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Distributional and natural history notes for *Bromeliohyla dendroscarta* (Anura: Hylidae) in Veracruz, Mexico

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Abstract

Distributional and natural history notes for *Bromeliohyla dendroscarta* (Anura: Hylidae) in Veracruz, Mexico. Two new locality records are reported for the critically endangered hylid frog, *Bromeliohyla dendroscarta,* in Veracruz, Mexico. The frogs were found in semideciduous tropical forest, an ecotone of semideciduous tropical forest and mountain cloud forest, and an agricultural mosaic; none of these habitats has been documented previously for this species. Information is provided on larval feeding habits, duration of larval development under natural conditions and external morphology of tadpoles.

Keywords: Altas Montañas region, morphology, reproduction, semideciduous tropical forest, tadpoles, *Tillandsia* sp.

Resumen

Notas distributivas y de historia natural de *Bromeliohyla dendroscarta* (Anura: Hylidae) en Veracruz, México. Se reportan dos nuevos registros de localidades para la rana hílida en peligro crítico, *Bromeliohyla dendroscarta* en Veracruz, México. Las ranas se encontraron en bosque tropical semicaducifolio, un ecotono de bosque tropical semicaducifolio y bosque mesófilo de montaña, y un mosaico agrícola, ninguno de estos hábitats ha sido documentado previamente para esta especie. Se proporciona información sobre hábitos de alimentación larvales; También se informa la duración del desarrollo larvario en condiciones naturales y la morfología externa de los renacuajos.

Palabras clave: bosque tropical semicaducifolio, morfología, Región de las Altas Montañas, renacuajos, reproducción, *Tillandsia* sp.

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Resumo

Notas de distribuição e história natural de *Bromeliohyla dendroscarta* (Anura: Hylidae) em Veracruz, México. Dois novos registros de localidade são relatados para o hilídeo Criticamente Ameaçado *Bromeliohyla dendroscarta,* em Veracruz, México. Os animais foram encontrados em uma floresta tropical semidecídua, um ecótono de floresta tropical semidecídua, uma floresta montana e um mosaico agrícola. Nenhum desses habitats foi documentado anteriormente para essa espécie. São fornecidas informações sobre hábitos alimentares larvais, duração do desenvolvimento larval em condições naturais e morfologia externa dos girinos.

Palavras-chave: Floresta tropical semidecídua, girinos, morfologia, região de Las Altas Montañas, reprodução, *Tillandsia* sp.

Introduction

Mexico ranks fifth in the world for amphibian species diversity, and more than 60% of its species are endemic (Parra-Olea *et al.* 2014). Unfortunately, Mexico also ranks second in the world for the number of threatened amphibian species (Stuart *et al.* 2006). Several different factors have a negative effect on amphibian populations. Destruction, fragmentation, and modification of natural habitats often is considered the main cause amphibian declines (Frías-Álvarez *et al.* 2010), but disease (e.g., chytridiomycosis), pollution, invasive species, overexploitation, increase in ultraviolet radiation, and global climate change also are important, and often act synergistically (Collins and Storfer 2003, Lips *et al.* 2008, Rovito *et al.* 2009, Aranda-Coello *et al.* 2018). Many Mexican species of amphibians that are listed as threatened on the IUCN Red List have remained undocumented by scientists for decades, because either the populations have been extirpated or the species have cryptic habits that hinder sampling (Kays and Allison 2001, Canseco-Márquez *et al.* 2018). Consequently, there often are substantial gaps in our knowledge of basic natural history, such as microhabitat use and breeding phenology, of these amphibians (Delia *et al.* 2013).

Hylidae is one of the most diverse anuran families in Mexico, with 99 described species (Frost 2018), of which about 68% are endemic (Parra-Olea *et al.* 2014) and about 59% are threatened (Frías-Alvarez *et al.* 2010). In a recent surge in fieldwork, several species of Mexican hylids that were "lost" to science for several decades have been rediscovered (e.g., Delia *et al.* 2013, Caviedes-Solis *et al.* 2015, Barrios-Amorós *et al.* 2016, Grünwald *et al.* 2016, García-Bañuelos *et al.* 2017, Canseco-Márquez *et al.* 2018). One such species is the Mexican endemic *Bromeliohyla dendroscarta* (Taylor, 1940) (García-Bañuelos *et al.* 2017, Canseco-Márquez *et al.* 2018), which is associated with bromeliads in cloud forest and pine-oak forest. The confirmed distribution of this species is limited to the states of Puebla, Oaxaca, and Veracruz (Canseco-Márquez *et al.* 2018). Several additional records of *B. dendroscarta* in Hidalgo (Hernández-Salinas and Ramírez-Bautista 2012) and in the Sierra de Los Tuxtlas in Veracruz are questionable. Molecular, morphological, and acoustical studies of available specimens are needed (fide Duellman 2001, Lamoreux *et al.* 2015, Lemos-Espinal and Smith 2016, Canseco-Márquez *et al.* 2018) to verify the identity of these frogs and the locality records. *Bromeliohyla dendroscarta* is listed in NOM-059-SEMARNAT-2010 as Subject to Special Protection (SEMARNAT 2010) and as Critically Endangered on the IUCN Red List (Santos-Barrera and Canseco-Márquez 2004). Many aspects of the biology of this species and the status of its populations remain unknown.

