lighter base, either followed by two yellow stripes or lined with light spots, with dark stripes in between. Caudal-fin golden yellow from base to its center, where it becomes transparent. Dorsal and pelvic fins hyaline and slightly dark posteriorly.



**FIGURE 1.** *Simpsonichthys lopesi*, holotype, MZUSP 103102, male, 33.3mm SL, Bahia, Muquém do São Francisco, temporary pool close to riacho de Santana (12°12'4.6"S 43°39'27.8"W), rio São Francisco basin.



**FIGURE 2.** Male of *Simpsonichthys lopesi*, spotted form, not preserved, from same locality of holotype.

Two different color patterns of male anal fin are evident in newly collected specimens, and become even more evident in specimens maintained in aquarium: one with stripes and another with spots. Even smaller adults already present the anal fin stripe or spot pattern well defined. Besides the difference in anal fin color pattern, other differences were identified.

Striped form (Fig. 1): Dark blue trunk with white ventral area. Dorsal scales lightly red at the end, from snout to base of caudal fin. Several lines of iridescent blue on the dorsal area, from eyes to caudal fin base. A line of iridescent blue spots begins near dorsal fin base and extends to caudal fin, where the spots get progressively larger. Another line is composed of eight irregular iridescent blue spots, parallel to the first line, beginning near the vertical line that crosses the end of the dorsal fin and extends to the caudal fin base. More



ventrally, a third line with smaller light and hardly noticeable spots is present. Dorsal fin with variable ground color, from reddish to golden, with yellow spots. Near the dorsal-fin base spots are larger and decrease when approaching the dorsal fin outline. Three light spots on the first rays of dorsal fin are present, starting on the fin base and spreading out towards the top with small spots on the higher part of the fin. Caudal fin with same pattern, but with less intense background body color. Two lines of red to golden small spots are present. Posteriorly on fins there are fine blue lines that are hardly noticeable. Pelvic fin light orange, more intense near base. Anal fin with five light and dark stripes. The external stripe is slender and almost black, becoming gray closer to edge. There is also a fine light yellow stripe, followed by a dark, almost black stripe and another light yellow stripe. The stripe nearest fin base is dark, but not as intense as the one located between the two light stripes. At the end of the intermediate light stripe there is a single, small iridescent light spot. There is an intermediate anal fin color pattern, with the proximal light stripe broken in elongated blotches and the distal stripe formed by small spots closely placed.



**FIGURE 3.** *Simpsonichthys lopesi*, female, not preserved, from same locality of holotype.

Painted form (Fig. 2): Dark blue body, with various lines of shiny scales on dorsal area, beginning near eyes and ending on caudal fin. Dorsal fin golden red with different sizes of scattered spots. Four shining light blue stripes on the first rays of dorsal fin, beginning near the base and ending dorsally. Anal fin reddish yellow on first rays near base, black on posterior rays, and outlined with three lines of light blue circular or oval spots. The first line of spots, nearest the base, presents about seven bigger spots arranged in a line. The second line is placed under the first line, presents about ten spots of various sizes, but these always smaller than the first line. The third line, closer to the fin, presents a group of smaller spots.

Female (Fig. 3): Body sides light purplish gray, golden on ventral area, with horizontal line of small dark brownish gray spots, sometimes coalesced to form horizontal stripes; spots on anterocentral portion of flanks black. Two black elliptical spots on the base of caudal fin, vertically arranged, with lighter margins. Two round black blotches, vertically arranged, on posterior portion of caudal peduncle. Iris light yellow, with dark gray stripe through center of eye. Opercular area light blue, with small gray spot. Dorsal and anal fins hyaline, with small dark brownish gray spots on membrane between the rays, and in continuity with the body. Pectoral and pelvic fins hyaline. Hyaline caudal fin with or without small dark spots on base. Some females present a black circular spot perfectly defined on middle of trunk.

**Distribution.** Known only from the type-locality in rio São Francisco basin, Bahia, Brazil.

**Habitat** (Fig. 4). The pool where specimens were collected from is located in a stream of the Santana basin that supplies the city of Muquém, on a left bank depression of the São Francisco river, near the mountains of the Espinhaço plateau, in an area of swamps and aluvial terraces. The pool was oval, with 20m

in length and 10m in width, and was used as a water supply for cattle. The substrate was clay, which rendered the water turbid. The water temperature at surface was approximately 29°C and, in the deepest portion and banks, approximately 22°C. The annual average temperature of the region is 24°C, with maximum of 30.8°C and minimum of 20.1°C. The water pH was 7.2, slightly alkaline, as result of calcareous aluvial depositions. Average depth of water column was 40cm, with deepest portions about 60cm. The region has annual average rainfall of 800 to 900mm, and a rainy season from November to March. The marginal vegetation is typically of the Caatinga biome, about 2m in height, that supplied a shady area where the fishes were easily found. The aquatic vegetation was composed essentially of *Echinodorus* sp. and *Nymphaea* sp. The left side of the pool was artificially extended about 60m and reached a depth of more than 2m, but the vegetation was scarce and few specimens of *S. lopesi* were captured. Sympatric with *S. lopesi* were the rivulids *S. flagellatus* and *Cynolebias gibbus*. This was also noticed by Nielsen (2008) who observed sympatry among species of *Hypsolebias* and *Cynolebias* in other pools, with species of *Cynolebias* foraging on species of *Hypsolebias*.

