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PENSOFT

Geographical distribution and potential geographical range of the Red Skink *Scincella assata* (Cope, 1864) (Squamata, Scincidae) in El Salvador

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Abstract

Scincella assata (Cope, 1864) is known from eight departments from El Salvador. Based on recent fieldwork and research in scientific collections and databases, we report 12 new records of *S. assata* from the country, bringing the total number of verified occurrences to 40. *Scincella assata* is recorded for first time in the departments of Morazan and Usulatán. Additionally, we conducted potential distribution modeling of *S. assata*. Results from the distribution modeling suggest the presence of this species in all 14 departments of El Salvador, four of which currently lack verified records.

Keywords

Deciduous forest, maximum entropy, pine-oak forest, records, Scincidae

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Introduction

The reptile diversity of El Salvador is represented by 100 species (Köhler et al. 2006; Henríquez and Vaquerano 2008; Valdenegro-Brito et al. 2020). The few inventories and the existence of unexplored areas in El Salvador suggest much more remains to be learned about the reptiles of this country (Herrera et al. 2005). One poorly known reptile species is *Scincella assata* (Cope 1864), a ground-dwelling lizard. This species is a small lizard, with an average snout-to-vent length (SVL) of 53 mm, a cylindrical and elongated body, and short limbs. The dorsal coloration is light brown, with a dark stripe demarcated by clear edges on both sides of the body that begins at the nostril and continues onto the tail. Ventrally these lizards are light-colored with reddish tones on the tail (García and Ceballos 1994). *Scincella assata* is known from the Pacific slopes of Latin America, from Jalisco, Mexico to southwestern Honduras (Köhler et al. 2006; McCranie 2018).

Currently, two subspecies are recognized: *S. a. assata* (Cope 1864) and *S. a. taylori* (Oliver 1937), which differ

by the number of scales rows around the midbody (24–28 in *S. a. taylori* versus 30–33 in *S. a. assata*) and the number of dorsal scales (58–69 in *S. a. taylori* versus 69–79 in *S. a. assata*) (Stuart 1940). Additionally, the dark lateral stripe of *S. a. assata* is complete versus interrupted at shoulder height in *S. a. taylori* (Stuart 1940). *Scincella a. taylori* is endemic to Mexico and occurs to west and south in the country in Jalisco, Colima, Michoacán, Guerrero, Oaxaca, and western Chiapas (Oliver 1937; Álvarez del Toro and Smith 1956; Álvarez del Toro 1982; García and Ceballos 1994). *Scincella a. assata* occurs in southern Chiapas, Mexico (Álvarez del Toro 1982; Castiglia et al. 2013), southern Guatemala, El Salvador (Günther 1902 in 1885–1902; Mertens 1952), and southwestern Honduras (McCranie and Köhler 1999).

From the country of El Salvador, Cope (1864) documented *Lampropholis assatum* (= *Scincella assata*) from near the volcano of Izalco. Later, Günther (1902 in 1885–1902) reported *Mocoa assata* (= *Scincella assata*) in El Salvador and Honduras without specifying a locality. No more information on distribution was reported until 2004, when *Sphenomorphus assatus* (= *Scincella assata*) was reported in the departments of Ahuachapán in El Imposible National Park, and Sonsonate, Izalco municipality (Leenders and Watkins-Colwell 2004). Later, *S. assatus* was reported for six new departments, Chalatenango, Cuscatlán, La Libertad, San Miguel, San Salvador, and Santa Ana (Köhler et al. 2006), from the Protected Natural Area of Colima (Herrera et al. 2006), and from Walter Thilo Deininger Park Natural Area in La Libertad Department (Morán-Hidalgo 2013). The objective of our study is updating the information on the geographic distribution of *Scincella assata* from El Salvador, including new locality records and identify potential distribution areas via computer modelling.

