

At the Lower Size Limit in Amniote Vertebrates: A New Diminutive Lizard from the West Indies

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ABSTRACT.—A new species of gekkonid lizard is described from Isla Beata and adjacent areas of Hispaniola, West Indies. *Sphaerodactylus ariasae*, sp. nov. is most closely related to *S. streptophorus*, from which it differs in size, color pattern, scalation, and snout shape. Its most distinctive feature is the very small adult body size, averaging only 16 (14-18) mm snout-to-vent-length. The new species and *S. parthenopion* (British Virgin Islands) are the smallest of the approximately 23,000 species of amniote vertebrates.

INTRODUCTION

The West Indies archipelago is a “hot spot” of biodiversity due to the large number of endemic species, rapidly disappearing habitats, and burgeoning human population (Hedges and Woods, 1993; Myers et al., 2000). Many new vertebrates have been discovered on the islands in recent years, including the smallest species of tetrapod (Estrada and Hedges, 1996). We describe herein a new lizard from Hispaniola that shares the distinction of being the smallest amniote vertebrate in the world (amniotes include reptiles, birds, and mammals). This new species of gecko of the genus *Sphaerodactylus* was found while conducting herpetological surveys on the southern tip of the Barahona Peninsula and adjacent Beata Island.

Length was measured with a digital readout micrometer caliper (Fowler-Sylvac) and recorded to the nearest 0.1 mm. We follow other authors in treating adult body size as maximum SVL in mm (Schwartz and Henderson, 1991) because growth often continues with age in adult reptiles. Distinguishing adults from juveniles is difficult in small species and samples; in addition, SVL may vary with preservation and age of specimen (Lazell, 1972). Body mass, which must be measured before preservation, is known for relatively few species. We determined adult males by

presence of an escutcheon, and adult females by presence of basic pattern (Thomas and Schwartz, 1983a) and enlarged ova, oviducts, or both. Specimens were collected by hand and preserved in >80 % ethanol to preserve morphology and genetic material. Common names of West Indian amphibians and reptiles are from Hedges (2001). Abbreviations are CMNH (Carnegie Museum of Natural History, Pittsburgh), MCZ (Museum of Comparative Zoology, Cambridge, Massachusetts), SVL (snout-vent length), and USNM (United States National Museum of Natural History, Washington, D.C.).

Sphaerodactylus ariasae, sp. nov.
Jaragua Sphaero Fig. 1

Holotype.—USNM 541804, female, from a sink hole and cave 2 km SE Punta Beata, Isla Beata, Pedernales Province, Dominican Republic, 17° 36.5' N, 71° 31.1' W, 5 m elevation, collected on 2 January 1998 by Richard Thomas and S. Blair Hedges. Original field number USNMFS 194747.

Paratypes.—All from the Dominican Republic, Pedernales Province: USNM 541805 (male), 541806 (male), type-locality; USNM 541807 (female), 541808 (male), 541809 (female), Punta Lanza, Isla Beata, 17° 35.8' N, 71° 32.6' W, 0 meters; MCZ R-182930 (female), USNM 541810 (female), 0.5 km NW Cabo Beata at Playa de Piticabo, 17° 36.7' N, 71° 25.7' W, 10 meters.

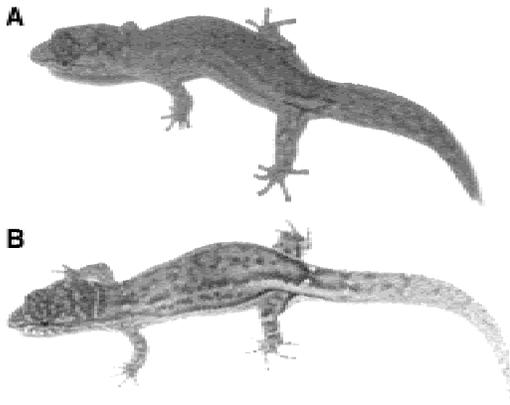


FIG. 1. A. *Sphaerodactylus ariasae*, adult female (USNM 541804), holotype. B. *S. streptophorus*, adult female (USNM 541813, Dominican Republic, Pedernales Prov., Hoyo de Pelempito).