Here, we provide novel distribution records for *B. dendroscarta,* along with information on larval feeding habits, the duration of larval development under natural conditions, and the external morphology of the larvae. We also comment on notable ecological aspects as observations on the diet of the larvae of *B. dendroscarta* and briefly discuss their implications for conservation.

Materials and Methods

Our study area is a region known as "Las Altas Montañas" in west-central Veracruz. The specific locality is Colonia Agrícola Rincón de las Flores (18°43'12.02" N, 96°50'54.59" W; 1150 m a.s.l.; Figure 1), in the municipality of Tezonapa. The predominant vegetation is semideciduous tropical forest (Figure 2 A, B); however, there also is an ecotone of semideciduos tropical forest and montane cloud forest (Figure 2C), along with patches of shade-grown coffee (*Coffea arabica* L.), banana (*Musa* sp.), and camedor palm (*Chamaedorea elegans* Mart.) (Figure 2D).

The field work was opportunistic. We sampled our study area in 2015 (19–20 March), 2017 (02–03 October), and 2018 (12–13 May), using visual encounter surveys focused on microhabitats often inhabited by amphibians, including bromeliads. We performed surveys from 09:00–13:00 h and from 21:00–01:00 h. Four people participated in each survey, for a total of 192 person-hours of survey time. Tadpoles and egg clutches that we discovered during these surveys were georeferenced (WGS 84) and subsequently monitored on 03, 06, 09, 10, and 13 October 2017 and 06 February 2018.

