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New distributional records of the Samana least gecko (*Sphaerodactylus samanensis*, Cochran~~,~~ 1932) with comments on its morphological variation and conservation status

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We report here five new localities ~~in~~ the distribution of the lizard *Sphaerodactylus samanensis* ~~and extend~~ its current geographic range to the west, in the Cordillera Central of Hispaniola. We also noticed phenotypic variation in the color pattern and scutellation on throat and pelvic ~~region~~ of males from both eastern and western populations, which is described below. Furthermore, based on these new data, we confirm that the species is not fitting in its current IUCN category, and in consequence propose updating its conservation status.

New distributional records of the Samana Least ~~Geckolet~~ (*Sphaerodactylus samanensis*, Cochran, 1932) with comments on its morphological variation and conservation status

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Abstract

We report here five new localities in the distribution of the lizard *Sphaerodactylus samanensis* and extend its current geographic range to the west, in the Cordillera Central of Hispaniola. We also noticed phenotypic variation in the color pattern and scutellation on throat and pelvic region of males from both eastern and western populations, which is described below. Furthermore, based on these new data, we confirm that the species is not fitting in its current IUCN category, and in consequence propose updating its conservation status.

Introduction

Lizards of the genus *Sphaerodactylus* (105 recognized species, Uetz *et al.* 2019), have diversified remarkably on Caribbean islands, and occur in Central and Northern South America (Hass 1991; Henderson and Powell 2009; Hedges *et al.* 2019; Hedges 2020). This is a clade of small geckos (geckolet) containing also one of the smallest amniote vertebrates in the world with a maximum snout-vent length of 18 mm (Hedges and Thomas 2001). Likewise, the largest species of this genus reaches up to a maximum of 37 mm (Barbour 1914; Schwartz and Garrido 1985; Fong and Diaz 2004).

Geckolets are one of the most dominant herpetofauna in the Antilles (Scantlebury *et al*. 2011), reaching densities greater than 60,000 ind/ha (Rodda *et al*. 2001). Nonetheless, numerous species are known only for one or a small number of localities (Hedges 1996; Powell and Inchaustegui 2009; Schwartz 1970; Schwartz and Henderson 1991). Among them, *Sphaerodactylus samanensis* is a species previously reported at a few places near to the type locality, along the southern side of the Samana Bay, Dominican Republic with an elevation range from 0 to 181 m.a.s.l (Schwartz and Henderson 1991; Thomas and Hedges 1993; Landestoy *et al*. 2016). Because its restricted distribution range and small extent of occurrence (100 km^2), *S. samanensis* is currently classified as a Critically Endangered species by both the IUCN Red List (2020), and the Dominican Republic's Red List of threatened species (MIMARENA, 2019). According to the records, this species inhabits the northeastern edge of the island (Figure 1) alongside Cordillera Oriental, a low mountain chain with Miocene Karst terrain (Bowin 1966, 1975).

The recent discovery of an individual of *Sphaerodactylus samanensis* in the surroundings of Pueblo Viejo Mine (PVM) by one of the authors (JU) encouraged us to perform new field surveys which resulted in the collection of this species at five new localities in central and eastern Dominican Republic. Our findings indicate that this species has a wider distribution than previously known, a finding relevant to its conservation status.

Methods

Study Area. We conducted fieldwork at six sites (Figure 1): 1) Caño Hondo (Los Haitises National Park), at the surroundings of the type locality and inside of its distribution range (Landestoy *et al*. 2016), 2) Cueva Casa Grande (western edge of the aforementioned park), and 3) Batey Piedra, all of them on the eastern edge of the Dominican Republic; and 4) Chacuey Abajo, 5) Cueva de Sanabe (inside Aniana Vargas National Park), and 6) Pueblo Viejo Mine (PVM), these last three on the Cordillera Central to the west. Eastern sites are placed on the northern slopes of the Cordillera Oriental, in the Ombrophile Rainforest (Hager and Zanoni 1993), which is adjacent to the Samana Bay and goes along Yuna River basin. Trees at these sites reach up to 30 m in height, bushes, some ferns and epiphytes are present, the ground is covered in leaf litter and organic material, as well as scattered karst-rock clusters. Sites on the Cordillera Central were located on the easternmost border of the mountain ridge where streams flow down to the Yuna River and eventually reach the Atlantic Ocean. The landscape mainly features farms and small patches of tropical rainforest. The ground is covered partially in leaf litter and organic material, as well as karst-rock clustered areas. The highest altitude reached in our study is 257 m.a.s.l. in the Central Cordillera, with the lowest spot at sea level along the Samana Bay.

