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Discovery of another new species of *Charadrahyla* (Anura, Hylidae) from the cloud forest of northern Oaxaca, México

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Abstract

Charadrahyla esperancensis, a new species of tree frog, is described from the cloud forest of Sierra d Juárez on the northern slopes of Oaxaca. This species is sympatric with *C. nephila* and is distinguished by the presence of a protuding snout with a distinctive downward slope posterior to the nostril in lateral view, with an evident rostral keel, and the flanks and anterior and posterior surfaces of limbs with yellow spots. With the discovery of this new species, the species number of the genus increases to seven and adds another species of *Charadrahyla* for the assemblage of anurans from northern Oaxaca. This is the first instance of sympatry of species in the genus *Charadrahyla*. Additionally, we provide a key to the species of the genus.

Key words: new species, frog, *Charadrahyla,* montane cloud forest, sympatry, conservation, Sierra Juárez, Oaxaca

Resumen

Se describe a *Charadrahyla esperancensis,* una nueva especie de rana arborícola del bosque mesófilo de la vertiente norte de Oaxaca en la Sierra de Juárez. Esta especie es simpátrida con *C. nephila* y se distingue por la presencia de un hocico protuberante que desciende hacia la parte posterior de la narina en vista lateral, quilla rostral evidente, superficie anterior y posterior de las piernas con manchas amarillas. Con el descubrimiento de esta nueva especie, el número de especies del género aumenta a siete y se agrega otra especie de *Charadrahyla* para el ensamble de anuros del norte de Oaxaca. Este es el primer caso de simpatría de especies del género *Charadrahyla*. Adicionalmente, se proporciona una clave para las especies del género.

Palabras clave: nueva especie, rana, *Charadrahyla,* bosque mesófilo de montaña, simpatría, conservación, Sierra Juárez, Oaxaca

Introduction

The humid slopes of northern Oaxaca are home of a large assemblage of amphibians, several of them endemic to the state and restricted to the cloud forest. The diversity of treefrogs in this area is high and the community of the stream-breeding hylid frogs is exceptional (Delia *et al*. 2013). Many species have been described from the area (e.g., Campbell & Duellman 2001) but unfortunately, several are considered at risk by the IUCN Red List.

The genus *Charadrahyla* comprises six species, three of which are distributed in Oaxaca: *C. altipotens* in the Sierra Madre del Sur, *C. chaneque* at the eastern margin of the Isthmus of Tehuantepec, and *C. nephila,* known

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from three mountain ranges forming the northern slopes of Oaxaca (Sierra Mazateca, Sierra de Juarez and Sierra Mixe) (Mendelson & Campbell 1999). *Charadrahyla nephila* is common in several streams in the cloud forest of the Sierra de Juarez. All known species of *Charadrahyla* occur in allopatric distributions.

During a study in search of some threatened, presumably extinct, species of hylid frogs in the cloud forest of La Esperanza in the Sierra de Juarez, we discovered specimens of undescribed species belonging to the genus *Charadrahyla* in a stream where it is common to find *C. nephila*. This is the first case of sympatry in this genus.

Material and methods

All measurements and terminology followed Duellman (2001); measurements were made using a digital calliper and rounded to the nearest 0.1 mm. Sex of specimens was determined by presence or absence of nuptial excrescences or by direct observation of the gonads. Webbing formulae followed Myers & Duellman (1982). Format of the description followed that of Campbell *et al*. (2009). Snout–vent length is abbreviated SVL throughout. Color notes were taken from field notes and from photographs of live specimens. Comparative material is given in Appendix.

Description of new species

***Charadrahyla esperancensis* sp. n.**
Esperanza Treefrog, Rana de la Esperanza
(Figs. 1,2,3)

Holotype. (Figs. 1 A,B,C; 2 A,B,C)**.** MZFC 28699. Adult male. Arroyo Los tres manantiales, La Esperanza, Oaxaca, Mexico. 1640 mts. 17.6236º N, 96.3652º W, 19 October 2016. Edna González-Bernal.

Paratype. MZFC 28693. Adult male. Dead on road near La Esperanza, Oaxaca, Mexico. 17.6275° N, 96.3625° W. 23 October 2016. Cynthia G. Ramírez-González.

