Hypsolebias shibattai, a new species of annual fish (Cyprinodontiformes: Rivulidae) from the rio São Francisco basin, northeastern Brazil

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Abstract

Hypsolebias shibattai n. sp. is described from a temporary pool located in the rio São Francisco basin, state of Bahia, Brazil. *Hypsolebias shibattai* belongs to the *H. magnificus* species-group. This new species differs from all other species of *Hypsolebias* by having a unique color pattern in the males: a golden-yellow coloration on the head, opercular region and body up to the beginning of the dorsal fin (vs. absence of golden-yellow color on anterior portion of body).

Resumo

Hypsolebias shibattai n. sp. é descrita de uma poça temporária localizada na bacia do rio São Francisco, estado da Bahia, Brasil. *Hypsolebias shibattai* pertence ao grupo de espécies *H. magnificus*. A nova espécie difere de todas as demais espécies de *Hypsolebias* por posssuir um padrão de colorido único nos machos: uma coloração amarelo-dourada na cabeça, região opercular e corpo até o começo da nadadeira dorsal (vs. ausência de coloração amarelo-dourada na porção anterior do corpo).

Zusammenfassung

Beschrieben wird *Hypsolebias shibattai* n. sp. von einem zeitlich begrenzten Tümpel im Becken des Rio São Francisco, im Bundesstaat Bahia, Brasilien. *Hypsolebias shibattai* gehört zu der *H.-magnificus*-Artengruppe. Die neue Art unterscheidet sich von allen anderen *Hypsolebias*-Arten durch die einzigartige Farbgebung der Männchen: ein Goldgelb auf Kopf, Kiemendeckelbereich und Rumpf bis hin zum Anfang der Rückenflosse (während bei den anderen Arten die goldgelbe Farbe im vorderen Bereich des Körpers fehlt).

Résumé

Hypsolebias shibattai n. sp. est décrit provenant d'une mare temporaire située dans le bassin du rio São Francisco, état de Bahia, Brésil. *Hypsolebias shibattai* appartient au groupe d'espèces *H. magnificus.* Cette nouvelle espèce se distingue de toutes les autres espèces d'*Hypsolebias* par un patron de coloration unique pour les mâles: une couleur jaune or de la tête, de la région operculaire et du corps jusqu'au début de la dorsale (au lieu d'une absence de cette couleur jaune or sur la portion antérieure du corps).

Sommario

Hypsolebias shibattai n. sp. è descritto da una pozza temporanea situata nel bacino del Rio São Francisco, stato di Bahia, in Brasile. *Hypsolebias shibattai* appartiene al gruppo di specie *H. magnificus.* Questa nuova specie differisce dalle altre del genere *Hypsolebias* per una colorazione unica dei maschi, caratterizzata da un giallo oro su testa, regione opercolare e corpo fino all'inizio della pinna dorsale (vs. assenza di colore giallo-oro sulla porzione anteriore del corpo).

INTRODUCTION

The genus *Hypsolebias* Costa encompasses Neotropical annual that live in seasonal pools and are included in subfamily Cynolebiinae Hoedeman, family Rivulidae. These pools are formed during the rainy season. In the dry season, the pools completely dry out and the fishes die, but the eggs resist desiccation and remain in the substratum during the dry period. The eggs develop

slowly and undergo stages of developmental arrest or diapause (Myers 1952; Wourms 1972).

The subfamily Cynolebiinae currently includes about 100 valid species. All are uniquely found in temporary seasonal pools and cannot survive in perennial aquatic habitats. Sexual dimorphism is very evident and includes striking color patterns, elongated fins in males (Costa 1995), and elaborate courtship behaviors (Belote 2000). Color patterns of Cynolebiinae have been proved to be an excellent source of phylogenetically informative characters (Costa 1998) and an important tool to diagnose species (Costa 1995).

Most Neotropical annual fish species were discovered after the year 1985, and specifically at the rio São Francisco basin, mostly after the1990´s, and this area is now known to be one of the richest areas for annual fish diversity in South America (e.g., Costa et al., 2012, Costa et al., 2014). New expeditions during the wet season have continuously documented the existence of species previously unknown to science in the area.

