

SHORT COMMUNICATION

Notes on external morphological variation, natural history, and distribution of *Dryaderces inframaculata* (Anura: Hylidae), a rare neotropical treefrog

Fábio Maffei,¹ Douglas Coutinho Machado,² Danyella Paiva da Silva,³ Bruno Tayar Marinho do Nascimento,⁴ and Marinus Steven Hoogmoed⁵

¹ Departamento de Ciências Biológicas, Faculdade de Ciências, Universidade Estadual Paulista, 17033-360, Bauru, SP, Brazil. E-mail: maffei.fabio@gmail.com.

² AcquaPlan Tecnologia e Consultoria Ambiental Ltda., 88331-510, Balneário Camboriú, SC, Brazil. E-mail: douglas@biologo.bio.br.

³ Laboratório de Herpetologia, Universidade Federal do Acre, 69915-900, Rio Branco, AC, Brazil. E-mail: dany.paiva@gmail.com.

⁴ Programa de Pós-graduação em Zoologia, Instituto de Biociências, Universidade Estadual Paulista, 18618-689, Botucatu, SP, Brazil. E-mail: tayarbio@gmail.com.

⁵ Laboratório de Herpetologia, Museu Paraense Emílio Goeldi, Caixa Postal 399, 66017-970, PA, Brazil. E-mail: marinus@museu-goeldi.br.

Keywords: Amphibia, Amazon forest, Belo Monte, Pará state, Rondônia state.

Palavras-chave: Amphibia, Amazônia, Belo Monte, Pará, Rondônia.

There are approximately 345 species of hylid frogs in Brazil (Segalla *et al.* 2016); 108 of these occur in Brazilian Amazonia (Hoogmoed and Galatti 2017). Jungfer *et al.* (2013) described the genus *Dryaderces* based on *Osteocephalus pearsoni* (Gauge, 1929). Boulenger (1882) described *Hyla inframaculata* based on only one specimen collected near Santarém in the state of Pará. Jungfer (2010) placed *Hyla inframaculata* in the genus *Osteocephalus*, and Hoogmoed

(2013) then placed *O. inframaculatus* (Boulenger, 1882) in *Dryaderces*; consequently, the genus contains two species—*D. inframaculata* (Boulenger, 1882) and *D. pearsoni* (Gauge, 1929)—and a third species is being described (Jungfer *et al.* 2013). *Dryaderces* occurs on the lower Andean slopes of central Peru to the Bolivian Amazon, and in the area between the Tapajós and Xingu rivers in a band south of the Amazon River in the states of Pará and Mato Grosso in Brazil (Hoogmoed 2013, Frost 2017, Pinto *et al.* 2017).

For about 120 years after its description, no new records of *Dryaderces inframaculata* were collected. Caldwell and Araújo (2005), working

Received 27 April 2017
Accepted 28 November 2017
Distributed June 2018

close to the type locality of *D. inframaculata* and also in the Belo Monte area did not collect it. Similarly, neither Knispel and Barros (2009) collecting in Altamira, nor Oliveira *et al.* (2013) working west of the Belo Monte area, found *D. inframaculata*. Hoogmoed (2013) examined seven individuals (3 males, 3 females, and a half-grown specimen) collected in 2001 and 2012 in the area of the hydroelectric plant of Belo Monte, Rio Xingu, Vitória do Xingu in the state of Pará, Brazil. These specimens were compared with the holotype of *D. inframaculata* (BMNH 1947.2.13.10). Subsequently, Vaz-Silva *et al.* (2015) reported the species from the Belo Monte area, and Pinto *et al.* (2017) recorded new localities in southern part of the state of Pará and adjacent northern Mato Grosso.

Following the publication of Hoogmoed (2013), the Museu Paraense Emílio Goeldi (MPEG) in Belém received 30 new specimens of *Dryaderces inframaculata* (MPEG 38782–38808, 38890, 39005–39006) from the area of Belo Monte in the municipality of Vitória do Xingu in the state of Pará on the left bank of the lower Xingu River (03°12' S, 51°46' W, 100 m a.s.l.). Data on two other specimens were obtained. The first (Figures 1A, 1B) was from Itaituba (Miritituba District, Rio Tapajós in the state of Pará at 04°16'18" S, 55°56'09" W, 39 m a.s.l.) and was not collected. The second (Figures 1C, 1D) from 20 km S of the urban center of Porto Velho in the state of Rondônia (08°57'37" S 63°52'09" W, 109 m a.s.l.) was collected and deposited in the Zoological Collection of the Federal University of Goiás (ZUFG 10280). The specimen from Porto Velho extends the known distribution of the species 1200 km SW of the type locality (Santarém) and 1450 km SW of Vitória do Xingu into the state of Rondônia (Figure 2) (cf. Pinto *et al.* 2017). Thus, the range of *D. inframaculata* is expanded considerably and now can be assumed to occupy a large area bound by the Madeira River in the west, the Xingu River in the east, the Amazon River in the north, and the northern part of Mato Grosso in the south; the range includes parts of the states