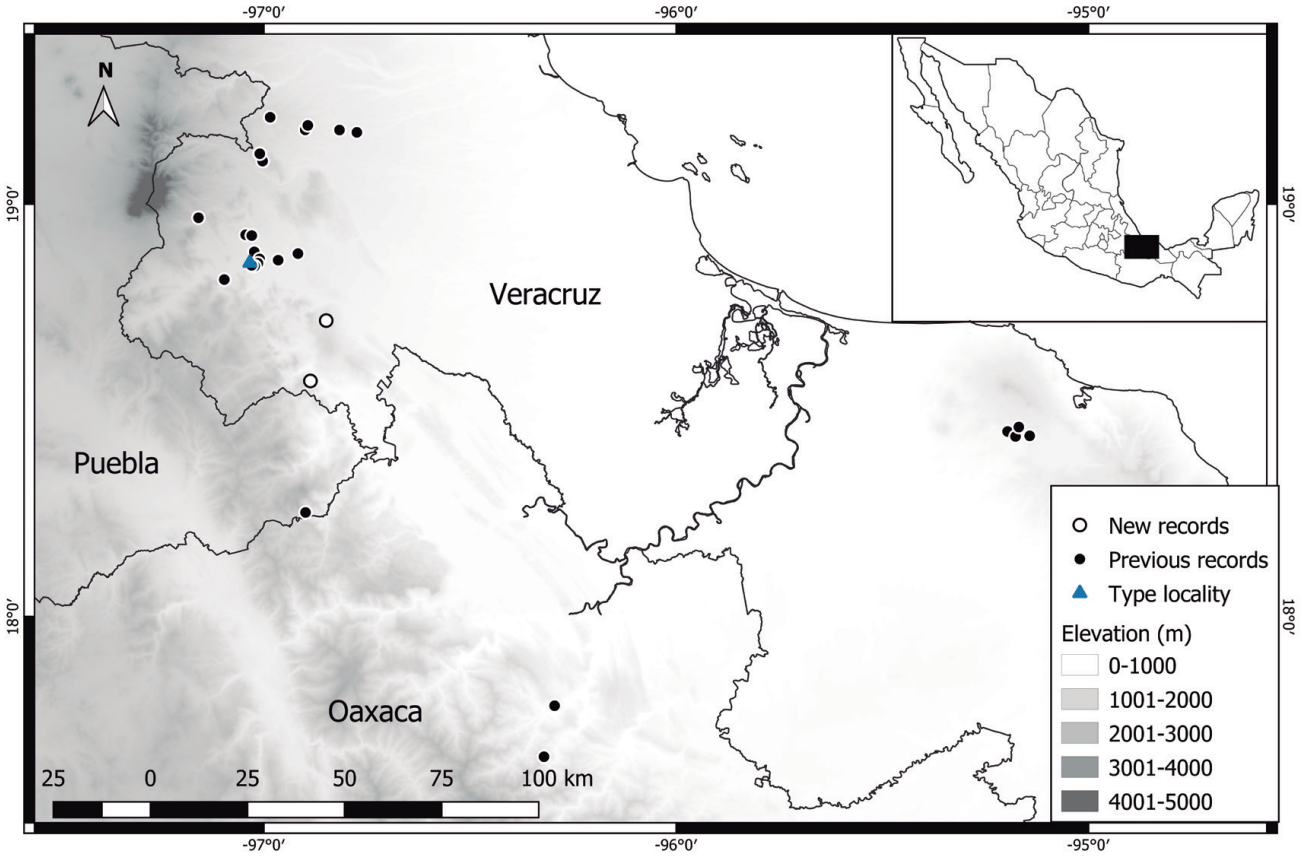

Figure 1. Geographic distribution of *Bromeliohyla dendroscarta,* showing the new localities.

Figure 2. Habitat occupied by *Bromeliohyla dendroscarta* in the Colonia Agrícola Rincón de las Flores, Tezonapa, Veracruz: semideciduous tropical forest (**A, B**); semideciduous tropical forest and mountane cloud forest (**C**); mixed agriculture of shade-grown coffee, banana and camedor palm (**D**); and *Tillandsia* sp. microhabitat (**E, F**). Photos by Víctor Vásquez-Cruz (A, B), Raul Andrés Díaz-Ramos (C, F), Arleth Reynoso-Martínez (D), and Alfonso Kelly-Hernández (E).

We identified all living frogs using Duellman (1964, 2001) with supplemental comparison against Canseco-Márquez *et al.* (2018) and followed the taxonomy of Frost (2018). Gosner (1960) and Gómez *et al.* (2016) were used to describe embryonic and larval morphology. We used a FastestDrops MX 60× portable microscope and a Samsung WB100 digital camera to observe and record images of eggs and tadpoles.

Results

On 20 February 2015 at ca. 11:00 h, in a forest mosaic of planted coffee, native trees with abundant bromeliads and other epiphytes, camedor palm, and banana (18°43'03.34" N, 96°50'55.88" W; 1054 m a.s.l.), we observed an adult *Bromeliohyla dendroscarta* [snout–vent length (SVL) 31.5 mm] in a bract of bananas. The frog were captured by hand, photographed, and released; we deposited a photo voucher in the University of Texas at Arlington Digital Collection (UTADC-9265). The dorsal coloration of the frog is uniform yellow, without patterns (Figure 3H). The anterior and posterior surfaces of the thighs are yellow and the discs of the fingers are darker. The flanks are yellow-cream, the throat and belly are white, and the iris is golden with shades of bronze and tenuous black reticulations. We resampled this site on 02 October 2017, but did not find any adult of *B. dendroscarta.*

Additionally, on 26 April 2016 at about 15:00 h, Cerón-de la Luz (pers. comm.) found an individual adult *B. dendroscarta* (SVL = 30 mm) in a bract of a *Musa* sp. in a patch of coffee at Acticpac (18°34'16.19" N, 96°53'13.61" W; WGS 84; 597 m a.s.l.) in the municipality of Zongolica in the state of Veracruz. At this site, the predominant vegetation is semideciduous tropical forest along with patches of shade-grown coffee and banana.

On 03 October 2017 at ca. 12:50 h, we observed eight tadpoles and three anuran egg masses in bromeliad phytotelmata (*Tillandsia* sp.; Figure 2E–F) growing 0.3–3 m above the ground in a patch of semideciduous tropical forest (18°42'54.63" N, 96°50'57.90" W; WGS 84; 1141 m a.s.l.). Five and three tadpoles were in each of two bromeliads, respectively. The tadpole bodies are depressed dorsoventrally; the small eyes are lateral and body color ranges from white to translucent cream (Figure 3F). The egg masses were in two other bromeliads. One had two egg masses containing three living and four dead eggs, and the second bromeliad had a single egg mass with five eggs. The mass with four eggs was covered by water, which may have been the cause of the death of the embryos. The egg diameter ranged from 23–31 mm; the eggs have a slightly milky, translucent coloration, and a uniformly cream vitellus (Figure 3A). We made our observations on the mass that contained three eggs.

