

Rediscovery of the rocket frog

Allobates olfersioides (Anura: Aromobatidae) through citizen science in Rio de Janeiro state, Southeastern Brazil

Allobates Zimmermann & Zimmermann, 1988 is the most speciose Neotropical genus within Aromobatidae, currently with 63 species widely distributed in Central and South America (Frost 2023, Silva et al. 2022). The genus is well-known for its cryptic pattern designs and conspicuous behavior, such as diurnal habits and nursery of tadpoles (Caldwell et al. 2002, Grant et al. 2006, Verdade & Rodrigues 2007, Melo-Sampaio et al. 2018). The Atlantic Forest harbors only one species of *Allobates* (Verdade & Rodrigues 2007). However, recent acoustic evaluations highlighted that *Allobates olfersioides* (Lutz 1925) may represent a complex of species (Forti et al. 2017). Currently, the species is considered Least Concern (LC) by the IUCN, even though its population decrease is recognized in Espírito Santo and Rio de Janeiro (IUCN 2023). Its disappearance is well documented in several localities in Rio de Janeiro state (Weygoldt 1989, Izecksohn & Carvalho-e-Silva 2001, Caram et al. 2016). In some protected areas, the species has been missing for decades, such as Parque Nacional da Tijuca with no records over the past 30 years (Dorigo et al. 2021), and Parque Nacional Serra dos Órgãos over the past 50 years (Carvalho-e-Silva et al. 2020). Citizen science and other well-established methods have been considered a valuable approach to collecting information on species and biodiversity (Schmeller et al. 2009, Van Strien et al. 2013, Robinson et al. 2018, Rowley et al. 2019). Here, we report a new record of *Allobates olfersioides* through citizen science, an underdeveloped activity for herpetofauna in Brazil. We also review aspects of its distribution and natural

history based on our observations.

No standardized method was used to find the specimens. Occasional photographic records were made during trekking and fauna observation activities on a protected area in Niterói, state of Rio de Janeiro. The area is characterized by a secondary forest with abundant leaf litter, in a near-urban environment. Individuals were photographed and identified as *Allobates olfersioides* according to morphological characteristics described by Lutz (1925) and following available literature (Verdade & Rodrigues 2007, Forti et al. 2017). Images were deposited at the scientific collection of the Instituto Vital Brazil (IVBA342 and IVBA343). Later in May 2024, one specimen was collected under the permit INEA 090/2023. The specimen was euthanized, fixed, and housed at Coleção Científica de Amphibia, Instituto Vital Brazil (IVBA) (IVBA 356). A review of the records for the state of Rio de Janeiro from 1923 to the date of our records was made through available literature and online databases that harbor digitized scientific collections records – such as SpeciesLink (specieslink.net/) and SiBBR (www.sibbr.gov.br/) – and citizen science platform iNaturalist (www.inaturalist.org/). The map was constructed using QGIS 3.16.9 software (Fig. 1), with coordinates expressed in SIRGAS 2000. The approximate altitude was found through available geographic coordinates.

On 10 December 2021, two adult individuals of *Allobates olfersioides* were observed on leaf litter at 19:56h and 20:45h (Fig. 2a-b) during a trail in the Parque Estadual da Serra da Tiririca (22°57'19" S; 43°01'24" W) at 29 m asl. The individuals were distanced 170 m from each other. One specimen was foraging through vegetation (Fig. 2b). On 12 February 2022 at 11:30h, we found seven juveniles of *A. olfersioides* on a dry stream bank near a pond, approximately 100 m far from the last individual sighted in December 2021 (Fig. 2c). In addition, on 19 February, we recorded males calling at the same location where the juveniles were observed by 11:30h. All records were made inside the forest, at about fifteen meters distance from the paved road.