The systematics of *Hypsolebias* has been in a state of flux in the last few years (Costa 1995, 1998, 2006, 2010). The genus *Hypsolebias* was first described as a subgenus of *Simpsonichthys* Carvalho (Costa 2006), but a little later, Costa (2010) elevated *Hypsolebias* to the generic status, since *Hypsolebias* was hypothesized to be closely related to species of the genera *Spectrolebias* Costa, *Cynolebias* Steindachner and *Austrolebias* Costa rather than *Simpsonichthys*.

Hypsolebias consists in a species-rich clade of South American annual fishes, comprising 46 species (Eschmeyer 2014) that are distributed throughout two types of open vegetation, the Cerrado, a savanna-type of vegetation from central Brazil, and the Caatinga, a semi-arid scrub forest from northeastern Brazil. *Hypsolebias* species occcur in the middle rio São Francisco basin and tributaries, the middle rio Jequitinhonha basin, the middle and upper rio Tocantins basin, with a few species in the rio Jaguaribe basin, smaller coastal drainages of northeastern Brazil, and a species was recently described for the rio Parnaíba basin (Costa 2007; Costa et al. 2012; Costa et al. 2014). We herein describe an additional new species for the genus from the middle rio São Francisco basin in the state of Bahia, Brazil.

MATERIAL AND METHODS

Measurements were taken point-to-point under a stereomicroscope with a digital caliper to the nearest 0.1 mm, 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).

Counts of vertebrae and pleural ribs were taken from radiographs of the holotype and five female and five male paratypes. Terminology for frontal squamation follows Hoedeman (1958) and Costa (2006). For vertebral counts the caudal compound centrum was counted as a single element. Comparisons with congeners were based primarily based on the literature (Costa 2003, 2007). Institutional abbreviations are MZUEL (Museu de Zoologia da Universidade Estadual de Londrina, Brazil), UNITAU (Universidade de Taubaté, Brazil), and ZUEC (Museu de Zoologia da Universidade Estadual de Campinas, Brazil).

Hypsolebias shibattai, n. sp.

(Figs 1-2; Table I)

Holotype: ZUEC 7648, 1 male, 32.3 mm SL: Brazil, Bahia, Bom Jesus da Lapa, rio São Francisco basin, temporary pool at road BR-430, 13°21'16"S, 43°17'15"W, altitude 433 m; Mayler Martins & Luciano Medeiros de Araujo, 12 January 2013.

Paratypes: ZUEC 7649, 3 males 27.2-34.4 mm SL, 3 females 21.3-25.7 mm SL; MZUEL 7879, 2 males, 30.4-31.7 mm SL, 2 females, 23.3-23.8 mm SL: same data as holotype.

Diagnosis: *Hypsolebias shibattai* differs from the remaining *Hypsolebias* species by having a unique color pattern in males; a golden-yellow coloration on the head, opercular region and body up to the beginning of the dorsal-fin (vs. absence of golden-yellow color); by having 5-6 transverse red bars alternating with 5-6 dark greenish bars along the body below the dorsal-fin (vs. red bars absent or 11-13 reddish brown bars in *H. brunoi* and *H. flammeus;* 10-11 red bars in *H. picturatus;* 3 red bars in *H. magnificus* and *H. harmonicus);* by having bright golden-yellow lines parallel to rays on the dorsal-fin (vs. lines absent or blue lines parallel in *H. fulminantis;* golden-yellow lines only on anterior portion of dorsal fin in *H. adornatus* and *H. lopesi*, or anal-fin in *H. hellneri);* slender bright yellow-gold lines in the upper portion of caudal-fin changing into a slender light bright blue lines towards middle portion of caudal-fin (vs. lines absent in caudal-fin or

dark blue lines in *H. fulminantis*, or thick 3-5 lines in *H. radiosus);* and caudal fin with background color light red with slender bright blue lines, parallel to fin rays (vs. lines absent or background color dark red with metallic dark blue lines in *H. fulminantis);* pelvic-fin golden-yellow (vs. pale yellow with black tip *H. mediopapillatus* and *H. ghisolfi* and translucent in the remaining species of the *Hypsolebias magnificus*-group); slender black distal line in anal and caudal fins (vs. slender black distal line absent in anal and caudal fins of congeners). Additionally, females possess a lower head depth (83.3-85.3% HL vs. 89.8-111.7% HL), and a lower eye diameter (27.7-30.3% HL vs. 31.8-35.8% HL) when compared with congeners, except *H. picturatus*. Additional distinguishing characters between the new species and congeners are provided in the Discussion, below.