of Rondônia, Pará, and Mato Grosso. It is noteworthy that although collections have been made on both sides of the Xingu River in the area of Belo Monte, *D. inframaculata* was only found along the western bank of the river.

Only few habitat data are available (Hoogmoed 2013). However, if the localities of the recently collected *Dryaderces inframaculata* are projected on a Google Earth image map (dated December 2011) of the Vitória do Xingu area (Figure 3A), we can infer that most the frogs occurred in forested areas. However, most of the frogs were collected in July 2014; by this time, the forested areas had been reduced to slivers or narrow bands along creeks near areas that had been cleared for large-scale infrastructural projects. Now most of the localities from which *D. inframaculata* were collected have disappeared under water of Belo Monte Lake (Figure 3B). Hoogmoed (2013) posited that the species should be considered vulnerable, or even endangered, because most of its range in Vitória do Xingu would be destroyed by roads, canals, lakes, and other infrastructural constructions related to the hydroelectric dam of Belo Monte; this is exactly what happened as is shown in Figure 3B. The fact that *D. inframaculata* is known to occur in four localities distant from Belo Monte (Pinto *et al.* 2017) should positively influence the conservation status of this species. Nevertheless, the status of *D. inframaculata* is suspect given the limited numbers of specimens from other localities.

Dryaderces inframaculata is not listed in the Brazilian list of endangered species, but at the recent (2008–2014) evaluation it was cited as Data Deficient (Haddad *et al.* 2016). Likewise, the IUCN Red List refers to the species as “Data Deficient” given the absence of information in 2004 on its range, status, and ecological requirements (Azevedo-Ramos 2004). The new data presented here (and by Pinto *et al.* 2017) support reconsideration of the Data Deficient status of *D. inframaculata*.

Both *Osteocephalus* and *Dryaderces* are known for the dramatic ontogenetic changes that



Figure 1. (A) An individual of *Dryaderces inframaculata* photographed (not collected) in the municipality of Itaituba in the state of Pará in dorsal view; and (B) ventral view; (C) Juvenile *Dryaderces inframaculata* (ZUFG 10280) collected in the municipality of Porto Velho in the state of Rondônia in dorsolateral view; and (D) ventral view; (E) Preserved juvenile *Dryaderces inframaculata* (MPEG 38807) from Vitória do Xingu in the state of Pará, showing the basic dorsal pattern before undergoing ontogenetic change.

take place after metamorphosis; these include color pattern, iris color, and skin structure, as well as sexual dimorphism in size. The recently collected material is a rich source of data on external morphological characters and anecdotal natural history data, to complement the information provided by Hoogmoed (2013) on the basis of only eight individuals.

Ten *Dryaderces inframaculata* with SVLs less than 30 mm (18.9–28.9 mm) were considered juveniles; those with SVLs of 30–40 mm (7 specimens, 30–36.9 mm) were classified as half-grown frogs, where as those with SVLs greater than 40 mm were considered adults. Males (with nuptial pads) have SVLs of 41.1–48.2 mm ($N = 10$, 43.57 ± 2.33) and females (with ovaries)