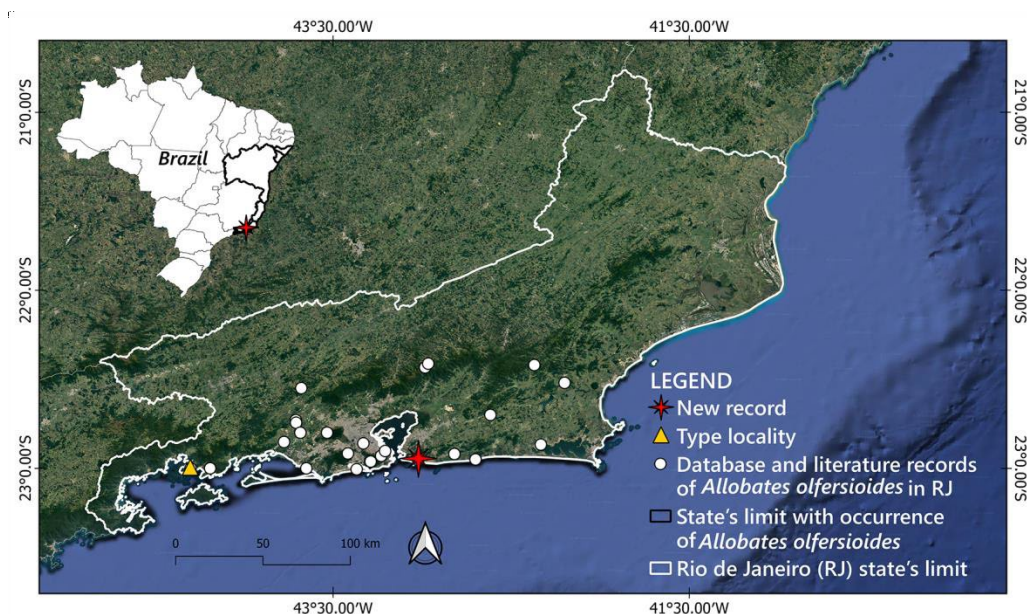


Figure 1. Geographic distribution of *A. olfersioides* in Rio de Janeiro (RJ) State. Coordinate system SIRGAS 2000 Political boundaries (IBGE, 2019) Image (Google Satellite, 2022).



Figure 2. New record of *A. olfersioides* in Niterói, Rio de Janeiro, Parque Estadual Serra da Tiririca on 10 December 2021 and 12 February 2022: a. IVBA342 first individual on a rolled leaf, b. IVBA343 second individual foraging after sunset, c. Juvenile among the leaf litter in the sandbank, d. Human interference in the reproductive site of amphibians, where *A. olfersioides* was found. Photographs by Rafael Carvalho de Mattos (a) and Miguel Relvas Ugalde (b, c, d).

We were able to locate 799 records of *A. olfersioides* in Rio de Janeiro state from the literature and internet databases. (Table 1). These records cover 26 localities in 12 municipalities that range from 2 to 1282 m asl. Fourteen of these localities were below 100 m asl, seven were between 165 and 642 m asl, and five were above 800 m asl. We discarded one record from Niterói as its coordinates led to a point in the ocean. Most records fall within protected areas, such as Parque Nacional da Serra dos Órgãos, Parque Nacional da Tijuca, Floresta Nacional Mario Xavier, Parque Estadual Cunhambebe, APA Rio Guandu, APA Macaé de Cima, and Reserva Biológica do Tinguá.

The records found in the review that included dates showed that specimens were historically collected throughout the year, except in May, and were more frequent during the rainy season (December–March). On the other hand, according to our data, there are two major encounter gaps: 1987 - 2012 and 2012- 2021. Considering our review, the only two records of *A. olfersioides* in Rio de Janeiro state in the 21st century are from the municipalities of Maricá and Niterói, in 2012 and 2021 (Figs. 2a-c), respectively.

The earliest documented specimen of *A. olfersioides* was collected in 1923 in Niterói, followed by more specimens

gathered in Angra dos Reis in 1924. The record in Niterói was the sole entry for the city in our literature review, representing a 98-year gap from our current record. Although the encounter gap weakly predicts escalation of threat status for missing species (Scheffers et al. 2012), the reports of *A. olfersioides*' disappearance and the large intervals between encounters since 1987 call attention to its conservation.

