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A rare new treefrog of the genus *Sarcohyla* (Anura: Hylidae) from Guerrero, Mexico

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Abstract

Based on morphological data collected from treefrogs related to *Sarcohyla hazelae*, we describe a new species of the genus *Sarcohyla* from the cloud forest of the Sierra Madre del Sur of Guerrero, Mexico. We compare physical charactersitics of this new species to its closest relatives within the genus *Sarcohyla*, including dorsal and ventral coloration, head shape, tympanum distinctiveness, morphometrics and the condition of the tubercles on hands and feet. We analyze accoustic data from the advertisement call of males of the new species. We discuss the relationship of the species described herein with several of its cogeners, plus we resurrect the *Sarcohyla hazelae* group for these frogs. We describe habitat and distribution species related to *Sarcohyla hazelae* and also comment on the conservation priorities of these frogs.

Key words: Amphibia, Anura, Conservation, Cloud forest, Guerrero, Hylidae, New species, Oaxaca, *Sarcohyla hazelae*, *Sarcohyla thorectes*, *Sarcohyla toyota* **sp. nov.**, Sierra Madre del Sur, Taxonomy, Toyota, Treefrogs

Resumen

Basándose en datos morfológicos tomados de ranitas de arbol relacionadas con *Sarcohyla hazelae*, se describe una nueva especie de rana del genero *Sarcohyla* del bosque mesófilo de montaña de la Sierra Madre del Sur de Guerrero, México. Se comparan carácteres diagnósticos como coloración dorsal y ventral, forma de cabeza, distinctividad de tímpano, morfometría, condición de tuberculos de mano y pie con especies cercanamente relacionados y se analizan datos acústicos de la nueva especie. Se explican las relaciones de la nueva especie con las especies cercanamente relacionadas y se reestablece el grupo *Sarcohyla hazelae* para estas ranas. Se aporta información sobre el hábitad y la distribución de las ranas del grupo *Sarcohyla hazelae* y se presenta algunas prioridades sobre su conservación.

Palabras claves: Amphibia, Anura, bosque mesófilo de montaña, conservación, Guerrero, Hylidae, nueva especie, Oaxaca, *Sarcohyla hazelae*, *Sarcohyla thorectes*, *Sarcohyla toyota* **sp. nov.**, Sierra Madre del Sur, ranitas de arbol, taxonomía, Toyota

Introduction

Despite thorough study in recent decades, the biodiversity of Mexico continues to present researchers with new species and high endemism. Amphibians are of particular interest, due to the small distributions of many species (Parra-Olea *et al.*, 2014) and the extinction crisis affecting amphibians worldwide (McCallum, 2007). *Sarcohyla* Duellman, Marion & Hedges 2016, which was recently erected to contain some species previously assigned to *Plectrohyla* Brocchi 1877. This genus comprises twenty-four species (Frost, 2019). However, no morphological synapomorphies have been proposed, and the genus is diagnosed primarily by molecular evidence (Duellman *et al.*, 2016).

Species of *Sarcohyla* are restricted to Mexico from southeastern Sinaloa and southern Durango on the Pacific

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versant, and from Hidalgo and northern Puebla on the Atlantic versant, south to the Isthmus of Tehuantepec in eastern Oaxaca. They also occur along the length of the Trans-Mexican Volcanic Belt (Eje Neovolcanico Transversal). Within this area, *Sarcohyla* inhabits approximately twenty-five Biogeographical Formations as defined by Grünwald *et al.* (2015).

No less than seven new *Sarcohyla* have described in the last two decades: *S. ameibothalame* (Canseco-Márquez *et al*. 2002); *S. calthula* (Ustach *et al*. 2000), *S. cyclada* (Campbell & Duellman 2000); *S. ephemera* (Meik *et al*. 2005), *S. hapsa* Campbell *et al*. 2018; *S. miahuatlanensis* (Meik *et al*. 2006); *S. psarosema* (Campbell & Duellman 2000). While the distinctiveness of some of these species has been questioned (e.g. *S. calthula, S. cyclada, S. ephemera* and *S. miahuatlanensis*; Caviedes-Solis, 2013; Caviedes-Solis & Nieto-Montes de Oca, 2018), evidence suggests that at least three species of *Sarcohyla* exist in western and southern Mexico which have not been formally described. These undescribed species include a form related to *S. bistincta* (Cope 1877) from the Sierra Madre del Sur in Guerrero; a taxon related to *S. cembra* (Caldwell 1974) from the vicinity of Malinaltepec, Guerrero and a species related to *S. thorectes* (Adler 1965) from the vicinity of Puerto de Gallo, Guerrero that were not described due to a lack of specimens for a detailed morphological study (Caviedes-Solis, 2013). Herein, we formally describe the latter taxon and present morphological data for the new species, *S. hazelae* (Taylor 1940), and *S. thorectes*.

Duellman *et al.* (2016) refrained from defining species groups, but defined *Sarcohyla* as containing "moderate to large frogs having thick, glandular skin and enlarged prepollex without a projecting spine, and the alary process of the premaxilla not bifurcate posteriorly". While recognizing *Sarcohyla* as a separate genus agrees with our results, their definition of the genus does not. As noted by Kaplan *et al.* (2016), several species not addressed in the molecular analysis of Duellman *et al.* (2016) do not share the morphological synapomorphy of thick skin suggested by them to diagnose *Sarcohyla*. Kaplan *et al.* (2016) considered the species with thin skin to be *S.charadricola* (Duellman 1964), *S.chryses* (Adler 1965), *S.sabrina* (Caldwell 1974), and *S.thorectes,* to which we add *S. hazelae*, *S. labedactyla* (Mendelson & Toal 1996), *S. psarosema*, *S. mykter* (Adler & Dennis 1972), as well as the species described herein. We recognize the genus *Sarcohyla* as suggested by Duellman *et al.* (2016), but highlight that the genus needs a precise morphological definition.

Materials and methods

Taxonomic Sampling. We performed numerous trips to southern Mexico between 2009 and 2018 in an attempt to collect specimens of all known species related to the "*Hyla hazelae* Group" (*sensu* Duellman, 1970). We photographed all frogs in life, including their lateral, dorsal, and ventral profiles, and obtained images of each individual showing flank and ventral coloration. We euthanized frogs with topical aplication of 1% benzocaine. We collected tissue samples from thigh muscle upon death and preserved it in 96% ethanol. We fixed specimens in 10% of stock solution formalin and stored them in 70% ethanol. The material collected is deposited at the Museo de Zoología, Facultad de Ciencias (MZFC), Universidad Nacional Autónoma de Mexico (UNAM) in Mexico City, Mexico (See Appendix 1).

Museum acronyms throughout follow Sabaj-Pérez (2016). We examined and measured specimens of *Sarcohyla* in the following collections and list the acronyms used in parenthesis: Museo de Zoología "Alfonso L. Herrera" de la Facultad de Ciencias, Universidad Nacional Autónoma de México (MZFC). We also examined photographs of specimens housed at: Amphibian and Reptile Diversity Research Center of the University of Texas at Arlington (UTA-A); University of Kansas Natural History Collection (KU); Field Museum (FMNH); Museum of Comparative Zoology, Harvard University (MCZ); Museum of Vertebrate Zoology, University of California Berkeley (MVZ); University of Michigan Museum of Zoology (UMMZ). Field number abbreviations are as follows: CIG (Christoph I. Grünwald); ANMO (Adrian Nieto Montes de Oca); JAC (Jonathan A. Campbell). Specimen numbers for all material examined, including specimens examined by photographs, are provided in Appendix 1.

Morphological Measurements. The characters and terminology follow Duellman (1970), however we took some measurements not taken by Duellman (1970). Measurements taken for each specimen (abbreviations listed in parenthesis) as follows: snout–vent length (SVL), head length, from the tip of the snout in a straight line to immediately above jaw angle (HL), head width, at tympanum (HW), eyelid width (ELW), interorbital distance (IOD), internarial distance (IND), eye–nare distance (END), diameter of eye (ED), width of tympanum (TW), height of tympanum (TH), eye–tympanum distance (ETD), upper arm length, measured from axilla to elbow (UpL), fore-

arm length, measured from elbow to proximal end of outer palmar tubercle (FoL), hand length, measured from the proximal end of the outer palmar tubercle to tip of the third finger (HaL), length of 1st finger, (1FL), length of 2nd finger (2FL), length of 3rd finger (3FL), width of pad on 3rd finger (3FPW), width of 3rd finger (3FW), length of 4th finger (4FL), width of pad on 4th finger (4FPW), width of 4th finger (4FW), femur length (FeL), tibia length (TL), tarsal length (TaL), foot length, measured from the proximal end of the outer metatarsal tubercle to the tip of the pad on the the fourth (longest) toe (FL), length of 1st toe (1TL), length of 2nd toe (2TL), length of 3rd toe (3TL), width of pad on 3rd toe (3TPW), width of 3rd toe (3TW), length of 4th toe (4TL), width of pad on 4th toe (4TPW), width of 4th toe (4TW), length of 5th toe (5TL). All finger and toe lengths were measured from the proximal end of the first subarticular tubercle to tip of the pad on the digit.

Measurements were made with Truper (Mexico) brand digital calipers and rounded to the nearest 0.1 mm. The sex of adult specimens was determined by presence of vocal slits, secondary sexual characters such as nuptial excrescences, or by having observed the males calling in life. Webbing formulae follow Myers & Duellman (1982) as modified by Savage & Heyer (1997). Descriptions of color in life are based on photographs taken of the live specimens.

Results

Sarcohyla toyota sp. nov.

Toyota's Treefrog, Rana arborícola de Toyota
(Figs. 1, 2, 3, 4A, 4D, 4G, 4J, 5A, 5D, 5G, 6, 10A, 10B)

Hyla thorectes—Duellman (2001): 886–887, 1132, in part.
Plectrohyla sp. 5 *aff. P. thorectes*—Faivovich *et al*. (2005): 35, 66, 71, 103, 183.
Plectrohyla aff. thorectes sp5—Wiens *et al*. (2010): 881.
Plectrohyla thorectes—Caviedes-Solis (2013): 4, 8, 20, 29, 32, 34, 39, in part.
Plectrohyla aff. thorectes—Kaplan *et al*. (2016): 265.
Sarcohyla aff. thorectes—Caviedes-Solis & Nieto-Montes de Oca (2018): 8,13,17.
Sarcohyla sp.—Faivovich *et al*. (2018): 4.

