

Population status of *Centrolene savagei* (Anura:Centrolenidae) in the Western and Central Andes of Colombia*


María Lucia Prado-Sañudo^{1,2}, Alan Giraldo², Wilmar Bolívar-García²



Abstract

Objectives: to determine the population status of *Centrolene savagei* (Centrolenidae) in the Western and Central Andes of Colombia. **Scope:** promotion of the population study of the endemic glassfrogs species of Colombia. **Methodology:** *C. savagei* (Centrolenidae) has only been registered in the Central and Western Andes of Colombia. We conducted a visual encounter survey in eight different localities where *C. savagei* was previously reported: Alto Bonito, Florencia, La Pastora, Santa Rosa de Cabal, Filandia, Boquía, Alto el Otoño and Chicoral, with an effective sampling effort of 54 h per locality. Each captured individual was marked, sexed and the height above water level of the perch was registered. Furthermore, all detected clutches in each survey were also marked and height above water level was recorded. We use a standard capture-recapture model to estimate the size of the population in each study site assuming closed population conditions. **Main Results:** *C. savagei* was absent at La Pastora and Florencia. In all localities where *C. savagei* was registered, male individuals and clutches were usually found between 1.5-2.0 m, while female individuals remain most of the time above 6 m height, and only go down for reproduction. The population size of *C. savagei* in the study area of Alto del Otoño was 132 ± 13 ind, in Chicoral was 41 ± 8 ind and in Santa Rosa de Cabal was 37 ± 6 ind. In Filandia, Boquía and Alto Bonito, recaptures were not carried out, so the size of the population could not be estimated. **Conclusions:** The presence of *C. savagei* in 75% of the localities where it had previously been reported suggests that the biotic and abiotic conditions in these sites are still adequate to sustain populations of this endemic species.

Key words: Amphibians; Centrolenidae; population size; capture-recapture; perche site.

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¹Universidad del Valle, Facultad de Ciencias Naturales y Exactas, Departamento de Biología, Programa de postgrado en Ciencias Biología. Cali, Valle, Colombia. Maestra en Ciencias Biología. Email: maria.prado@correounivalle.edu.co  orcid.org/0000-0002-8443-7706 **Google Scholar**

²Universidad del Valle, Facultad de Ciencias Naturales y Exactas, Departamento de Biología, Grupo de Investigación en Ecología Animal. Cali, Valle, Colombia. Doctor en Oceanografía, Doctor en Ciencias Biología Email: alan.giraldo@correounivalle.edu.co  orcid.org/0000-0001-9182-888X **Google Scholar**. wilmar.bolivar@correounivalle.edu.co  orcid.org/0000-0002-9395-721X **Google Scholar**



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Estado de la población de *Centrolene savagei* (Anura: Centrolenidae) en los Andes occidentales y centrales de Colombia

Resumen

Objetivos: determinar el estado de las poblaciones de *Centrolene savagei* (Centrolenidae) in la cordillera central y occidental de los Andes colombianos. **Alcance:** promover el estudio de las poblaciones de especies endémicas de ranas de cristal en Colombia. **Metodología:** *C. savagei* (Centrolenidae) ha sido registrada únicamente en la cordillera central y occidental de los Andes Colombianos. Realizamos muestreos por encuentro visual en ocho localidades en donde *C. savagei* ha sido previamente registrada: Alto Bonito, Florencia, La Pastora, Santa Rosa de Cabal, Filandia, Boquía, Alto el Otoño and Chicoral, con un esfuerzo efectivo de muestreo de 54 h por localidad. Cada individuo capturado fue marcado y sexado, registrando la altura sobre el nivel de agua de su percha. Además, todas las posturas detectadas durante cada muestreo también fueron marcadas y se registró su altura sobre el nivel del agua. Utilizamos un modelo estándar de captura-recaptura para estimar el tamaño de la población en cada uno de los sitios de estudio asumiendo condicione de población cerrada. **Principales resultados:** *C. savagei* estuvo ausente en La Pastora y Florencia. En todas las localidades en donde *C. savagei* fue registrada, los machos y las posturas se encontraron generalmente entre 1.5-2 m de altura, mientras que las hembras estuvieron la mayor parte del tiempo por arriba de los 6 m de altura, bajando solo para actividades reproductivas. El tamaño de la población de *C. savagei* en la zona de estudio del Alto del Otoño fue de 132 ± 13 ind, en Chicoral fue de 41 ± 8 ind y en Santa Rosa de Cabal fue de 37 ± 6 ind. En Filandia, Boquía y Alto Bonito, no se realizaron recapturas, por lo que no se pudo estimar el tamaño de las poblaciones. **Conclusiones:** La presencia de *C. savagei* en el 75% de las localidades donde previamente había sido reportada, sugiere que las condiciones bióticas y abióticas en estos sitios aún son adecuadas para sostener poblaciones de esta especie endémica.