Our records were made inside a protected area close to urban environment, which may present some threats to this population – such as edge effect (Schlaepfer & Gavin 2001, McDonald et al. 2009) and presence of introduced species (e.g., cats, dogs, and chickens) and people (Pontes & Pontes 2016) (Fig. 2d). On the other hand, given the characteristics of the recorded sites, it is possible that different areas within Parque Estadual da Serra da Tiririca could harbor *A. olfersioides*. Therefore, we propose that intensive surveys should be the initial conservation initiative for the species.

As observed by Ramalho et al. (2020) for the Cerrado Rocket Frog, *Allobates goianus* (Bokermann, 1975), the difficulty in finding *A. olfersioides* may be related to the fact that most herpetofauna surveys are usually conducted at night. This may partially explain the low number of *A. olfersioides* records in recent years.

Table 1. Specimens of *Allobates olfersioides* from Rio de Janeiro obtained through review on online platforms and literature, followed by date of collection (month followed by year), city, coordinates, and altitude (meters above sea level).

Source	Date	Specimens	City	Coordinates	Altitude
Specieslink	1923	US-Animalia 96412	Niterói	22°58'59.9"S 43°07'00.1"W	-
Specieslink	04 - 1924	US-Animalia 96539 - 96540	Angra dos Reis	23°00'00.0"S 44°18'00.0"W	37
SIBBR	1943	MNRJ80226 - 80239	Rio de Janeiro	22°54'10.1"S 43°12'27.0"W	410
SIBBR	12 - 1944	MNRJ51976 - 51985	Rio de Janeiro	22°54'10.0"S 43°12'27.0"W	4
Verdade and Rodrigues 2007	03 - 1946	MNRJ23716 - 719	Rio Bonito	22°42'00.0"S 42°36'57.6"W	165
SIBBR	01 - 1957	MNRJ78784	Teresópolis	22°24'44.0"S 42°57'56.0"W	874
Specieslink	11 - 1964	DZSJRP-Amphibia-adults 476 - 478	Rio de Janeiro	23°00'18.7"S 43°22'03.0"W	3
Specieslink	03 - 1964	DZSJRP-Amphibia-adults 580	Rio de Janeiro	23°00'18.7"S 43°22'03.0"W	3
SIBBR	02 - 1966	MNRJ70142 - 70146	Rio de Janeiro	22°57'42.8"S 43°17'20.4"W	410
Specieslink	02 - 1966	DZSJRP-Amphibia-adults 710	Rio de Janeiro	22°57'42.8"S 43°17'20.4"W	410
Specieslink	12 - 1967	FNJV 0032130	Rio de Janeiro	22°54'10.1"S 43°12'27.0"W	410
Specieslink	11 - 1968	FNJV 0044152	Rio de Janeiro	22°54'10.1"S 43°12'27.0"W	410
SIBBR	02 - 1969	MNRJ78782 - 78783	Rio de Janeiro	22°57'42.8"S 43°17'20.4"W	410
SIBBR	08 - 1970	MNRJ70147 - 70150	Engenheiro Paulo de Frontin	22°32'59.0"S 43°40'42.0"W	386
SIBBR/Specieslink	01 - 1971	ZUEC-AMP 1219 - 1222	Itaguaí	22°51'08.0"S 43°46'31.0"W	23
Specieslink	01 - 1971	DZSJRP-Amphibia-adults 1751 - 1752	Seropédica	22°43'46.6"S 43°42'33.1"W	33
SIBBR	01 - 1971	MNRJ79099	Seropédica	22°44'38.0"S 43°42'27.0"W	39
SIBBR/Specieslink	07 - 1973	ZUEC-AMP 2741 - 2750	Itaguaí	22°51'08.0"S 43°46'31.0"W	23
Specieslink	12 - 1977	FNJV 0032824	Teresópolis	22°26'00.0"S 42°59'00.0"W	938
Verdade and Rodrigues 2007	09 - 1978	MNRJ4143	Casimiro de Abreu	22°31'12.0"S 42°12'00.0"W	2
SIBBR	01 - 1978	MNRJ40422	Engenheiro Paulo de Frontin	22°32'59.0"S 43°40'42.0"W	386
Specieslink	01 - 1978	ZUEC-AMP 10824	Engenheiro Paulo de Frontin	22°30'00.0"S 43°36'36.0"W	642