Fieldwork. We carried out three field trips under permission number 004080 issued by the Dominican Republic's Ministry of Environment and Natural Resources (Ministerio de Medio Ambiente y Recursos Naturales - MIMARENA). Specimens were collected between August 2018 and May 2019 during diurnal surveys. We took coordinates with a personal navigator (Garmin Map 64s) and described habitat characteristics at each collection site. Every collected specimen was photographed, measured, fixed with 95% ethanol and then stored in 70% ethanol. All the specimens were deposited in the Herpetology Collection of the Museo Nacional de Historia Natural Profesor Eugenio de Jesús Marcano (MNHNSD) in Santo Domingo, Dominican Republic.

Morphological revision. We used a digital calliper to measure snout-vent length (SVL) of individuals to the nearest tenth of a millimeter. Our scale counts follow Thomas and Schwartz

(1966) and Thomas *et al*. (1992) and consists in: 1) escutcheon length, we considered the maximum number of scales (anterior to posterior); 2) escutcheon width, we considered the maximum number of scales transversally across the patch (including extensions onto thighs); and 3) escutcheon total scales, we considered all scales on the pelvic scutcheon. In order to support our observations, we added two more scale counts: 1) number of gular scales in contact with the first infralabial, here we considered all adjacent scales (including postmentals) to the first infralabial scale; and 2) number of scales per dorsal band, we considered the maximum number of pigmented scale rows covered by a dorsal band in a longitudinal count. Specimens were sexed by examining the sexually dimorphic color pattern and the gonads to confirm the presence of hemipenes. We used photographs taken in the field by ML to describe the coloration in life of the specimens. Also, we followed Kohler (2012) to name the colors in our description. In addition, we follow taxonomy prior to prior Köhler *et al*. 2019 regarding Anolis as a valid genus for Dactyloid lizards from La Hispaniola.

Data Analysis. We estimated the occurrence of this species based on our field measurements of the extension of Karst (where we observed *Sphaerodactylus samanensis*), additionally supported by the estimation of the area of Karst in contact with them, through the data previously reported by Servicio Geologico Nacional (2010). Geographic data and map designing were drawn in ArcGIS version 10.3. Additionally, we follow IUCN (2001) defining: 1) Extent of occurrence (EOO) and 2) Area of occupancy (AOO).

Results

We observed this species out of the surroundings of the type locality for the first time (specimens collected per locality are detailed in Table S1). Subsequently, we are confirming its occurrence in the Cordillera Central and adding five localities to its currently known occurrence (Figure 1). This extends its geographic range by 82.2 km to the northwest. All individuals were observed by day, under rocks in habitat mixed between karst-rock clusters and tropical forest, with bushes and trees approaching 30 m tall, ground covered in leaf-litter and rocks covered with moss, lichens, ferns and other epiphytes. Additionally, we recorded two other geckolets: *Sphaerodactylus darlingtoni* and S*. difficilis* in sympatry with *S. samanensis*. Other sympatric lizards recorded during surveys were *Celestus sepsoides, C. stenurus, Anolis cybotes,* and *A. distichus*