Holotype. MZFC 34666 (CIG-1066) (Fig. 1 in life; Fig. 2 in preservative), an adult male from Mexico: Guerrero: 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, 2020 masl, collected 11 September 2016 by C. I. Grünwald, H. Franz-Chávez, and K. I. Morales-Flores. (Figs. 1, 2)

Paratypes (5). MZFC 34662–65 (CIG-1062–1065) (Figs 3B–3E, 4D, 4J, 5A, 5D), topotypic, with same data as type specimen; MZFC 34661 (CIG-0924) (Figs 3A, 4A, 4G), topotypic, collected 15 July 2016 by C. I. Grünwald and H. Franz-Chávez.

Diagnosis. Small, broad-headed *Sarcohyla* (males 28.5–32.2 mm) with distinctly short snout, long fingers, long legs and head broader than body. Adult males to 32.2 mm SVL. Adult female size unknown. Eyes distinctly large, tympanum distinctly small (TW/SVL ratio 0.03), and snout short (END/HL ratio 0.23–0.27). Numerous tubercles beneath cloacal opening (Fig. 5G). Venter white with dark gray and brown marbling (Figs. 2B, 4G, 4J) and lacking any iridescent green coloration on dorsum (Figs. 4A, 4D). Comparisons with similar species, with character states of *Sarcohyla toyota* in parenthesis: *Sarcohyla thorectes* (Figs. 4B, 4E) differing by presence of iridescent green blotches on dorsum (complete absence of iridescent green; Figs. 4A, 4D); white coloration with dark gray and brown marbling on anterior 60% of venter, including chest and abdomen, posterior 40% of venter flesh-colored (Figs. 4H, 4K) (white or yellow coloration with dark gray and brown marbling on 100% of venter, no flesh colored skin present; Figs. 4G, 4J); distinct rostral keel present (Fig. 5A) (rostral keel absent; Fig. 5B); dark brown markings on face and flank not continuous, not forming mask (Fig. 5E)(dark brown markings and face and flank continuous, forming mask; Fig. 5D); tympanum distinct, >26% of ED (tympanum indistinct, ≤23% of ED); nostrils slightly protruding, head bluntly rounded in dorsal profile (Fig. 5B) (nostrils greatly protruding, head distinctly truncate in dorsal profile; Fig. 5A); lateral profile of snout rounded (lateral profile of snout distinctly truncate); yellow ventral coloration completely lacking or limited (Figs. 4H, 4K) (varying amounts of yellow ventral coloration present on throat, chest, sides of abdomen, thighs and feet; Figs. 4G, 4J); superarticular tubercles on first phalange of fingers on hand conical or barely bifid (superarticular tubercles on first phalange of fingers hand distinctly bifid); tarsal fold distinct (tarsal

fold indistinct or absent); subarticular tubercles on foot conical (subarticular tubercles on foot slightly bifid); outer metatarsal tubercle absent or indistinct (outer metatarsal tubercle distinct). *Sarcohyla toyota* further differs from *S. thorectes* by following mensural proportions (values for *S. thorectes* given in parenthesis): longer hand, HA/SVL ratio 0.32–0.37 (0.27–0.33); smaller tympanum, TW/SVL ratio in males 0.027–0.029 (0.035–0.039); larger eye ED/SVL ratio 0.13–0.14 (0.12–0.13); lower TW/ED ratio in males 0.20–0.23 (0.27–0.32); shorter snout END/HL ratio 0.23–0.27 (0.27–0.29). *Sarcohyla hazelae* differing by (values for *S. toyota* given in parenthesis): larger body size in males 35.0–38.8 mm SVL (28.5–32.2 mm SVL); inmaculate white venter (Figs. 4I, 4L) (white or yellow background with dark gray and brown marbling on 100% of venter; Figs. 4H, 4K); green dorsal ground coloration with iridescent green spots (Figs. 4C, 4F) (no green ground coloration or iridescent green spots present on dorsum; Figs. 4A, 4D); snout longer and rounded in both dorsal and lateral profile (Figs. 5C, 5F) (short snout truncate in both dorsal and lateral profile; Figs. 5A, 5D); superarticular tubercles on first phalange offingers on hand conical or barely bifid (superarticular tubercles on first phalange of fingers hand distinctly bifid). *Sarcohyla toyota* further differs from *S. hazelae* by the following mensural proportions (values for *S. hazelae* given in parenthesis): longer hand, HA/SVL ratio 0.32–0.37 (0.30–0.32); smaller tympanum, TW/SVL ratio in males 0.027–0.029 (0.035–0.038); larger eye, ED/SVL ratio 0.13–0.14 (0.10–0.11); lower TW/ED ratio in males 0.20–0.23 (0.33–0.37); shorter snout END/HL ratio 0.23–0.27 (0.27–0.28).

FIGURE 1. Holotype of *Sarcohyla toyota*, **sp. nov.** in life, MZFC 34666 (CIG-1066) from 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico.(A) Dorso-lateral perspective. (B) Dorsal perspective. (C) Lateral perspective.

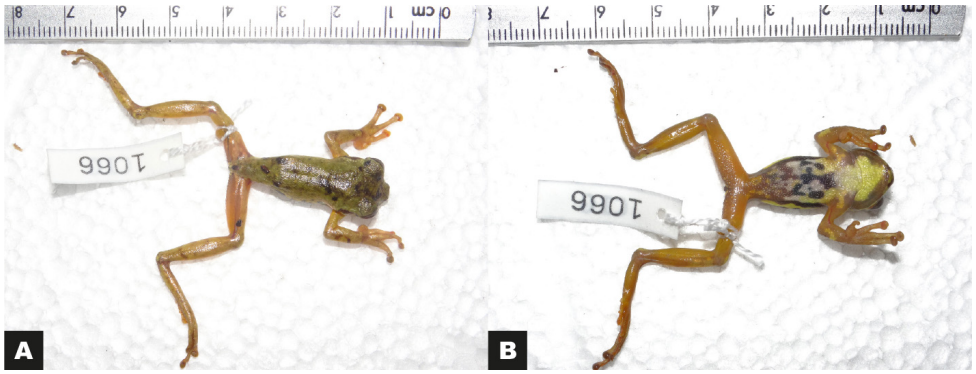

FIGURE 2. Holotype of *Sarcohyla toyota*, **sp. nov.** in preservative, MZFC 34666 (CIG-1066) from 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico.(A) Dorsal perspective. (B) Ventral perspective.

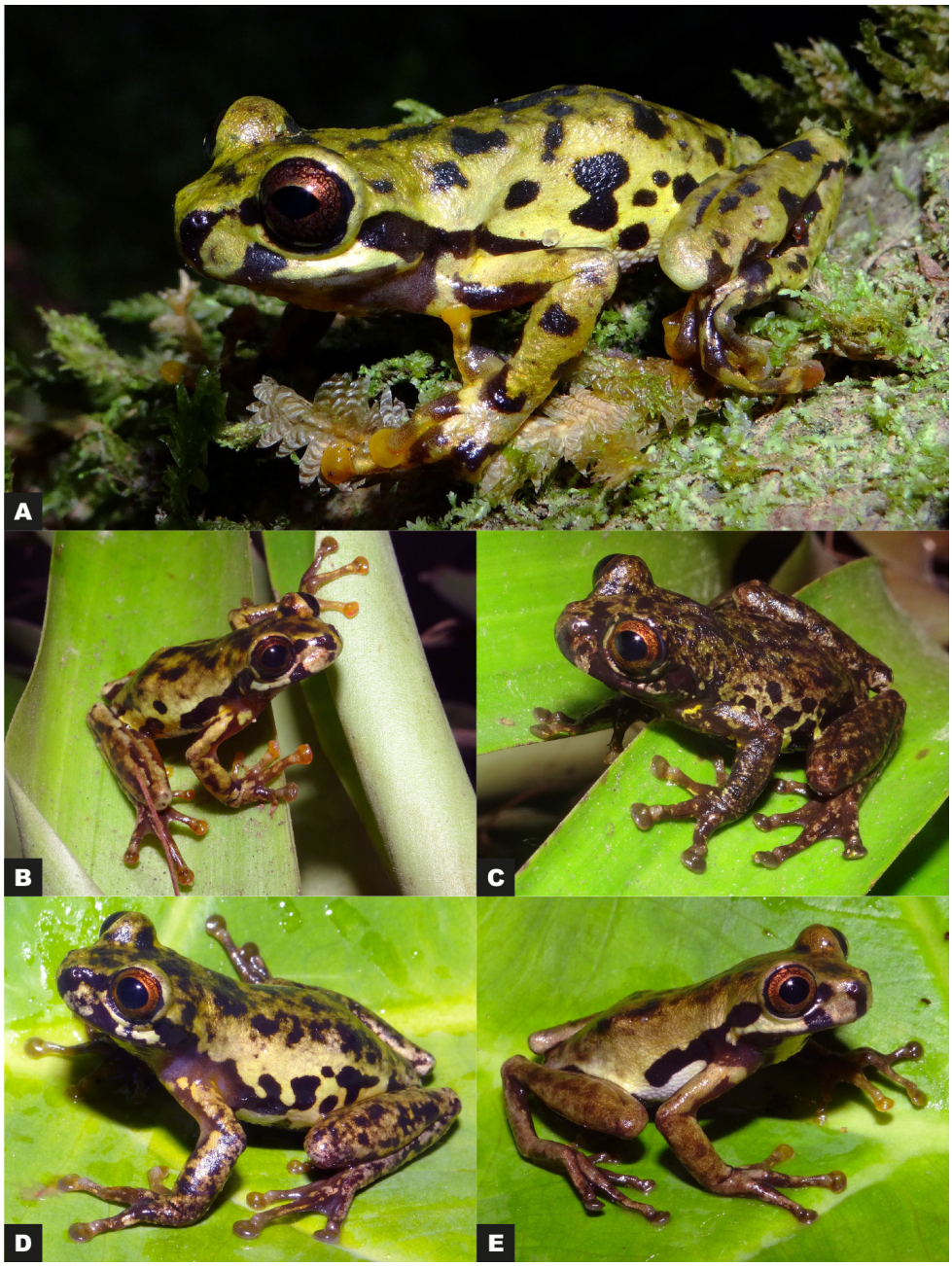

FIGURE 3. Paratypes of *Sarcohyla toyota*, **sp. nov.** in life, from 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico.(A) MZFC 34661 (CIG-0924). (B) MZFC 34663 (CIG-1063). (C) MZFC 34664 (CIG-1064). (D) MZFC 34665 (CIG-1065). (E) MZFC 34662 (CIG-1062).