Diagnosis. This species of *Charadrahyla* has a moderate size (males 44.3–48.9 mm SVL). It is distinguished from all members of the genus by the presence of a distinct rostral keel in a protuding snout with a downward slope posterior to the nostril; in lateral view, vocal slites absent and rounded yellow spots on flanks and on posterior and anterior surfaces of the thighs. *Charadrahyla esperancensis* is sympatric with *C. nephila*, but differs by its smaller size (males 44.3–48.9 vs 70.9 mm SVL), small dark brown spots on dorsum (vs large dark brown blotches on dorsum), dark transverse bars on fingers absent (vs present). The new species resembles superficially with *C. taeniopus* (Fig. 1G,H), but this species is distributed on the Atlantic Slopes in the states of Hidalgo, Puebla and Veracruz, whereas *C. esperancensis* is distributed on the Sierra Juarez at northern Oaxaca and it may be distinguished from *C. taeniopus* by having a evident rostral keel and vocal slites absent (Fig. 2 C,D,E).

Description of holotype. Body moderately slender, SVL 48.9 mm, tibia length 25.2 mm, foot length 22.06 mm, head length 16.63 mm, head width 16.79 mm, diameter of tympanum 2.61 mm, diameter of eye 4.36 mm, interorbital distance 5.85 mm, eye–tympanum distance 2.91 mm. Head as wide as long; snout pointed in dorsal profile, rostral keel evident (Figs. 1C, 2C); lateral profile protruding with snout slopes downward posterior to the nostril; canthus rostralis distinct and angular; loreal region concave; nostrils ovoid, slightly protuberant, directed posterolaterally; internarial region slightly concave. Top of head flat; interorbital region 34.8% of head width; diameter of eye 26.0 % of head width. Supratympanic fold distinct, thick, extending posteroventrally from posterior margin of orbit until insertion of forearm; tympanum distinct, round; tympanic annulus mostly distinct, obscured by supratympanic fold dorsally; width of tympanum 59.8% diameter of eye; width of tympanum 89.6% eye–tympanum distance. Axillary membrane absent; thoracic fold absent; dermal fold on wrist present. Fingers long and slender, with slightly lateral fringes, bearing large, rounded terminal discs; relative finger lengths: I < II < IV < III; discs on Fingers II, III, IV approximately equal in size, as wide as tympanum; disc on Finger I smaller, width 52.4% width of tympanum. Subarticular tubercles large, diameter about two-third width of terminal disc on same finger, rounded, none bifid; supernumerary tubercles smaller than subarticular tubercles, rounded, distinct.