Fig. 1. *Hypsolebias shibattai*, ZUEC 7648, male, holotype, 32.3 mm SL: Brazil, Bahia, Bom Jesus da Lapa. Photo by R. Suzart.

Fig. 2. *Hypsolebias shibattai*, ZUEC 7649, female, paratype, 25.7 mm SL: Brazil, Bahia, Bom Jesus da Lapa. Photo by D. Nielsen.

Table I. Morphometric and meristic data for the holotype (H) and paratypes of *Hypsolebias shibattai*.

	H	Paratypes	
	Male	Male n=5	Females n=5
Standard length (mm)	32.3	27.2-34.4	21.3-25.7
Percents of standard length			
Body depth	33.9	33.9-37.7	33.0-35.6
Caudal peduncle depth	14.8	14.7-16.6	12.6-17.0
Pre-dorsal length	51.4	50.6-53.7	60.1-66.8
Pre-pelvic length	44.6	43.8-49.6	46.8-53.0
Length of dorsal-fin base	36.5	36.4-40.9	23.9-27.9
Length of anal-fin base	37.1	33.4-44.1	26.7-29.4
Caudal-fin length	31.4	29.4-34.8	28.2-31.4
Pectoral-fin length	27.1	26.8-32.0	22.6-28.0
Pelvic-fin length	9.4	9.3-10.6	10.3-12.9
Head length	31.8	31.4-34.8	30.7-33.8
Percents of head length			
Head depth	88.9	86.6-95.0	83.3-85.3
Head width	64.4	63.4-70.2	64.8-73.6
Snout length	12.3	11.9-14.8	13.8-14.6
Lower jaw length	18.6	17.2-22.7	13.5-16.2
Eye diameter	26.4	25.5-28.0	27.7-30.3
Counts			
Dorsal-fin	20	20-21	13-14
Caudal-fin	19	19-20	19-20
Anal-fin	19	19-20	16-17
Pelvic-fin	6	6	5
Pectoral-fin	13	12-13	12
Meristic			
Scales in longitudinal series	25	25-27	
Scales in transversal series	11	11	
Horizontal scales around caudal peduncle	12	12	

Description: Morphometric data presented in Table I. Largest specimen examined 34.4 mm SL. Body relatively deep, compressed, greatest body depth at level of pelvic-fin insertion. Snout blunt. Urogenital papilla cylindrical and 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 end of anal fin base, nearly straight on caudal peduncle. Eyes positioned on dorsal portion of sides of head.

Tip of both dorsal and anal fins long and pointed in males, rounded in females. Short filamentous ray extensions on the tip of dorsal and anal fins in males, filaments absent in females. Caudal-fin rounded. Pectoral-fins elliptical, fifth branched ray more elongated than remaining rays. Posterior margin of each pectoral-fin reaching vertical through base 4th or 5th anal-fin ray in males, and middle of pelvic-fin in females, not reaching anal fin. Tip of pelvic fin reaching base of 1st to 2nd anal-fin rays in males and not reaching anal fin in females. Pelvic-fin bases close to each other. Dorsal-fin origin anterior to anal fin in males, at vertical through base of second anal-fin ray. Dorsal-fin origin posterior to anal-fin origin in females, on vertical through base of second anal fin ray. Dorsal-fin origin between neural spines of vertebrae 8 and 9 in males, and between neural spines 8 and 10 in females. Anal-fin origin at level of 9-10 pleural ribs in males, and 10-12 in females. Dorsal-fin rays 20-21 in males, 13-14 in females, anal-fin rays 19 in males, 16-17 in females, caudal-fin rays 19-21, pectoral-fin rays 12-13, pelvic-fin rays 5-6.

Cephalic neuromasts: supraorbital 13-14, parietal 3, anterior rostral 1, posterior rostral 1, infraorbital 2 + 21, preorbital 3, otic 2, post-otic 2, supratemporal 1, median opercular 1, ventral opercular 2, preopercular 12-14, mandibular 10, lateral mandibular 4-5, paramandibular 1. One neuromast on each scale of lateral line. Two neuromasts on caudal-fin base.

