

## TWO NEW SPECIES OF *ELEUTHERODACTYLUS* FROM REMNANT CLOUD FOREST IN HAITI (ANURA: LEPTODACTYLIDAE)

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**ABSTRACT:** Two new arboreal leptodactylid frogs, *Eleutherodactylus corona* and *E. dolomedes*, are described from remnant cloud forest in the Massif de la Hotte, Dept. du Sud, Haiti. One (*E. corona*) is a bromeliad/orchid specialist whereas the other (*E. dolomedes*) is more generalized in habitat preference. Both belong to the *bakeri* series of the large subgenus *Euhyas*.

**Key words:** Caribbean; West Indies; Hispaniola; Systematics; Vocalization; New species

ALTHOUGH frogs of the neotropical genus *Eleutherodactylus* (approximately 500 species) are found in a wide range of habitats, the highest species densities are seen in cloud forests of intermediate elevation (1000–3000 m: Duellman, 1979; Lynch and Duellman, 1980; Schwartz, 1973). Such areas can harbor as many as 18–20 sympatric species (Hedges and Thomas, 1987; Lynch and Burrowes, 1990). Unfortunately, in Haiti, virtually all of the original cloud forest (and other forest) has been removed, largely for the local production of charcoal used in cooking. The clusters or patches of trees that remain often are on very steep (sometimes vertical) slopes, in deep ravines, or in highly dissected karst regions where travel—even on foot—is difficult. We recently visited such an area of remnant cloud forest habitat in the Massif de la Hotte, on the Tiburon peninsula, and collected two new arboreal species of *Eleutherodactylus*.

### MATERIALS AND METHODS

We use the following abbreviations: SVL, snout–vent length; HL, head length (tip of snout to jaw articulation); HW, head width; TYM, tympanum width; EL, eye length; EN, eye–naris distance; THL, thigh length; SHL, shank length; and FTW, fingertip (III) width. Museum abbreviations follow standardized usage (Leviton et al., 1985). Measurements (in mm) were taken with digital calipers (0.01 mm accuracy)

and live masses were taken with a Pesola spring scale (0.01 g accuracy). We recorded calls with a Sony TCM 5000 recorder and Electrovoice 635A microphone. Call analyses were made with a Digital Sona-Graph 7800 and Kay Sona-Graph 7900 printer. Terminology for call parameters follows Duellman and Trueb (1986), with values reported as means,  $\pm 2$  SE, and range.

### *Eleutherodactylus corona* sp. nov.

Fig. 1A

**Holotype.**—USNM 310824, an adult male from Caye Paul (10.7 km WNW Les Platons), Dépt. du Sud, Haiti, 1120 m, collected by Manuel Leal and Richard Thomas on 4 June 1991.

**Paratypes** (11).—USNM 310825–31, KU 218429–32, paratopotypes; all with same data as holotype.

**Diagnosis.**—A member of the subgenus *Euhyas* (Hedges, 1989) by its possession of a liver with long and pointed left lobe. Additionally, it can be placed in the *bakeri* series of that subgenus by its relatively short vomerine odontophores (a derived trait within *Euhyas* but convergent with members of the subgenus *Eleutherodactylus*), paired vocal sac, and possession of a single, wide shank bar (faint, but present in some individuals). Its small size (17.2–18.4 mm SVL, four males; 16.6–19.1 mm, three females) greenish-brown coloration with ir-

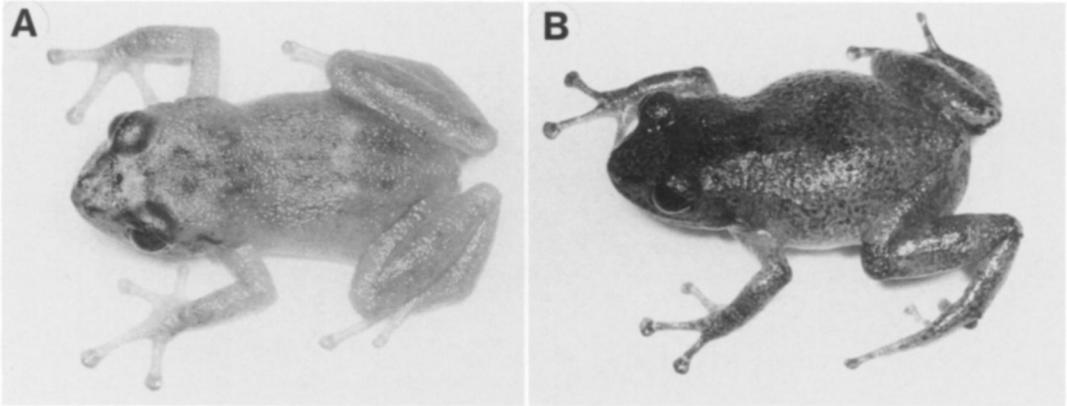


FIG. 1.—(A) *Eleutherodactylus corona* (USNM 310826), male, 18.4 mm SVL. (B) *E. dolomedes* (KU 218434), male, 21.6 mm SVL.