Palabras clave: Anfibios, Centrolenidae, tamaño poblacional, Captura-Recaptura, Sitio de percha.

Introduction

The Centrolenidae family is a clade of anurans, commonly known as glassfrogs, endemic to the Neotropical region, that inhabits from southern Mexico through Central America and into South America mainly through the Andes Cordillera from Venezuela to Bolivia, with species in the Amazon and Orinoco River basins, the Guyana Shield Region, eastern Brazil, and northern Argentina (Frost, 2017). Considerable

advances in phylogenetic knowledge of the family Centrolenidae have been achieved (Cisneros-Heredia and McDiarmid, 2003; 2004), but the natural history, ecology, and conservation status of most species are virtually unknown.

Currently, 74 out of the 153 species of glassfrogs have been reported in Colombia (Amphibia web, 2017). One of this is *Centrolene savagei* (Ruíz and Lynch, 1991), an endemic species to Colombia that is characterized by a small body size, green dorsum with dark green and white dots, rounded snout when viewed dorsally, and lack of humeral spine. Since 2004, this species has been listed by IUCN as vulnerable (Castro-Herrera and Bolívar-García, 2010, Bolívar-García et al., 2013; IUCN, 2017; Vargas-Salinas et al., 2017), being mainly affected by the clearing of forests for agriculture and by environmental pollution (Blaustein and Kiesecker, 2002; Bolívar-García et al., 2013).

Centrolene savagei (Fig. 1) has been reported from the Central and Western Andes of Colombia, in some locations of the departments of Antioquia, Quindío, Risaralda, Caldas, Tolima and Valle del Cauca (Ruíz-Carranza and Lynch, 1991; Cadavid et al., 2005; Vargas-Salinas et. al., 2007; Castro-Herrera and Vargas-Salinas, 2008; Guayasamin et al., 2008; Luna-Mora, 2011; Rojas-Morales et al., 2011; Escobar-Lasso and Rojas-Morales, 2012; Díaz-Gutiérrez et al., 2013). However, population sizes have not been estimated yet although this is a main ecological index in order to determine the conservation status of a species. In this paper, we used capture-recapture techniques in order to estimate the population size of *Centrolene savagei* population in the localities where it has been previously registered and we report the results of observations about the height of perches of males and females of this specie in the study sites.



Figure 1. *Centrolene savagei* (Photo: María Lucía Prado)

Materials and Methods

Capture-recapture data were collected in eight field trips carried out between October 2012 and June 2013 to eight different localities in the Western and Central Andes of Colombia (Fig. 2, Table 1). Each field trip lasted 3 days and every study area was sampled three consecutive days. In each locality, a 500 m transect was established along a creek, and a visual encounter survey was conducted at night by two observers 6 h hours during night, and 3 h during daylight. The effective effort was equivalent to 54 hours in each study area.



Figure 2. Sampled localities at Western and Central Colombian Andes.

Table 1. Sampling localities. Lat: latitude, Lon: Longitude, E: Elevation (m above sea level), P: mean precipitation (mm/year), T: mean temperature (°C)

Locality	Lat	Lon	E	P	T
Alto Bonito	05°06'42.9"N	75°30'33.4"W	1,780	2,600	18
Florencia	05°31'41.3"N	75°02'52.0"W	1,520	1,460	20
La Pastora	04°42'07.0"N	75°32'04.9"W	2,100	2,220	12
Santa Rosa de Cabal	04°53'23.5"N	75°37'10.3"W	1,650	2,573	19
Finlandia	04°40'57.6"N	75°38'21.2"W	1,830	2,515	17
Boquía	04°38'05.8"N	75°35'28.2"W	1,720	1,820	15
Alto el Otoño	03°22'21.4"N	76°36'08.1"W	1,650	2,000	18
Chicoral	03°33'44.5"N	76°35'35.1"W	1,790	1,200	19

All individuals detected were marked with a consecutive number using the toe clipping techniques. A recapture history for each locality was assembled from the subsequent surveys. Considering the short sampling time, we assumed closed population conditions and used the adjusted Lincoln-Petersen model (N_B) in order to estimate the population size. This estimation was only carried out in the localities where the recapture was positive, and the population size record was used in order to define the *Centrolene savagei* density in each study area as individuals per hectare.