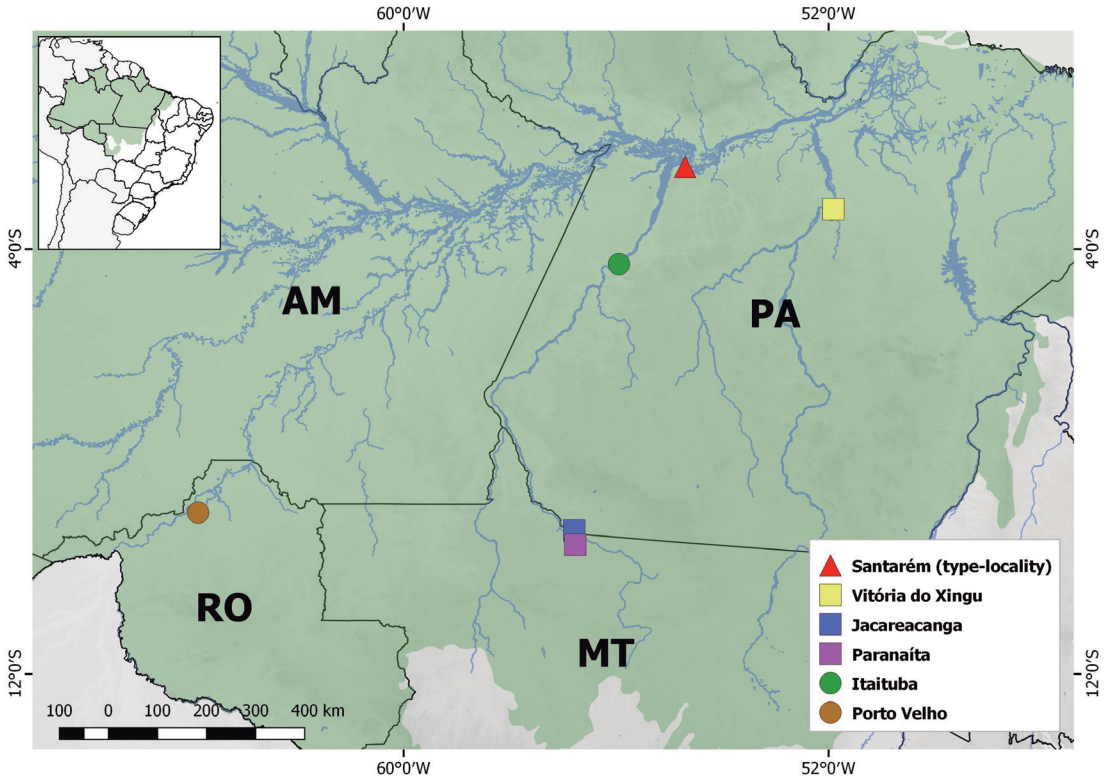


Figure 2. Map showing the present known distribution of *Dryaderces inframaculata* in Amazonian Brazil. Symbols: triangle = type locality; squares = previous records; dots = new records. Brazilian states: AM = Amazonas; PA = Pará; RO = Rondônia; MT = Mato Grosso.

have SVLs 50.4–65 mm ($N = 12$, 60.45 ± 4.72). These size ranges (including the material reported by Hoogmoed 2013) generally agree with his data, but the SVL range of females is broader and shows that females mature at a smaller size than previously thought.

Juvenile *Dryaderces inframaculata* undergo a considerable ontogenetic change in pattern. One juvenile (probably not in MPEG collection) photographed alive in Belo Monte has a bright red iris (like juvenile *Osteocephalus*). Adults have yellowish to orange-brown irises. Juveniles from Belo Monte basically have a gray back with a black T-shaped mark from between the eyes to the sacrum. The vertical (=

vertebral) part of the T starts is wide at the back of the head and gradually tapers to a blunt tip in the sacral region. The smallest juvenile (MPEG 38807, SVL 18.9 mm; Figure 1E) is not recently metamorphosed, but probably is just a few weeks old. It has a curved black band from the lip below the nostril through the nostril and along the canthus rostralis to the anterior corner of the eye; there is a black spot on the lip below the eye and an anterior black spot on the lip between the black band and the spot below the eye. A white spot on the posterior part of the maxilla under the tympanum. The snout is gray, with a vertical band between the nostrils descending to the upper lip. A black, straight-