Diagnosis.—This very small *Sphaerodactylus* is closest to *S. streptophorus* Thomas and Schwartz (Hispaniolan Small-eared Sphaero; *difficilis* complex; Thomas and Schwartz, 1983b) in general scale morphology (flattened, keeled, imbricate dorsal body scales) and basic elements of the color pattern (narrow pale neck band and sacral ocelli). It differs in size (maximum SVL 18 mm versus 26 mm in *S. streptophorus*), in having a proportionately shorter head and narrower, flatter snout (Fig. 2A-C), in having the snout scales both extensively keeled (keeling extending farther toward the tip and onto the lores) and more imbricate, more-swollen dorsal body scales, and lower and more sharply keeled dorsal head granules (vs. subconical, not strongly keeled granules). Snout length/snout height versus head length completely separates *S. ariasae* (0.287-0.343) and *S. streptophorus* (0.180-0.270), including juveniles of the latter (Fig. 2D). The new species is more heavily pigmented (dark brown vs. gray-tan ground color) than *S. streptophorus*, has complete dorsolateral lines, and males have plain heads instead of having scattered vermiculations.

Sphaerodactylus ariasae could be confused with two other small and dark sphaerodactyls occurring in southern Hispaniola, although neither is closely related. *Sphaerodactylus plummeri* Thomas and Hedges

(1992), the Barahona Big-scaled Sphaero, is distinguished by its large scales, resulting in low scale counts (midbody scales number 34-36 in *S. plummeri* versus 44-51 in *S. ariasae*, and dorsals number 17-21 in *S. plummeri* versus 24-29 in *S. ariasae*). *Sphaerodactylus altavelensis* Noble and Hassler (Table 1), the Alto Velo Sphaero (see Thomas and Schwartz, 1983a) can be distinguished by its larger adult body size (22-29 mm SVL), presence of scapular ocelli, and absence of a neck band.

Description.—The Holotype and seven paratypes range in SVL from 14.1-17.9 mm (see measurements). Rostral scale broadly rounded, with a small, semicircular flat area delimited by a raised ledge; supranasals elongate, roughly triangular, widest laterally, and bordered below by a squarish, swollen upper postnasal; lower postnasal flat and cobble-like; 1 (5 specimens) or 2 internasals present; 3 upper labials to mid-eye. Snout scales flat and cobble-like to subimbricate and keeled, with keeled scales extending onto lores and sometimes almost to length of snout. Scales become narrower, erected, and keeled on the frontal region, and smaller, lower, and keeled on the parietal region and onto the neck, where they become more imbricate until condition of flattened, somewhat swollen, keeled, and imbricate dorsal body scales is attained. Scales across snout (counted between sutures of 2nd and 3rd supralabials on each side) number 9-11 (mode 9); scales along snout from internasal to anterior edge of orbit 5-6 (mode 6). Dorsal interribral scales 40-44; ventral interribral scales 30-35. Dorsal interauricular scales 41-47 (\bar{x} = 44.3); ventral interauriculars 28-40 (\bar{x} = 36.9). Dorsal scales from axilla to groin 24-29 (\bar{x} = 26.3); ventral scales axilla to groin 23-28 (\bar{x} = 25.6); scales around midbody number 44-51 (\bar{x} = 48.0). Subdigital lamellae 8-10 (mode 9). Escutcheons 4-5 scales long by 13-16 scales wide in 2 males (total escutcheon scales 36 and 56). Tail scales acute, flattened, keeled, with some raised tips; median ventral tail scales enlarged, rounded, flat, and smooth.

Coloration consists of dark-edged pale postocular stripes that widen posteriorly, with upper edge becoming somewhat