SIBBR	10 - 1987	MNRJ40580	Engenheiro Paulo de Frontin	22°32'59.0"S 43°40'42.0"W	386
SIBBR	06 - 2012	MNRJ80679	Maricá	22°55'10.0"S 42°49'07.0"W	4
SIBBR	03 - 2012	MNRJ79896 - 79899	Maricá	22°55'10.0"S 42°49'07.0"W	4
Present study	12 - 2021	IVBA342 - 343	Niterói	22°57'19.2"S 43°01'24.3"W	29
Present study	02 - 2024	IVBA356	Niterói	22°57'19.2"S 43°01'24.3"W	29
SIBBR	-	MF614175 - 614176	Maricá	22°57'00.0"S 42°42'00.0"W	4
SIBBR	-	MF624103	Maricá	22°57'00.0"S 42°42'00.0"W	4
SIBBR	-	MF614241	Maricá	22°57'00.0"S 42°42'00.0"W	4
SIBBR	-	MF624178 - 624179	Maricá	22°57'00.0"S 42°42'00.0"W	4
Verdade and Rodrigues 2007	-	EI4321-56	Itaguaí	22°48'00.0"S 43°41'00.0"W	8
Verdade and Rodrigues 2007	-	JJ7792-96	Itaguaí	22°48'00.0"S 43°41'00.0"W	8
Verdade and Rodrigues 2007	-	JJ7787	Itaguaí	22°48'00.0"S 43°41'00.0"W	8
Specieslink	-	US-Animalia 565104 - 565105	Rio de Janeiro	22°55'48.0"S 43°13'48.0"W	47
Verdade and Rodrigues 2007	-	MNRJ5094	Angra dos Reis	23°00'00.0"S 44°11'24.0"W	456
Verdade and Rodrigues 2007	-	EI8598-600	Engenheiro Paulo de Frontin	22°30'00.0"S 43°36'36.0"W	642
Verdade and Rodrigues 2007	-	JJ7788-91	Engenheiro Paulo de Frontin	22°30'00.0"S 43°36'36.0"W	642
SIBBR	-	MNRJ79396 - 79398	Rio de Janeiro	22°54'10.1"S 43°12'27.0"W	410
Verdade and Rodrigues 2007	-	MNRJ15398-406	Araruama	22°51'36.0"S 43°19'48.0"W	29
Verdade and Rodrigues 2007	-	MNRJ15431-39	Araruama	22°51'36.0"S 43°19'48.0"W	29
Verdade and Rodrigues 2007	-	MZUSP73714	Rio de Janeiro	22°55'00.0"S 43°25'00.0"W	94
Verdade and Rodrigues 2007	-	MZUSP73753	Rio de Janeiro	22°55'00.0"S 43°25'00.0"W	94
Verdade and Rodrigues 2007	-	MZUSP76653	Rio de Janeiro	22°55'00.0"S 43°25'00.0"W	94
Verdade and Rodrigues 2007	-	MZUSP93651-65	Rio de Janeiro	22°55'00.0"S 43°25'00.0"W	94
Verdade and Rodrigues 2007	-	MZUSP93671	Rio de Janeiro	22°55'00.0"S 43°25'00.0"W	94
Verdade and Rodrigues 2007	-	MNRJ23730-34	Rio de Janeiro	23°00'00.0"S 43°39'00.0"W	13
Verdade and Rodrigues 2007	-	MZUSP9801-9803	Rio de Janeiro	23°00'00.0"S 43°39'00.0"W	13
Verdade and Rodrigues 2007	-	MNRJ23721-23	Teresópolis	22°26'00.0"S 42°29'00.0"W	1282
Verdade and Rodrigues 2007	-	MZUSP53448-51	Teresópolis	22°26'00.0"S 42°29'00.0"W	1282
Verdade and Rodrigues 2007	-	US-Animalia 208396-208401	Teresópolis	22°26'00.0"S 42°29'00.0"W	1282
Verdade and Rodrigues 2007	-	EI4290	Nova Iguaçu	22°33'00.0"S 43°26'00.0"W	869
Verdade and Rodrigues 2007	-	EI4306	Nova Iguaçu	22°33'00.0"S 43°26'00.0"W	869
Verdade and Rodrigues 2007	-	JJ224-231	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537
Verdade and Rodrigues 2007	-	MZUSP76418	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537
Verdade and Rodrigues 2007	-	MZUSP76728-29	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537
Verdade and Rodrigues 2007	-	MZUSP93624-49	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537
Verdade and Rodrigues 2007	-	MZUSP93666-767	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537
Verdade and Rodrigues 2007	-	MZUSP93914- 94377	Rio de Janeiro	22°33'00.0"S 43°26'00.0"W	537

