



# Range Extension of the Blue-sided Leaf Frog, *Agalychnis annae* (Anura: Hylidae): Using Citizen Science across Suburban Areas in Costa Rica

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Populations of the Blue-sided Leaf Frog (*Agalychnis annae*) are fragmented by urban development and restricted to riparian forests and urban green spaces in the Central Valley of Costa Rica (Hoffman 2006; IUCN SSC Amphibian Specialist Group & Nature Serve 2020) and in Panama (Hertz et al. 2012). A few stable populations remain in Costa Rica (Whitfield et al. 2017; Abarca et al. 2018), and the species has been detected in other scattered locations, including a single individual reported in Panama (Hertz et al. 2012). The distribution of this species in Costa Rica includes the Cordillera de Talamanca, Cordillera de Tilarán, and Cordillera Central at elevations of 600–1,650 m asl. Blue-sided Leaf Frogs have been reported in urban and semi-urban parts of the Central Valley, as well as on coffee farms in the foothills of Talamanca (Leenders 2016; Cossel and Kubicki 2019). The species’ extent of occurrence (EOO) is estimated at 16,414 km<sup>2</sup> (IUCN SSC Amphibian Specialist Group & Nature Serve 2020), but it has suffered dramatic population declines with the emergence of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), throughout its range between the mid-1980s and ~2005 and is cataloged as Vulnerable (VU) on the IUCN Red List (IUCN SSC Amphibian Specialist Group & Nature Serve 2020).

In recent years, observations of this species have increased, mainly through social networks; in some cases, reports merely document randomly dispersed individuals, whereas others indicate that reproductive activity has been observed. Although citizen science may have a spatial bias and species may be misidentified, it can be quite effective when working with easily identifiable species (Gómez-Hoyos et al. 2018; Auguste 2020). Herein, we report new locations for *A. annae* in the southwestern Central Valley, San José Province, Costa Rica, and observations about the environment.

We visited locations in three cantons of San José: León Cortés, Dota, and Tarrazú, a sector known locally as the “Zona de los Santos” (Fig. 1), in which some people had provided observations of *A. annae*. At each locality, we recorded land use, relief, extent of urbanization, and geographical coordinates. When a visit to the observation site was not possible, we solicited the information of interest from reliable persons.

We obtained reports from 10 different locations within the Zona de los Santos, all of them outside the distribution reported for *Agalychnis annae* in the IUCN Red List account (IUCN SSC Amphibian Specialist Group & Nature Serve



**Fig. 1.** Map of Costa Rica showing the previously documented distribution of the Blue-sided Leaf Frog (*Agalychnis annae*) in solid orange, whereas orange with diagonal lines indicates areas where the species might be extirpated according to IUCN SSC Amphibian Specialist Group & Nature Serve (2020). The Zona de los Santos (entirely outside the previously documented range) is indicated in green.



**Fig. 2.** Blue-sided Leaf Frogs (*Agalychnis annae*) recorded in the Zona de los Santos by local people. Numbers correspond to Table 1. Photographs by Elena Padilla (1), Ashly Carrión (2), Marilyn Ureña (3), Enrique Cordero (4), Alex Campos (5), Johan Mora (8), Leonel Gamboa (10), and Isaura Rojas (11).

2020). At seven localities we corroborated the presence of the species with images (Fig. 2). Photographic vouchers were deposited in the Biodiversity Collections at the University of Texas at Austin digital collection (TNHC 115473–9). For the three localities where photographs were not available, the reports emanated from reliable sources with adequate biological training. Most records were in coffee-growing areas, near human settlements, and near water (Table 1).