TABLE 1. Comparison of diagnostic characters of *Sarcohyla toyota* sp. nov, *Sarcohyla thorectes* and *Sarcohyla hazelae*. Abbreviations used in table are as follows: TW (tympanum width); ED (eye diameter).

***Sarcohyla toyota* sp. nov.**	***Sarcohyla thorectes***	***Sarcohyla hazelae***
No iridescent green spots on dorsum	Iridescent green spots on dorsum	Iridescent green spots on dorsum
White coloration with dark gray or brown and yellow marbling on entire venter	White coloration with dark gray or brown marbling only on chest and upper abdomen	White coloration on entire venter
Rostral keel absent	Rostral keel present	Rostral keel absent
Dark brown markings on head and flank continuous, forming face mask	Dark brown markings on head and flank not continuous, not forming face mask	Dark brown markings on head and flank continuous, forming face mask
Nostrils visibly protruding, head truncate from dorsal profile	Nostrils barely protruding, head bluntly rounded from dorsal profile	Nostrils barely protruding, head rounded from dorsal profile
Yellow ventral coloration widespread on throat, hands, abdomen, flanks, groin, thighs	Yellow ventral coloration extremely limited or absent	Yellow ventral coloration absent
Tarsal fold indistinct	Tarsal fold distinct on posterior half of tarsus	Tarsal fold barely visible on posterior half of tarsus
Lateral profile of snout distinctly truncate	Lateral profile of snout slightly rounded	Lateral profile of snout rounded
TW/ED ratio in males 0.20–0.23	TW/ED ratio in males 0.27–0.32	TW/ED ratio in males 0.33–0.37
Subarticular tubercles on distal end of fingers distinctly bifid	Subarticular tubercles on distal end of fingers conical, or barely bifid	Subarticular tubercles on distal end of fingers conical
Tympanum barely distinct	Tympanum visibly distinct	Tympanum barely distinct
Outer metatarsal tubercle distinct, rounded	Outer metatarsal tubercle tiny, barely visible	Outer metatarsal tubercle indistinct, barely visible

Description of holotype. Adult male, 29.8 mm SVL; head broad and wider than body; top of head flat; HL 10.2 mm; HW 9.7 mm; head longer than wide, cephalic index 1.05; HL/SVL ratio 0.34; nostrils protuberant, oval, directed horizontally; snout truncate in dorsal profile with no distinct rostral keel (Fig. 1B); snout short and truncate in lateral profile (Fig. 1A); canthus moderately angular; loreal region concave; lips thick and barely flared; ED 4.0 mm; ELW 2.4 mm; IOD 5.7 mm; IND 2.4 mm; END 2.7 mm; ETD 2.1 mm; tympanum small, round and indistinct, TW 0.8 mm; TW/ED ratio 0.2; supratympanic fold from eye, above tympanum and down to above arm insertion, barely covers upper edge of tympanum; HaL 9.7 mm; fingers long, 3FL 6.8 mm, 4FL 4.9 mm, 3FL/SVL ratio 0.23; finger lengths 1 < 2 < 4 < 3; fingers with vestigial webbing, hand webbing formula: **I** 3-3 **II** 3-3 **III** 2□-2¾ **IV**; finger discs large, 3FPW 1.9 mm, 3FPW/3FW ratio 2.1; 4FPW 1.8 mm, 4FPW/4FW ratio 1.9, 4FPW/TW ratio 2.3; prepollex enlarged, bifid, covered with nuptial excrescenses consisting of minute spinules on prepollex and thumb; subarticular tubercles large, bifid; indistinct supernumerary pustules rounded; palmar tubercle bifid; dermal fold on wrist; UaL 6.4 mm; FaL 7.1 mm; tubercles on ventrolateral edge of forearm in row, interrupted, not forming a continuous fold; FL 14.2 mm; toes long, 3TL 6.7 mm, 4TL 8.9 mm, 4TL/SVL ratio 0.28; toe lengths 1<2<3<5<4; toes about half webbed, foot webbing formula: **I** 2½-2½ **II** 1½-2¾ **III** 2½-2½ **IV** 2-1¾**V**; toe discs large, 4TPW 1.7 mm, 4TPW/4TW ratio 1.8, 4TPW/TW ratio 2.1; toe subarticular tubercles moderately large, round , not bifid: indistinct supernumerary pustules rounded; inner metatarsal tubercle distinct, moderately rounded; outer metatarsal tubercle present, small, rounded in shape; low tarsal fold present but indistinct; a row of slightly raised tubercles on tarsus; FeL 13.4 mm; TL 15.1 mm; TaL 8.3 mm; tibio-tarsal articulation extends to anterior portion of eye; cloacal opening directed postero-ventrally; cloacal sheath moderately long, grooved medially; no transverse fold above cloacal opening; six large pale yellow tubercles on posterior surface of thigh and below level of cloacal opening. Skin on dorsum smooth; lateral skin shagreen; skin on venter of head shagreen, ventral skin of body and thighs granular. No axillary membrane. Dentigerous processes of prevomers large and postero-medially inclined between two moderate-sized ovoid choanae. Vocal slits present, large, extending from median part of tongue to angle of jaw. Vocal sac single, median, subgular and moderately distensible. Pupil horizontal.

Color of holotype in life: Dorsum of head, body and limbs yellowish brown, mottled with indistinct blotches of darker brown; no iridescent green spots or blotches present; flanks bright yellow; pale brown blotches present

on snout and lips; continuous dark brown dorso-lateral stripe extending from behind eye through tympanum and along flank to groin, equally dark brown blotches on flank above brown dorso-lateral stripe; no inter-orbital bar; no barring on limbs (Figs. 1A, 1B, 1C). Lower portions of head and throat pale yellow; chest and abdomen white and yellow with bold dark gray and brown marbling on entire chest and abdomen, with no flesh colored skin present; ventral coloration of limbs yellowish-orange. Iris coppery brown.

Color of holotype in preservative: Dorsum of head and body gray with dark brown indistinct blotches, dorsal surfaces of limbs beige; flanks gray with dark brown marbling; venter white to cream, with dark gray marbling; throat white; ventral surfaces of limbs beige (Figs. 2A, 2B).

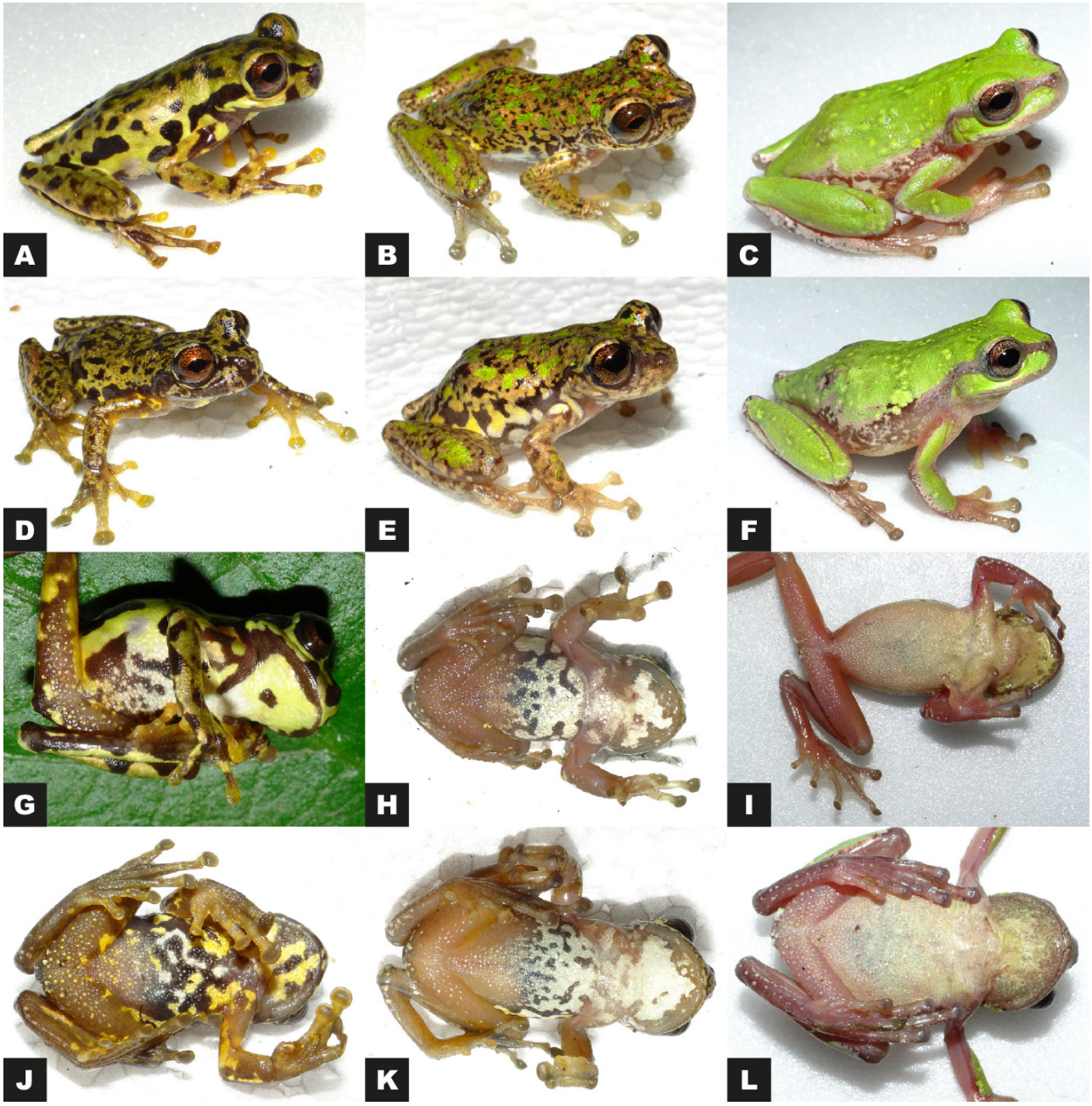

FIGURE 4. Comparative photos of *Sarcohyla hazelae* group in life. (A) *Sarcohyla toyota* **sp. nov.**, MZFC 34661 (CIG-0924). (B) *Sarcohyla thorectes*, MZFC 34669 (CIG-1060). (C) *Sarcohyla hazelae*, MZFC 34670 (CIG-1245). (D) *Sarcohyla toyota* **sp. nov.**, MZFC 24664 (CIG-1064). (E) *Sarcohyla thorectes*, MZFC 34668 (CIG-1059). (F) *Sarcohyla hazelae*, MZFC 34672 (CIG-1247). (G) Ventral perspective of *Sarcohyla toyota* **sp. nov.**, MZFC 34661 (CIG-0924). (H) Ventral perspective of *Sarcohyla thorectes*, MZFC 34673 (CIG-1058). (I) *Sarcohyla hazelae*, MZFC 34670 (CIG-1245). (J) Ventral perspective of *Sarcohyla toyota* **sp. nov.**, MZFC 34664 (CIG-1064). (K) Ventral perspective of *Sarcohyla thorectes*, MZFC 34669 (CIG-1060). (L) Ventral perspective of *Sarcohyla hazelae*, MZFC 34672 (CIG-1247).

