




Hylid frogs are some of the most charismatic and endangered anurans in Mexico. During a time where amphibian extinctions are becoming a common occurrence, it is important to celebrate rediscoveries. With rediscoveries of endangered species also comes an urgent need to acquire basic natural history information and population data. Pictured here is an individual of *Duellmanohyla ignicolor* found near La Esperanza, Oaxaca, Mexico.  © Itzue W. Caviedes Solis



Missing in action for nearly 50 years: rediscovery of the Mexican treefrog *Duellmanohyla ignicolor* (Anura: Hylidae)

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ABSTRACT: The genus *Duellmanohyla* currently is comprised of eight species distributed from eastern Veracruz, Mexico, to western Panama. Three species in this genus occur in Mexico (*D. chamulae*, *D. ignicolor*, and *D. schmidtorum*), of which the first two are endemic to the country and are considered Endangered by the IUCN, whereas *D. schmidtorum* is classified as Vulnerable. We conducted surveys at the type localities and surrounding regions of the species of *Duellmanohyla* distributed in Mexico. We found one individual of *D. chamulae* near Rayón Mezcalapa, Chiapas; three individuals of *D. schmidtorum* from San Rafael, Chiapas; and rediscovered three individuals of *D. ignicolor*, a species that has not been found since 1970, near La Esperanza, Santiago Comaltepec, Oaxaca.

Key Words: *Duellmanohyla ignicolor*, *Duellmanohyla chamulae*, *Duellmanohyla schmidtorum*, Mexico, Oaxaca, rediscovery

RESUMEN: El género *Duellmanohyla* está compuesto por ocho especies que se distribuyen del este de Veracruz, México, hasta el oeste de Panamá. Tres especies en este género se distribuyen en México (*D. chamulae*, *D. ignicolor* y *D. schmidtorum*), de cual las dos primeras son endémicas al país y están consideradas En Peligro por UICN, mientras que *D. schmidtorum* está clasificada como Vulnerable. El trabajo de campo fue realizado en los alrededores de las localidades tipo de las especies de *Duellmanohyla* que se distribuyen en México. Reportamos un individuo de *D. chamulae* cerca de Rayón Mezcalapa, Chiapas; tres individuos de *D. schmidtorum* de San Rafael, Chiapas; y redescubrimos tres individuos de *D. ignicolor*, una especie que no se había encontrado desde 1970, cerca de La Esperanza, Santiago Comaltepec, Oaxaca.

Palabras Claves: *Duellmanohyla ignicolor*, *Duellmanohyla chamulae*, *Duellmanohyla schmidtorum*, Mexico, Oaxaca, redescubrimiento

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INTRODUCTION

Mexico contains a remarkable amount of amphibian diversity and endemism, as it harbors 376 species of amphibians, of which 60% are endemic to the country (Flores-Villela, 1993; Parra-Olea et al., 2014). Approximately 20% of the world's amphibian diversity is found in Mexico, a country that ranks third with respect to global amphibian endemism (Stuart et al., 2008). Nonetheless, the same anthropomorphic and climatic pressures that are impacting other amphibian populations in Latin America and the world are threatening Mexico's unique amphibian diversity (Young et al., 2001; Lips et al. 2004; Stuart et al., 2008; Frías-Alvarez et al., 2010). In particular, montane stream-breeding frogs in Latin America are susceptible to unexpected population declines, even within protected areas (Pounds et al., 1997; Lips, 1999). Low population density or species rarity can lead to the false assumption that a species has gone extinct, but with comprehensive surveys such species sometimes can be rediscovered (Caviedes-Solis et al., 2015).

The genus *Duellmanohyla* currently is comprised of eight species distributed from eastern Veracruz, Mexico, to western Panama (Aguilar-López et al., 2010; Frost, 2016). Three of the species are distributed in Mexico: *D. chamulae* and *D. ignicolor* were described from Vista Hermosa, Sierra de Juarez, Oaxaca by Duellman (1961); and *D. schmidtorum* was described from Finca el Porvenir, San Marcos, Guatemala by Stuart (1954) (Fig. 1). *Duellmanohyla chamulae* and *D. ignicolor* are endemic to Mexico and considered Endangered by the International Union for Conservation of Nature (IUCN) (Santos-Barrera and Muñoz-Alonso, 2004a; Santos-Barrera et al., 2004), and *D. schmidtorum* is found in Guatemala and Mexico and is classified as Vulnerable (Santos-Barrera and Muñoz-Alonso, 2004b). Of these taxa, these authors noted *D. chamulae* as “not a rare species”; however, *D. schmidtorum* was indicated as “not very common” and *D. ignicolor* as “relatively uncommon and known only from a few localities.” Mexican law protects the three species under the “Special Protection” category (SEMARNAT, 2010).