On 06 October 2017, the embryos were in Gosner Stage 18; we observed spasmodic muscular responses (simple flexures) and division of the gill plate into ridges (visceral arches) (Figure 3B). On October 09 just prior to hatching, one embryo was in Stage 20. We based this on our observation that circulation in gills was absent and the cornea was opaque (Figure 3C); both of the latter are characteristic of Stage 21. On 10 October 2017, all tadpoles had hatched and had the same developmental characteristics (Figure 3D). The tadpoles had advanced to Stage 25 on 13 October, when the gills were atrophied and the spiracle had developed on the left side of the body (Figure 2E). We found a recent metamorph in Stage 45 on 06 February 2018 in one of the egg-bearing bromeliads. The lateral eyes of the froglet were well developed and the corner of the mouth was located posterior to the level of the eye, and vestiges of tail remained. The dorsum and extremities were yellowish-green but the rest of body was translucent white; the iris was yellow (Figure 3G). We also observed tadpoles feeding on plant detritus and the body of an arthropod (order Orthoptera) in the bromeliad phytotelmata (Figure 4).

On 13 May 2018 in an ecotone of semideciduos tropical forest and montane cloud

Figure 3. Morphology of embryonic development (**A–C**), larvae (**D–F**), postmetamorphic juvenile (**G**) and adult (**H**) of *Bromeliohyla dendroscarta* of the Colonia Agrícola Rincón de las Flores, Tezonapa, Veracruz. Photos by Arleth Reynoso-Martínez (A–D, F) and Víctor Vásquez-Cruz (E, G, H).