Although most species of *Allobates* are known as diurnal frogs (Menin et al. 2008, Simões et al. 2019), many species of the genus have little detailed information about their daily activity pattern (Ramalho et al. 2020). One individual here was observed in activity after the sunset feeding. Such prolonged activity was also reported for *A. goianus*, which has peaks of calling activity at dusk and dawn, with extended activity after sunset mainly during rainfall (Ramalho et al. 2020). New information on the species' biology can give much-needed insights about the group, since the knowledge gap on the species' natural history represents a handicap to understanding the differences among *A. olfersioides* populations at the Atlantic Forest (Verdade & Rodrigues 2007).

The species was once considered to have three distinct lineages: *Allobates alagoanus* (Bokermann 1967), *Allobates capixaba* (Bokermann 1967), and *Allobates carioca* (Bokermann 1967). These three species were synonymized by Verdade & Rodrigues (2007) based on their similar morphology. The official list of Brazilian amphibians (Segalla et al. 2021) considers *Allobates olfersioides* a single species with a wide distribution in the Brazilian Atlantic Forest (Verdade & Rodrigues 2007), but some authors call attention to differences in its populations. Recently, the description of the acoustic repertoire for five populations of *A. olfersioides* has shown that at least the population from Rio de Janeiro should be considered a different species from the northeastern populations (Forti et al. 2017). In addition, according to Dubeux et al. (2019), larvae from the states of Alagoas and Rio de Janeiro differ in labial tooth row formula, dorsal fin position, and nostril shape.

The previous national red list of threatened species considered *A. olfersioides* as VU (Vulnerable), where the status was attributed only to the population known for the state of Rio de Janeiro (ICMBIO 2018). However, the current national red list of threatened species considers *A. olfersioides* a single species and classifies it as DD. New studies are necessary with the reappearance of populations in the Rio de Janeiro state. Understanding the population variation of *A. olfersioides* is fundamental for its conservation. The species' reappearance represents an opportunity to better study the species inside protected areas, especially those surrounded by urban areas.

Acknowledgement

We thank Instituto Estadual do Ambiente - INEA for the collection permits (INEA #090/2023).

References

Bokermann, W.C.A. (1975): Uma nova espécie de *Colostethus* do Brasil Central (Anura, Dendrobatidae). Iheringia. Série Zoologia 46: 13-18.
 Caldwell, J.P., Lima, A.P., Keller, C. (2002): Redescription of *Colostethus marchesianus* from its type locality. Copeia 2002: 157-165.
 Caram, J., Gomes, M.R., Luna-Dias, C.D., Carvalho-e-Silva, S.P.D. (2016): Updated list of anurans from Floresta Nacional Mário Xavier, Seropédica, Rio de Janeiro, Brazil: changes from 1990 to 2012. Check List 12(6): 1-7.
 Carvalho-e-Silva, S.P.D., Carvalho-e-Silva, A.M.P.T.D., Folly, M., Luna-Dias,