Finally, each captured individual was sexed through physical observations of characteristics such as size and buccal slips, and the height above water level of the perch was registered. Furthermore, all detected clutches in each transect were marked with a consecutive number/ and the height above water level was recorded. In order to search individuals and clutches at heights above 3 m, four ascent stations were set up along each transect, and ascent equipment was used to reach heights up to 6 meters above the ground.

Results

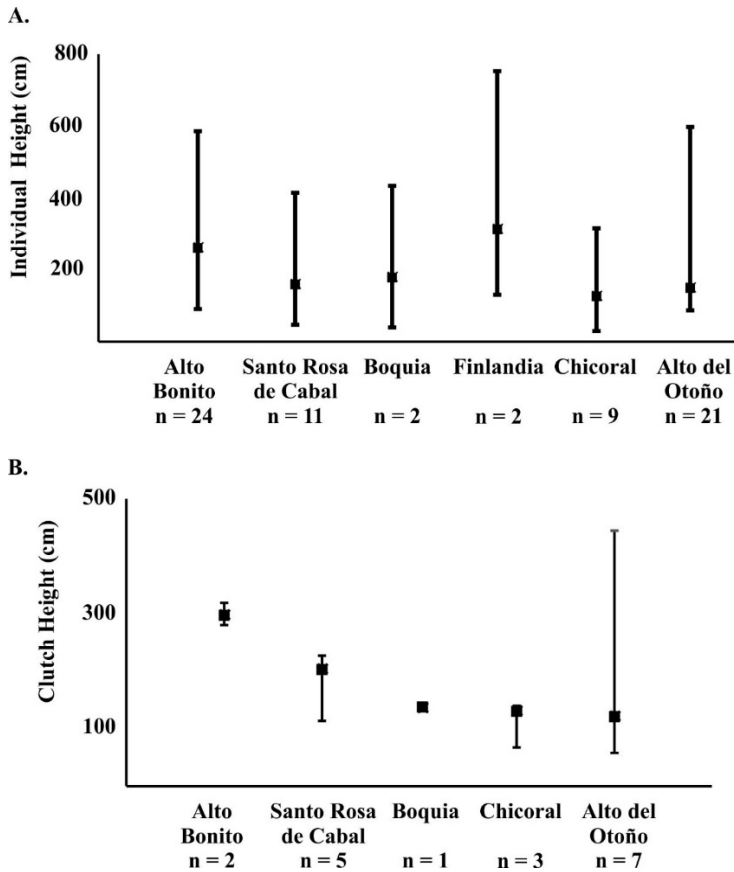
A total of 49 adult individuals (46♂ and 3♀), 9 juveniles, 18 egg clutches, and 2 amplexus were registered during this study. However, at La Pastora and Florencia, no individuals of *Centrolene savagei* were found (Table 2). The highest number of individuals marked was in Alto el Otoño (21 individuals) and the lowest was in Filandia and Boquía (2 individuals). The standardized amount of individuals and clutches of *Centrolene savagei* found per hour during the sampling effort was among 0.25 (Alto el Otoño) and of 0.09 (Finlandia and Boquía).

Only at Alto del Otoño, Chicoral, and Santa Rosa de Cabal recapture was present. The estimate population size in the Alto del Otoño was 132 ± 13 individuals (density = 440 ± 43 Ind/ha), followed by the population found at Chicoral with 41 ± 8 individuals (density = 137 ± 27 Ind/ha), and the last one found at Santa Rosa de Cabal with 37 ± 6 individuals (density = 123 ± 20 ind/ha). No recaptures occurred at Filandia, Boquía or Alto Bonito. Therefore, no estimation of population size at these localities could be done.

Adult individuals were found between 59 and 445 cm above water level, with a mean height of 182.5 ± 78.6 cm and female individuals were found between 114 to 124 cm above water level (Fig. 3A). Egg clutches were found at the same height range, with a mean height of 180.7 ± 99.9 cm (Fig. 3B).