Variation. The morphometric variation of the type series is summarized in Table 2. Variation in color as follows: four specimens with yellow or yellowish brown dorsal coloration, one tan, one darker brown with yellow highlights; varying degrees of dark gray and brown marbling on venter; three paratypes with abundant yellow coloration on venter, three with sparse yellow ventral coloration (Figs. 3A–3E); 6–13 tubercles present below cloacal opening.

Advertisement call. Male advertisement call consisting of single two–three pulse note sounding like rapid "crehk-crehk-crehk", with length about 17–20 milliseconds repeated about every 5 seconds in call group (Fig. 7). Call groups may consist of 3–6 notes, however due to relatively low volume of call and tendency to call from above fast-flowing water it is difficult to discern how many different individuals are calling at a given time. The call has a dominant frequency of 4.75 kHz. The call is only moderately loud, and can be heard over the sound of the fast flowing water.

Distribution and habitat. This species appears to be restricted to the immediate vicinity of the type locality in the central portion of the Sierra Madre del Sur of Guerrero, Mexico (Fig. 8). It has been collected between 1975–2185 masl. The habitat at tht type locality is cloud forest, with tropical evergreen forest at lower elevations and pine forest at immediately higher elevations(Fig. 9A). It has been collected only in the immediate vicinity of slow to fast moving streams, secondary to larger water ways, and with heavily vegetated banks (Fig. 9B). The frogs are usually found on vegetation above or near the water.

FIGURE 5. Comparative photos of *Sarcohyla hazelae* group in life. (A) Dorsal perspective of head of *Sarcohyla toyota* **sp. nov.**, MZFC 34661 (CIG-0924). (B) Dorsal perspective of head of *Sarcohyla thorectes*, MZFC 34669 (CIG-1060). (C) Dorsal perspective of head of *Sarcohyla hazelae*, MZFC 34672 (CIG-1247). (D) Lateral perspective of head *Sarcohyla toyota* **sp. nov.**, MZFC 34664 (CIG-1064). (E) Lateral perspective of head *Sarcohyla thorectes*, MZFC 34668 (CIG-1059). (F) Lateral perspective of head *Sarcohyla hazelae*, MZFC 34670 (CIG-1245). (G) Cloacal tubercles and groin coloration of *Sarcohyla toyota* **sp. nov.**, MZFC 34662 (CIG-1062). (H) Cloacal tubercles and groin coloration of *Sarcohyla thorectes*, MZFC 34674 (CIG-1061). (I) Cloacal tubercles and groin coloration of *Sarcohyla hazelae*, MZFC 34672 (CIG-1247).

TABLE 2. Mensural variation of morphometrics and comparisons amongst *Sarcohyla toyota*, *S. thorectes*, and *S. hazelae*. For abbreviations used, see text. All measurements are in mm.

Species	*Sarcohyla toyota*						*Sarcohyla thorectes*					*Sarcohyla hazelae*		
SFN	CIG 1066	CIG 0924	CIG 1062	CIG 1063	CIG 1064	CIG 1065	CIG 1020	CIG 1058	CIG 1059	CIG 1060	CIG 1061	CIG 1245	CIG 1246	CIG 1247
SVL	29.80	28.60	31.30	28.88	32.24	28.50	31.65	30.55	29.37	29.80	37.51	37.59	38.81	37.17
HL	10.19	9.75	9.92	10.00	11.28	10.23	10.45	10.39	10.18	10.84	12.68	12.58	12.90	11.97
HW	9.73	9.48	10.22	9.10	10.38	9.76	10.02	10.20	10.00	10.13	12.39	12.88	13.30	12.87
HL/SVL	0.34	0.34	0.32	0.35	0.35	0.36	0.33	0.34	0.35	0.36	0.34	0.33	0.33	0.32
HL/HW	1.05	1.03	0.97	1.10	1.09	1.05	1.04	1.02	1.02	1.07	1.02	0.98	0.97	0.93
ED	3.98	4.03	4.00	3.66	4.39	3.80	4.13	3.86	3.90	3.78	4.47	4.13	4.07	3.91
ED/SVL	0.13	0.14	0.13	0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.11	0.10	0.11
ED/HL	0.39	0.41	0.40	0.37	0.39	0.37	0.40	0.37	0.38	0.35	0.35	0.33	0.32	0.33
ELW	2.39	1.96	2.16	2.15	2.25	2.48	2.50	2.53	2.42	2.52	3.01	2.71	2.56	2.60
IOD	5.73	5.12	5.77	5.52	5.87	5.78	5.86	6.38	6.45	6.21	7.64	6.84	6.76	6.83
TW	0.83	0.80	0.84	0.83	0.87	0.82	1.11	1.18	1.15	1.16	1.45	1.36	1.40	1.43
TW/ED	0.21	0.20	0.21	0.23	0.20	0.22	0.27	0.31	0.29	0.31	0.32	0.33	0.34	0.37
TW/SVL	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
END	2.70	2.37	2.70	2.46	2.60	2.63	2.84	2.94	2.96	2.93	3.49	3.57	3.50	3.23
END/HL	0.26	0.24	0.27	0.25	0.23	0.26	0.27	0.28	0.29	0.27	0.28	0.28	0.27	0.27
IND	2.36	2.63	2.65	2.30	2.62	2.51	2.58	2.55	2.57	2.62	2.95	2.86	2.93	2.79
IND/END	0.87	1.11	0.98	0.93	1.01	0.95	0.91	0.87	0.87	0.89	0.85	0.80	0.84	0.86
ETD	2.09	1.65	1.74	1.68	1.91	1.90	1.92	1.94	1.76	1.95	2.14	2.16	2.09	2.07
FeL	13.38	13.58	13.40	12.69	13.49	13.25	14.00	13.88	13.71	14.30	15.74	15.96	17.25	16.57
TL	15.11	14.70	14.92	13.64	15.25	14.46	15.40	15.32	15.25	16.01	18.20	17.55	18.72	17.49
TaL	8.26	8.58	8.88	7.88	9.06	8.58	9.28	8.94	8.93	8.57	10.27	10.23	10.02	10.49
FL	14.23	14.34	14.34	13.40	15.16	13.82	13.20	13.70	14.14	13.77	15.92	16.86	17.91	16.22
HaL	9.65	9.93	10.33	10.76	11.00	9.53	8.63	9.40	9.63	9.65	11.13	11.90	12.51	11.35
FaL	7.07	6.90	7.45	6.97	7.97	7.08	7.05	6.72	6.35	6.63	8.31	8.19	9.70	8.84
UaL	6.44	5.75	6.70	5.96	7.30	6.14	6.44	6.12	5.70	6.14	7.80	7.91	8.62	7.70
FeL/SVL	0.45	0.47	0.43	0.44	0.42	0.46	0.44	0.45	0.47	0.48	0.42	0.42	0.44	0.45
FL/SVL	0.48	0.50	0.46	0.46	0.47	0.48	0.42	0.45	0.48	0.46	0.42	0.45	0.46	0.44
HaL/SVL	0.32	0.35	0.33	0.37	0.34	0.33	0.27	0.31	0.33	0.32	0.30	0.32	0.32	0.31
1FL	2.86	2.96	2.79	2.71	3.66	2.72	3.37	2.55	2.45	2.15	2.88	3.17	3.33	2.91

.....continued on the next page

TABLE 2. (Continued)

Species	*Sarcohyla toyota*						*Sarcohyla thorectes*					*Sarcohyla hazelae*		
SFN	CIG 1066	CIG 0924	CIG 1062	CIG 1063	CIG 1064	CIG 1065	CIG 1020	CIG 1058	CIG 1059	CIG 1060	CIG 1061	CIG 1245	CIG 1246	CIG 1247
2FL	4.57	4.40	3.96	4.70	4.80	4.12	3.67	3.78	3.62	3.54	4.67	5.93	6.00	6.26
3FPW	1.93	1.25	2.21	1.78	2.38	1.90	1.90	1.75	1.73	1.71	2.12	2.29	2.47	2.30
3FW	0.93	0.59	0.94	0.91	1.17	0.86	1.00	0.65	0.69	0.91	1.03	1.23	1.24	1.20
3FL	6.81	6.34	6.70	6.46	7.40	6.34	5.03	6.19	5.96	6.24	7.59	8.22	8.33	7.65
4FPW	1.76	1.35	2.19	1.83	2.43	1.78	1.86	1.66	1.62	1.58	2.10	2.00	2.24	2.11
4FW	0.94	0.70	1.07	0.92	1.22	0.92	0.90	0.80	0.81	0.95	1.11	1.30	1.30	1.33
4FL	4.94	5.00	5.10	4.88	5.58	4.72	4.00	4.62	4.38	4.34	5.53	6.07	6.47	6.17
3FPW/3FW	2.08	2.12	2.35	1.96	2.03	2.21	1.90	2.69	2.51	1.88	2.06	1.86	1.99	1.92
4FPW/4FW	1.87	1.93	2.05	1.99	1.99	1.93	2.07	2.08	2.00	1.66	1.89	1.54	1.72	1.59
3FL/SVL	0.23	0.22	0.21	0.22	0.23	0.22	0.16	0.20	0.20	0.21	0.20	0.22	0.21	0.21
3FL/HaL	0.71	0.64	0.65	0.60	0.67	0.67	0.58	0.66	0.62	0.65	0.68	0.69	0.67	0.67
4FL/HaL	0.51	0.50	0.49	0.45	0.51	0.50	0.46	0.49	0.45	0.45	0.50	0.51	0.52	0.54
1TL	3.08	3.85	3.43	2.58	3.72	3.35	2.34	2.20	2.29	2.21	2.62	3.28	3.17	3.34
2TL	4.91	4.55	5.00	4.76	5.37	4.87	3.15	2.73	2.88	3.20	2.90	5.79	5.15	5.23
3TL	6.69	7.02	7.42	7.29	8.28	6.97	5.31	4.91	5.10	5.30	5.70	7.36	8.37	8.09
4TPW	1.71	1.23	2.10	1.66	2.26	1.66	1.66	1.41	1.50	1.35	1.93	1.82	2.03	1.85
4TW	0.96	0.60	1.07	0.95	1.26	0.94	0.94	0.60	0.65	0.76	0.87	1.14	1.22	1.30
4TL	8.85	8.30	8.88	9.00	10.95	8.50	8.12	8.66	8.57	8.20	10.55	10.33	10.60	10.15
5TL	6.22	5.52	5.54	5.45	7.23	5.88	5.25	6.24	6.42	5.53	7.27	7.57	7.50	7.59
4TL/FL	0.62	0.58	0.62	0.67	0.72	0.62	0.62	0.63	0.61	0.60	0.66	0.61	0.59	0.63