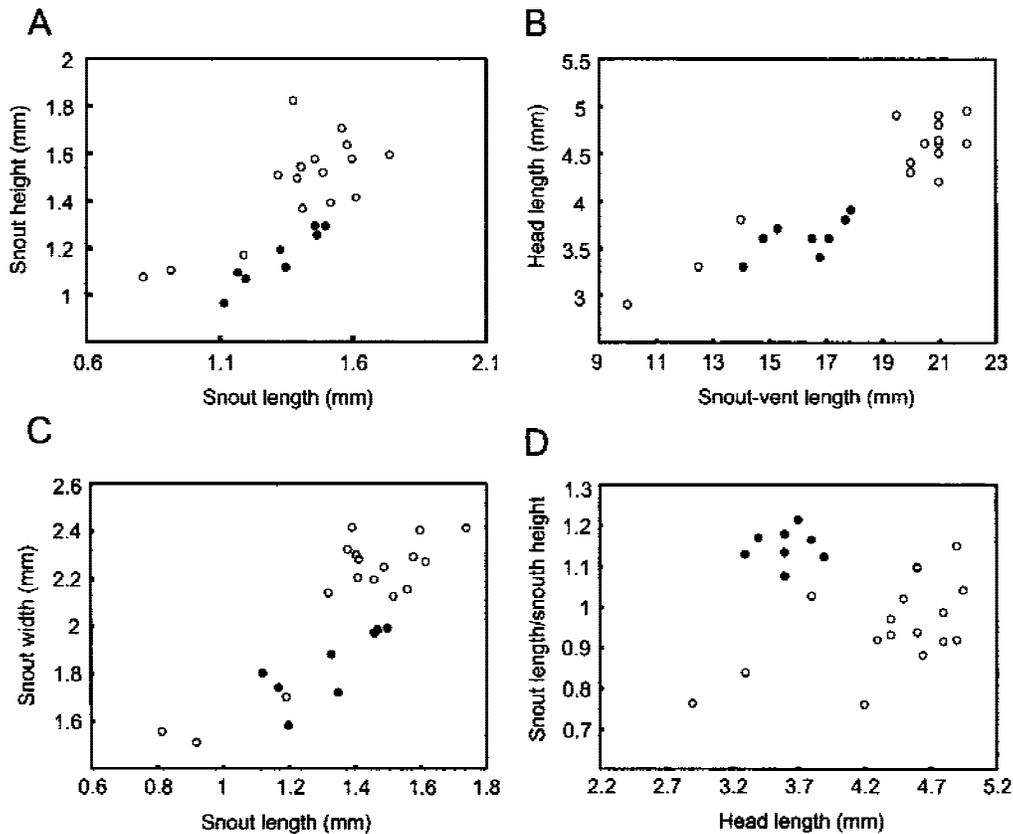


FIG. 2. Comparison of head shape in *Sphaerodactylus ariasae* (closed circles) and *S. streptophorus* (hollow circles). A. Snout height versus snout length. B. Head length versus snout-vent length (the three smallest *S. streptophorus* are juveniles). C. Snout width versus snout length. D. Snout length/snout height versus head length.

emarginated in and bending mesiad, outlining an incomplete cephalic figure. Two specimens (USNM 541804, 541810) have short diagonal (rising anteriad) light dashes that are reduced homologues of the wedge-marks discussed by Thomas and Schwartz (1983b). All specimens with indications of a transverse narrow, pale necklace mark that may be interrupted in the midline. All specimens have complete longitudinal, pale dorsolateral lines, which have dark edges in the most boldly marked individuals. Lines tend to fade slightly at midbody, but become intensified on sacrum and onto tail. Both metachrotic males (USNM 541806, 541808) with all pattern elements extremely faint. Except for these two males, all specimens have a pair of pale sacral ocelli indicated by a slight indenting of the mesial dark sacral lines. Males evidently

undergo pattern reduction characteristic of many sphaerodactyls. Metachrotic males plain headed (yellowish in life), with no signs of the prominent vermiculations of metachrotic male *S. streptophorus*.

Measurements.—SVL: 14.1 (USNM 541801), 14.8 (541809), 15.3 (541807), 16.5 (541808), 16.8 (541805), 17.1 (MCZ-R-182930), 17.7 (USNM 541806), and 17.9 (541804) mm. Lengths of two complete tails: USNM 541808 (12.5 mm) and 541806 (15.0 mm). Live body mass: USNM 541808 (0.12 g), 541806 (0.14 g), 541804 (0.14 g), and MCZ-R-182930 (0.13 g).

Etymology.—We are pleased to name this species in honor of Yvonne Arias. Yvonne is long-time friend and champion of conservation efforts in the Dominican Republic, and especially in the Jaragua National Park, where this species occurs. "Jaragua"

TABLE 1. Comparison of four species of *Sphaerodactylus* from southern Hispaniola.

Character	<i>S. ariasae</i>	<i>S. streptophorus</i>	<i>S. plummeri</i>	<i>S. altavelensis</i> ¹
Maximum SVL, adult males (mm)	18	24	22	28
Maximum SVL, adult females (mm)	18	26	22	29
Dorsals, axilla to groin	24-29 (\bar{x} = 26.3)	25-37 (\bar{x} = 31.1)	17-21 (\bar{x} = 18.1)	26-36 (\bar{x} = 30.1)
Ventrals, axilla to groin	23-28 (\bar{x} = 25.6)	24-33 (\bar{x} = 28.2)	22-24 (\bar{x} = 22.4)	22-32 (\bar{x} = 27.9)
Scales around midbody	44-51 (\bar{x} = 48.0)	41-62 (\bar{x} = 50.8)	34-36 (\bar{x} = 35.1)	44-62 (\bar{x} = 50.7)
Escutcheon (length × width, in scales)	4-5 × 13-16	3-7 × 10-26	6 × 15-20	3-6 × 22-27
Snout scales	Strongly keeled	Weakly keeled	Smooth	Strongly keeled
Dorsal ground color	Dark brown	Gray-tan	Gray-brown	Gray
Pale neck band	Present	Present	Absent	Absent
Scapular ocelli	Absent	Present or Absent	Absent	Present
Male head pattern	Absent	Vermiculations	Absent	Spots or vermiculations
Pale dorsolateral lines	Complete	Incomplete	Absent	Absent
Sample size	8	123	10	22