Table 2: Individuals of *Centrolene savagei* registered at the study localities

Locality	Males	Females	Juveniles	Amplexus	Clutches
Alto del Otoño	20	1	6	1	7
Florencia	0	0	0	0	0
Chicoral	8	0	2	0	3
Finlandia	2	0	0	0	0
Santa Rosa de Cabal	7	2	0	1	5
Boquía	2	0	1	0	1
La Pastora	0	0	0	0	0
Alto Bonito	7	0	0	0	2

**Figure 3.** Height of adults (A) and egg clutch (B) of *Centrolene savagei* at sampling localities.

Discussion

This study provides the first quantitative assessment of population metrics of *C. savagei* in six localities of Colombia. Baseline population vital rates, including density, survival, and population growth rates are critical for determining extinction risk and population trends. Mark–recapture studies are a particularly robust method for determining population vital rates and can be used to monitor changes through time (Cole et al., 2014). Although, long term monitoring is essential to accurately distinguish drivers of population dynamics, assess extinction risk and rigorously estimate population parameters (Pechmann et al., 1991; Bonebrake et al., 2010), some authors like Funk et al. (2003) and Cole et al. (2014) have suggested that short-term capture-recapture analysis, assuming closed populations, is a good method for monitoring density of small frogs over time.

Our result suggests that some sites (e.g., Alto el Otoño, Chicoral and Santa Rosa de Cabal) may be capable of supporting larger breeding populations and thus have greater conservation value for this endemic species. However, no presence records in some locations (e.g., Florencia and Ucumari) where it had been previously recorded (Ruíz and Lynch, 1991; Rojas-Morales et al., 2011; Prado-Sañudo et al., 2018) suggests that the species could have been extinguished from those areas, that the population size is so small that it requires a greater sampling effort in order to determine their occurrences, or that the local conditions of these areas were not the proper ones for the reproduction of the species, decreasing the chance of visual encounters.

Unfortunately, the low rate of recaptures only allowed estimating the population size at three locations: Alto del Otoño, Chicoral, and Santa Rosa. Populations of Filandia, Boquía and Alto Bonito require a higher sampling effort in order to achieve a population estimate and be able to draw more accurate conclusions. However, a positive record of *C. savagei* in all of these locations, suggest that local biotic and abiotic conditions are enough for sustaining individuals of this species. Otherwise, the low rate of recaptures could be associated with a low detectability of *C. savagei* in the study zones. It is usually common in complex and heterogeneous systems, such as tropical forests, and may derive from a cryptic coloration of *C. savagei*, sex behavior patterns or with a seasonal reduced individual foraging activity and reproduction (Haddad and Giaretta, 1999; Ruíz-Gutierrez and Zipkin, 2011; Kajin and Grelle, 2012; Maritz and Alexander, 2012).

The range height of perching between 1.5 – 2 m tend to provide favorable conditions to reduce predation by small terrestrial mammals on individuals or eggs. However, it does not represent a risk to the survival of tadpoles because of the impact when they hit the water (Hampton and Otto, 2014; Cisneros-Heredia and Guayasamin, 2014). Females usually stay at a higher level within the forest (Restrepo and Naranjo, 1999;

Quintero et al., 2008), reducing drastically their detectability by traditional sampling methods. However, it is important to emphasize that, despite the ascents made with the equipment (reaching heights of up to 6 meters), no females of the species were found between 2.0-6.0 meters high, suggesting that females preferred perches above 6 m height, getting down only for reproduction, that they usually migrate to the inner part of the forest, or that other sampling techniques are required in order to improve the results.

The presence of *C. savagei* in 75% of the localities where it had previously been reported suggests that the biotic and abiotic conditions in these sites are still adequate to sustain populations of this endemic species. With this study, we were able to report the size and density of the *C. savagei* in three sites of the Alto del Otoño, Chicoral and Santa Rosa de Cabal. In Filandia, Boquía and Alto Bonito it is required to increase the sampling effort in order to define the *C. savagei* vital rates. At two locations, Florencia and La Pastora, where this species has been previously recorded, it seems that it is no longer there. However, further studies are needed in order to determine the complete absence of the species at these localities.