All individuals of *S. samanensis* agree with the original description (Cochran 1932) in bearing a moderately short snout, a large rostral scale with a median groove, a medium-sized superciliar spine, a large third supralabial exceeding the center of the eye, imbricate-keeled dorsal scales and an orange head in males. Nevertheless, we noted some phenotypic variation between *S. samanensis* individuals from the surroundings of the type locality (Caño Hondo) and nearby eastern places (Cueva Casa Grande and Batey Piedra), and the western populations (Chacuey Abajo, Cueva de Sanabe, and PVM) (See Figure 2). The eastern individuals have 2.5–5.5 (average=4.1, SD=0.8) gular scales in contact with first infralabial instead of 4.5–7 (average=5.1, SD=0.6) in western individuals ($p < 0.001$) (See Figure 3), and a lower total number of pelvic scutcheon scales ranging from 25–32 scales (average=28.4, SD=2.5) instead of 30–39 scales (average=35.7, SD=2.9) in western specimens ($p < 0.001$). Eastern populations also differ in coloration by bearing dorsal bands and scapular ocelli in females and most males, which are absent in males of western samples (Figure 2). Eastern females have 3–4 dorsal bands vs 4–5 in western females ($p < 0.001$), and wider dorsal bands covering 3–7 dorsal scales (average=5, SD=1.2) instead of the thin dorsal bands of western females covering only 3 dorsal scales (average=3, SD=0; $p < 0.001$). Further details on measurements, coloration and scutellation are provided in Table S2.

Discussion

Our results update the distribution of *Sphaerodactylus samanensis* which now range from the region of the type locality (Boca del Infierno) in the Samana Bay (Cochran 1932) and surrounding areas (Thomas and Hedges 1993, Landestoy *et al.* 2016) to the Central Cordillera (Figure 1), an east-west airline distance of 82.2 km. Therefore, the distribution of this gecko is now only exceeded by those of *S. copei, S. darlingtoni, S. difficilis,* and *S. elegans* (Schwartz and Henderson 1991; Hedges 2020), species previously recognized as widely spread on Hispaniola (Hass 1991; Schwartz and Henderson 1991). We also report the maximum altitude so far recorded for this species: 257 m. a. s. l. exceeding by 200 meters former records reported by Cochran (1932) and Landestoy *et al.* (2016). These novel geographic data exceed those formerly known for this species confirming that it is not a short-ranged species but rather a widely distributed lineage that could be distributed even further.

Since large geographic ranges are scarcely recorded in *Sphaerodactylus* lizards, phenotypic variation has been barely noted and subsequently poorly studied (Schwartz 1966; Dood Jr and Ortiz 1984). Here we provide for the first time evidence of differences between eastern (including type locality) populations (n=24) and western populations (n=28), mainly in color pattern and scutellation (Table S2). Measurements did not differ. In spite of scutellation mostly overlapping between eastern and western populations, gular scales are longer in eastern individuals, better noted in the proximal rows of the throat (including postmentals) which have contact with the first infralabial and are clearly smaller in western individuals (Table 2, Figure 3). Likewise, the escutcheon plate in western males tends to contain more scales than those from eastern individuals. Surprisingly, differences between scutcheon width and scutcheon length are not significant (*p* = 0.7 and *p* = 0.1 respectively). This is because the difference does not depend on the width or length of the rows, but rather the number of additional (intruders) escutcheon scales surrounding the proximal edge of the escutcheon (Table S2). Concerning coloration, eastern individuals have 3–4 wide dorsal bands (each covering 3–7 dorsal scales) which are present in all females and some males (especially in males from the type locality); contrasting with western individuals which have 4–5 thin dorsal bands (each covering three dorsal scales) only present in females.