iridescent upper eyelids, dorsolateral grooves, and dorsoventrally flattened body distinguish *E. corona* from all other West Indian species. Two bromeliad-dwelling Puerto Rican species, *E. gryllus* and *E. jasperi*, bear a superficial resemblance to *E. corona* in that they are small, dorsoventrally flattened species; *E. jasperi* has iridescent upper eyelids and *E. gryllus* is green. However, both are members of the subgenus *Eleutherodactylus* (*auriculatus* section) and have a liver with a short and rounded left lobe. Also, they differ from *E. corona* in details of structure, color pattern, and vocalization (Rivero, 1978) that make close comparison unnecessary.

**Description.**—Head as wide as body, width less than length; snout subacuminate in dorsal view (with pointed tip), subacuminate in lateral view, overhanging lower jaw; nostrils moderately protuberant, directed dorsolaterally; canthus rostralis rounded, slightly concave in dorsal view; loreal region slightly concave, sloping gradually; lips not flared; upper eyelid bearing one moderate-sized, rounded tubercle; dorsal surface of head (including snout, interorbital space, and area just behind) mostly flat, but with one or several distinct subconical tubercles, especially noticeable in life; supratympanic fold weakly defined, concealing upper edge of tympanic annulus; tympanum moderate-sized, round, separated from eye by a distance less than its own diameter; one post-

rictal tubercle, enlarged, rounded; choanae moderate-sized, round, not concealed by palatal shelf of maxillary arch when palate is viewed from below; vomerine odontophores medial and posterior to choanae, each about the same size as a choana, round (patch-like), separated widely at midline; tongue round, posterior edge without notch, posterior one-half not adherent to floor of mouth; males with vocal slits and externally visible submandibular vocal sac, paired; left lobe of liver long and pointed.

Skin of dorsum smooth to weakly areolate, with a weakly-defined dorsolateral groove (indentation); skin of flanks areolate with a weakly-defined ventrolateral groove; skin of venter strongly areolate, without discoidal folds; anal opening not extended in sheath; supra-axillary and inguinal glandular areas present; ulnar tubercles absent; palmar tubercle single, about same size as thenar (oval, low); no supernumerary tubercles; subarticular tubercles of fingers oval, low, and rounded; well-defined lateral ridges on finger; all fingers with expanded tips; fingertips rounded, semicircular pad on ventral surface of fingertip; circumferential groove bordering distal three-fourths of finger pad; width of largest pad (III) three-fourths to same size as tympanum; first finger shorter than second when adpressed; heel tubercles absent; no tubercles along outer edge of tarsus; metatarsal tubercles low, inner

(oval) twice size of outer (subconical); several small, low, supernumerary plantar tubercles; subarticular tubercles of toes round and low; toes unwebbed; well-defined lateral ridges on toe; all toes with expanded tips; toetips rounded; semicircular pad on ventral surface of toetip; circumferential groove bordering distal three-fourths of toe pad; heels overlap when flexed legs are held at right angles to sagittal plane.

In alcohol, dorsal ground color brown (darker anteriorly); round, dark brown blotch on top of head just posterior to interocular region; faint trace of single, wide antibrachial, thigh, and shank bars; scapular chevron of "W"; narrow, dark brown supratympanic bar, weakly-defined; no canthal bar; one specimen (USNM 310826) with wide, white interocular bar; entire ventral surface tan (fine brown flecks); testicular peritoneum solid black, ovarian peritoneum with black flecks.

In life, dorsal ground color greenish-yellow to greenish-tan; posterior dorsum orange in some individuals; upper eyelids iridescent (light greenish-blue); iris golden brown above and below; scapular chevron or "W" dark brown; head and snout more heavily pigmented (dark brown spots); light brown shank bars evident in a few individuals; belly metallic light green, rest of venter yellowish-green.