Etymology. The specific epithet is a an invariable name in aposition honoring the Japanese automotive manufacturer Toyota, whose various four wheel drive models such as the Toyota Tacoma and the Toyota 4runner have been paramount to our field team's access into hard-to-reach areas of the Mexican back country.

Referred Specimens. *Plectrohyla aff. thorectes* Mexico: Guerrero: El Molote, Municipio de Atoyac de Álvarez (ANMO 020246); 8.21 km SW of Puerto de Gallo (UTA-A 56442); Carretera Nueva Dehli-La Guitarra (UTA-A 57681 (JAC 022224)).

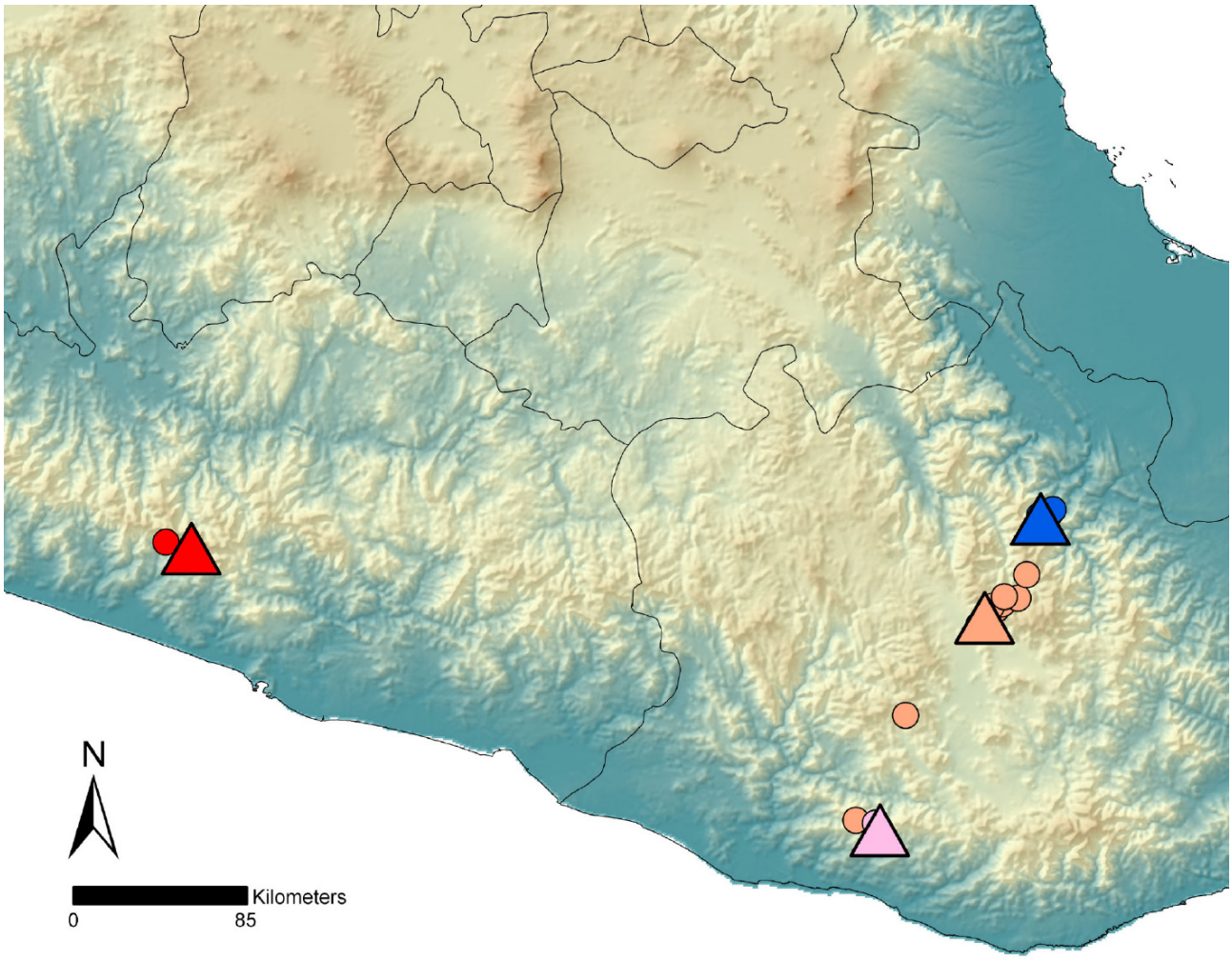

FIGURE 6. Map showing the type localities and distribution of the *Sarcohyla hazelae* group in southern Mexico. Red triangle represents the type locality of *Sarcohyla toyota* **sp. nov.** and red circle represents additional locality. Pink triangle represents the type locality of *Sarcohyla thorectes* and pink circle represents additional locality. Brown triangle represents the type locality of *Sarcohyla hazelae* and brown circles represent additional localities. Blue triangle represents the type locality of *Sarcohyla sabrina* and blue circles represent additional localities.

Discussion

Duellman (1970) erected the "*Hyla hazelae* Group" for *Hyla hazelae* and *H. thorectes* (=*Sarcohyla hazelae* and *S. thorectes*). He defined this group as consisting of small, stream breeding species; males attain a maximum SVL of 38.6 mm, and females reach 37.8 mm. The dorsum is uniform green or mottled green and brown, and the venter is pale yellow or white with bold mottling. Duellman (1970) diagnosed this group from other Middle American hylids by their large hands with vestigial webbing, half-webbed feet, and presence of a tympanum. He also brought attention to their small, relatively narrow tongues and large tubercles below the cloacal opening.

Duellman (2001) dissolved the *"Hyla hazelae* Group" and placed *Hyla hazelae* in the "*Hyla miotympanum* Group" and *H. thorectes* (at this point including specimens of *Sarcohyla toyota*) in the "*Hyla pictipes* group", along with nine species of Central American frogs related to *Isthmohyla pictipes* (Cope 1875). Based on a broad molecular

study of Hylidae, Faivovich *et al.* (2005) placed all frogs related to *H. bistincta* into *Plectrohyla.* They included *H. thorectes* and *H. hazelae* in *Plectrohyla*, giving the following justification: "*H. thorectes* is being tentatively included because a still undescribed species, very similar to *H. thorectes* (*Hyla* sp. 5) is nested within this clade. *Hyla hazelae* is tentatively included because of its similarities with *H. thorectes*." The specimen of "*Hyla* sp. 5" which they included in their study and considered to be a "undescribed species very similar to *H. thorectes*" is JAC 2224 (UTA-A 57681) which we have examined and referred to *S. toyota*. Duellman *et al.* (2016) erected *Sarcohyla* for all species of *Plectrohyla* (*sensu* Faivovich *et al.* 2005) occurring west of the Isthmus of Tehuantepec.

FIGURE 7. Photos of specimens of *Sarcohyla hazelae* group in life. (A) *Sarcohyla toyota* **sp. nov.**, MZFC 34661 (CIG-0924). (B) *Sarcohyla toyota* **sp. nov.**, UTA-A 57681 (JAC-22224). , image by Luis Canseco–Márquez. (C) *Sarcohyla thorectes*, MZFC 34673 (CIG-1058). (D) *Sarcohyla thorectes*, MZFC 34674 (CIG-1061). (E) *Sarcohyla hazelae*, MZFC 34670 (CIG-1245). (F) *Sarcohyla hazelae*, MZFC 34672 (CIG-1247).

FIGURE 8. Type locality of *Sarcohyla toyota* **sp. nov.** at 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico. (A) General photo of type locality from road with stream where holotype MZFC 34666 (CIG-1066) was collected. (B) Photo of exact micro-habitat at type locality where holotype MZFC 34666 (CIG-1066) was collected.