The geological history of the island of Hispaniola is influenced mainly by water incursions and plate movements occurring since the late Mesozoic and into the Cenozoic (Mann *et al*. 1991; MacPhee and Iturralde-Vinent 1994; Hedges 1996; Iturralde-Vinent and McPhee 1999; Ricklefs and Bermingham 2008; Daza *et al*. 2019). This likely originated the vicariance phenomenon in the Proto Antilles as well as the overwater dispersion and later (approximately during Mid-Tertiary *sensu* Hedges 1996) divergence of lineages in vertebrate fauna on this island (Mann *et al*. 1991, Hedges 1992, Hedges 1996, Daza et al. 2019). These events could cause isolation (Hedges 1996, Daza et al. 1994) and the subsequent geographic restriction of emergent taxa to small areas, explaining why very few Sphaerodactylus species had been able to spread widely on Hispaniola. Those geologic events could have influenced dispersion and also the evolution of phenotypic features of *Sphaerodactylus samanensis*. Certainly, the distribution of this species seems to follow a geologic pattern overlapping two ancient karst formations (Figure 1): Los Haitises karst to the east and El Hatillo karst to the west, both structures raised in the Late Tertiary (Servicio Geológico Nacional 2010). This would agree with the phenotypic variation reported here, which follows an east-west geographic pattern. Future research should target molecular analysis and the revision of new specimens to determine patterns in the phenotypic variation in *S. samanensis.*

Because of its restricted range of distribution and threats to its habitat, both the Dominican Republic and IUCN Red-Lists currently list *Sphaerodactylus samanensis* as a Critically Endangered species (IUCN 2020). Nevertheless, our findings demonstrate that the occurrence of *Sphaerodactylus samanensis* is wider than previously reported, with an estimated EOO of 500 km^2. We observed that *S. samanensis* inhabits karst rocks, in contrast to sympatric congeners such as *S. darlingtoni* and *S. difficilis* which are more often recorded in leaf litter usually on soil, reducing therefore its AOO within this range. We also suggest that loss of karst formations, in particular loss of tree cover within karst areas, could threat some populations. Nonetheless, given its widened extent of occurrence, including its presence in protected areas (Los Haitises National Park to the east and Aniana Vargas National Park to the west), as well as the number of locations and mature individuals observed during fieldwork, we propose that the species be reclassified by the IUCN. Certainly, based on new information it would appear unlikely that the species would become extinct barring catastrophic climate events, however, continued destruction of karst habitat could become a future problem for the species, therefore we propose the category Near Threatened for *S. samanensis*.

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FIGURES

Figure 1. Map showing the distribution of *Sphaerodactylus samanensis*. Type locality is indicated by a red star. Localities with previous records are in yellow circles (taken from Thomas and Hedges 1991; and Landestoy *et al*. 2016) and new collecting sites are in white circles. All of them are named with numbers as follow: 1) 9 km west from Sabana del Mar, 2) Caño Hondo, 3) Cueva Casa Grande, 4) Batey Piedra, 5) Chacuey Abajo, 6) Pueblo Viejo Mine, 7) Cueva de Sanabe.

Figure 2. Color pattern variation in *Sphaerodactylus samanensis* between Eastern males A) MNHNSD 23.3718 (SVL = 26.3 mm), B) MNHNSD 23.3723 (SVL = 28.6 mm), and females C) MNHNSD 23.3717 (SVL = 27.8 mm); D) MNHNSD 23.3719 (SVL = 27.9 mm); and Western males E) MNHNSD 23.3733 (SVL = 27.5 mm), D) MNHNSD 23.3713 (SVL = 24.8 mm), and females E) MNHNSD 23.3736 (SVL = 27 mm), F) MNHNSD 23.3712 (SVL = 26.9 mm). Photographs by Miguel A. Landestoy.

Figure 3. Variation in the size of gular scales (pointed with black lines) of *Sphaerodactylus samanensis*. A) Eastern male (MNHNSD 23.3716) from Caño Hondo, B) western male (MNHNSD 23.3734) from Chacuey Abajo. Photographs by Miguel A. Landestoy.

Table 1(on next page)

Voucher codes of *Sphaerodactylus samanensis*'s specimens collected at 6 localities at the Dominican Republic in this study.

Table 1. Voucher codes of *Sphaerodactylus samanensis*'s specimens collected at 6 localities at the Dominican Republic in this study.