Methods

During 4–13 November 2019, we conducted fieldwork in a tropical deciduous forest in the departments of La Libertad, Sonsonate, Cabañas, Cuscatlán, and oak-pine forest in the department of Chalatenango. We took close-up photographs of the head and body of all specimens for scale counting with EF-S 35mm f /2.8 IS STM Canon macro lens. Additionally, we took morphometric measurements in the field: snout-to-vent length (SVL), length from tip of snout to vent; tail length (TaL), length from vent to tip of tail; head width (HW), measurements at the level of the postorbital region; head length (HL), length from tip of snout to posterior margin of tympanum; tympanum diameter (TD), maximum diameter of the ear; anterior limb length (AL), measured from the armpit to the tip of the third finger; posterior limb length (PL), measured from the groin to the tip of the fourth finger; fourth finger length (FL) fourth finger length of the posterior limb; trunk length (TL), measurement from the armpit to the groin; and snout-insert anterior limb length (SI), with calipers to the nearest 0.01 mm. The digital photographs of specimens were submitted to the Colección Digital de Vertebrados de la Facultad de Estudios Superiores Zaragoza, UNAM (MZFZ-IMG). Additionally, we reviewed the biological collection of the Museo de Historia Natural de El Salvador (MUHNES), we collected distribution data for *S. assata* from literature records (Appendix Table A1). Finally, we obtained the photographic records assigned to *S. assata* from the iNaturalist platform (https://www.inaturalist.org). However, because it is not possible to know with certainty the species based on photographs, we included such unverified records only in our maps, not in the distribution modeling.

We performed a distribution model to estimate the potential geographic distribution of *S. assata* in El Salvador. We used all available records of *S. assata* as presence points and eliminated duplicate records and points within distances less than 1 km. The bioclimatic variables were obtained to an oblique Mercator projection at 1 km^2 resolution in Worldclim (Fick and Hijmans 2017). We performed a Pearson correlation analysis to determine which variables were strongly correlated, and subsequently discarded those that did not provide bioclimatic information (>0.75 Pearson's coefficient). Finally, we used the maximum entropy algorithm MaxEnt (Phillips et al. 2006). The parameters used were: Cloglog output format, 75% of the data to calibrate and 25% for validation with 500 iterations, replicated run type Bootstrap, threshold rule minimum training presence. We evaluated the model with the ROC (receiver operating characteristics) partial curve (Peterson et al. 2008) in NicheToolbox (Osorio-Olvera et al. 2020), and we performed the analysis with 500 iterations, 0.05 omission ratio, and 50% random points.

Results

We produced 12 new locality records of *S. assata* during fieldwork. Two previously unreported specimens were found in MUHNES (Fig. 1).

New records. EL SALVADOR – **La Libertad department** • La Libertad municipality, Walter Thilo Deininger Park Natural Area; 13.4875°N, 089.2701°W; 20 m a.s.l.; 5 Nov. 2019; Néstor Herrera, Uri García and Antonio Valdenegro leg.; MZFZ-IMG 232 • same data as for preceding; MZFZ-IMG 235 • Huizucar municipality; 13.5898°N, 089.2331°W; 605 m a.s.l.; 4 Mar 2020; Hugo Solorzano leg.; MZFZ-IMG 277 • Comasagua municipality**,** Colegio Lamatepec; 13.6522°N, 089.2872°W; 1007 m a.s.l.; 9 Nov. 2015; Jose Antonio Puig leg.; MZFZ-IMG 272 – **Sonsonate department** • Izalco municipality, Quinta Quetzal; 13.7491°N, 089.6680°W; 460 m a.s.l.; 6 Nov. 2019; Néstor Herrera, Uri García and Antonio Valdenegro leg.; MZFZ-IMG 238 • same data as for preceding; MZFZ-IMG 240 – **Cabañas department** • Cinquera municipality, Parque ecológico Bosque de Cinquera; 13.8844°N, 088.9640°W; 350 m a.s.l.; 7 Nov. 2019; Néstor Herrera, Uri García and Antonio Valdenegro