*Measurements.*—The live masses (range and mean) of three adult males (including holotype), three adult females, and the holotype (separately) are 0.39–0.53 (0.45) g, 0.42–0.49 (0.46) g, and 0.42 g, respectively. Other measurements are given in Table 1.

*Etymology.*—A noun in apposition, from the Latin word for "crown," in reference to the several distinctive (in life) tubercles on the dorsal surface of the head in most specimens of this species.

*Natural history.*—The type-locality (Caye Paul) is near the western end of the Formon plateau, a karst platform lying immediately to the south of the central Massif de la Hotte (Pic Formon and Pic Macaya). The area is reached only from the south by a road that passes through Ducis, ascending the southeastern flank of the plateau to Les Platons (a small village next to

the ruins of a large citadel built in the early 19th century), and then continues westward along the plateau to Plaines Formon and Caye Paul. Caye Paul is a field station in Parc Nacional Macaya.

There apparently is no undisturbed forest remaining on the Formon plateau, but only occasional remnant patches of forest. Selective cutting is evident even within these patches, and any large trees still standing usually are dead and rotting (probably undesirable for charcoal). The area surrounding the field station is mostly open, with a few standing dead trees, some small pines, and thick undergrowth covering highly dissected limestone rock (Fig. 2). All specimens of *E. corona* were found inside several bromeliads and an orchid. The bromeliads, taken 1–3 m above the ground on standing dead trees during the day, also contained *E. heminota*, *E. lamprotes*, and eggs (presumably of one of those two larger species). At night, the distinctive call of *E. corona*, an explosive whistle (see below), was traced to a large orchid growing in a tree. The orchid contained several adult males and females, and a large, apparently communal, cluster of 50 eggs (presumably of *E. corona*) in different stages of development. The eggs began hatching on 9–10 June 1991, and the hatchlings (27) were glossy black above and below, except for a tan belly. The remaining eggs were either infertile (13) or still developing (10). Two females (USNM 310825, KU 218431) with masses of 0.49 g and 0.42 g (respectively) contained three enlarged ova (3.3 mm diameter) each, with a total mass of 0.075 g and 0.060 g (respectively), and a third female (USNM 310827) also contained three large eggs.

*Vocalization.*—The call of *E. corona* is a single, short, explosive whistle (Fig. 3A). Of five calls recorded (from one individual) and analyzed, the number of notes per call was one (no variation); the dominant frequency rises rapidly from  $2.52 \pm 0.08$  (2.4–2.6) kHz to  $5.40 \pm 0.09$  (5.3–5.5) kHz during the call; the call duration was  $56.6 \pm 0.70$  (55.5–57.5) msec; and the call rate was  $1.58 \pm 0.24$  (1.43–1.82) calls per minute.

TABLE 1.—Measurements (in mm) of two species of Hispaniolan *Eleutherodactylus*. Shown are means and ranges (in parentheses) of adults.

	<i>E. corona</i>			<i>E. dolomedes</i>	
	Males (3)	Females (3)	Holotype	Males (3)	Holotype
SVL	17.8 (17.2–18.4)	17.5 (16.6–19.1)	17.9	20.4 (18.7–21.6)	20.9
HL	7.00 (6.52–7.28)	6.76 (6.24–7.23)	7.19	7.83 (7.26–8.36)	7.87
HW	6.93 (6.54–7.24)	6.48 (5.90–6.96)	7.19	7.81 (7.19–8.18)	8.18
TYM	1.12 (1.05–1.22)	1.08 (0.98–1.22)	1.10	1.11 (1.01–1.17)	1.15
EL	2.35 (2.24–2.44)	2.40 (2.20–2.53)	2.44	2.67 (2.65–2.69)	2.69
EN	1.83 (1.75–1.93)	1.82 (1.59–1.98)	1.81	1.66 (1.54–1.73)	1.73
THL	7.55 (7.18–7.92)	7.44 (6.71–8.06)	7.56	7.86 (7.59–8.01)	7.99
SHL	8.58 (8.21–8.77)	8.63 (7.98–9.14)	8.77	8.89 (8.45–9.16)	9.07
FTW	0.88 (0.73–1.05)	0.86 (0.80–0.90)	0.86	1.04 (0.93–1.16)	1.03

*Distribution*.—Known only from the type-locality.