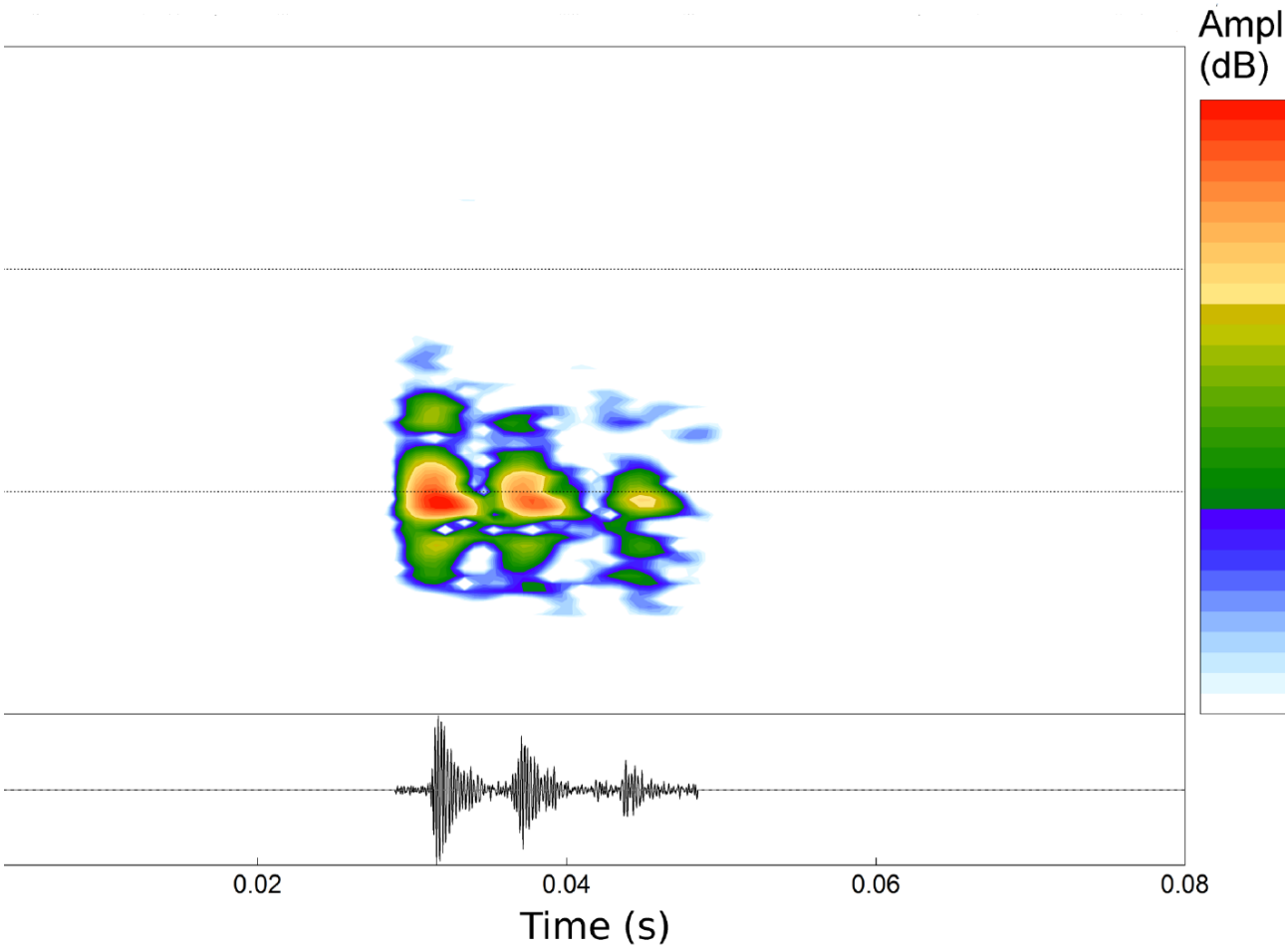

FIGURE 9. Call analysis of *Sarcohyla toyota* **sp. nov.** from 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico.

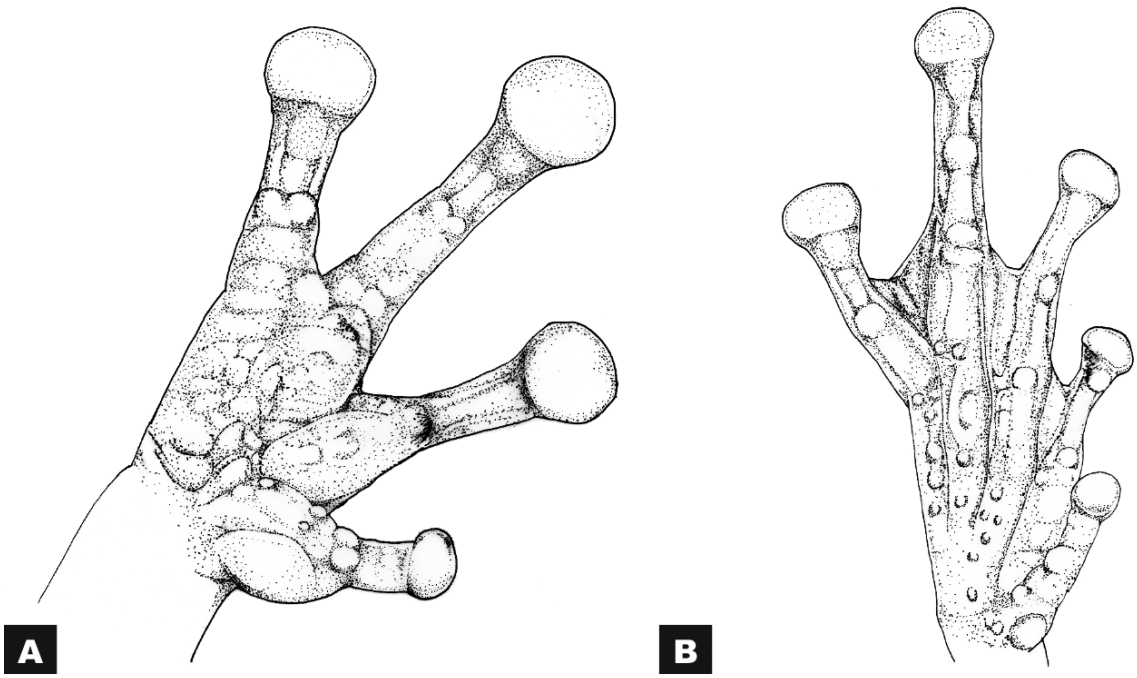

FIGURE 10. Ventral aspect of (A) hand and (B) foot of *Sarcohyla toyota* **sp. nov.** MZFC 34666 (CIG-1066) from 11.4 km (by road) SW of Puerto de Gallo, Municipio de Atoyac de Álvarez, Guerrero, Mexico.

TABLE 3. Variation and similarities of selected morphological characters amongst several closely related species of *Sarcohyla hazelae.* For abbreviations used, see text, except: DSATF (condition of distal subarticular tubercles on fingers); OMT (outer metatarsal tubercle); Nup. Exc. (nuptial excrescences). All measurements in mm.

Species	***Sarcohyla hazelae***	***Sarcohyla thorectes***	***Sarcohyla toyota***	***Sarcohyla sabrina***	***Sarcohyla robertsorum***	***Sarcohyla charadricola***	***Sarcohyla labedactyla***	***Sarcohyla psarosema***
Source	Our results; Duellman 1970	Our results; Duellman 1970	Our results	Orig. Desc.; Duellman 2001	Orig. Desc.; Duellman 1970	Orig. Desc.; Duellman 2001	Orig. Desc.; Duellman 2001	Orig. Desc.; Duellman 2001
SVL ♂	35.0–38.6	29.4–31.7	28.5–32.2	26.9–30.2	39.0–47.9	35.3–44.4	—	29.4–31.4
SVL f#	—	37.5	—	38.8–41.7	47.5–50.8	43.4–50.9	44.7	37.3
Skin thickness	Thin	Thin	Thin	Thin	Thick	Thin	Thin	Thick
HL/SVL	0.32–0.33	0.33–0.36	0.32–0.36	0.30–0.32	0.27–0.32	0.29–0.32	29.8	0.32–0.33
HaL/SVL	0.30–0.32	0.30–0.33	0.32–0.37	—	—	—	—	—
TW/ED ♂	0.33–0.37	0.27–0.32	0.20–0.23	—	0.36–0.47	0.3–0.37	—	—
TW/SVL ♂	0.036–0.038	0.035–0.039	0.027–0.029	—	0.048	0.036	—	—
END/HL	0.27–0.28	0.27–0.29	0.23–0.27	—	0.29	—	—	—
ED/HL	0.32–0.33	0.35–0.40	0.37–0.41	—	0.29	0.37	—	—
ED/SVL	0.10–0.11	0.12–0.13	0.13–0.14	0.11	0.09	0.11	—	—
Cephalic index	Head wider than long	Head about as long as wide	Head longer than wide	Head longer than wide	Head wider than long	Head wider than long	Head wider than long	Slightly longer than wide
Dorsal color	Green	Brown with darker brown blotches	Yellow/brown with darker brown marbling	Green	Brown and iridescent green	Green with dark gray marbling	Tan with brown mottling	Brown with white flecks
Ventral color	White	Dark gray or brown and white marbling	Dark gray or brown with white and yellow marbling	White with brown pigmentation	Gray with cream spots	White	Cream with black flecks	White with gray mottling
Finger webbing	Vestigial	Vestigial	Vestigial	Vestigial	Vestigial	Vestigial	One third	Vestigial
Finger length	Long	Long	Long	Long	Long	Long	Long	Long

.....*continued on the next page*

TABLE 3. (Continued)

Species	*Sarcohyla hazelae*	*Sarcohyla thorectes*	*Sarcohyla toyota*	*Sarcohyla sabrina*	*Sarcohyla robertsorum*	*Sarcohyla charadricola*	*Sarcohyla labedactyla*	*Sarcohyla psarosema*
DSATF	Round	Conical or slightly bifid	Bifid	Round or slightly bifid	Conical	Round	Round	Round and nearly flat
Toe webbing	Half	Half	Three fourths	Three fourths	Fourth fifths	Three fourths	One half	Two thirds
Tympanum	Barely distinct	Distinct	Barely distinct	Indistinct	Distinct	Distinct	Distinct	Indistinct
Tongue shape	Narrow, longate,elliptical	Narrow, elongate, oval	Narrow, elongate, oval	Broadly cordiform	Narrow, slightly longer than wide	Round	Broadly cordi-form	Cordiform
Cloacal tubercles	Present	Present	Present	Present	Present	Absent	Absent	Absent
Green iridescense	Present, spots	Present, spots	Absent	Unknown	Present, spots	Absent	Absent	Absent
Rostral keel	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent
Stream breeder?	Yes	Yes	Yes	Yes	Yes	Sometimes	Unknown	Yes
OMT	Present	Absent	Present	Absent	Present	Present	Absent	Absent
Vocal slits	Present	Present	Present	Absent	Absent	Absent	Unknown	Absent
Nup. Exc. ♂	Present	Present	Present	Absent	Present	Absent	Unknown	Present