The increased frequency of sightings of *A. annae* in Costa Rica suggests that the species is recovering from the chytrid fungus pandemic (Hoffman 2006; Leenders 2016); this is supported further by numerous reports and observation of adults and tadpoles at some of the sampled sites. Despite appearing to be relatively common in urban areas of the Central Valley and having been observed sporadically at various sites in the Zona de los Santos, until now this species had never officially been registered in that area (Leenders 2016; Cossel and Kubicki 2019; IUCN SSC Amphibian Specialist Group & Nature Serve 2020). This fact shows a historical lag that has characterized the Zona de los Santos in terms of herpetological research, highlights the potential importance of

some environments in these towns as refuges for threatened species, and shows a need for further exploration of this area (García-Rodríguez et al. 2012). Also, we have reports of two individuals in a coffee plantation from a nearby area outside the Zona de los Santos in La Legua, Aserri, 1.5 km west of San Andrés, León Cortés.

Remnants of riparian forests can support species living in disturbed environments (Almeida et al. 2020; da Rocha et al. 2020). However, other observations were relatively distant from such forest remnants or in areas without forests altogether, indicating that the species can survive in dramatically altered situations. Historically, *A. annae* has been associated with coffee plantations, as indicated by its local common name (“Rana de cafetal” = Coffee frog), and this type of agroecosystem can facilitate the species’ survival and recovery. However, additional factors, such as temperature, tadpole resistance to contaminated environments, tolerance to the Bd pathogen, and abundant vegetation, also must be considered if the species is to survive in human-modified environments (Brem and Lips 2008; Voyles et al. 2017). Although citizen-science encourages greater involvement of communities in the

**Table 1.** Report of localities for *A. annae* in the Zona de los Santos based on observations or sightings with photographs. Numbers correspond to those in Fig. 2. Asterisks (\*) mark records without photographs but confirmed by researchers.

Locality	Habitat
1 La Angostura, San Antonio, León Cortés (9.7238°N, 84.0641°W; elev. 1,640 m asl)	Flat gallery patch with little shade, next to a coffee plantation, 200 m to water
2 Ojo de Agua, San Andrés, León Cortés (9.7401°N, 84.0994°W; elev. 1,530 m asl)	Relatively flat area, with abundant vegetation adjacent to a coffee plantation; no natural water, only a tank where rainwater stagnates
3 Barrio Monserrat, San Pablo, León Cortés (9.6891°N, 84.0459°W; elev. 1,570 m asl)	In a house in a relatively flat area with abundant vegetation
4 El Sitio, San Pablo, León Cortés (9.6833°N, 84.0275°W; elev. 1,720 m asl)	Coffee plantation with little slope and little adjacent vegetation
5 Barrio Ares, Santa María, Dota (9.6491°N, 83.9694°W; elev. 1,560 m asl)	Flat area with several ponds (some large); abundant adjacent vegetation in a residential area near small disturbed wetland
6 Barrio el INVU, Santa María, Dota (9.6560°N, 83.9697°W; elev. 1,549 m asl)	Road-killed on bridge over the Río Pirris*
7 Barrio Imas, Santa María, Dota (9.6438°N, 83.9680°W; elev. 1,610 m asl)	Coffee plantation adjacent to a patch of forest*
8 Canet, San Marcos, Tarrazú (9.6801°N, 84.0044°W; elev. 1,620 m asl)	Swamp with several ponds surrounded by large expanses of coffee; terrain relatively flat; tadpoles recorded at this site
9 San Miguel, San Marcos, Tarrazú (9.6519°N, 84.0329°W; 1,364 m asl)	Coffee plantation; 5 m from a stream*
10 Barrio Montero, San Lorenzo, Tarrazú (9.6434°N, 84.0319°W; elev. 1,423 m asl)	Coffee plantation with some <i>Eucalyptus</i> trees
11 Rancho Margoth, La Legua, Aserri (9.7263°N, 84.1023°W; elev. 1,663 m asl)	Coffee plantation with little shade; 100 m to a stream

conservation of threatened species, more focused research is needed to determine what factors allow *Agalychnis annae* to survive in these altered ecosystems and the actual sizes of these populations.