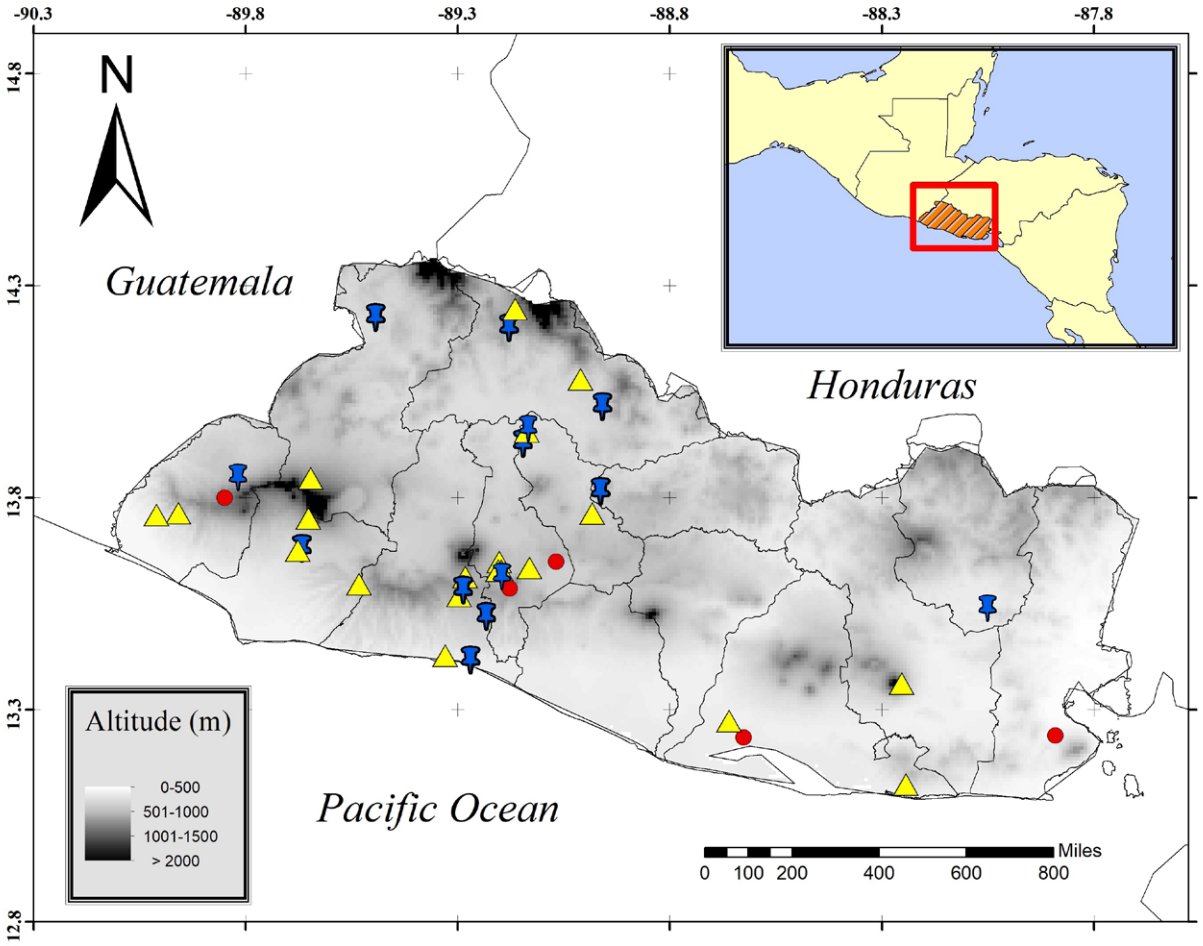

Figure 1. Geographical distribution of *Scincella assata* in El Salvador. Yellow triangles represent literature records; blue symbols represent new records; red circles represent iNaturalist records.