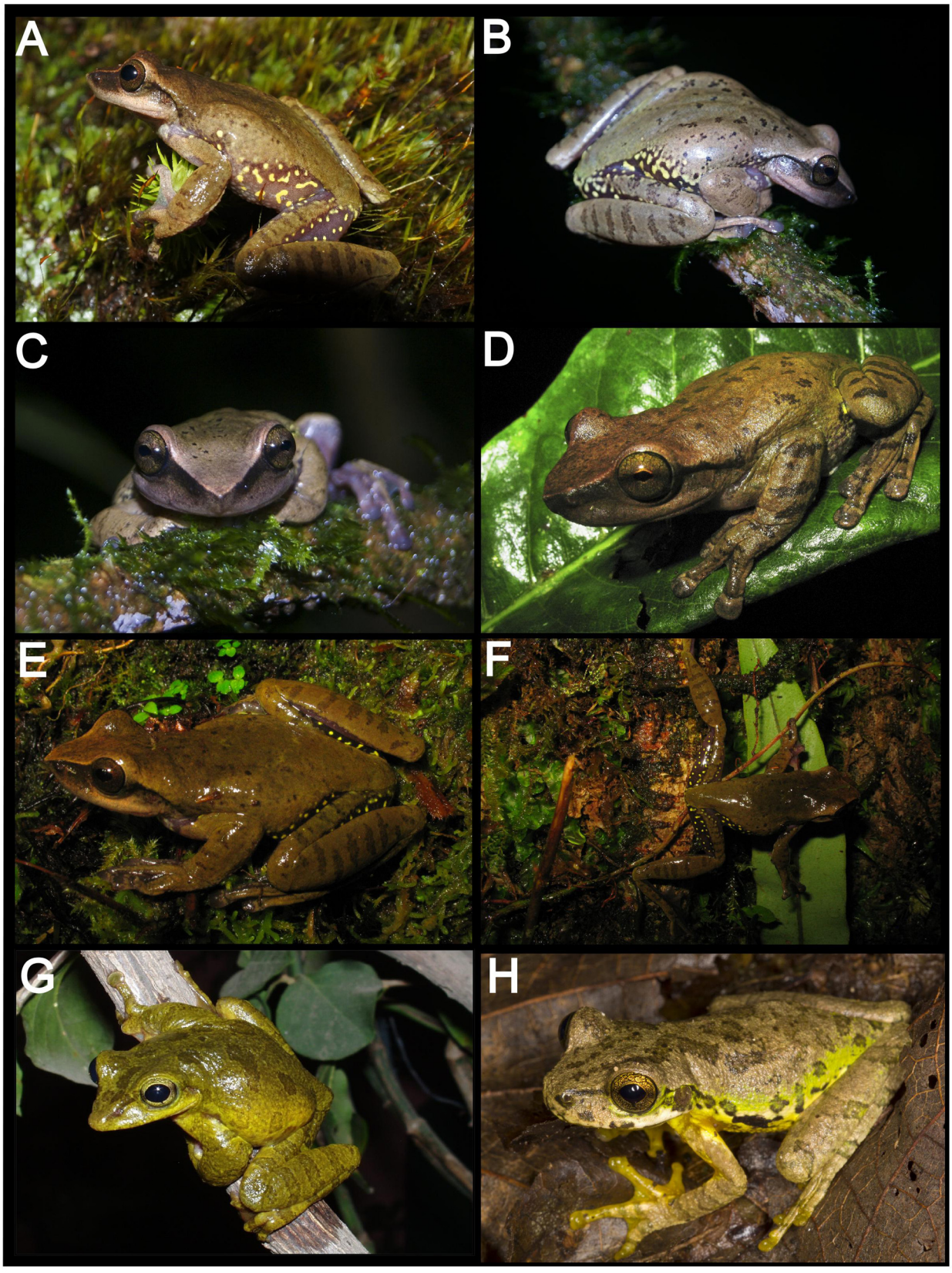

FIGURE 1. Specimens in life of *Charadrahyla esperancensis*: A,B,C: male holotype (MZFC 28699), D,E,F (male specimens, not collected) (F, same specimen that E, showing the rounded yellow spots on posterior parts of thighs, and *C. taeniopus*: G (male from Tlatlauquitepec, Puebla), H (female from Hidalgo).