In a very detailed molecular study of the "*Hyla bistincta* group" (= *Sarcohyla*), Caviedes-Solis (2013) included tissues of both *S. thorectes* and the specimen of *S. toyota* JAC 2224 (UTA-A-57681). She considered both specimens to represent "*P. thorectes"* (= *S. thorectes*), but recognized their distinctiveness based on molecular data, and suggested that the two populations represent different species. Caviedes-Solis (2013) also found a close relationship between *S. thorectes, S. toyota* (which she included as "*P. thorectes*") and *S. hazelae*. Caviedes-Solis & Nieto-Montes de Oca (2018) further elaborated on the results of Caviedes-Solis (2013) and published a molecular phylogeny of *Sarcohyla* based on two mitochondrial genes (*ND1* and *12S*) and three nuclear genes (*Rag-1*, Rhod, and *POMc*). They emphasized the likelihood of the Guerrero population of *S. thorectes* (=*S. toyota*) representing a new species based on molecular and morphological data, yet did not present any morphological data. They also confirmed the close relationship of *S. thorectes, S. toyota* (as *S. thorectes*) and *S. hazelae.*

Caviedes-Solis (2013) and Caviedes-Solis & Nieto-Montes de Oca (2018) analyzed molecular data for 17 of the 24 species of *Sarcohyla,* and presented evidence of five phylogenetic clades within *Sarcohyla*. Their proposed clades are: 1. thin-skinned species from the Sierra Madre Oriental consisting of *Sarcohyla arborescandens, S. cyclada*, *S. celata* and potentially *S. siopela* and *S. calvicollina*; 2. thin-skinned species from southern Mexico consisting of *S. robertsorum* (Taylor 1940) as sister to a clade composed of *Sarcohyla hazelae*, *S. thorectes*, *S. toyota* (see above); 3. combination of thin-skinned and thick-skinned species consisted of *S. crassa, S. miahuatlanensis*, *S. cembra* and an undescribed species from Malinaltepec, Guerrero; 4. thin-skinned species, limited to central Guerrero, consists of *Sarcohyla chryses* and *S. mykter;* 5. thick-skinned species related to *Sarcohyla bistincta,* including *S. pethether*, *S. calthula* and *S. ephemera*. However, Caviedes-Solis (2013) and Caviedes-Solis & Nieto-Montes de Oca (2018) did not formaly describe the five species clades as species groups.

Faivovich *et al.* (2018) presented a similar tree, which included five clades similarly arranged to the five included in Caviedes-Solis & Nieto-Montes de Oca (2018). They showed five clades which included the following species: Clade 1. *Sarcohyla cyclada*, *S. celata, S. arborescandens*; Clade 2. *Sarcohyla miahuatlanensis*, *S. cembra*, *S. crassa*, *S.* **sp. nov.**; Clade 3. *Sarcohyla robertsorum*, *S. thorectes*, *S. toyota*, *S. hazelae*; Clade 4. *Sarcohyla bistincta*, *S. hapsa*, *S. calthula* (=*S. labeculata*), *S. penthether*, *S.* **sp. nov.**; Clade 5. *Sarcohyla chryses*, *S. mykter*, *S. ameibothalame*. Faivovich *et al.* (2018) made no attempt to describe the five clades of *Sarcohyla* as species groups, noting that the relationship amongst the clades of *Sarcohyla* remained tentative.

Campbell *et al.* (2018) followed the general taxonomy proposed by Faivovich *et al.* (2005), Duellman *et al.* (2016) and Caviedes-Solis & Nieto-Montes de Oca (2018) in their review of one of the clades of *Sarcohyla,* those related to the species *S. bistincta.* They formally defined this clade as the *Sarcohyla bistincta* group, described the populations from Central Mexico as *S. hapsa*, and elevated the binomial *Sarcohyla labeculata* for populations formerly described as *S. ephemera* and *S. calthula*.

Herein, we follow the proposal of five molecular clades presented by Caviedes-Solis & Nieto-Montes de Oca (2018) in our review of the second species clade, the one consisting of *Sarcohyla hazelae, S. thorectes* and *S. toyota*. We consider *S. toyota* closely related to *S. hazelae* and *S. thorectes* as was suggested by previous authors (see above). Together these species are sister to *S. robertsorum*, and likely *S. sabrina* also falls within this clade. *S. sabrina* has not been collected in at least 40 years, and we tentatively include it here based on its similarities with *S. hazelae*. These species share some characters which are unique amongst Mexican hylids, such as presenting iridescent green spots on the dorsum (*S. robertsorum*, *S. hazelae*, *S. thorectes*; dark gray and brown marbling on a white back ground (*S. thorectes*, *S. toyota*); hands large in relation to body size, with vestigial webbing between the fingers; numerous large tubercles with pale coloration (yellow or white) are present below the cloacal opening; moderately thin (*S. robertsorum*), thin (*S. hazelae, S. sabrina*) or very thin skin (*S. thorectes*, *S. toyota*) tympanum visible but indistinct (*S. thorectes*), barely visible *(S. hazelae, S. toyota*), or invisible (*S. sabrina*); small, narrow tongue; quadratojugal reduced to small spur or absent.

All five species strictly stream-breeding, species with known reproduction activity laying eggs on leaves above flowing water. Distributed in the Sierra Madre Oriental of Hidalgo and Puebla (*S. robertsorum*), in the Sierra Madre del Sur of Guerrero and Oaxaca (*S. thorectes*, *S. toyota*), as well as in the Sierra Juárez complex of northern Oaxaca and higher portions of the Valles Centrales region of Central Oaxaca, and potentially in the higher portions of the Mixteca Alta. (*S. hazelae*, *S. sabrina*). The elevational range extends from 1700–3050 masl. Habitats include humid pine-oak woodland and montane cloud forest. Assuming that *S. sabrina* is not extinct a molecular analysis could confirm its placement close relation to the other four species (*S. robertsorum*, *S. thorectes*, *S. hazelae*, and *S. toyota*).

Conservation

Sarcohyla hazelae and *S. thorectes* have been reported as extinct or possibly extinct in various international lists of threatened amphibians (Santos-Barrera & Canseco-Márquez 2004a, 2004b, Mendelson & Kabay, 2009). *Sarcohyla hazelae* was rediscovered by Heimes & Aguilar (2011) and they commented extensively on their conservation status in the Sierra Juárez, Oaxaca. Caviedes-Solis *et. al* (2015) reported having collected *S. hazelae* from the Sierra Juárez in 2011 and 2012. They furthermore reported range extensions for *S. hazelae* from Santa Vicente Laxichio, Oaxaca (2011) and Santa Catarina Juquila, Oaxaca (2012), both in the Sierra Madre del Sur. *Sarcohyla thorectes* was rediscovered by Delia *et al*. (2013) at the type locality after 28 years of absence from amphibian surveys in the area. Caviedes-Solis *et al.* (2015) reported a 2012 record of *S. thorectes* from Santa Maria Juquila, Oaxaca. We collected five specimens of *S. thorectes* from near the type locality in 2016. (See Appendix 1). To our knowledge, *Sarcohyla toyota* has been collected in 1969, 1977, 2002, 2009 and 2016. Based on the amount of calling males heard in 2016, we found both *S. thorectes* and *S. toyota* to be relatively abundant at their type localities and the immediate vicinity, neither species has been found outside of a ten kilometer radius from their type localities, despite various attempts to do so. Both species should be considered to have extremely restricted distributions in cloud forest, which is very sensitive to human modification. We consider that both species warrant immediate conservation efforts due to their limited distribution and sensitive habitat. *Sarcohyla hazelae* is more widespread, and has been collected at at least eight localities in the Sierra Juárez and potentially at two localities in central Oaxaca. *Sarcohyla hazelae* appears to be moderately abundant at collecting sites despite extensive anthropogenic habitat modification (H. Franz, pers. obs.). We do not feel that *S. hazelae* is threatened with immediate extinction as indicated by IUCN (Santos Barrera & Canseco–Márquez, 2004). *Sarcohyla sabrina*, which we tentatively consider to belong to the *S. hazelae* group (see above), has not been located since the collection of type material despite extensive efforts by the authors and other teams of researchers (Campbell, pers. comm., Canseco-Marquez, pers. comm.) It is possible that *S. sabrina* is already extinct, a fate which appears to have fallen upon several species of *Sarcohyla* from the northern slopes of the Sierra Juárez (*S. calvicollina* (Toal 1994), and *S. cyanomma* (Caldwell 1974) (Canseco-Marquez, pers. comm.). Further field work should be carried out in surrounding areas to confirm the conservation status of *S. sabrina.*

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Literature Cited

Adler, K. (1965) Three new frogs of the genus Hyla from the Sierra Madre del Sur of México. *Occasional Papers of the Museum of Zoology, University of Michigan,* 62, 1–18.

Adler, K.A. & Dennis, D.M. (1972) New tree frogs of the genus *Hyla* from the cloud forests of western Guerrero, México. *Occasional Papers of the Museum of Natural History, University of Kansas,* 7, 1–19.