leg.; UOGV 3829 – **Cuscatlán department** • Suchitoto municipality, Hacienda Los Nacimientos; 13.9979°N, 089.1466°W; 260 m a.s.l.; 8 Nov. 2019; Néstor Herrera, Uri García and Antonio Valdenegro leg.; MZFZ-IMG 243 • same data as for preceding; MZFZ-IMG 245 – **Chalatenango department** • La Palma municipality, San José Sacare; 14.2708°N, 089.1799°W; 1215 m a.s.l.; 10 Nov. 2019; Néstor Herrera, Uri García and Antonio Valdenegro leg.; MZFZ-IMG 249 • same data as for preceding; MZFZ-IMG 251 • Concepción Quezaltepeque; 14.0843°N, 088.9597°W 417 m a.s.l.; 1 Feb. 2020; Rubencho Guerra leg.; MZFZ-IMG 275 – **Ahuachapán department** • Ahuachapán municipality, Colonia Santa Cecilia, Barrio Los Ausoles; 13.9172°N, 089.8184°W; 770 m a.s.l.; Gabriel Ceren leg.; MUHNES uncataloged – **Morazán department** • El Divisadero municipality, Quebrada El Gigante, Loma tendida; 13.6092°N, 088.0520°W; 270 m a.s.l.; Steve Perrigs leg.; MUHNES 30-313 – **Santa Ana department** • Metapán municipality, Parque Nacional San Diego La Barra; 14.2942°N, 089.4942°W; 500 m a.s.l.; 1 Jan. 2007; Vladen Henríquez leg.; MZFZ-IMG 271 – **San Salvador department** • San Salvador municipality,Parque Zoológico Nacional; 13.6844°N, 089.1964°W; 659 m a.s.l.; 15 Dec. 1977; MUHNES 30-349.

Identification. The dorsal color in all specimens is brown; the ventral color is cream; having reddish coloration on the tail; all specimens have a continuous lateral dark stripe, from the nostrils to end of the tail and a dorsolateral pale line (Fig. 2). All the examined specimens are consistent in having a single frontoparietal scale, undifferentiated nuchal scales, seven supralabial scales, six infralabials scales, four supraocular scales, elongated frontal scale. The examined specimens have 28–2 ($\bar{x}$ = 30) rows of scales around midbody; 66–73 ($\bar{x}$ = 70) dorsal scales. According to Stuart (1940), *S. assata* have 30–33 ($\bar{x}$ = 30.5) rows of scales around midbody; 69–79 ($\bar{x}$ = 73) dorsal scales, with undifferentiated nuchal scales, and with a striped tail pattern.

Species distribution modeling (SDM). According to the correlation analysis of climatic variables and the natural history of the species, we extracted four temperature variables and five precipitation variables: Mean Diurnal Range (Mean of monthly (max temp - min temp)) (BIO 2), Isothermality (BIO2/BIO7) (×100) (BIO3), Max. Temperature of Warmest Month (BIO 5), Mean Temperature of Wettest Quarter (BIO 8), Annual Precipitation (BIO 12), Precipitation Seasonality (Coefficient of Variation) (BIO 15) Precipitation of Driest Quarter (BIO 17), Precipitation of Warmest Quarter (BIO 18), Precipitation

Figure 2. Specimens of *Scincella assata*. **A.** MZFZ-IMG 237; Walter Thilo Deininger Park Natural Area, La libertad, El Salvador. **B.** MZFZ-IMG 240; Quinta Quetzal, Izalco, Sonsonate. **C**. MZFZ-IMG 244; Hacienda Los Nacimientos, Suchitoto, Cuscatlán. **D.** MZFZ-IMG 251; San José Sacare, La Palma, Chalatenango.

of Coldest Quarter (BIO 19). The model value of area under curve was AUC = 0.82, and the value of the partial ROC was high (1.64); we therefore considered this a good performance of the model. The environmental variables with a high percentage of contribution were Max. Temperature of Warmest Month (33.4%) and Annual Precipitation (21%). Results from the distribution modeling suggest the presence of this species in all 14 departments of El Salvador, four of which currently lack verified records (Fig. 3).