Frontal squamation E-patterned; E-scales overlapping medially; no row of scales anterior to G-scale; supraorbital scales 1. Longitudinal series of scales 25-26; transverse series of scales 11-12; scale rows around caudal peduncle 12. Small papillae contact organs present only on inner surface of three dorsal-most pectoral fin rays in males, absent in flank scales and ventral portion of opercular area. Total vertebrae 25-26.

Coloration in life (Figs 1-2): Males: Sides of head, opercular region and sides of body up to the beginning of the dorsal-fin golden yellow, 5-6 vertical red bars alternating with 5-6 dark greenish bars. Multiple light-blue spots scattered over all body and head. Green metallic blotch in third dark green bar, its center at midline. Top of head red. Iris yellow, with dark bar through center of eye. Unpaired fins red, with metallic yellow or green lines on fin membranes, parallel to fin rays. Pelvic-fin red with marginal dark blue line. Dorsal and anal fins with marginal slender black line. Pectoral-fin hyaline.

Females: Side of body light gray, without vertical

bars. Abdominal area pale yellow, 4-6 small dark spots in center of body. Small gray spots scattered over body. Opercular region pale green. Iris pale yellow, with black bar through center of eye. Fins hyaline.

Distribution (Fig. 5): Known only from the type locality, a temporary pool beside the highway BR-430, at Bom Jesus da Lapa, rio São Francisco basin, Bahia state, Brazil.

Habitat (Fig. 6): The type locality is a typical annual pool in Caatinga biome, located about 18 km southeast of the city of Bom Jesus da Lapa. The substrate is composed of clay and sand with slightly turbid water. Aquatic vegetation is dense with large stands of *Utricularia* sp. and *Nymphaea* sp. Two other annual rivulids *(Cynolebias* sp. and *Hypsolebias* sp.) were collected sympatrically with *H. shibattai*. The average depth of the pool is 80cm, with the deepest portions about 1.2m deep The water is slightly acidic (pH 6.5), with a low

Fig. 3. *Hypsolebias fulminantis*, male. Brazil, Bahia Guanambi (not preserved). Photo by M. Chauche.

Fig. 4. *Hypsolebias fulminantis*, female. Brazil, Bahia Guanambi (not preserved). Photo by M. Chauche.

electric conductivity (22 μS/cm). The temperature on the water surface was approximately 30°C, and in the deepest portion and shaded banks was approximately 26°C. The region's annual average temperature is 28°C, with maximum of 34°C and minimum of 20°C. The rainy season is from December to March. The Caatinga region can sometimes be subjected to a "veranico" or Indian summer, which consists of a dry period with high temperatures within a rainy season (Nielsen 2008).

Behavior in captivity: *Hypsolebias shibattai* follows the same reproductive habits known for other *Hypsolebias* species. The male is territorial, and when a female enters inside his territory the male starts the spawning ritual. After inducing a meeting, the male begins the courtship display, with waving motions of the body, while moving around and in front of the female. The male places its snout in the region in the substratum where it wishes to dig. The female accepts the invitation and slides alongside the male, whereupon both dig into the substratum with waving vibrations of the body. They submerge into the substratum, where the female lays an egg. At that exact moment, the male presses the female against the substratum with his body and fertilizes it. After fecundation, the couple remain submerged for some seconds to a few minutes, emerging together or not, perchance at different places and times (Belote 2000).

Etymology: The specific name is in honor of Oscar Akio Shibatta, for his contribution to South American ichthyology.

DISCUSSION

In addition to characters presented in the Diagnosis, *Hypsolebias shibattai* is distinguished from all other species from the *Hypsolebias magnificus* species-group by the tip of both dorsal and anal fin elongated and pointed, except *H. fulminantis* (vs. tip pointed, but short); higher pre-dorsal length in males (50.6-53.7% SL vs. 28.3-50.4%); higher head length in males (31.4-34.8% SL vs. 24.4-