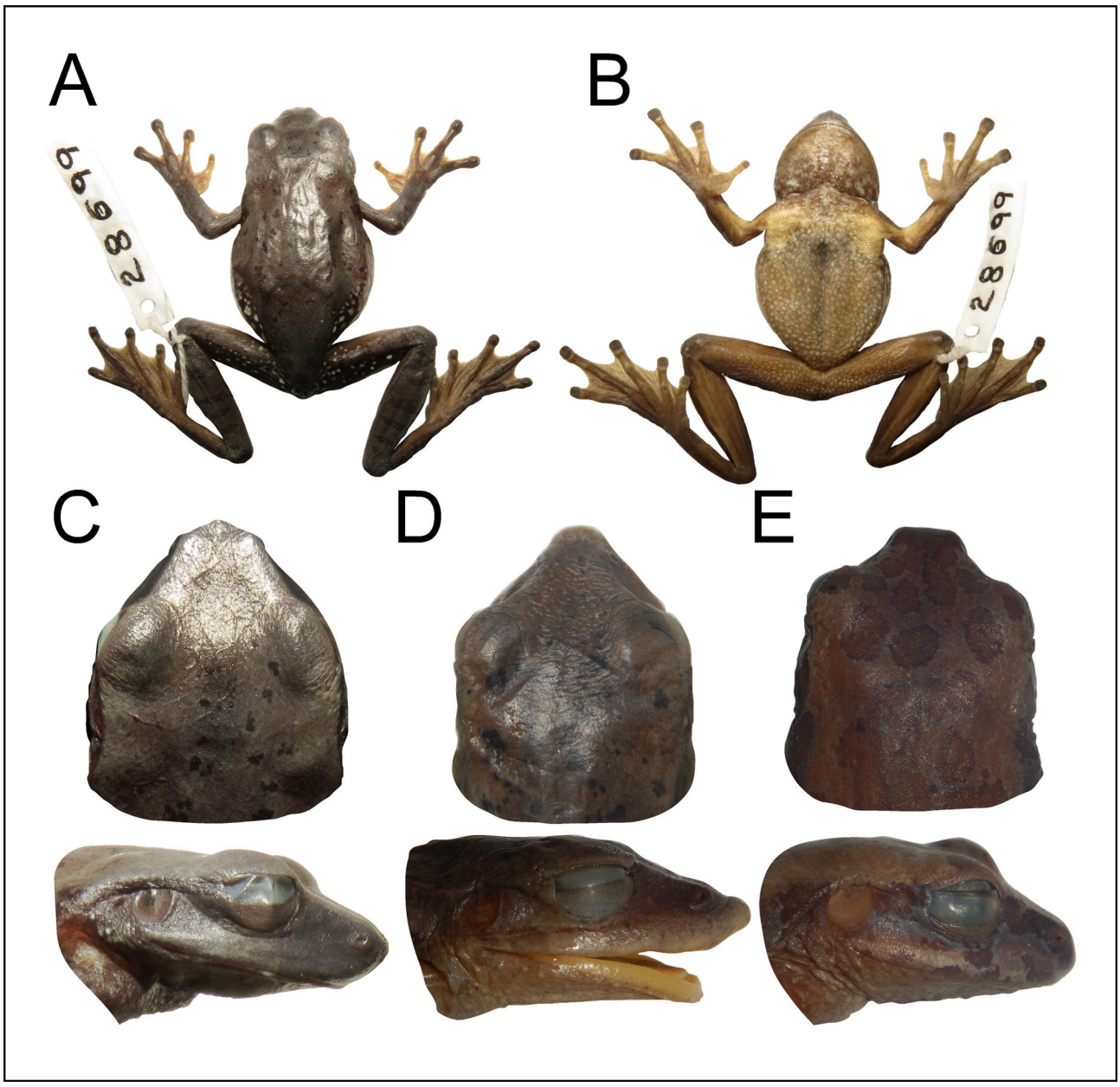

FIGURE 2. Dorsal (A) and ventral view (B) of the preserved holotype of *Charadrahyla esperancensis* (MZFC 28699); dorsal and lateral view of the head of *C. esperancensis* (C); male (D) and female (E) of *C. taeniopus* (MZFC 5150, 7714 respectively).

Hand webbing formula: **I**2–2$^{1}/_{2}$ **II**2–2$^{1}/_{2}$**III**2$^{1}/_{2}$–2**IV** (Fig. 3). Heels of adpressed hind limbs overlap, tibiotarsal articulation extending just past snout; tarsal fold absent; tibia length 51.5% SVL; foot length 45.1% SVL. Inner metatarsal tubercle distinct, large, ovoid, between 1.8 times larger than subarticular tubercles; outer metatarsal tubercle absent; subarticular tubercles distinct, large, elevated, rounded, diameter about one-half width of terminal disc on same toe; supernumerary tubercles small, rounded, arranged in rows along axis of proximal portions of phalanges. Toes long and slender, bearing rounded, terminal discs slightly smaller than discs on fingers. Foot webbing formula: **I**1–1$^{1}/_{2}$**II**1–2**III**1–2**IV**2–1**V** (Fig. 3). Cloacal opening directed posteroventrally at mid level of thighs. Skin on dorsal surfaces smooth; skin on ventral surfaces distinctly granular; skin on flanks between forelimbs and hind limbs distinctly thick and smooth.

Tongue large, cordiform (notched posteriorly), barely free posteriorly. Vomerine odontoids five on right side and six on left, situated on transverse, dentigerous processes at midlevel between choanae, choanae subtriangular, widely separated.

Color. In life (Fig. 1A–C), dorsum of body, head and lateral surfaces of head are pale brown. A dark brown

mask in the lateral surfaces of head that begins in nostrils and continue until posterior part of tympanum. Dorsum with small distinct irregular dark brown spots. Dorsal surfaces of limbs pale brown with distinct dark brown transverse bars, three on forearm, four on thigh, and six on tibia; anterior and posterior surfaces of limbs with rounded and irregular small yellow spots; discs darker that fingers; flanks dark brown with distinctive irregular large yellow spots, some rounded. Venter of throat pale cream slightly mottled with irregular dark brown spots. Chest pale cream immaculate. Belly immaculate, granular. Undersurface of thighs pale cream and granular, palpebral membrane clear.