C.D., Bezerra, A.D.M., Gomes, M.D.R., Caram, J., Peixoto, O.L., Izecksohn, E. (2020): Parque Nacional da Serra dos Órgãos: the highest Amphibian diversity within an Atlantic Forest protected area. Biota Neotropica 20(3): e20201033.
 Dorigo, T.A., Siqueira, C.C., Oliveira, J.C., Fusinato, L.A., Santos-Pereira, M., Almeida-Santos, M., Carneiro, T.M., Reis, C.N.C., Rocha, C.F.D. (2021): Anfíbios e répteis do Parque Nacional da Tijuca, Brasil, uma das maiores florestas urbanas do mundo. Biota Neotropica 21(2): e20200978.
 Dubeux, M.J.M., Silva, G.R.S.D., Nascimento, F.A.C.D., Gonçalves, U., Mott, T. (2019): Síntese histórica e avanços no conhecimento de girinos (Amphibia: Anura) no estado de Alagoas, Nordeste do Brasil. Revista Nordestina de Zool 12(1): 18-52.
 Forti, L.R., da Silva, T.R.Á., Toledo, L.F. (2017): The acoustic repertoire of the Atlantic Forest Rocket Frog and its consequences for taxonomy and conservation (*Allobates*, Aromobatidae). ZooKeys 692: 141-153.
 Frost, D.R. (2023): Amphibian Species of the World: An Online Reference. Version 6.0. American Museum of Natural History, New York, USA. <<https://amphibiansoftheworld.amnh.org/index.php>, accessed on 07.01.2022>.
 Grant, T., Frost, D.R., Caldwell, J.P., Gagliardo, R., Haddad, C.F.B., Kok, P.J.R., Means, D.B., Noonan, B.P., Schargel, W.E., Wheeler, W. (2006): Phylogenetic systematics of Dart-Poison Frogs and their relatives (Amphibia: Athesphatanura: Dendrobatidae). Bulletin of the American Museum of Natural History 299: 1-262.
 IUCN (2023): *Allobates olfersioides*. The IUCN Red List of Threatened Species 2023: e.T55122A117548027. <<https://dx.doi.org/10.2305/IUCN.UK.2023-1.RLTS.T55122A117548027.en>, accessed on 20 May 2024>
 Izecksohn, E., Carvalho-e-Silva, S.P.D. (2001): Anfíbios do município do Rio de Janeiro. Editora UFRJ, Rio de Janeiro.
 Lutz, A. (1925): Batraciens du Brésil. Comptes Rendus et Mémoires Hebdomadaires des Séances de la Société de Biologie et des ses Filiales. Paris 93(2): 137-139.
 McDonald, R.I., Forman, R.T., Kareiva, P., Neugarten, R., Salzer, D., Fisher, J. (2009): Urban effects, distance, and protected areas in an urbanizing world. Landscape and Urban Planning 93(1): 63-75.
 Melo-Sampaio, P.R., De Oliveira, R.M., Prates, I. (2018): A new nurse frog from Brazil (Aromobatidae: *Allobates*), with data on the distribution and phenotypic variation of western Amazonian species. South American Journal of Herpetology 13(2): 131-149.
 Menin, M., Waldez, F., Lima, A.P. (2008): Temporal variation in the abundance and number of species of frogs in 10,000 ha of a forest in Central Amazonia, Brazil. South American Journal of Herpetology 3(1): 68-81.
 Pontes, R., Pontes, J.A.L. (2016): Anfíbios da Serra da Tiririca: Diversidade e Conservação. pp. 19-68. In: Marafon, G. (ed). Biodiversidade e sociedade no Leste Metropolitano do Rio de Janeiro Organização Marcelo Guerra Santos, Rio de Janeiro.
 Ramalho, W.P., Guerra, V., Ferraz, D., Machado, I.F., Mendonça do Prado, V.H. (2020): Filling gaps on the endangered Cerrado Rocket Frog *Allobates goianus* (Bokermann, 1975) (Anura: Aromobatidae): new distributional record and comments on its daily activity. Cuadernos de Herpetologia 34(1): 93-97.