¹The nominate subspecies, *S. a. altavelensis*

was a name used by native Amerindians for a large region of southern and western Hispaniola.

Natural history.—All the specimens were collected in leaf litter of xeric woods over limestone substratum. The forest canopy was typically 5-10 m above ground. The two localities visited on Isla Beata were near Punta Beata and Punta Lanza. The first is a point of land at the northernmost tip of the island. A small naval station and fishing village are located along the west side of Punta Beata. A trail leads directly inland from the naval station along a water pipe for 1-2 km to a limestone sink and cave (the type-locality). The two specimens were collected in leaf litter around the sinkhole. Punta Lanza, on the west side of Isla Beata, about 3 km SW Punta Beata, is reached by a coastal trail that borders a limestone escarpment. The specimen from this locality was collected in leaf litter at the base of the escarpment. Other reptiles found at Punta Lanza were *Typhlops syntherus* Thomas, the Barahona Blindsnake, and *Amphisbaena hyporissor* Thomas, the Barahona Amphisbaena. The two specimens from Cabo Beata were taken in leaf litter during the day, in partially cut-over (degraded) limestone forest near the coast.

Distribution.—This species is known only from Isla Beata and the adjacent southernmost tip (Cabo Beata) of the Barahona Pen-

insula, Dominican Republic, completely within Jaragua National Park.

Specimens examined.—*Sphaerodactylus parthenopion* Thomas: British Virgin Islands: Virgin Gorda: ca. 0.5 miles N Pond Bay (AMNH 92821), hillside above Pond Bay (AMNH 92822-24, MCZ 77211-14). *Sphaerodactylus streptophorus*: Dominican Republic; Pedernales Province, Pedernales, CMNH 56806-15; Hoyo de Pelempito, USNM 541811-541817.

Remarks.—The classification of West Indian *Sphaerodactylus* is not well established, largely because of high species diversity (84 species; Hedges, 2001) and limited number of diagnostic morphological characters. *Sphaerodactylus arisae* has been placed in the *difficilis* complex, along with approximately 16 species from Hispaniola, most possessing scapular ocelli (Thomas and Schwartz, 1983b; Thomas and Hedges, 1988, 1992, 1993, 1998). Allozyme and immunological data support some cohesiveness in this complex within a more inclusive *argus* series (Hass, 1991), although more data are needed to establish a robust phylogenetic framework.

The related *S. streptophorus* occurs in the upper Barahona Peninsula and in southeastern Haiti, in areas of more moderate (semi-xeric) habitat than the most extreme (xeric) areas of the Barahona Peninsula. *Sphaerodactylus ariasae* is probably blocked

from occupying the middle and upper portion of the Peninsula, if not by habitat, by the occurrence of the similarly sized *S. plummeri*. Very small species of *Sphaerodactylus* are found on most of the Greater Antilles but do not coexist in the same habitat. We have collected at Boucan Detwi and near Troudiye (12 km NW of Piticabo), very close to the distribution of *S. ariasae*, and found only *S. plummeri* (Thomas and Hedges, 1992). The habitat of the Piticabo area and Beata is xeric woods, whereas the region around Troudiye and the more northern part of the Barahona Peninsula are dominated by more open, xeric scrub habitat. Another small and unrelated gecko, *S. altavelensis*, occurs on nearby Isla Alto Velo, about 12 km southwest of Beata, across a deep-water passage.