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References

- Amphibiaweb. (2017). *Amphibia Web*. University of California, Berkeley, CA, USA. Retrieved from: <http://amphibiaweb.org>
- Blaustein, A. R. and Kiesecker, J. M. (2002). Complexity in conservation: lessons from the global decline of amphibian populations. *Ecology Letters*, 5, 597–608. DOI: 10.1046/j.1461-0248.2002.00352.x
- Bonebrake, T. C., Christensen, J., Boggs, C. L. and Ehrlich, P. R. (2010). Population decline assessment, historical baselines, and conservation. *Conservation Letters*, 3(6), 371–378. DOI: 10.1111/j.1755-263X.2010.00139.x
- Bolívar-García, W., Prado-Sañudo, M. L., Soria, A. M. and Rivera, N. (2013). *Centrolene savagei* (Ruíz-Carranza y Lynch, 1991) rana de cristal. *Catálogo de Anfibios y Reptiles de Colombia*, 1(1), 15–18.
- Cadavid, J. G., Román-Valencia, C. and Gómez, A. (2005). Composición y estructura de anfibios anuros en un transecto altitudinal de los Andes Centrales de Colombia. *Revista del Museo Argentino de Ciencias Naturales*, 7(2), 103–118.
- Castro-Herrera, F. and Bolívar-García, W. (2010). *Libro rojo de los anfibios del Valle del Cauca*. Feriva Impresores SA. Cali-Colombia.
- Castro-Herrera, F. and Vargas-Salinas, F. (2008). Anfibios y reptiles en el departamento del Valle del Cauca, Colombia. *Biota Colombiana*, 9(2), 251–277.
- Cisneros-Heredia, D. F. and Guayasamin, J. M. (2014). Notes on the taxonomy of some glassfrogs from the Andes of Peru and Ecuador (Amphibia: Centrolenidae). *Papéis avulsos de zoologia (São Paulo)*, 54(12), 161–168. DOI: <http://dx.doi.org/10.1590/0031-1049.2014.54.12>
- Cisneros-Heredia, D. F. and McDiarmid, R. W. (2003). Ecuadorian Glass Frogs: Current state of knowledge, new research trends and conservation. Abstract of a poster presented at the 2003 *Joint Meeting of Ichthyologists and Herpetologists*, Manaus, Brazil. PeerJ Preprints | <https://doi.org/10.7287/peerj.preprints.2164v1>