Locality	Province	Coordinates (lat, lon)	Alt. (m)	Specimens voucher	
				Males	Females
Caño Hondo (Los Haitises National Park)	Hato Mayor	19.05894, -69.4633	44	MNHNSD 23.3715−16, 23.3718	MHNHSD 23.3717, 23.3719−20, 23.3722, 23.3893
Cueva Casa Grande	Monte Plata	19.04214, -69.72787	225	MNHNSD 23.3723	MNHNSD 23.3724−26, 23.3894
Batey Piedra	Sanchez Ramirez	19.06997, -69.90815	35	MNHNSD 23.3895−96, 23.3899	MNHNSD 23.3729−31, 23.3897−98, 23.3900−02
Chacuey Bajo	Sanchez Ramirez	19.10689, -70.04149	115	MNHNSD 23.3733−35, 23.3905	MNHNSD 23.3736, 23.3903−04, 23.3906−08
Pueblo Viejo Mine	Sanchez Ramirez	18.92348, -70.15423	195	MNHNSD 23.3699, 23.3706−07, 23.3909	MNHNSD 23.3697−98, 23.3701−05, 23.3910−14
Cueva de Sanabe (Aniana Vargas National Park)	Sanchez Ramirez	19.00004, -70.23809	257	MNHNSD 23.3713	MNHNSD 23.3712

Table 2(on next page)

Color pattern, measurements (in mm) and scutellation of both eastern and western populations of *Sphaerodactylus samanensis*.

Table 2. Color pattern, measurements (in mm) and scutellation of both eastern and western populations of *Sphaerodactylus samanensis*.

	Eastern Population		Western Population	
	Males (n=7)	Females (n=17)	Males (n=9)	Females (n=19)
Coloration of the Ocular Halo	Pearl/ Bluish pearl	Copper yellow	Pearl blue/Pearl	Pearl yellow/copper yellow
Scapular ocelli	Present/Absent	Present	Absent	Present
Coloration of dorsal bands	Dark Brown/ Yellowish brown	Dark brown	−	Dark brown
SVL (mm)	25.1−28.6 (26.8±1.18)	14.6−28.1 (22.3±5.0)	24.8−28.1 (26.7±0.9)	21.0−29.7 (26.1±2.1)
Number of head stripes	0−0 (0±0.0)	2−4 (3.8±0.4)	0−0 (0±0)	2−4 (3.8±0.4)
Number of neck bands	0−1 (0.5±0.5)	1−1 (1.0±0)	0−0 (0±0)	1−2 (1.2±0.4)
Escutcheon scales (length)	3−4 (3.2±0.4)	0−0 (0±0)	3−5 (3.7±0.6)	0−0 (0±0)
Escutcheon scales (wide)	10−13 (11.5±0.9)	0−0 (0±0)	10−17 (12.2±2.0)	0−0 (0±0)
Escutcheon scales (total)	25−32 (28.4±2.5)	0−0 (0±0)	30−39 (35.7±2.9)	0−0 (0±0)
Number of dorsal bands	0−4 (2.8±1.9)	3−4 (3.1±0.3)	0−0 (0±0)	3−6 (4.3±0.6)
Number of scales per dorsal band	0−6 (3.8±1.8)	3−7 (5.0±1.2)	0−0 (0±0)	3−3 (3.0±0)
Number of scales in contact with 2nd infralabial	2.5−5.5 (4.1±0.8)		4.5−7 (5.1±0.6)	

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Figure 1

Map showing the distribution of *Sphaerodactylus samanensis*. Type locality is indicated by a red star. Localities with previous records are in yellow circles (taken from Thomas and Hedges 1991; and Landestoy *et al*. 2016) and new collecting site