In preservative (Fig. 2 A,B,C), dorsum of body, head and lateral surfaces of head are dull gray, with small distinct irregular dark spots. Dorsal surfaces of limbs dull gray with distinct dark transverse bars, three on forearm, four on thigh, and six on tibia; anterior and posterior surfaces of limbs with rounded and irregular small pale cream spots. Flanks dark brown with distinctive pale cream large irregular spots, some rounded; venter of throat pale brown slightly mottled with irregular cream spots. Chest pale cream with irregular dark spots few scattered on anterior part. Belly pale brown, granular. Undersurface of thighs pale brown and granular, palpebral membrane dark gray.

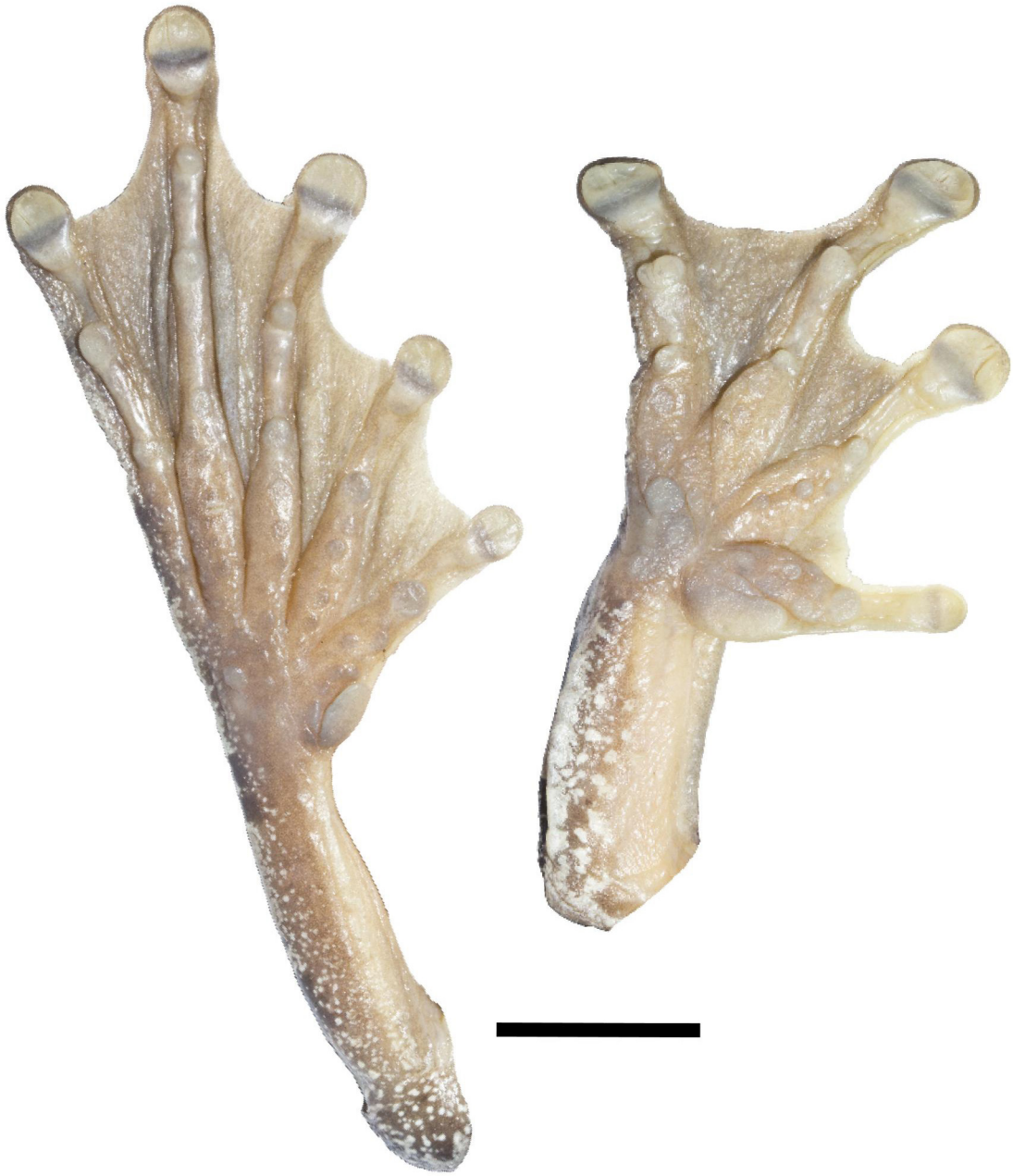

FIGURE 3. Ventral aspects of hand and foot of the holotype of *Charadrahyla esperancensis* (MZFC 28699). Bar= 10 mm.