Brocchi, P. (1877) Description d'un nouvveau genre de phaneroglosse hylaeforme (*Plectrohyla guatemalensis). Bulletin de la*

Société Philomathique de Paris, Series 7 (1), 92–93.
Caldwell, J. (1974) A Re-evaluation of the *Hyla bistincta* Species Group, with Descriptions of Three New Species (Anura: Hylidae). *Occasional Papers of the Museum of Natural History, The University of Kansas, Lawrence, Kansas,* 1–37. https://doi.org/10.5962/bhl.part.14776
Campbell, J.A., & Duellman, W.E. (2000) New species of stream-breeding Hylid frogs from the northern versant of the highlands of Oaxaca, Mexico. *Scientific Papers, Natural History Museum, The University of Kansas,* 16, 1–28. https://doi.org/10.5962/bhl.title.16165
Campbell, J.A., Brodie Jr., E.D., Caviedes-Solis, I.W., Nieto-Montes de Oca, A., Luja, V.H., Flores-Villela, O., García-Vázquez, U.O., Sarker, G.C., Wostl, E. & Smith, E.N. (2018) Systematics of the frogs allocated to *Sarcohyla bistincta* sensu lato (Cope, 1877), with description of a new species from Western Mexico. *Zootaxa,* 4422 (3), 366–384. https://doi.org/10.11646/zootaxa.4422.3.3
Canseco-Márquez, L., Mendelson III, J.R. & Gutiérrez-Mayen, M.G. (2002) A new species of *Hyla* (Anura: Hylidae) from the Mixteca Alta, Oaxaca, Mexico. *Herpetologica,* 58, 260–269. https://doi.org/10.1655/0018-0831(2002)058[0260:ANSOHA]2.0.CO;2
Caviedes-Solis, I.W. (2013) *Filogenia molecular del grupo Plectrohyla bistincta (Anura: Hylidae)*. Master's thesis. Universidad Nacional Autónoma de Mexico, Mexico, D.F., 50 pp.
Caviedes-Solis, I.W. & Nieto-Montes de Oca, A. (2018) A multilocus phylogeny of the genus *Sarcohyla* (Anura: Hylidae), and an investigation of species boundaries using statistical species delimitation. *Molecular Phylogenetics and Evolution,* 118, 184–193. https://doi.org/10.1016/j.ympev.2017.09.010
Caviedes-Solis, I.W., Vaìzquez-Vega, L.F., Solano-Zavaleta, I., Peìrez-Ramos, E., Rovito, S.M., Devitt, T.J., Heimes, P., Flores-Villela, O., Campbell, J.A. & Nieto-Montes de Oca, A. (2015) Everything is not lost: recent records, rediscoveries, and range extensions of Mexican hylid frogs. *Mesoamerican Herpetology,* 2 (3), 230–241.
Cope, E.D. (1863) On *Trachycephalus*, *Scaphiopus* and other Batrachia. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 15, 43–54.
Cope, E.D. (1875) On the Batrachia and Reptilia of Costa Rica. *Journal of the Academy of Natural Sciences of Philadelphia,* Series 2, (8), 93–154.
Cope, E.D. (1878 [dated 1877]) Tenth contribution to the herpetology of tropical America. *Proceedings of the American Philosophical Society*, 17, 85–98.
Delia, J.R., Whitney, J.L. & Burkhardt, T. (2013) Rediscovery of "lost" treefrogs from the Oaxacan highlands of Mexico. *Biodiversity and Conservation,* 22, 1405–15. https://doi.org/10.1007/s10531-013-0481-9
Duellman, W.E. (1964) A review of the frogs of the Hyla bistincta group. *University of Kansas Publications, Museum of Natural History,* 15, 469–491. https://doi.org/10.5962/bhl.part.7290
Duellman, W.E. (1970) The hylid frogs of Middle America. *Monograph of the Museum of Natural History, University of Kansas,* 1, 1–753, 72 pls. https://doi.org/10.5962/bhl.title.2835
Duellman, W.E. (2001) The hylid frogs of Middle America. Vol. 1 & 2. *Society for the Study of Amphibians and Reptiles,* Ithaca, NY, 603 pp. & 1159 pp., 92 pls.
Duellman, W.E., Marion, A.B. & Hedges, S.B. (2016) Phylogenetics, classification, and biogeography of the treefrogs (Amphibia: Anura: Arboranae). *Zootaxa,* 4104 (1), 1–10. https://doi.org/10.11646/zootaxa.4104.1.1
Faivovich, J., Haddad, C.F.B., García, P.C.A., Campbell, J.A. & Wheeler, W.C. (2005) Systematic review of the frog family Hylidae, with special reference to Hylinae: Phylogenetic analysis and taxonomic revision. *Bulletin American Museum Natural History,* 294. https://doi.org/10.1206/0003-0090(2005)294[0001:SROTFF]2.0.CO;2
Frost, D.R. (2019) Amphibian Species of the World: an Online Reference. Version 6.0. American Museum of Natural History, New York, USA. Available from: http://research.amnh.org/herpetology/amphibia.index.html (accessed 13 March 2019)
Grünwald, C.I., Jones, J.M., Franz-Chávez, H. & Ahumada-Carrillo, I.T. (2015) A new species of *Ophryacus* (Serpentes: Viperidae: Crotalinae) from eastern Mexico, with comments on the taxonomy of related pitvipers. *Mesoamerican Herpetology,* 2 (4), 387–416.
Heimes, P. & Aguilar, R. (2011) *Plectrohyla hazelae* (Taylor, 1940) not extinct. *Herpetological Review,* 42 (1), 41–42.
Kaplan, M., Heimes, P., Zarza, E. & McCormack, J.E. (2016) On the morphology of *Plectrohyla chryses* (Anura: Hylida; Hylini), with comments on some controversial characters, phylogenetic relationships, and diagnosis of this species. *Caldasia*, 38 (2), 257–273. https://doi.org/10.15446/caldasia.v38n2.60921
McCallum, M.L. (2007) Amphibian Decline or Extinction? Current Declines Dwarf Background Extinction Rate. *Journal of Herpetology,* 41 (3), 483–491. https://doi.org/10.1670/0022-1511(2007)41[483:ADOECD]2.0.CO;2
Meik, J.M., Canseco-Márquez, L., Smith, E.N. & Campbell, J.A. (2005) A new species of *Hyla* (Anura: Hylidae) from Cerro

Las Flores, Oaxaca, Mexico. *Zootaxa,* 1046 (1), 17–27.
https://doi.org/10.11646/zootaxa.1046.1.2

Meik, J.M., Canseco-Márquez, L., Smith, E.N. & Campbell, J.A. (2006) New species of the *Plectrohyla bistincta* group (Hylidae: Hylinae; Hylini) from Oaxaca, Mexico. *Journal of Herpetology,* 40, 304–309.
https://doi.org/10.1670/0022-1511(2006)40[304:NSOTPB]2.0.CO;2

Mendelson III, J.R. & Toal III, K.R. (1996) A new species of *Hyla* (Anura: Hylidae) from the Sierra Madre del Sur of Oaxaca, Mexico, with comments on *Hyla chryses* and *Hyla mykter*. *Journal of Herpetology,* 30, 326–333.
https://doi.org/10.2307/1565169

Mendelson III, J.R. & Kabay, E.H. (2009) On the distribution and status of *Plectrohyla hazelae* (Taylor, 1940) (Amphibia: Hylidae) from Oaxaca, Mexico. *Herpetological Review,* 40 (3), 301–302.

Myers, C.W. & Duellman, W.E. (1982) A new species of Hyla from Cerro Colorado, and other tree frog records and geographical notes from western Panama. *American Museum Novitates,* 2752, 1–25.

Parra-Olea, G., Flores-Villela, O. & Mendoza-Almeralla, C. (2014) Biodiversidad de Anfibios en Meìxico. *Revista Mexicana de Biodiversidad*, 85, 460–466.
https://doi.org/10.7550/rmb.32027

Sabaj-Pérez, H.M. (2016) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 6.5 American Society of Ichthyologists and Herpetologists, Washington, D.C., United States. Available from: http://www.asih.org/ (accessed 13 March 2019)

Santos-Barrera, G. & Canseco-Márquez, L. (2004a) *Plectrohyla hazelae. The IUCN REd List of Threatened Species*, 2004, e.T55501A11318111.

Santos-Barrera, G. & Canseco-Márquez, L. (2004b) *Plectrohyla thorectes. The IUCN REd List of Threatened Species*, 2004, e.T55501A11318111.

Savage, J.M. & Heyer, R.W. (1997) Digital webbing formulae for anurans: a refinement. *Herpetological Review,* 28, 131.

Taylor, E.H. (1940 "1939") New species of Mexican Anura. *University of Kansas Science Bulletin,* 26, 385–405.
https://doi.org/10.5962/bhl.part.1706

Toal, III, K.R. (1994) A new species of *Hyla* (Anura: Hyldae) from the Sierra de Juárez, Oaxaca, México. *Herpetologica,* 50, 187–193.

Ustach, P.C., Mendelson III, J.R., McDiarmid, R.W. & Campbell, J.A. (2000) A new species of *Hyla* (Anura: Hylidae) from the Sierra Mixes, Oaxaca, Mexico, with comments on ontogenetic variation in the tadpoles. *Herpetologica,* 56, 239–250.

Wiens, J.J., Kuczynski, C.A., Hua, X. & Moen, D.S. (2010) An expanded phylogeny of treefrogs (Hylidae) based on nuclear and mitochondrial sequence data. *Molecular Phylogenetics and Evolution,* 55, 871–882.
https://doi.org/10.1016/j.ympev.2010.03.013

APPENDIX 1. Specimens Examined

Sarcohyla charadricola (5 specimens). **MEXICO:** PUEBLA: 14.4 km W of Huachinango **(**MCZ-A 34964–65, UMMZ 118166); 11.7 km W of Huachinango (UMMZ 121567 (UMFS 8738, 8743)).

Sarcohyla hazelae (7 specimens). **MEXICO:** OAXACA: 2 km S of El Punto, Municipio de Santa Catarina Ixtepeji (MZFC 34670–71(CIG 1245–46)); 3.5 km N of Hwy. 175 on road to San Pedro Nexicho, Municipio de Santa Catarina Ixtepeji (MZFC 34672 (CIG 1247)); San Vicente Laxichío, Municipio de San Vicente Laxichío (AMNO 02645); Cerro San Felipe, ca. 16 km N of Oaxaca (FMNH 100047, 126419); Oaxaca (FMNH 108510).

Sarcohyla robertsorum (8 specimens). **MEXICO:** HIDALGO: Zoquizoquipan (AMNO 02665; El Chico National Park (FMNH 126591, 126612, MCZ-A 25646–47, UMMZ 106401 (UMFS 5585–87)).

Sarcohyla sabrina (2 specimens). **MEXICO:** OAXACA: 15.8 km (by road) S of Vista Hermosa, Sierra Juárez (KU 137086); 11.9 km (by road) S of Vista Hermosa, Sierra Juárez (KU 137067).

Sarcohyla thorectes (6 specimens). **MEXICO:** OAXACA: Approximately 37 km N of San Gabriel Mixtepec on road to Oaxaca, Municipio de San Juan Lachao (MZFC 34667 (CIG 1020), MZFC 34668–69 (CIG-1059–60), MZFC 34673–74 (CIG 1058, 1061), AMNO 02032).

Sarcohyla toyota (9 specimens). **MEXICO:** GUERRERO: 11.4 km SW of Puerto de Gallo, Municipio de Atoyac de Álvarez (MZFC 34661–34666 (CIG 1062–66, 0924); El Molote, Municipio de Atoyac de Álvarez (ANMO 020246); 8.21 km SW of Puerto de Gallo (UTA-A 56442); Carretera Nueva Dehli-La Guitarra (UTA-A 57681(JAC 22224)).