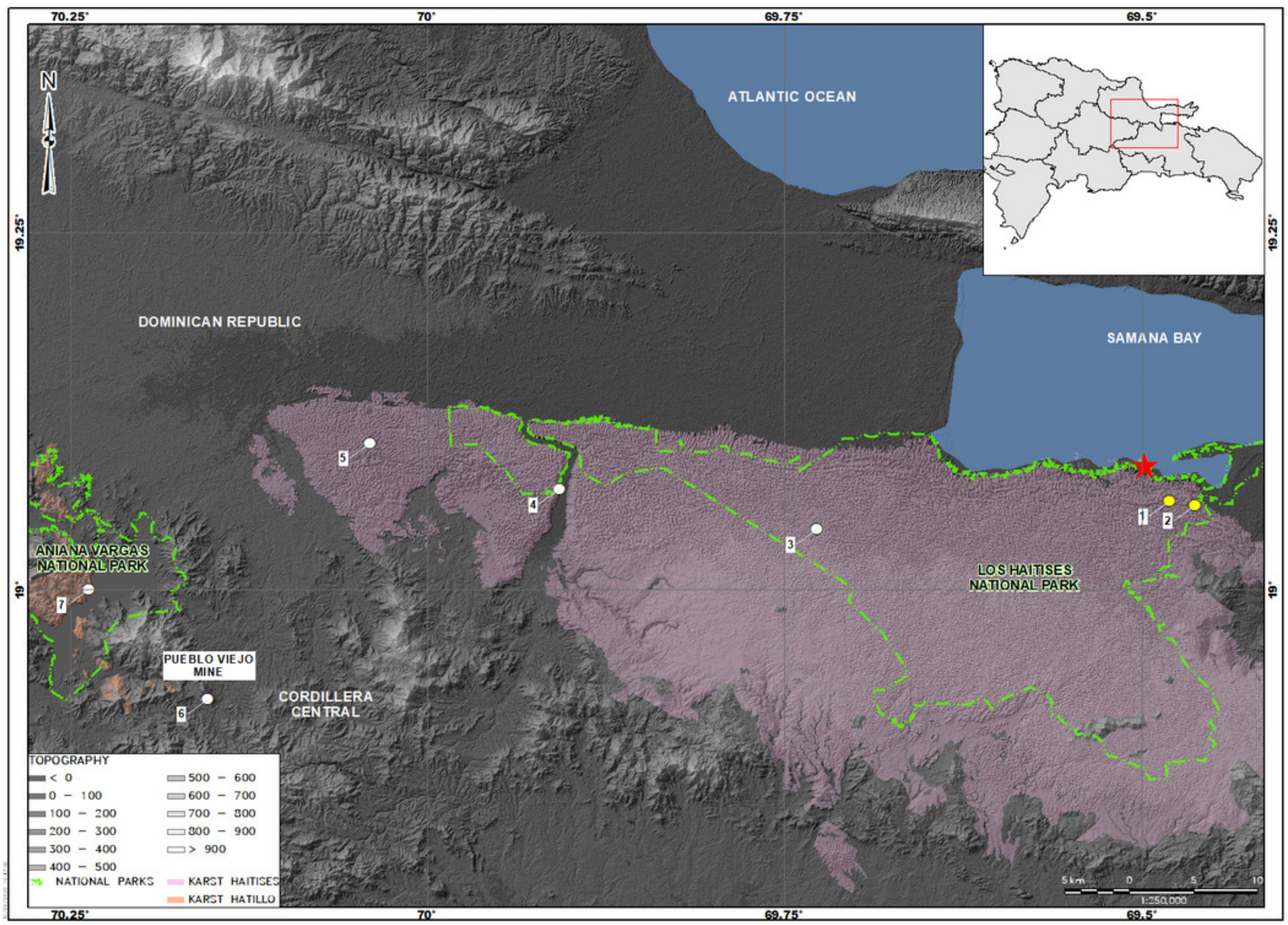


Figure 2

Color pattern variation in *Sphaerodactylus samanensis* between Eastern males A) MNHNSD 23.3718 (SVL = 26.3 mm), B) MNHNSD 23.3723 (SVL = 28.6 mm), and females C) MNHNSD 23.3717 (SVL = 27.8 mm); D) MNHNSD 23.3719 (SVL = 27.9 mm); and Western males E)