Whereas individuals of both *D. schmidtorum* and *D. chamulae* have been found during the last seven years (Muñoz-Alonso, 2010), the last known record for *D. ignicolor* corresponds to 24 adult males collected in 1970 (Caldwell, 1974); females of this species remain unknown. Previous surveys for stream-breeding frogs in the Mexican highlands have failed to find *D. ignicolor*; no adults were detected during the years 2000, 2004, 2007, 2010, 2011, or 2014, despite surveys conducted in streams within the expected elevational range of 680–1,850 m at the type locality in the Sierra de Juarez (Lips et al., 2004; Delia et al., 2013; Caviedes-Solis et al., 2015). Thirteen tadpoles found in 2004 tentatively were referred to as *D. ignicolor* (Lips et al., 2004); however, after further inspection they did not match the description and illustrations provided by Duellman (2001) (J. Mendelson III, pers. comm.). Subsequently, these specimens were lost.

MATERIALS AND METHODS

We surveyed localities in the surrounding areas of the type localities of the three species of *Duellmanohyla* distributed in Mexico: Santiago Comaltepec, Oaxaca (3 days), Rayón Mezcalapa (2), and San Rafael, Chiapas (1) (Fig. 1). The collecting effort included two field biologists: Itzue Caviedes-Solis and Ross Furbush. We searched for approximately six hours each night in September of 2015, using visual encounter and acoustic surveys along slow flowing streams. We captured the frogs by hand and euthanized them with an anesthetic, according to the University of Washington IACUC protocol (#4209-01). We collected liver tissue samples and preserved them in ethanol for molecular genetic studies. We fixed the specimens with buffered formalin and preserved them in 70% ethanol. All specimens are deposited at the Burke Museum of Natural History and Culture, University of Washington (Accession #s 2016–22).

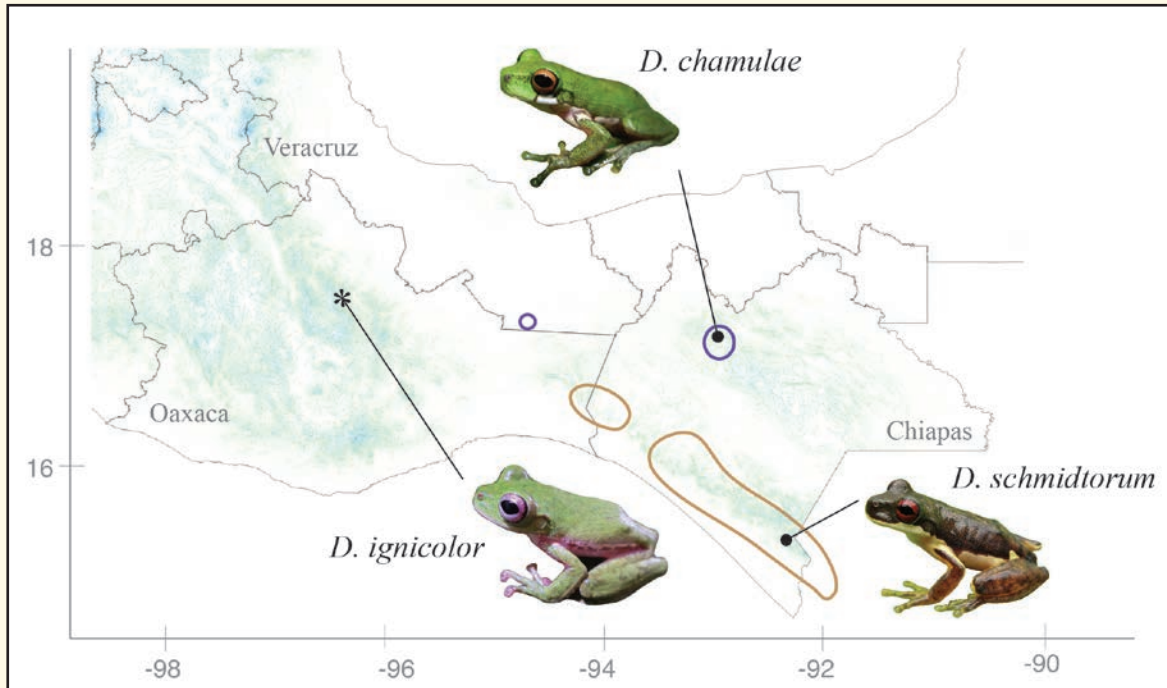


Fig. 1. Distribution map of species in the genus *Duellmanohyla* in Mexico.