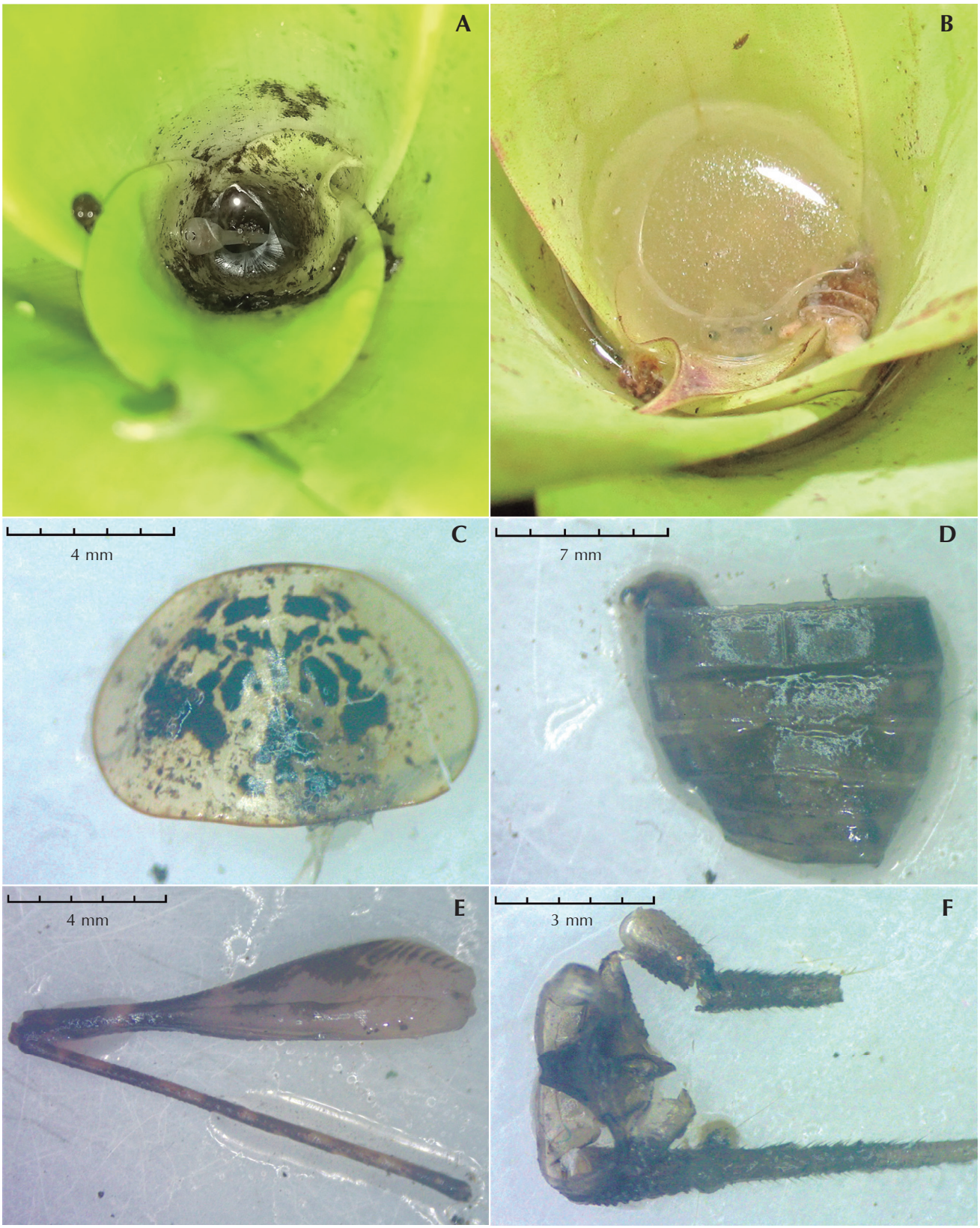

Figure 4. Tadpoles of *Bromeliohyla dendroscarta* feeding on detritus on the water surface (**A**) and on an arthropod (**B**). Remains of the arthropod determined as an individual of order Orthoptera (**C–F**). Photos by Arleth Reynoso-Martínez (A) and Víctor Vásquez-Cruz (B–F).

forest (18°42'36.63" N, 96°51'8.36" W; WGS 84; 1326 m a.s.l.), we observed a tadpole and two different egg clutches in the same bromeliad, which was located 2.6–3 m above the ground. One egg mass contained five eggs in Stage 14, and the other, eight eggs in Stage 19.

Discussion

The characteristics of the adult and tadpoles match those described for *Bromeliohyla dendroscarta* by Duellman (1964, 2001) and Canseco-Márquez *et al.* (2018), thereby confirming our identification of the species. Our two new records from localities Acticpac and Colonia Agrícola Rincón de las Flores complement the distribution of *B. dendroscarta* because they are 33.5 and 23.3 km, respectively, southwest of the type locality (Figure 4). Previously, only montane cloud forest and pine-oak forest were known to support *B. dendroscarta,* and both are considered threatened (Mora-Donjuán and Alanís-Rodríguez 2016, Ochoa-Ochoa *et al.* 2017). To the latter, we now add semideciduous tropical forest; an ecotone of semideciduous tropical and montane cloud forest; and a mosaic of shade-grown coffee with banana, camador palm, and bromeliad-laden native trees as three new habitats known for *B. dendroscarta.* Although several studies document amphibians and reptiles inhabiting of coffee agroecosystems in Mexico (e.g., Pineda *et al.* 2005, Macip-Ríos and Casas-Andreu 2008), none reported the presence of *B. dendroscarta.* Recently, García-Bañuelos *et al.* (2017) reported the presence of *B. dendroscarta* in a small parch of cloud forest surrounded by coffee.

Previously, numerous tadpoles and egg masses of *B. dendroscarta* had been reported in large bromeliads (60–130 cm diameter) in January, February, July, and August (Duellman 1964, 2001, García-Bañuelos *et al.* 2017, Canseco-Márquez *et al.* 2018). Our observations occurred in the months of October and May, and involved smaller bromeliads (25–35 cm diameter) with fewer clutches and tadpoles. This supports the suggestion of García-Bañuelos *et al.* (2017) that this species reproduces throughout much of the year. Further, we hypothesize that previous records of numerous clutches and tadpoles reflect multiple oviposition events.

Although, other species that reproduce in bromeliads feed their tadpoles with eggs, as is the case of *Triprion spinosus* (Steindachner, 1864) and *Aparasphenodon arapapa* Pimenta, Napoli, and Haddad, 2009 (Jungfer 1996, Lourenço-de-Moraes *et al.* 2013), we no found evidence of such behavior. The tadpoles did not contain eggs in their stomachs and adults were not observed near the bromeliads; thus, it seems likely that the tadpoles feed on what they find in the bromeliad.

Given the existence of these additional populations of *B. dendroscarta,* this endemic, highly imperiled species seems to have broader habitat tolerances than previously documented, and offers an opportunity for detailed study of its biology in the future. However, the near future of these populations is uncertain. Agricultural activity is increasing in the area, and even more worrisome is the presence of the chytrid fungus in nearby areas since the 1970s (Cheng *et al.* 2011).

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