*Remarks*.—Although the call of *E. corona* (Fig. 3A) is unique, the sharply rising aspect is seen in other members of the *bakeri* series: *E. amadeus* (Hedges et al., 1987: their Fig. 3), *E. bakeri*, *E. eunaster*, *E.*

*heminota*, and the new species described below. This feature is not found in other Hispaniolan species of *Eleutherodactylus* and therefore may be another diagnostic trait of the *bakeri* series. The apparent lack of sexual dimorphism in body size in *E. corona*, if confirmed by additional speci-



FIG. 2.—Remnant forest at Caye Paul, Dépt. du Sud, Haiti; the type locality of *E. corona* and *E. dolomedes*.

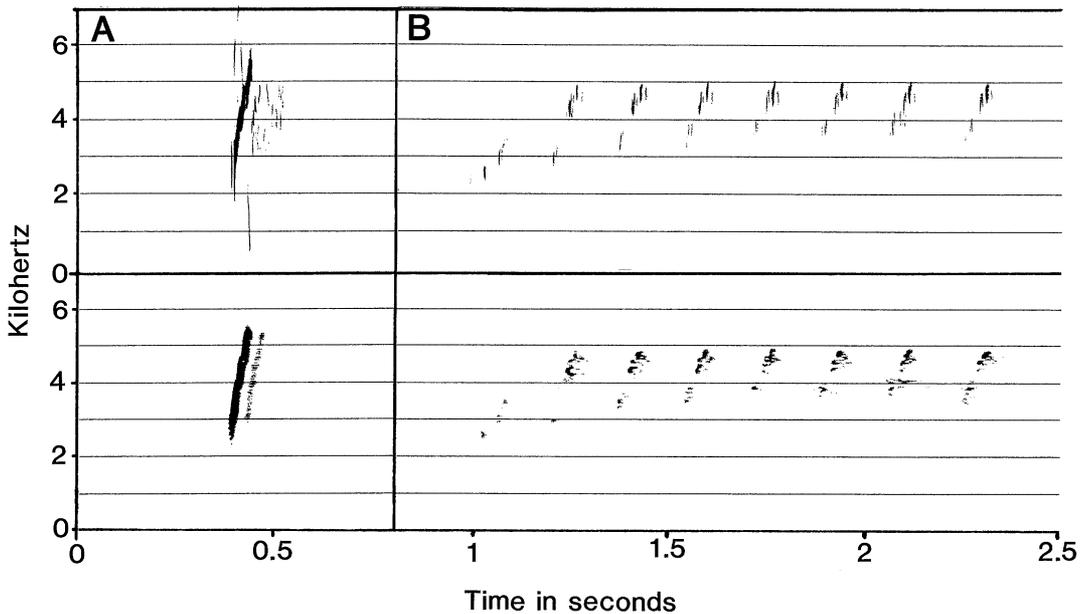


FIG. 3.—Audiospectrograms of (A) *Eleutherodactylus corona* (specimen number unknown) and (B) *E. dolomedes* (USNM 309780), male, 20.9 mm SVL. Each call is shown with 300 Hz filter (above) and 45 Hz filter (below).

mens, is unusual among species of *Eleutherodactylus* where females are nearly always larger than males (e.g., Lynch, 1979). However, one of the few other species with this characteristic (*E. bakeri*) also is in the *bakeri* series (other species are *E. hypostenor* and *E. ruthae*; Hedges and Thomas, 1987).

The convergent resemblance of bromeliad-dwelling species of *Eleutherodactylus* was described by Hedges (1989) as the bromeliad ecomorph. These species usually have a dorsoventrally flattened body, a short and rounded (in dorsal profile) head, often with a pointed tip, eyes oriented more forward (Hedges et al., 1992), short digits, digital fringe, relatively large and rounded digital tips, and a dark snout grading posteriorly to a lighter body color. Most species are green, yellow, or brown, and lack a distinctive dorsal pattern.

*Eleutherodactylus corona* is a typical member of the bromeliad ecomorph. Besides two new Cuban species described elsewhere (Hedges et al., 1992), the other West Indian members of this ecomorph are: *E. jamaicensis* (Jamaica), *E. auricu-*

*latoides*, *E. fowleri*, *E. heminota*, *E. lamprotes*, and an undescribed species (Hispaniola), and *E. gryllus* and *E. jasperi* (Puerto Rico).