Discussion

Scincella assata inhabits different environments between sea level and 1300 m, including dry forest, premontane evergreen forest, subtropical humid forest, savanna, and pine-oak forest (Köhler et al. 2006). San Jose Sacare, La Palma department is the locality with the highest elevation of *S. assata* in El Salvador, above 1215 m. Although it is present in different habitats, the species has common requirements, such as a considerable litter cover, and it can be found in different types of plantations with trees that provide shade that protects them from the intense heat (Fig. 4).

Scincella assata has a strong affinity to a combination of high temperatures with low precipitation that corresponds to a deciduous forest; however, the variables that were used to model the distribution include lower temperatures, which correspond to the habitat of oak forest, where this species was also found. According to the species distribution model, it might be possible to find *S. assata* in all departments of El Salvador. Specifically, in southern and northern Santa Ana, Ahuachapán, central to northern Sonsonate, La Libertad, central San Salvador, Cuscatlán, northern and western Chalatenango, Western Cabañas, Western San Vicente, La Paz, central and southern Usulután, central and southern San Miguel, northern and southern Morazán, and northern and southern La Unión. However, the species has not yet been recorded in the departments of San Vicente, La Paz, and La Unión (Fig. 3). It is important to mention that there is a record obtained in the iNaturalist platform of *S. assata* from the south of the Union department, and according to our SDM, this area has a high probability of presence of the species. Although the characteristics of the photograph indicate that it is *S. assata*, this record has not been verified.

In El Salvador, favorable conditions for *S. assata* were predicted by SDM for most of the country except for the areas above 1300 m a.s.l. Regardless, a greater sampling effort is needed to verify these assumptions based on SDM, especially since there are potential areas where the species has not been reported.