DISCUSSION

Approximately 23,000 of the 28,000 species of living tetrapods are amniotes, with the rest being amphibians. Two species of frogs are the smallest living tetrapods (Estrada and Hedges, 1996), while several geckos (*Sphaerodactylus*) and chameleons (*Brookesia*) are the smallest amniotes. The smallest chameleon is *Brookesia tuberculata*, the Dwarf Chameleon, with a maximum SVL of 19 mm and mean of 18 mm (Glaw et al., 1999). Two species of geckos, *S. parthenopion* (Thomas, 1965), the Virgin Islands Dwarf Sphaero, and *S. ariasae*, are slightly smaller, with maxima of 18 mm and mean adult body sizes of 16 mm (Fig. 3). Both *Sphaerodactylus* also are similar in maximum body mass [*S. ariasae*, 0.14 g ($n = 4$); *S. parthenopion*, 0.15 g ($n = 12$; MacLean, 1985)]. Another West Indian species, *S. elasmorhynchus* (Thomas, 1966), the Snout Shield Sphaero, may be of similar small size but it is known from one specimen (a sub-adult or adult female 17 mm SVL) and the adult size cannot be determined at this time. We have repeatedly failed to collect additional specimens of this species.

Extremes in size often occur on islands. For example, one of the two smallest frogs (*Eleutherodactylus iberia* Estrada and Hedges, the Monte Iberia Eleuth) and the

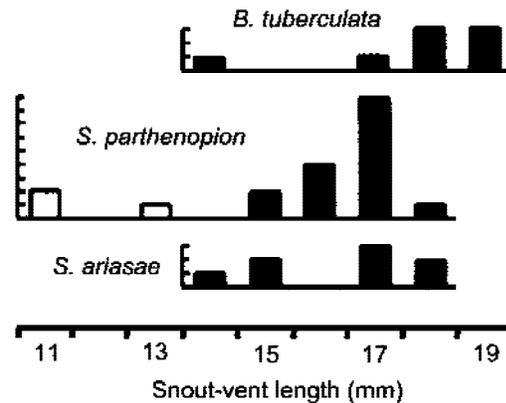


FIG. 3. Histograms of body size (SVL) in the three smallest species of amniotes: *Brookesia tuberculata*, *Sphaerodactylus parthenopion*, and *S. ariasae*. White bars indicate juveniles.

smallest bird (*Mellisuga helenae* [Lembeye], the Bee Hummingbird) are Cuban. The largest tortoise (*Aldabrachelys elephantina* [Duméril and Bibron], the Aldabra Tortoise) occurs on Aldabra Island and the largest butterfly in the Western Hemisphere (*Papilio homerus* Fabricius, the Homerus Swallowtail) occurs on Jamaica. This situation is probably explained by the reduced higher-level taxonomic diversity found on many islands. Groups that reach those islands and undergo adaptive radiation often fill niches or habitats that otherwise would be occupied by other taxonomic groups. This is especially evident in the West Indies, where unusually large radiations of certain vertebrate groups led to species representing morphological extremes (Hedges, 1996). In the case of the smallest vertebrates, it is possible that the niches they occupy on islands may be occupied by invertebrates on the mainland.

The lower limit of body size has several physiological limitations. The smallest terrestrial animals have the highest surface to volume ratios, thus potentially increasing the rate of water loss. Although some reptiles living in dry environments have special adaptations to reduce water loss (Mautz, 1982), *Sphaerodactylus parthenopion*, occurring in semi-arid habitat in the British Virgin Islands, does not exhibit these adaptations. This species has the proportionately high water loss rate expected for

small species adapted to humid habitats. Rather than evolving resistance to desiccation, it apparently selects the most humid microhabitats available within its niche (MacLean, 1985).

Sphaerodactylus species that occur in similar habitats often have similar characteristics, regardless of their phylogenetic relationships. The forest-dwelling species tend to be cryptic rather than boldly colored. This has been described as the *forest ecomorph*, which is further subdivided into a *mesic forest ecomorph* and a *xeric forest ecomorph* (Thomas et al., 1992). Members of the latter group, which includes *S. arisae*, are very small, dark or drab species that occur in the leaf litter of xeric (often coastal) forests.

Acknowledgments.—We thank the government of the Dominican Republic (Departamento de Vida Silvestre and Dirección Nacional de Parques) for permission to collect and export specimens; Grupo Jaragua (Yvonne Arias, Sixto Inchaustegui) for logistical support; Jennifer Cutraro, Renee Sharp, and Michael Tracy for field assistance; the staffs of the American Museum of Natural History, Field Museum of Natural History, Museum of Comparative Zoology, United States National Museum of Natural History, University of Kansas Museum of Natural History, and the University of Michigan Museum of Zoology for information or loan of comparative material; and Robert Powell and Robert Henderson for comments on the manuscript. This research was supported by grants from the U.S. National Science Foundation (BSR-8906325, BSR-9123556, and DEB-9525775 to S. B. Hedges).

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