Another feature of bromeliad-dwelling *Eleutherodactylus* in the West Indies appears to be small clutch size (Hedges et al., 1992). The clutch size of *E. corona* (three) is the second smallest in the West Indies, between *E. limbatus* (one) and *E. thorectes* (four). For comparison, two terrestrial species with similar-sized females, *E. haitianus* (17.5 mm) of Hispaniola and *E. sisypodemus* (16.0 mm) of Jamaica, have clutch sizes of nine and 10, respectively (S. B. Hedges, unpublished data). One possible explanation for this trend may be the morphological constraint of a "flattened" habitus in bromeliad-dwelling species, limiting the body space available for eggs. Such smaller clutches, if not compensated by smaller egg size or greater frequency of clutches, would mean that a greater proportion of reproductive effort is expended per egg in these species. Alternatively, the smaller clutch size may be the result of selection for larger offspring size at hatching. A prediction of the second hypothesis

is that the eggs and offspring of bromeliad-dwelling species are significantly larger than in other species of *Eleutherodactylus*. It is perhaps noteworthy that the only known live-bearing species in the genus (*E. jasperi*) is a bromeliad specialist (Drewry and Jones, 1976). Although some preliminary data suggest that egg size is not correlated with clutch size (Wake, 1978), a critical comparison of body size, clutch size, and egg size in West Indian *Eleutherodactylus* (S. B. Hedges, unpublished data) may shed light on these hypotheses.

For the other new species discovered at Caye Paul on the Formon plateau, we propose the name

*Eleutherodactylus dolomedes* sp. nov.

Fig. 1B

*Holotype*.—USNM 309780, an adult male from Caye Paul (10.7 km WNW Les Platons), Dept. du Sud, Haiti, 1120 m, collected by S. Blair Hedges on 1 June 1991.

*Paratypes* (2).—KU 218434, paratopotype, collected by S. Blair Hedges, Richard Thomas, Manuel Leal, and Nicholas Plummer on 4 June 1991; USNM 310823, paratopotype, collected by Richard Thomas on 4 June 1991.

*Diagnosis*.—A member of the subgenus *Euhyas* (Hedges, 1989) by its possession of a liver with a long and pointed left lobe, and smooth venter (mostly). Additionally, it can be placed in the *bakeri* series of that subgenus by its relatively short vomerine odontophores and possession of a single, wide shank bar.

*Eleutherodactylus dolomedes* differs from all other members of the *bakeri* series by its single, external, submandibular vocal sac (paired or absent in the other members: *amadeus*, *bakeri*, *corona*, *eunaster*, *glanduliferoides*, *glaphycompus*, *heminata*, *semipalmatus*, and *thorectes*). In addition, the combination of orange-brown dorsal color, very short snout (EN <10% SVL), and unique seven note call (Fig. 3B) distinguishes it from all other species.

*Description*.—Head as wide as body, width less than length; snout subacuminate

in dorsal view, subacuminate in lateral view, overhanging lower jaw; nostrils weakly protuberant, directed dorsolaterally; canthus rostralis rounded, straight in dorsal view; loreal region slightly concave, sloping gradually; lips not flared; upper eyelid bearing small, rounded tubercles; interorbital space without tubercles; supratympanic fold weakly defined, concealing upper edge of tympanic annulus; tympanum small, round, separated from eye by a distance equal to its own diameter; one or two enlarged, subconical post-riotal tubercles; choanae moderate-sized, round, not concealed by palatal shelf of maxillary arch when palate is viewed from below; vomerine odontophores medial and posterior to choanae, each larger than a choana, straight and angled postero-medially, separated moderately at midline; tongue longer than wide, posterior edge without notch, posterior two-thirds not adherent to floor of mouth; males with vocal slits; vocal sac median subgular and externally visible; liver with long and pointed left lobe.

Skin of dorsum moderately tuberculate, without dorsolateral folds; skin of flanks similar to dorsum; skin of venter smooth anteriorly grading to tuberculate posteriorly, without discoidal folds; anal opening not extended in sheath; no glandular areas present; ulnar tubercles low, subconical; palmar tubercle single, about the same size as thenar (oval, low); several moderate-sized subconical, supernumerary tubercles; subarticular tubercles of fingers round and subconical; well defined lateral ridges on finger; all fingers with expanded tips; fingertips rounded, semicircular pad on ventral surface of fingertip; circumferential groove bordering distal three-fourths of finger pad; width of largest pad (III) same size as tympanum; first finger shorter than second when adpressed; heel tubercles absent; small, subconical, tubercles along outer edge of tarsus; metatarsal tubercles elevated, inner (elongate) three times size of outer (conical); several small, subconical, supernumerary plantar tubercles; subarticular tubercles of toes oval and rounded; toes unwebbed; weak lateral ridges on toe; all toes with expanded tips;

toetips rounded; semicircular pad on ventral surface of toetip; circumferential groove bordering distal three-fourths of toe pad; heels just touch when flexed legs are held at right angles to sagittal plane.