**Behavior in captivity.** Males active during the day, especially for feeding, reproduction and territorial defense. Those males that displayed very quick swimming movements were more aggressive, especially with females. When two males were maintained together one may die victim of the other. Fishes newly collected from the pool present a body color similar to the water, in yellowish white, that changes in captivity, presenting a color similar to *S. igneus* (reddish yellow), but with a greenish blue reflex, just like in *S. adornatus*. During courtship of females, the abdominal area becomes white in males and the rest of the body dark blue with light iridescent spots.

**Etymology.** The name *lopesi* is in honor of Edson Lopes, because of his contribution to our knowledge on raising and breeding annual fishes in captivity.



**FIGURE 4.** Type locality of *Simpsonichthys lopesi* near riacho de Santana, São Francisco river basin.



## Discussion

*Simpsonichthys lopesi* presents all the characteristics of the subgenus *Hypsolebias* (Costa 2006), such as the second pharyngobranchial longer than larger, and a shorter lateroventral hyomandibular process.

The presence of two patterns of coloration in males highlights a phenotypic diversity observed for the first time in Brazilian annual fishes. This morphological variation did not allow us to distinguish those samples as two distinct species, because morphometric and meristic characters were constant and females do not present such color differences. Nevertheless, in spite of the fact that the number of fishes captured did not allow for genetic analyses, this species deserves more attention because it may help shed light on sympatric speciation processes.

The dorsal fin originating anterior to the vertical line through the pelvic fin is a rare characteristic among the Rivulidae. Besides *Simpsonichthys adornatus* and *S. lopesi*, the unique species that presents this characteristic is *S. multiradiatus*, a species also in the subgenus *Hypsolebias* of the *S. flammeus* group. The dorsal fin of *S. adornatus* originates between neural spines 3 and 5 in males, and 11 and 12 in females. In *S. lopesi* the pattern is similar, and females present the dorsal fin originating between neural spines 10 and 11. In *S. multiradiatus* the dorsal fin originates between neural spines of the seventh and eighth vertebrae in males, and between neural spines 8 and 10 in females.

*Simpsonichthys adornatus* and *S. lopesi* are easy to distinguish from *S. multiradiatus* by color pattern. *Simpsonichthys multiradiatus* is characterized by having the body, dorsal and anal fins, with a light metallic greenish blue background color, with 10–14 vertical reddish brown stripes. The anal fin has a similar pattern as the body, with a greenish blue background and with six reddish brown stripes. The caudal fin maintains the reddish brown stripes with greenish blue spots near the base. The scales are reddish on the head. Females have a brown color and a unique black spot on the centre of the body; around the black spot there is a green reflection, but very subtle. There are also light gray stripes on its trunk.

In spite of being morphologically similar, *S. lopesi* differs from *S. adornatus* because of the variable color pattern of its anal fin, with stripes, stripes and spots, and only spots. Even males of *S. lopesi* with only spots on their anal fin are easily distinguished from *S. adornatus*, because its spots are of a different color, distribution and size. In males of *S. adornatus*, the body background color and the dorsal and anal fins are light blue. Other male characters of *S. adornatus* further distinguish it from *S. lopesi*: parallel and longitudinal lines of light blue small spots practically on the entire trunk (with slight variation of intensity according to specimen age); scales with reddish edges near the head; caudal fin with background color similar to the body, becoming transparent as it gets closer to the margin; dorsal fin with many small light blue spots irregularly distributed over the light blue background; absence of spots over transparent fin areas; dorsal fin with light blue background and a yellowish discoloration near the base of the fin, same pattern of many small spots irregularly distributed, but with light blue lines at fin base, some of them beginning on the base while others begin between the base and the margin; anal fin with light blue background with small spots irregularly distributed all over the fin, not forming lines as in *S. lopesi*. In females of *S. adornatus*, the background color is light brown with irregular spots, but with less intensity and quantity that in *S. lopesi*. In *S. adornatus* there are just small spots whereas in *S. lopesi* there are larger spots; the two spots on caudal fin base are similar in both species. Females of *S. lopesi* possess dorsal and anal fins with black spots in continuity with the body, which differs from *S. adornatus*.

From the morphological characters observed, *S. lopesi* and *S. adornatus* appear to be sister-species. The distinction of these two species would be easier if all of the individuals *S. lopesi* presented solely the striped anal fin pattern. Even so, the lesser modal number of dorsal-fin rays is a character that can be used to distinguish the two species. Besides, the pools in which *S. lopesi* and *S. adornatus* were found are at a distance of 99km from each other, and represent very different regions. Whereas *S. adornatus* is found at banks of the rio São Francisco, *S. lopesi* is found in the riacho de Santana, about 40km away from the rio São Francisco.

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