Variation. The body measurements and coloration of the paratype (MZFC 28693) are as follow: SVL 5.49 mm, head length 18.91 mm, head width 17.24 mm, diameter of tympanum 3.11 mm, interorbital distance 7.43 mm. Snout slightly pointed in dorsal profile; lateral profile rounded. Fingers of hands and foots, broad. Terminal discs wide. Hand webbing formula: **I**2–2$^{1}/_{2}$**II**1$^{1}/_{2}$–2$^{1}/_{2}$**III**2-2**IV**, foot webbing formula: **I**1-1**II**1-1$^{1}/_{2}$**III**1-2**IV** 2-1**V**. In preservative, dorsum of body, head and lateral surfaces of head are brownish green mottled with irregular dark spots. Dorsal surfaces of limbs pale gray with few dark transverse bars on thighs. Flanks pale brown with distinctive pale cream rounded spots. Venter of throat and chest immaculate, belly granular and immaculate. Undersurface of thighs pale gray and granular, venter palpebral membrane light. The color patterns of two additional live males (not collected) (Fig. 1D–F) were as follows: dorsum of body olive green, head copper brown and lateral surfaces of head dark brown, one specimen with a slender dark brown mask in the lateral surfaces of head (Fig. 1D). Dorsum almost immaculate or slightly mottled with irregular or rounded dark spots. Dorsal surfaces of limbs with four dark brown transverse bars on forearm, five on thigh, and six or seven on tibia; flanks dark brown with few or many distinctive rounded yellow spots in the anterior part of axillary region. SVL 45.9 and 44.3 mm.

Etymology. The specific epithet is taken from the Spanish word “Esperanza” referring the name of the town where this species is found. This is a recognition to the community effort to preserve the biodiversity of the local cloud forest.

Distribution and ecology. *Charadrahyla esperancensis* is known from a single locality at La Esperanza village in the Sierra de Juárez in northern Oaxaca, Mexico, at 1640 m elevation. This species was discovered at the margins of a mountain stream whose course has been diverted by the Oaxaca–Tuxtepec highway (MX Hwy 175) (Fig 4A). The vegetation type is montane cloud forest with treeferns and oaks. The site receives an average 2000 mm of rainfall annually. The mean temperature is 18°C. The stream has a pebble and rock substrate and is not more than 5 meters wide. Due to steep slopes, it has several falls. The first specimen was found at night (21.44 hrs CST) at the margins of the stream, under the cover of fallen logs. The temperature at the time of discovery was 18°C with a 76% relative humidity. The mass was 9 g. It seems that on rainy nights this species tends to move considerable distances as another two individuals were found crossing the paved road from the village towards the forest. This species is sympatric with other endemic species: *Charadrahyla nephila, Craugastor polymniae, C. spatulatus*, *Duellmanohyla ignicolor, Incilius spiculatus,* and a number of salamander species. Among these species, *C. nephila* is considered as vulnerable, *C.polymniae* as critically endangered and *C. spatulatus, D. ignicolor*, and *I. spiculatus* as endangered by IUCN. All of these species are considered threatened by habitat destruction.

Discussion

With the description of the new species, the Mexican endemic genus *Charadrahyla* increases to seven species. The common species *C. taeniopus* is known from several localities along the Sierra Madre Oriental of Hidalgo, Puebla and central Veracruz. Two species are found only in the Sierra Madre del Sur of Guerrero: *C. tecuani* and *C. trux*; this last species was rediscovered recently (Grunwald *et al*. 2016). There are four species in Oaxaca: *C. altipotens* in the Sierra Madre del Sur, also rediscovered recently (Barrio-Amoros *et al*. 2016; DeSantis *et al*. 2016), *C. chaneque* on the eastern margin of the Isthmus of Tehuantepec, *C. nephila* in three mountain ranges on the northern slopes, and there is a single and isolated record reported by Perez-Higareda (1981) from the Sierra de los Tuxtlas, Veracruz, however, this record seems to be doubtful (Mendelson & Campbell 1999); and the new species *C. esperancensis*, which is sympatric with *C. nephila* in La Esperanza, Oaxaca.