- Cisneros-Heredia, D. F. and McDiarmid, R. W. (2004). Observations on the taxonomy, distribution, and conservation status of the centrolenids from Ecuador (Anura: Centrolenidae). Abstract of a poster presented at the 2004. *Joint Meeting of Ichthyologists and Herpetologists*. Oklahoma, USA.
- Cole, E. M., Bustamante, M. R., Almeida-Reinoso, D. and Funk, W. C. (2014). Spatial and temporal variation in population dynamics of Andean frogs: Effects of forest disturbance and evidence for declines. *Global ecology and conservation*, 1, 60–70. DOI: 10.1016/j.gecco.2014.06.002
- Díaz-Gutiérrez, N., Vargas-Salinas, F., Rivera-Correa, M., Rojas-Morales, J. A., Escobar-Lasso, S., Velasco, J. A., Gutiérrez-Cárdenas, P. D. and Amézquita, A. (2013). Description of the previously unknown advertisement call and tadpole of the Colombian endemic glassfrog *Centrolene savagei* (Anura: Centrolenidae). *Zootaxa*, 3686(2), 289–296. DOI: 10.11646/zootaxa.3686.2.9.
- Escobar-Lasso, S. and Rojas-Morales, J. A. (2012). Antidepredatory behaviors of the Colombian endemic glassfrog *Centrolene savagei* (Anura: Centrolenidae). *Boletín científico museo de historia natural Universidad de Caldas*, 16(1), 226–232.
- Frost D. R. (2017). Amphibian species of the world: an online reference. Version 6.0. Retrieved from: <http://research.amnh.org/herpetology/amphibia/index.html>
- Funk, W. C., Almeida-Reinoso, D., Nogales-Sornosa, F. and Bustamante, M. R. (2003). Monitoring population trends of *Eleutherodactylus* frogs. *Journal of Herpetology* 37(2): 245–256. DOI: 10.1670/0022.1511(2003)037[0245:MPTOEF]2.0.CO;2
- Guayasamin, J. M., Castroviejo-Fisher, S., Ayarzagüena, J., Trueb, L., Villa, C. (2008). Phylogenetic relationships of glassfrogs (Centrolenidae) based on mitochondrial and nuclear genes. *Molecular Phylogenetics and Evolution*, 48(2), 574–595. DOI: 10.1016/j.ympev.2008.04.012.
- Guayasamin, J. M., Castroviejo-Fisher, S., Trueb, L., Ayarzagüena, J., Rada, M. and Vila, C. (2009). Phylogenetic systematics of Glassfrogs (Amphibia: Centrolenidae) and their sister taxon *Allophryne ruthveni*. *Zootaxa*, 2100, 1–97. DOI: 10.11646/zootaxa.2100.1.1
- Haddad C. F. and Giaretta A. A. (1999). Visual and acoustic communication in the Brazilian torrent frog, *Hylodes asper* (Anura: Leptodactylidae). *Herpetologica*, 55(3), 324–333.
- Hampton, P. M. and Otto, K. L. (2014). Notes on the reproductive biology of the glass frog *Centrolene bacatum* (Anura: Centrolenidae). *Phyllomedusa*, 13(2), 137–140. DOI: <https://doi.org/10.11606/issn.2316-9079.v13i2p137-140>
- IUCN SSC Amphibian Specialist Group. 2017. *Centrolene savagei*. The IUCN Red List of Threatened Species 2017: e.T54990A63062174. Retrieved from <https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T54990A63062174.en>.
- Kajin, M. and Grelle, C. E. V. (2012). Microhabitat selection when detection is imperfect: the case of an endemic Atlantic forest mammal. *Ecological research*, 27, 1005–1013. DOI: 10.1007/s11284-012-0977-x
- Luna-Mora, V.F. (2011). *Anfibios. Norte del departamento del Tolima, Colombia*. Ibagué, Colombia: Fundación herencia natural y fundación biología y conservación ambiental.
- Maritz, B. and Alexander, G. (2012). Population density and survival estimates of the African viperid, *Bitis schneideri*. *Herpetologica*, 68(2), 195–202. DOI: 10.1655/HERPETOLOGICA-D-11-00043.1
- Pechmann, J. H. K., Scott, D. E., Semlitsch, R. D., Caldwell, J. P., Vitt, L. J., and Gibbons, J. W. (1991). Declining amphibian populations: The problem of separating human impacts from natural fluctuations. *Science*, 253(5022), 892–895. doi:10.1126/science.253.5022.892
- Prado-Sañudo, M. L., Giraldo, A., and Bolívar-García, W. (2018). Parental attendance and site selection of *Centrolene savagei* (Ruiz and Lynch 1991) in the western and central Andes of Colombia. *Herpetology Notes*, 11, 293–299.
- Quintero-Ángel, A., Díaz, N., Velasco J. A. and Osorio, D. (2008). Comportamiento reproductivo de la rana de cristal *Cochranella savagei* (Anura: Centrolenidae) en los Andes centrales de Colombia. In: libro resúmenes. Topes de Collantes, Cuba, *VIII Congreso Latinoamericano de Herpetología*
- Restrepo, J. H. and Naranjo L. G. (1999). Ecología reproductiva de una población de *Cochranella ignota* (Anura: Centrolenidae). *Revista de la academia colombiana de ciencias exactas, físicas y naturales*, 23(86), 49–59.
- Rojas-Morales, J. A., Escobar-Lasso, S. and Gutiérrez-Cárdenas, P. D. A. (2011). Contribución al conocimiento de los anfibios de la región centro-sur de Caldas: primeros registros de ranas de cristal (Anura: Centrolenidae) para el municipio de Manizales, Colombia. *Boletín científico museo de historia natural Universidad de Caldas*, 15(1), 75–83.
- Ruiz-Carranza, P. M. and Lynch, J.D. (1991). Ranas Centrolenidae de Colombia III. Nuevas especies de *Cochranella* del Grupo granulosa. *Lozanía*, 59, 1–20.
- Ruiz-Gutiérrez, V. and Zipkin, E.F. (2011). Detection biases yield misleading patterns of species persistence and colonization in fragmented landscapes. *Ecosphere* 2(5), 1–14. DOI: 10.1890/ES10-00207.1
- Vargas-Salinas, F., López-Aranda, F. and Muñoz-González, N. (2007). Savage Glassfrog *Cochranella savagei* (Reproduction). *Herpetological review* 38(4), 436–437.
- Vargas-Salinas, F., Ospina-L, A. M., Ríos-Soto, A. M. and Rivera-Correa, M. (2017). *Centrolene savagei*, *Catalogue of American amphibians and reptiles*, 912, 1–12