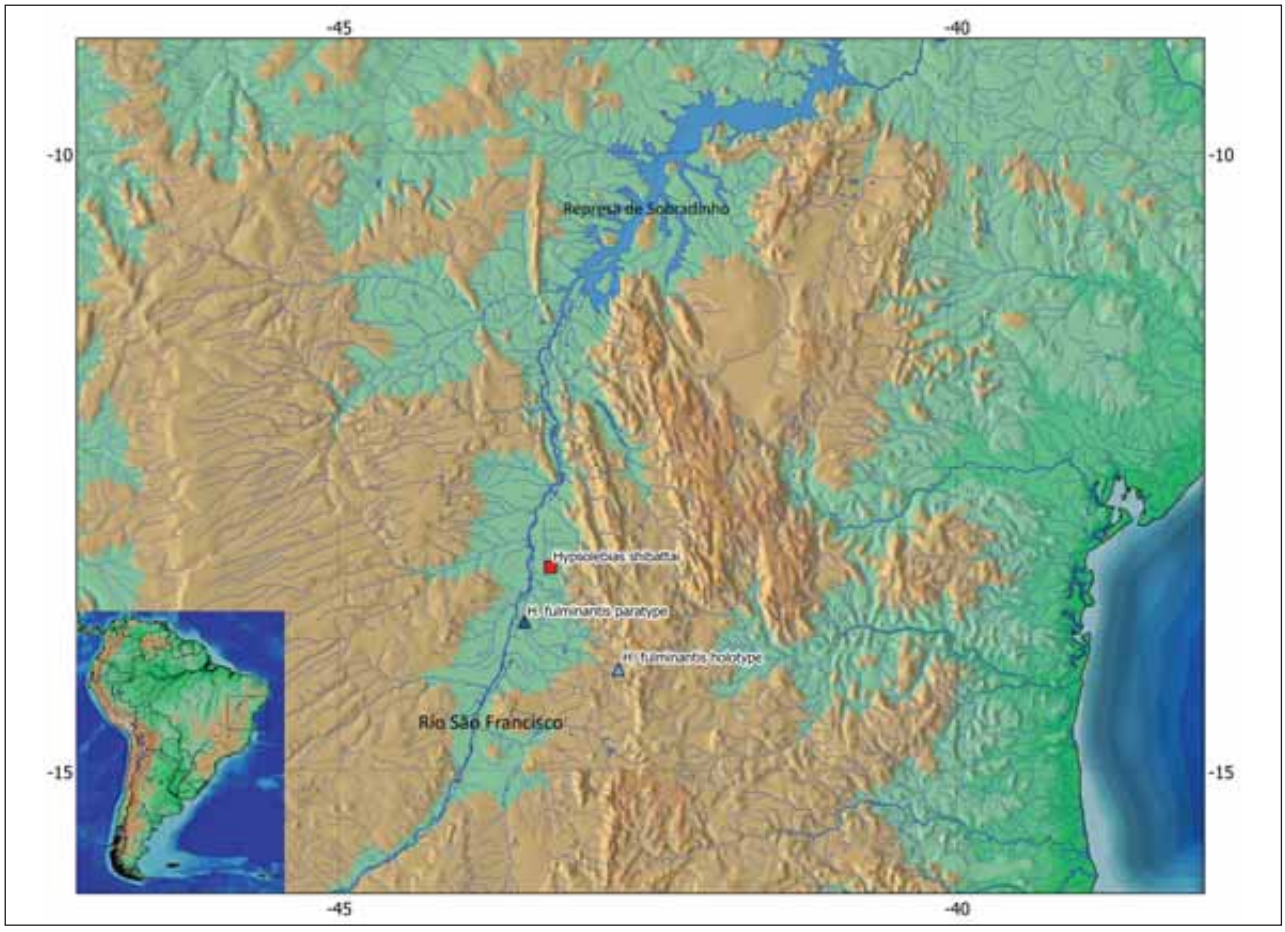

Fig. 5. Map from northeastern Brazil (inset) showing known localities for *H. shibattai* and *H. fulminantis.*

29.8%); lower head depth in males, except *H. lopesi* (86.6-95.0% HL vs. 98.1-120.1%); lower eye diameter in males (24.5-26.1% HL vs. 26.3-35.6%); and a lower number of rays on the caudal fin, except *H. fulminantis* (19-20 vs. 21-25).

Males of *H. shibattai* differ from males of *H. fulminantis* (Fig. 3) by having a higher pre-dorsal length (50.0-53.7% SL vs. 42.8-48.4%); lower caudal-fin length (29.4-34.8% SL vs. 38.9-40.7%); higher head length (31.4-34.8% SL vs. 25.1-29.0%); lower head depth (86.6-95.0% HL vs. 98.1-115.7%); lower eye diameter (25.5-28.4% HL vs. 29.3-34.5%); lower number of anal-fin rays (19 vs. 20-22); and a lower number of caudal-fin rays (19 vs. 20-23). *Hypsolebias shibattai* males also differ from males of *H. fulminantis* by the presence of a black line in the margin of the dorsal and anal fins (vs. black line in the marginal region absent), by the presence of a green metallic spot in third greenish bar (vs. absent), and a red pelvic-fin with marginal dark blue line (vs. bright blue, anterior rays pale red).