 Robinson, O.J., Ruiz-Gutierrez, V., Fink, D. (2018): Correcting for bias in distribution modelling for rare species using citizen science data. Diversity and Distributions 24 (4): 460-472.
 Rowley, J.J.L., Callaghan, C.T., Cutajar, T., Portway, C., Potter, K., Mahony, S., Trembath, D.F., Flemons, P., Woods, A. (2019): FrogID: Citizen Scientists Provide Validated Biodiversity Data on Frogs of Australia. Herpetological Conservation & Biology 14(1): 155-170.
 Scheffers, B.R., Joppa, L.N., Pimm, S.L., Laurance, W.F. (2012): What we know and don't know about Earth's missing biodiversity. Trends in Ecology & Evolution 27(9): 501-510.
 Schlaepfer, M.A., Gavin, T.A. (2001): Edge effects on lizards and frogs in tropical forest fragments. Conservation Biology 15(4): 1079-1090.
 Schmeller, D.S., Pierre-Yves, H., Julliard, R., Gruber, B., Clobert, J., Dziock, F., Szabolcs, L., Piotr, N., Deri, E., Budrys, E., Kull, T., Tali, K., Bauch, B., Settele, J., Van Swaay, C., Kobler, A., Babij, V., Papastergiadou, E., Henle, K. (2009): Advantages of Volunteer-Based Biodiversity Monitoring in Europe. Conservation Biology 23(2): 307-316.
 Segalla, M.V., Berneck, B., Canedo, C., Caramaschi, U., Cruz, C.A.G., Garcia, P.C., Grant, T., Haddad, C.F.B., Lourenço, A.C.C., Mângia, S., Mott, T., Nascimento, L.B., Toledo, L.F., Werneck, F.P., Langone, J.A. (2021): List of Brazilian amphibians. Herpetologia Brasileira 10(1): 121-216.
 Silva, L.A., Marques, R., Folly, H., Santana, D.J. (2022). A new Amazonian species of *Allobates* Zimmermann & Zimmermann, 1988 (Aromobatidae) with a trilled advertisement call. PeerJ 10: e13026.
 Simões, P.L., Santana, D., Lima, A.P. (2019): A name for the nurse-frog (*Allobates*, Aromobatidae) of Floresta Nacional de Carajás, Eastern Brazilian Amazonia. Zootaxa. 4550(1): 71-100.
 Sistema da Informação sobre a Biodiversidade Brasileira (SIBBR). (2002): Governo Federal. <https://ala-bie.sibbr.gov.br/alabie/search?q=allobates+olfersioides&lang=pt_BR>, accessed on 07.01.2022>
 Van Strien, A.J., Van Swaay, C.A.M., Termaat, T. (2013): Opportunistic citizen

- science data of animal species produce reliable estimates of distribution trends if analysed with occupancy models. *Journal of Applied Ecology* 50: 1450–1458.
- Verdade, V.K., Rodrigues, M.T. (2007): Taxonomic review of *Allobates* (Anura, Aromobatidae) from the Atlantic Forest, Brazil. *Journal of Herpetology* 41(4): 566–580.
- Weygoldt, P. (1989): Changes in the composition of mountain stream frog communities in the Atlantic mountains of Brazil: frogs as indicators of environmental deterioration? *Studies on Neotropical Fauna and Environment* 24 (4): 249–255.
- Zimmermann, H., Zimmermann, E. (1988): Etho-Taxonomie und zoogeographische Artengruppenbildung bei Pfeilgiftfroschen (Anura: Dendrobatidae). *Salamandra* 24: 125–160.

Keywords: amphibia, Atlantic Forest, conservation biology, diurnal frogs, natural history.

Article No.: e257502

Received: 18 August 2024 / Accepted: 24 March 2025

Available online: June 2025 / Printed: June 2025

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