Conservation status. The montane cloud forests of the northern slopes of Oaxaca is the habitat of *Charadrahyla esperancensis.* The forests in this region are considered one of the best remnants of this vegetation, and part of the largest and most continuous patch of this vegetation in the country (Toledo-Aceves *et al*. 2011). In the past, the forests at "La Esperanza" were exploited by a paper factory that used to extract wood. Through communal intervention these commercial activities ceased. At the present time, patches of the forests where this species exists are under a community conservation status through the "*indigenous and community conserved areas"* (ICCA) modality (Brown *et al*. 2011). The community voluntarily conserves 4420.85 ha of montane cloud forests and receives payments for environmental services for 2565 ha (Fig 4B).

Even when the locality is under a communal protected status, the forest in the area is crossed by a two-lane

paved road, which represents a potential threat to the species. It seems that on rainy nights this species tends to move long distances. On a single survey night we observed individuals crossing the road on the aim of reaching the higher habitats in the forest. On that night, along 12 meters of road, we found two live adults and four individuals killed by cars. On addition, the fact that this species tends to move long distances makes it more vulnerable to habitat fragmentation.

Another potential threat is global warming. A state-wide study of the impact of climate change on vegetation types projects that montane cloud forests will be highly vulnerable to shifts in the climate conditions currently associated with this ecosystem (J.N. Williams, pers. comm.). In relation to diseases, a previous study in the area reports the existence of *Batrachochytrium dendrobatidis.* Observations on tadpoles showed that 49% presented missing mouth parts (Lips *et al*. 2004). Since then, no formal research has been conducted in the area to evaluate the incidence of this disease in adult amphibians.

FIGURE 4. Type locality of *Charadrahyla esperancensis* (A), and Community cartel indicating the protection of the northern region where the new species lives (B)

Key to the species of the genus *Charadrahyla*

1 Hypertrophied webbing between the first and second toes present 2
- Hypertrophied webbing absent 3
2 Adult males 52.5–57.8 mm SVL; proportionately longer legs (tibia/SVL 0.51–0.54). . . . . *C. tecuani*
- Adult males 79.1–81.0 mm SVL; proportionately shorter legs (tibia/SVL 0.43–0.49) . . . . . *C. trux*
3 Snout pointed in dorsal profile 4
- Snout rounded in dorsal profile 6
4 A distinct rostral keel; rounded yellow spots on flanks and on posterior and anterior surfaces of the thighs . . . . . *C. esperancensis* **sp. n.**
- Rostral keel absent 5
5 Snout acuminate and protruding in males and blunt in females; Adult males 65.9 mm SVL and 70.0 mm females. . . . . *C. taeniopus*
- Snout acuminate not protruding; Adult males 80.6 mm SVL and 78.8 mm females . . . . . *C. altipotens*
6 Smooth dorsal skin texture; vocal slits present . . . . . *C. nephila*
- Tuberculate dorsal skin texture; vocal slits absent . . . . . *C. chaneque*

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APPENDIX. Comparative specimens examined.

Charadrahyla chaneque. **MEXICO**: **OAXACA**: Chalchijapa (MZFC 18911-12).

Charadrahyla nephila. **MEXICO**: **OAXACA**: 4.2 km S Vista Hermosa on Hwy 175, ca 1.2 km S La Esperanza (MZFC 15974-75); stream crossing Hwy 175, 7.2 km S Vista Hermosa (MZFC 16796, 16822).

Charadrahyla taeniopus. **MEXICO**: **HIDALGO**: 4 km este de Tlanchinol (MZFC 6484); Apantlazol (MZFC 6485, 21036); Tenango de Doria, Temapa (MZFC 6486); 1 km NE Zetoy (MZFC 7713); Texme (MZFC 7714); terracería a Eloxochitlán (MZFC 21035); Texme, Tenango de Doria (MZFC 7714); Huehuetla (MZFC 7715); Bernardo, 1.5 km (MZFC 6453); Tlanchinol (MZFC 15235); S de Calnali (MZFC 21034). **PUEBLA**: 5 km NE Teziutlán, Río Xoloatl (MZFC 5149-56); Sompatisoya, Hueytamalco (MZFC 8297); Villas Cuetzalan (MZFC 16301-03).