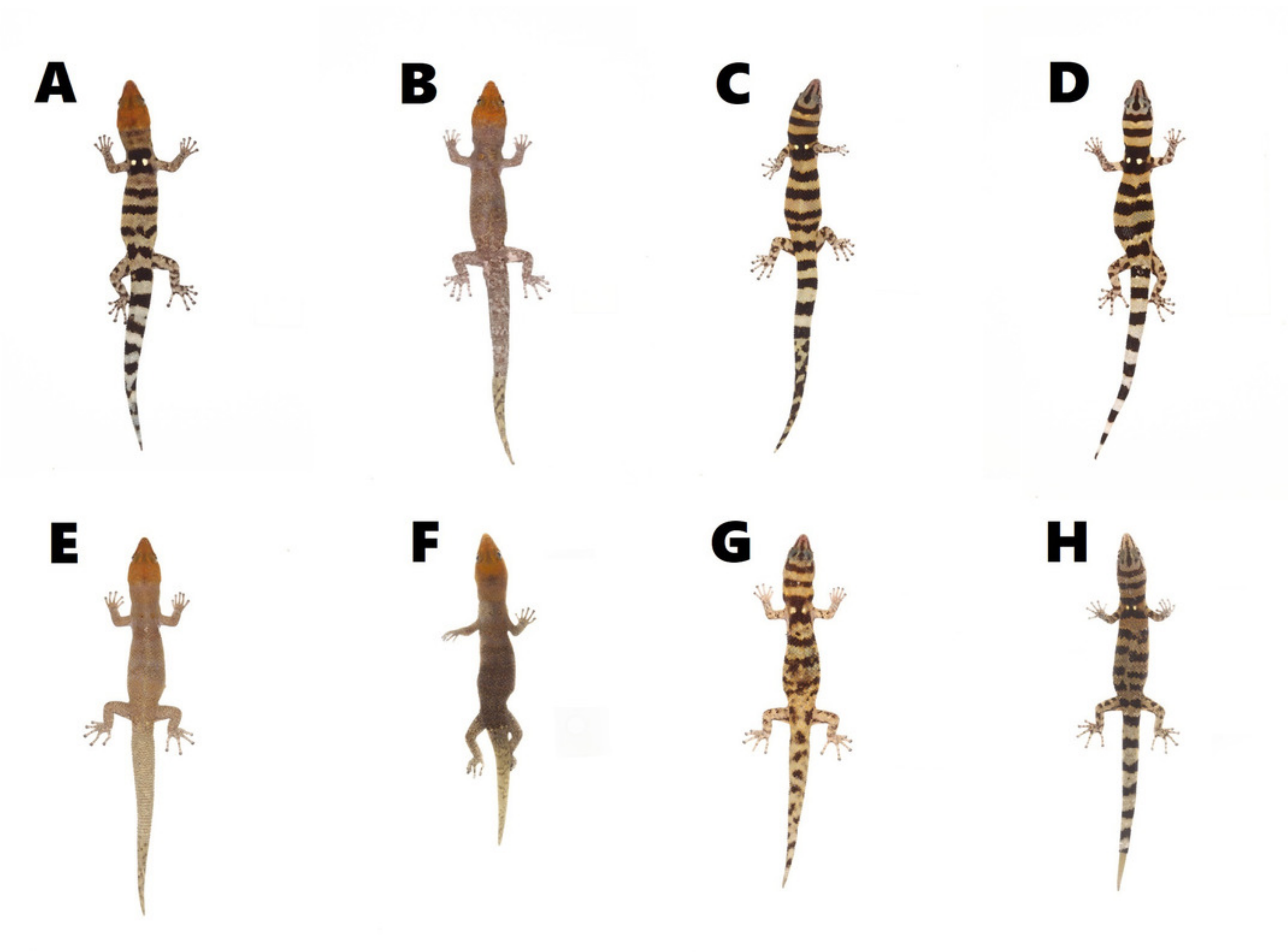
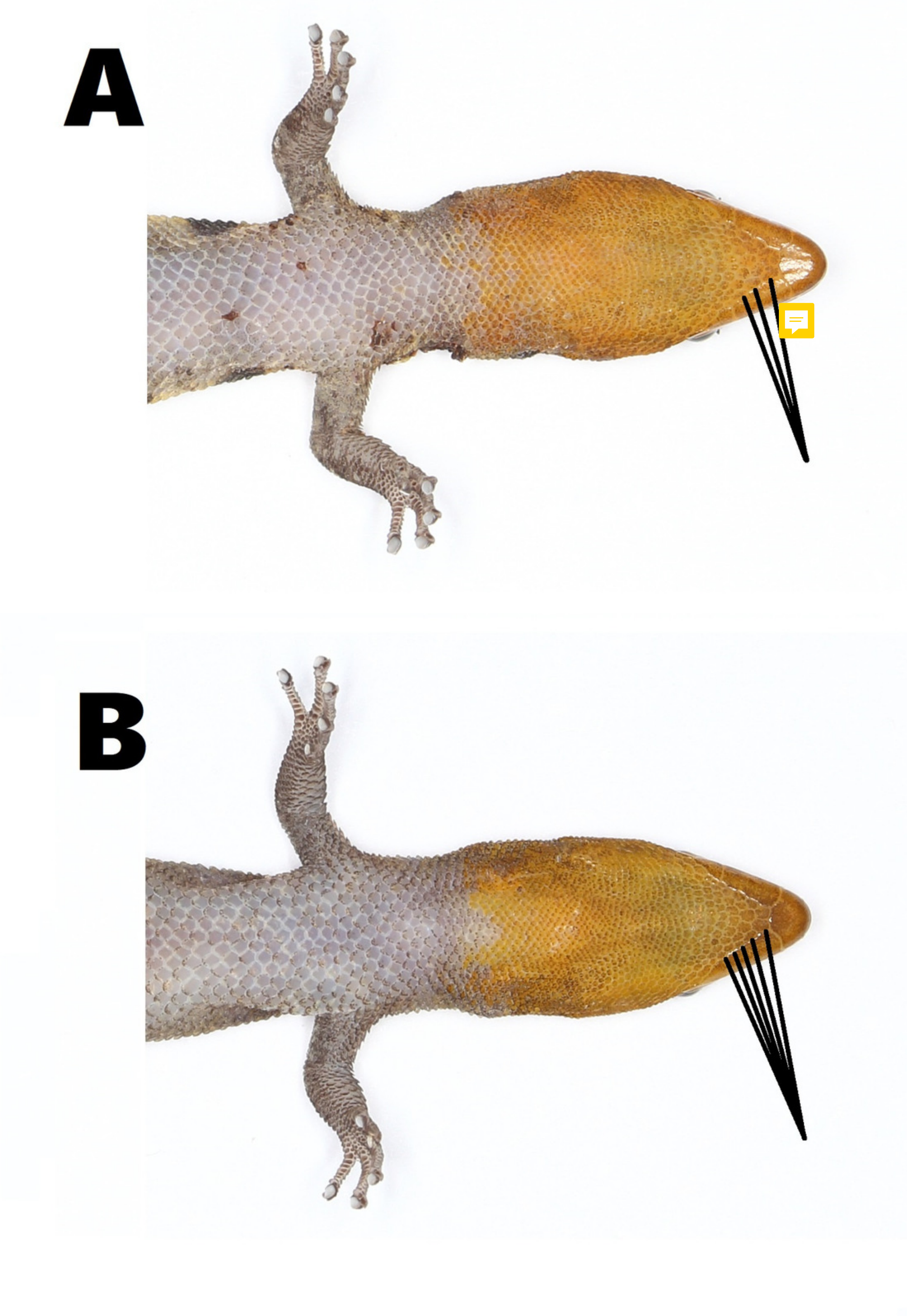


Figure 3

Variation in the size of gular scales (pointed with black lines) of *Sphaerodactylus samanensis*. A) Eastern male (MNHNSD 23.3716) from Caño Hondo, B) western male (MNHNSD 23.3734) from Chacuey Abajo. Photographs by Miguel A. Landestoy.


A
B