Females of *H. shibattai* differ from females of *H. fulminantis* (Fig. 4) by possessing a lower caudal-fin length (28.2-31.4% SL vs. 36.7-39.5%), lower head depth (83.3-85.3% HL vs. 89.8-111.7%), lower eye diameter (27.7-30.3% HL vs. 31.0-35.6%), lower number of dorsal-fin rays (13-14 vs. 15-17), and a lower number of anal-fin rays (16-17 vs. 18-21). Females of *H. shibattai* present a light gray body coloration (vs. darker gray in *H. fulminantis)*. Additionally, *H. shibattai* females have 4-6 small dark spots in the center of the body (vs. 1-2 rounded big dark spots in *H. fulminantis)*, and does not have vertical bars, while *H. fulminantis* has 15-18 vertical rows of faint dark greenish gray spots, sometimes coalescing to form bars.

The tip of each pelvic in reaches the base of the 1st or 2nd anal-fin ray in males of *Hypsolebias shibattai* (vs. 3rd anal-fin ray in males of *H. fulminantis*) and did not reach the anal fin in females (vs. 2nd anal-fin ray in females of *H. fulminantis)*.

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 (Costa 2006, 2007, Nielsen 2008). Following Costa (2007), *Hypsolebias shibattai* belongs to the *Hypsolebias magnificus* species-group. This group is distinguished from the remaining species groups within *Hypsolebias* by having vertical dark bluish gray bars alternating with red bars on the anterior portion of flanks in males (secondarily dark gray and red bars present only in young males of *H. adornatus* and *H. lopesi)* (vs. a distinct type of color pattern in the remaining *Hypsolebias* species). The *Hypsolebias magnificus* species-group is distributed only in the middle rio São Francisco basin. There are currently nine

Fig. 6. Type locality of *Hypsolebias shibattai*, Brazil, Bahia, Bom Jesus da Lapa, 18 km southeast to rio São Francisco basin. Photo by M. Martins.

species described in the *Hypsolebias magnificus* species-group: *H. hellneri* (Berkenkamp 1993), *H. adornatus* (Costa 2000), *H. fulminantis* (Costa & Brasil 1993), *H. carlettoi* (Costa & Nielsen 2004), *H. magnificus* (Costa & Brasil 1991), *H. picturatus* (Costa 2000), *H. harmonicus* Costa 2010, and *H. lopesi* (Nielsen et al. 2010), *H. caeruleus* Costa, 2013. *Hypsolebias shibattai* and *H. fulminantis* appear to be sister-species, since males of both species share several color and morphological fin traits such as a hyaline pectoral fin in males, dorsal, anal and caudal fins with bright-colored stripes parallel to fin rays, and the shape of dorsal and anal fins, elongated and pointed with short filaments (Costa 2006). In *Hypsolebias shibattai*, there are 1 or 2 transverse green metallic spots at the third greenish bar, a condition considered as plesiomorphic for Cynolebiasinae (Costa 2006), while in *H. fulminantis*, spots are absent or fused with blue scales, which is considered to be as an autopomorphic condition for the species (Costa 2006).

Hypsolebias shibattai is one more annual species to be found in the proximities of the city of Bom Jesus da Lapa, state of Bahia, about 18.5 km to the east of the rio São Francisco, on the right bank, a distance of about 112 km in a straight line from the type locality of *H. fulminantis* (Guanambi). There exists, however, another population of *H. fulminantis* which is located about 32 km from the type-locality of *H. shibattai*. Both populations of *H. fulminantis* are found at the rio das Rãs drainage, whereas *H. shibattai* is found at the right bank of the rio São Francisco.

Hypsolebias shibattai can be already considered as critically endangered since it is only known to occur from a single pool which is in an ongoing pace of disturbance. The owner of the area was at the time of collecting deepening the puddle with a digger in an attempt to accumulate more water for drought periods. The farmer was informed of the existence of annual fishes in this pool and has promised not to alter it further.

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