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RESULTS

On 8 September 2015, we recorded three male individuals of *Duellmanohyla ignicolor* from near La Esperanza, Santiago Comaltepec, Oaxaca (UWBM 9205–9207). We found the three frogs on tree leaves between 1 and 1.5 m above the ground: one was on a branch overhanging a slow flowing stream and the other two were found less than 2 m away from the water. The water source was located among the limits of cloud forest, cow pastures, and riparian vegetation. On 12 September 2015, we found one male *D. chamulae* near Rayón Mezcalapa, Chiapas (UWBM 2904), in a patch of cloud forest downstream from a cow pasture. The individual was calling approximately 5 m upslope from a slow flowing stream, and was found on a leaf approximately 1.5 m from the ground. We also found three individuals of *D. schmidtorum* near San Rafael, Chiapas (UWBM 2908–2910). On 14 September 2015, we found additional individuals of *D. schmidtorum* in cloud forest habitat, on leaves of low vegetation less than 1 m above the ground and less than 3 m from a fast flowing river. We provide color images of all the specimens in Fig. 2, and present their morphometric data in Table 1.

Our specimens match the descriptions of these species provided by Duellman (1961, 2001); however, we also recorded new color variation among adult males of *D. ignicolor*. The dorsum of one specimen (UWBM 9205; Fig. 2 D) was uniform green, whereas the dorsal coloration of the other three (KU 87160, UWBM 2206, 2207; Fig. 2 C, E, and F) contained various brown and dark green irregular markings and cream spots that extend from the dorsum to the arms and legs. The iris color of the holotype was described as pale gold, probably similar to the specimen in Fig. 2 C; however, the iris color of the three specimens we found (Fig. 2D–F) was pale red/pink. The original description of *D. ignicolor* noted red or orange red coloration on the thighs, ventral surfaces of the shanks, anterior surfaces of the tarsi, and upper proximal surfaces of the 1st, 2nd, and 3rd toes (Duellman, 2001); pale pink-orange was present in the same areas in our three specimens (Fig. 2D–F), but it also extended to the four fingers and five toes and toepads. As noted by Duellman (2001), all of our specimens have a white line on their sides, along with a discontinuous brown line below. Interrupted marked bands (Fig. 2C–F) are present on the dorsal parts of the thighs and arms, and one of the males (Fig. 2 F) showed scars on the head. We are not including detailed descriptions of *D. chamulae* and *D. schmidtorum*, but the color pattern of the specimens agrees with the variation noted by previous authors (Campbell and Smith, 1992; Duellman, 2001; Aguilar-López et al., 2010).



Fig. 2. Color variation in specimens of the genus *Duellmanohyla*. *D. chamulae* (A = KU 58062; and B = UWBM 9204); *D. ignicolor* (C = KU 87160; D = UWBM 9205; E = UWBM 9206; and F = UWBM 9207); *D. schmidtorum* (G = KU 58016-29; H = UWBM 9208; I = UWBM 9209; and J = UWBM 9210). A, C, and H correspond to specimens previously collected (AmphibiaWeb, 2016).

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Table 1. Morphological measurements (mm) for specimens of *Duellmanohyla*. UWBM = Burke Museum of Natural History and Culture, University of Washington. SVL – snout–vent length.