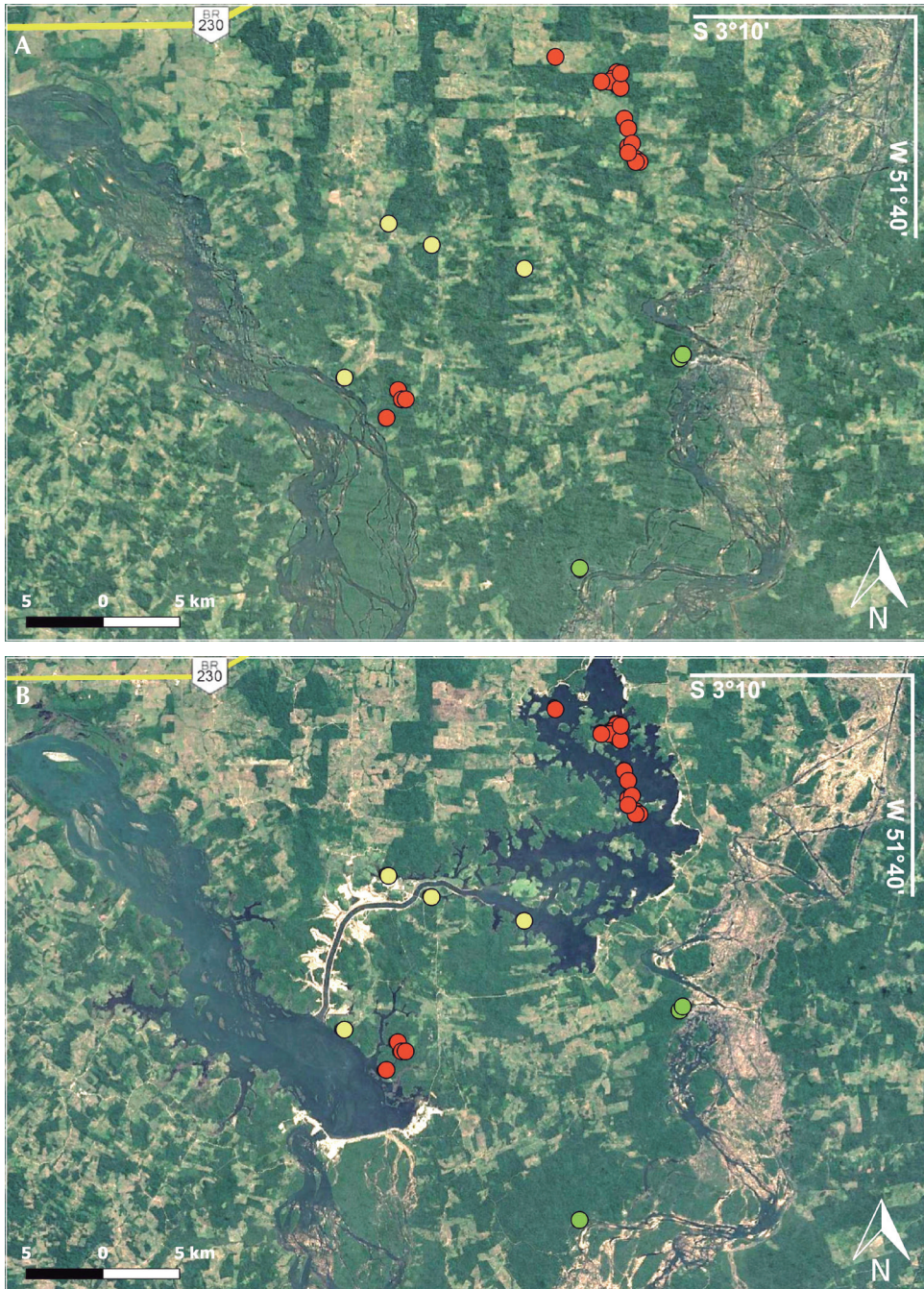


Figure 3. Distribution of *Dryaderces inframaculata* in Vitória do Xingu, state of Pará, northern Brazil, projected on a Google Earth© map (Image Landsat / Copernicus) showing the vegetation in (A) December 2011 and (B) in December 2016 and the lake of Belo Monte. The yellow line in the upper left corner is the Transamazônica Road BR-230. The dots correspond to individuals collected in 2001 (green), 2012 (yellow), and 2014 (red).