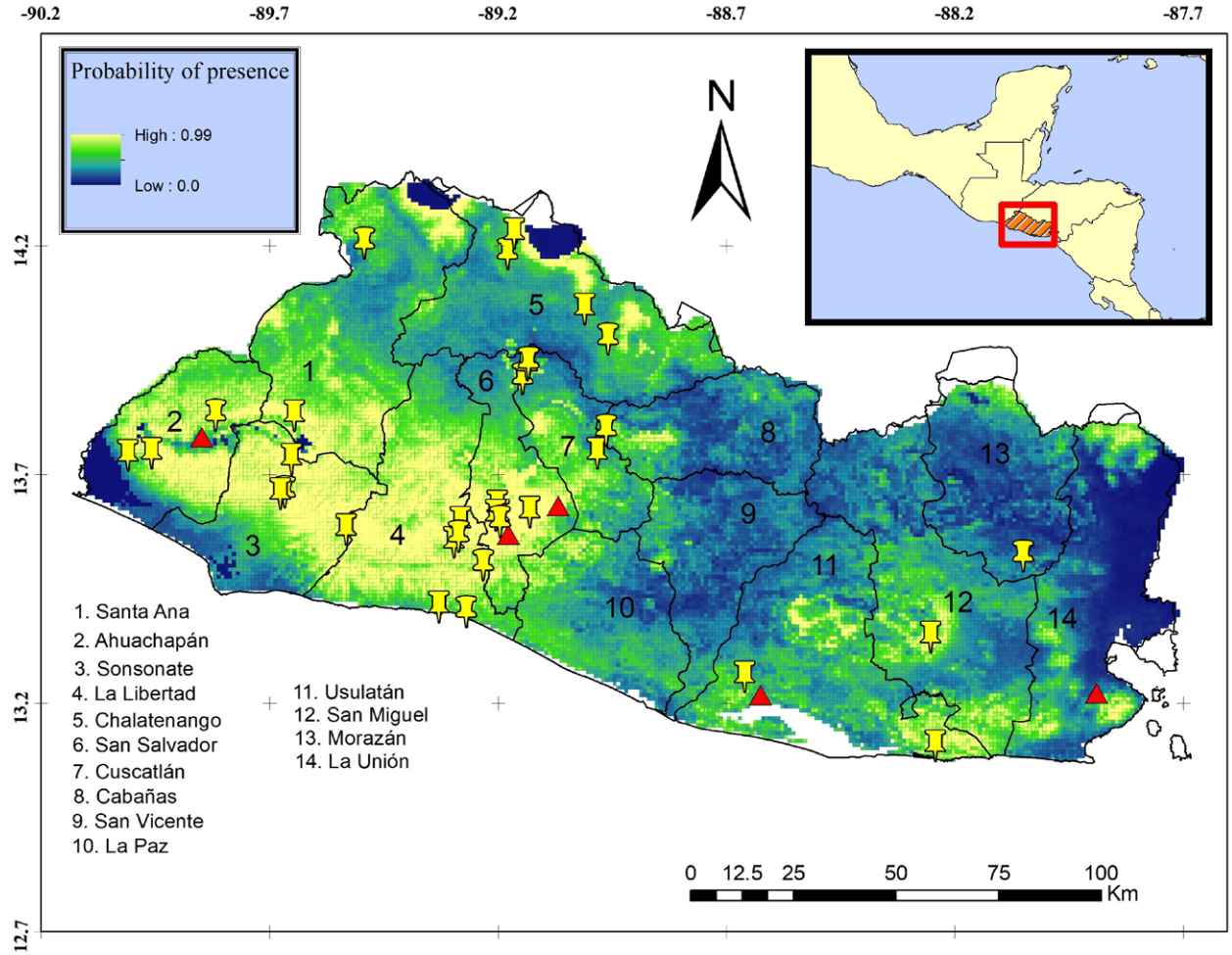

Figure 3. Map showing the potential distribution based on SDM for *Scincella assata*. Yellow symbols represent presence records, red triangles represent iNaturalist records.

Figure 4. Habitats of *Scincella assata*. **A**. Marañon plantation in Hacienda Los Nacimientos, Cuscatlán Department, 267 m. **B.** Coffee plantation within pine-oak forest, in San José Sacare, Chalatenango Department, 1215 m.

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Authors' Contributions

All the authors conducted fieldwork, collected specimens, participated in writing; AEBV and NHS compiled the database. AEVB made the literature review, designed the map, and modeling species distribution.

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Appendix

Table A1. Literature records of *Scincella assata* used in this study included in the distribution maps.

Department	Municipality	Locality	Number collection	Citation
Ahuachapán	San Francisco Menéndez	Parque Nacional El Imposible	YPM 12992	Leenders 2003
Ahuachapán	El Refugio	Vicinity of Mariposario of Francisco Serrano	SMF 79243	Köhler et al. 2006
Chalatenango	Dulce Nombre de Maria	Hacienda El Morito	SMF 44388	Köhler et al. 2006
Chalatenango	La Palma	San José Sacaré	FMNH 10966	Köhler et al. 2006
Cuscatlán	Tenancingo	0.5 km E Tenancingo	KU 184383	Köhler et al. 2006
La Libertad	Santa Tecla	Finca El Paraíso	SMF 42207, 42585–89, 42602, 42675, 42676, MVZ 40396	Köhler et al. 2006
La Libertad	Santa Tecla	Finca Los Cedros	SMF 42895–96	Köhler et al. 2006
San Miguel	San Miguel	Volcán de San Miguel	KU 291286	Köhler et al. 2006
San Salvador	San Salvador	Near Instituto Tropical de Investigaciones Científicas	SMF 44287, UMMZ 117607	Köhler et al. 2006
San Salvador	San Salvador	San Salvador	SMF 46901, ZMB 35686, 35687, 35692, FMNH 64989	Köhler et al. 2006
San Salvador	San Salvador	Ciudad Universitaria	KU 184384	Köhler et al. 2006
San Salvador	San Salvador	Ciudad de Soyapango	KU 184385	Köhler et al. 2006
Santa Ana	Santa Ana	Finca El Milagro	KU 289795	Köhler et al. 2006
Sonsonate	Izalco	Finca Nuevos Horizontes	YPM 12314, 12439	Leenders and Watkins-Colwell 2004
Sonsonate	Izalco	Izalco	USNM 192604, 523448	Köhler et al. 2006
Sonsonate	Izalco	Hacienda Chilata	MVZ 40362–40386	Köhler et al. 2006