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### Literature Cited

- Abarca, J.G., S.M. Whitfield, K. Sánchez-Paniagua, and J.A. Cambronero-Granados. 2018. *Agalychnis annae* (Blue-Sided Leaf Frog). Predation. *Herpetological Review* 49: 726–727.
- Almeida, P.C.D., M.T. Hartmann, and P.A. Hartmann. 2020. How riparian forest integrity influences anuran species composition: a case study in the Southern Brazil Atlantic Forest. *Animal Biodiversity and Conservation* 209–219. <https://doi.org/10.32800/abc.2020.43.0209>.
- Auguste, R.J. 2020. Using citizen science to rapidly determine the distribution of exploited Green Iguanas (*Iguana iguana*) across urban areas in Trinidad and Tobago. *Reptiles & Amphibians* 27: 419–421.
- Brem, F.M. and K.R. Lips. 2008. *Batrachochytrium dendrobatidis* infection patterns among Panamanian amphibian species, habitats and elevations during epizootic and enzootic stages. *Diseases of Aquatic Organisms* 81: 189–202. <https://doi.org/10.3354/dao01960>.
- Cossel, J.O., Jr. and B. Kubicki. 2017. *A Field Guide to the Frogs and Toads of Costa Rica*. BookBaby. New Jersey, United States.
- da Rocha, M.C., M.B. dos Santos, R. Zanella, O.D. Prestes, A.S. Gonçalves, and A.P. Schuch. 2020. Preserved riparian forest protects endangered forest-specialists amphibian species against the genotoxic impact of sunlight and agrochemicals. *Biological Conservation* 249: 108746. <https://doi.org/10.1016/j.biocon.2020.108746>.
- García Rodríguez, A., G. Chaves, C. Benavides Varela, and R. Puschendorf. 2012. Where are the survivors? Tracking relictual populations of endangered frogs in Costa Rica. *Diversity and Distributions* 18: 204–212. <https://doi.org/10.1111/j.1472-4642.2011.00862.x>.
- Gómez-Hoyos, D., R. Méndez-Arrieta, A. Méndez-Arrieta, R. Seisdedos-de-Vergara, J. Abarca, C. Barrio-Amorós, and J. González-Maya. 2018. Anuran inventory in a locality of the buffer area of La Amistad International Park, Costa Rica: pilot study for Citizen Science application. *Anales de Biología* 40: 57–64. <https://doi.org/10.6018/analesbio.40.07>.
- Hertz, A., S. Lotzkat, A. Carrizo, M. Ponce, G. Köhler, and B. Streit. 2012. Field notes on findings of threatened amphibian species in the central range. *Amphibian and Reptile Conservation* 6: 9–30.
- Hoffmann, H. 2006. Some ecological notes on *Agalychnis annae* (Anura: Hylidae). Algunos apuntes ecológicos sobre *Agalychnis annae* (Anura: Hylidae). *Brenesia* 65: 73–77.
- IUCN SSC Amphibian Specialist Group & Nature Serve. 2020. *Agalychnis annae*. *The IUCN Red List of Threatened Species* 2020: e.T55288A158518518. <https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T55288A158518518.en>.
- Leenders, T. 2016. *Amphibians of Costa Rica. A Field Guide*. A Zona Tropical Publication. Comstock Publishing Associates, Cornell University Press, Ithaca, New York, USA.
- Voyles, J., L.R. Johnson, J. Rohr, R. Kelly, C. Barron, D. Miller, J. Minster, and E.B. Rosenblum. 2017. Diversity in growth patterns among strains of the lethal fungal pathogen *Batrachochytrium dendrobatidis* across extended thermal optima. *Oecologia* 184: 363–373. <https://doi.org/10.1007/s00442-017-3866-8>.
- Whitfield, S.M., G. Alvarado, J. Abarca, H. Zumbado, I. Zuñiga, M. Wainwright, and J. Kerby. 2017. Differential patterns of *Batrachochytrium dendrobatidis* infection in relict amphibian populations following severe disease-associated declines. *Diseases of Aquatic Organisms* 126: 33–41. <https://doi.org/10.3354/dao03154>.