edged band from the eye to the groin, with a short, anteriorly curved dorsal extension just anterior to the groin. The upper surfaces of the limbs are boldly patterned with black and gray transverse bands. The backs of the thighs are uniformly brown. The underside of the limbs, belly, and throat are white and lack black spots. The lower lip has some gray spots along the edge. In the next larger juvenile (MPEG 38790, SVL 21.4 mm) the pattern on the snout is the same, but the ventral part of the lateral band includes white elements and has partly changed into a band of black spots. In slightly larger juveniles, the black band on the snout has lighter areas and its borders are less distinct. The backs of the thighs are patterned with black spots and lines on a brown ground color; the anterior surface has the same pattern on a white background. The back has more dark pattern elements, and the posterior and anterior surfaces of the thighs have a pattern of black spots and lines on a white (bluish-white in life) background. There are black spots on the throat and belly. The dark transverse bands on the limbs are less distinct. The belly and throat of some, but not all, juveniles are not spotted, but in others black spots are present. As females grow, the dorsal dark element remains more or less unchanged, but in males, it expands laterally on the back and connects to dark pattern elements on the flanks. The dorsal ground color of most males and some females remains gray with a dark pattern as in half-grown; in some males and most females, the back is brown with a darker pattern that has become less distinct. When found in the daytime, the frog from Itaituba was light beige with dark brown bands on the back. The pattern on the backs of the thighs is variable, and changes ontogenetically from uniform gray to large black spots and lines on a white background. In some specimens (e.g., ZUFG 10280), the spots and lines on the back of the thigh are smaller and tend to form a reticulum. The large white spot at the posterior end of the

maxilla, under the tympanum is distinct in all specimens.

The structure of the dorsal skin varies in *Dryaderces inframaculata*. In males, it is granular and shagreen or warty, and in females, smooth, shagreen, granular or slightly warty; juveniles and half-grown have smooth to warty skin. All specimens have a variable number of enlarged warts on top of the head, including the *canthus rostralis*. There seems to be a slight dimorphism in skin texture, with males being wartier than females. However, warts in males do not have keratinized tips as in *Osteocephalus*.

The smallest male *Dryaderces inframaculata* with nuptial pads has a SVL of 41.1 mm; two males with SVLs of 41.5 and 44 mm lacked nuptial pads. The smallest female (SVL 50.4 mm) has small ovaries. Reproductive data were gathered with inventory activities; see Table 1. Rainfall is highest in Vitória do Xingu in March (358 mm), and starts to diminish in June to reach a low (36 mm) in October and then increase in December (Climate-Data.org 2017). The most precipitation (i.e., the rainy season) falls between January and May, whereas the dry season with significantly less precipitation extends from June to December. The species seems to be active throughout most of the year, and most prevalent in the early dry season. Most reproductive activity occurs in July when males have nuptial pads and females have eggs and oviducts in different developmental stages; juveniles and half-grown are present at the same time.


Acknowledgments.—AMBIENTARE provided financial and logistical support for the Itaituba and Porto Velho field trips. Specimen ZUFG 10280 was collected under IBAMA's 617/2015 license (Process 02001.000328/2009-98). The Environmental Program in the Belo Monte area that yielded the material reported here was conducted under IBAMA license numbers 251/2013 and 108/2012. Thanks to Linda Trueb for English review. 

Table 1. Data on reproduction. A. Juvenile, B. Half-grown, C. Males with white nuptial pads, D. Males with brown nuptial pads, E. Males without nuptial pads, F. Females with mature black ovarian eggs, G. Females with small oviducts and ovarian eggs, H. Females with large oviducts and small ovaries, I. Females with enlarged oviducts, and white and black ovarian eggs, J. Females with small ovaries.

Categories	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A						1	9		1			
B						2	1		1		1	
C	1		2			1	2					
D							1					
E							1					1
F	1		1				1					
G		1										1
H						1	1		1			
I							2					
J							1	1				
Total	2	1	3			5	19	1	3		1	2