In alcohol, dorsal ground color is dark brown (USNM 309780, KU 218434) or tan (USNM 310823); one scapular and one midbody chevron, darker brown and ill-defined; narrow, light, dorsolateral stripes well-defined (USNM 310823), faint (KU 218434), or not present (USNM 309780); dark brown interocular blotch with two posterior "prongs," bordered anteriorly by light snout (USNM 310823), two small pale areas (USNM 309780) or dark snout (KU 218434); tympanum solid medium brown; supratympanic bar, dark brown; single, dark brown antibrachial, thigh, and shank bars; dark brown patch on knee; entire ventral surface flecked lightly (USNM 310823) or moderately (USNM 309780, KU 218434) with brown.

In life, dorsal ground color orange-brown (USNM 309780, KU 218434) or orange-tan (USNM 310823) with brown body markings and gray limb markings; upper eyelid iridescent; iris grayish-brown above and below; entire ventral surface gray (brownish flecks on pale background); no flash markings; groin region and concealed areas of legs grayish-brown; testicular peritoneum gray.

*Measurements.*—Live masses are 0.66 g (USNM 309780) and 0.92 g (KU 218434). Other measurements are given in Table 1.

*Etymology.*—From the Greek; "crafty" or "deceitful," in allusion to the ventriloquial call of this species.

*Natural history.*—All three specimens were collected at night while calling within 100 m of the field station (Caye Paul). The call (see below) is ventriloquial and the interval between calls is long (about 2 min), making it difficult to trace. The species appeared to be uncommon, as only one or two other individuals were heard calling, although a scarcity of arboreal frogs in an area nearly devoid of trees is not unexpected. The first specimen collected (holotype) required over 1 h to locate. It was finally traced to the underside of a green leaf at the top of a small tree (3 m

high) growing between a jumble of limestone rocks, all of which was covered with vines and briars. The second specimen (USNM 310823) was on a leaf of a small tree, and the third specimen (KU 218434) was on top of the horizontal trunk of a large fallen tree, about 2 m above the ground. The last two specimens were calling during a light rain and strong wind.

*Vocalization.*—The call of *E. dolomedes* is a rapid, seven-note, high-pitched series of "chirps" give in very widely-spaced intervals (Fig. 3B). Each call begins with a slightly lower-pitched note. Of the two calls recorded (holotype), the number of notes per call was seven (no variation); the dominant frequency was 4.71 (4.67, 4.75) kHz; the call duration was 1.32 (1.30, 1.34) ms; and the call rate was 0.46 calls per minute (i.e., 130 s between the two calls). Other calls heard were similar in all respects to the two recorded, including the long interval (about 2 min) between calls.

*Distribution.*—Known only from the type locality.

*Remarks.*—*Eleutherodactylus dolomedes* is a distinctive species that does not bear a close resemblance to any other member of the *bakeri* series. However, it shares one character with *E. corona* which is not found in other species in the series: iridescent upper eyelids (although not as prominent as in *E. corona*).

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## TWO NEW SPECIES OF *SPHAERODACTYLUS* FROM EASTERN CUBA (SQUAMATA: GEKKONIDAE)

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ABSTRACT: Two new species of *Sphaerodactylus* are described from eastern Cuba: *S. schwartzi* is from low elevation xeric habitats in western Guantánamo Province, and *S. cricoderus* is from moderate elevations on the north and south slopes of the Sierra Maestra in Santiago de Cuba Province. The two new taxa appear to be sister species and allied to *S. ramsdeni*, also endemic to eastern Cuba. Together, these three species form the *ramsdeni* group, which is characterized by dark, short-snouted species with very small dorsal scales, more than one internasal, and lack of marked sexual dichromatism. Convergence in the genus *Sphaerodactylus* is discussed, and two ecomorphs are proposed (mesic forest and xeric forest).

*Key words:* Reptilia; Systematics; Caribbean; West Indies; Cuba; Ecomorph

THE *Sphaerodactylus* of Cuba (14 species) fall into seven morphologically definable entities (Schwartz and Garrido, 1985; Thomas, 1975; Thomas and Schwartz,

1966): (1) the *nigropunctatus* complex which includes *S. nigropunctatus* Gray and *S. torrei* Barbour—these are large species with granular scales, banded patterns, and