| UWBM | Sex | SVL | Tibia | Head Length | Head Width | Eye Diameter | Tympanum Diameter |
|-----------------------|-----|-------|-------|-------------|------------|--------------|-------------------|
| <i>D. chamulae</i> | | | | | | | |
| 09204 | M | 28.21 | 13.47 | 9.38 | 8.71 | 3.29 | 1.79 |
| <i>D. ignicolor</i> | | | | | | | |
| 09205 | M | 35.39 | 18.75 | 11.05 | 10.90 | 4.68 | 2.15 |
| 09206 | M | 35.30 | 18.03 | 10.61 | 11.00 | 5.40 | 2.12 |
| 09207 | M | 34.71 | 18.75 | 10.97 | 10.95 | 4.56 | 2.02 |
| <i>D. schmidtorum</i> | | | | | | | |
| 09208 | M | 29.48 | 14.85 | 9.02 | 9.09 | 3.79 | 1.76 |
| 09209 | M | 30.23 | 14.91 | 9.63 | 9.41 | 3.38 | 1.68 |
| 09210 | M | 30.69 | 14.79 | 9.12 | 9.73 | 3.64 | 1.95 |

DISCUSSION

Recently, many amphibian surveys have been conducted in Sierra de Juarez during the rainy season, and all failed to detect *Duellmanohyla*. Our success in finding *D. ignicolor* in this region might have resulted from favorable weather conditions, as well as from surveys conducted in new localities with adequate microhabitats. During 2015 the climate phenomenon “El Niño” caused precipitation anomalies throughout Mesoamerica. Records show a significant precipitation reduction in Mexico during the summer before our surveys in 2015 (Servicio Meteorológico Nacional, 2016), which corresponds to the breeding season for most Mexican treefrogs (Duellman, 2001). Some studies have suggested that an increase in temperature along with a reduction of water availability could cause a displacement of the breeding season for species dependent on temporary ponds for reproduction (Blaustein et al., 2001). *Duellmanohyla ignicolor*, for example, requires slow flowing freshwater streams for breeding (Duellman, 1963). These conditions might explain why a delayed rainy season in the summer 2015 might have produced favorable breeding conditions for *D. ignicolor* in late September.

The genus *Duellmanohyla* was described as a monophyletic stream-breeding lineage from the Central American highlands (Campbell and Smith, 1992), but recent phylogenetic analyses found that *Duellmanohyla* is paraphyletic with respect to *Bromeliohyla* and *Ptychohyla* (Duellman, et al., 2016). These three genera are difficult to distinguish based on their adult morphology, and although their reproductive modes and larvae are distinctly different, “the existing molecular data are unable to resolve their relationships” (Duellman et al., 2016: 19). The new genetic resources that we collected from these new specimens of *D. ignicolor*, *D. chamulae*, and *D. schmidtorum* hopefully will contribute to resolving the phylogeny of this Mesoamerican group of frogs.

Mexican endemic species of *Duellmanohyla* are distributed in two states involved with ongoing conservation efforts. Santiago Comaltepec, in the state of Oaxaca, is a member of the “Payment For Environmental Services” program, which helps protect forested areas. In the same municipality, a project was dedicated to search for rare and endangered treefrogs, which is funded by a Conservation Leadership Fellowship (L. Canseco-Márquez, pers. comm.). The state of Chiapas hosts a program called “Strategy for the Conservation of Critically Threatened Amphibians from Chiapas, Mexico,” which meets annually to discuss local amphibian conservation (Luna-Reyes et al., 2010); it also maintains a compilation of records of the state’s amphibian diversity, including the conservation status for each species. A potential cause of amphibian population declines in Chiapas has been the pathogenic

fungus *Batrachochytrium dendrobatidis*. This pathogen has been reported as abundant in populations of *D. schmidtorum*, and although individuals of *D. chamulae* were not tested or found, the pathogen has been reported from within its potential distribution (Muñoz-Alonso, 2010). *Duellmanohyla ignicolor* might also have been affected by *B. dendrobatidis*, which has been found in Sierra de Juárez (Hernández, 2012).

During a time when amphibian extinctions are becoming more common, it is important to celebrate rediscoveries. With rediscoveries, however, also comes an urgent need to acquire basic natural history and population data for such endangered species as *D. ignicolor*. Although emerging conservation programs are present in the state of Oaxaca, these efforts could be more strategic if we knew the population status of *D. ignicolor* and understood the life history of this species. Treefrogs generally are cryptic and females in this genus do not call, unlike their male counterparts, which might explain why females of *D. ignicolor* have never been found. Females must be discovered to understand the sexual dimorphism, phenology, and breeding behavior of this species. Additional surveys will continue to improve our understanding of *D. ignicolor*, and allow us to promote the importance of endemic treefrogs to scientists, the Mexican government, and local communities.

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