References

- Azevedo-Ramos, C. 2004. *Dryaderces inframaculata*. The IUCN Red List of Threatened Species 2004: e. T55513A11322157. Electronic Database accessible at <http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T55513A11322157.en>. Captured on 12 January 2017.
- Boulenger, G. A. 1882. *Catalogue of the Batrachia Salientia s. Ecaudata in the Collection of the British Museum*. 2nd edition. London. Trustees British Museum. 592 pp.
- Caldwell, J. P. and M. C Araújo. 2005. Amphibian faunas of two eastern Amazonian rainforest sites in Pará, Brazil. *Occasional Papers Sam Noble Oklahoma Museum of Natural History* 16:1–41.
- Climate-Data.org. 2017. Clima Vitória do Xingu. Electronic database accessible at <https://pt.climate-data.org/location/313630>. Captured on 01 January 2017.
- Frost, D. R. (ed.). 2017. Amphibian Species of the World: an Online Reference. Version 6.0 (28 March 2017). Electronic Database accessible at [http://research.amnh.org/vz/herpetology/amphibia/American Museum of Natural History, New York, USA](http://research.amnh.org/vz/herpetology/amphibia/American_Museum_of_Natural_History,_New_York,_USA). Captured on 01 April 2017.
- Haddad, C. F. B., I. F. Machado, J. G. R. Giovanelli, Y. S. L. Bataus, V. M. Uhlig, F. R. Q. Batista, C. A. G. Cruz, C. E. Conte, C. Zank, C. Strüsmann, C. Canedo, D. Loebmann, D. L. Silvano, F. Nomura, H. B. A. Pinto, I. B. Amaral, J. L. R. Gasparini, L. B. Nascimento, M. R. C. Martins, M. F. Napoli, M. Gordo, M. S. Hoogmoed, M. S. Kienle, N. M. Maciel, P. H. Valdujo, P. C. A. Garcia, R. J. Sawaya, R. Lingnau, R. P. Bastos, and U. Caramaschi. 2016. Avaliação do Risco de Extinção de *Dryaderces inframaculata* (Boulenger, 1882), no Brasil. Processo de avaliação do risco de extinção da fauna brasileira. ICMBio. Electronic Database accessible at <http://www.icmbio.gov.br/portal/faunabrasileira/estado-de-conservacao/7816-anfibios-dryaderces-inframaculata>. Captured on 21 April 2017.
- Hoogmoed, M. S. 2013. Rediscovery of the rare tree frog *Hyla inframaculata* Boulenger, 1882 (Anura: Hylidae), in Amazonian Brazil with notes on variation and distribution, and its generic allocation. *Amphibia-Reptilia* 34: 421–432.
- Hoogmoed, M. S. and U. Galatti. 2017. Censo da Biodiversidade. Anfíbios. Museu Paraense Emílio Goeldi. Electronic Database accessible at <http://www.museu-goeldi.br/censo>. Captured on 21 January 2017.

- Jungfer, K.-H. 2010. The taxonomic status of some spinybacked treefrogs, genus *Osteocephalus* (Amphibia: Anura: Hylidae). *Zootaxa* 2407: 28–50.
- Jungfer, K.-H., J. Faivovich, J. M. Padial, S. Castroviejo-Fisher, M. M. Lyra, B. V. M. Berneck, P. P. Iglesias, P. J. R. Kok, R. D. Macculloch, M. T. Rodrigues, V. K. Verdade, C. P. Torres Gastello, J. C. Chaparro, P. H. Valdujo, S. Reichle, J. Moravec, V. Gvoždík, G. Gagliardi-Urrutia, R. Ernst, I. De la Riva, D. B. Means, A. P. Lima, J. C. Señaris, W. C. Wheeler, and C. F. B. Haddad. 2013. Systematics of spiny-backed treefrogs (Hylidae: *Osteocephalus*): an Amazonian puzzle. *Zoologica Scripta* 42: 351–380.
- Knispel, S. R. and F. B. Barros. 2009. Anfíbios anuros da região urbana de Altamira (Amazônia Oriental), Pará, Brasil. *Biotemas* 22: 191–194.
- Oliveira, E. A., E. J. H. Ruz, and F. B. Barros. 2013. Herpetofauna de las proximidades de la Caverna Planaltina, Brasil Novo, Pará (Amazonia Brasileña). *Herpetotropicos* 9: 55–68.
- Pinto, K. C., L. S. S. Cruz, M. Penhacel, M. D. P. Rossi, and W. Vaz-Silva. 2017. *Dryaderces inframaculata* (Boulenger, 1882) (Anura: Hylidae): distribution extension on states of Mato Grosso and Pará, northern Brazil. *Herpetology Notes* 10: 115–117.
- Segalla, M. V., U. Caramaschi, C. A. G. Cruz, T. Grant, C. F. B. Haddad, P. C. A. Garcia, B. V. M. Berneck, and J. Langone. 2016. Brazilian amphibians: list of species. *Herpetologia Brasileira* 5: 34–46.
- Vaz-Silva, W., R. M. Oliveira, A. F. N. Gonzaga, K. C. Pinto, F. C. Poli, T. M. Bilce, M. Penhacek, L. Wronski, J. X. Martins, T. G. Junqueira, L. C. C. Cesca, V. Y. Guimarães, and R. D. Pinheiro. 2015. Contributions to the knowledge of amphibians and reptiles from Volta Grande do Xingu, northern Brazil. *Brazilian Journal of Biology* 75: S205–S218.

Editor: Ariovaldo Antonio Giaretta