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A New Riparial Frog of the Genus *Eleutherodactylus* (Anura: Leptodactylidae) from Eastern Cuba

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ABSTRACT.—A new species of frog is described from the north slope of the Sierra Maestra, Eastern Cuba. It is closely related to *Eleutherodactylus riparius*, but differs from in several morphological and acoustical characters. The new species is associated with the edges of upland streams. Information on the natural history of the new species is provided.

INTRODUCTION

Estrada and Hedges (1998) reviewed the Cuban riparian frogs of the genus *Eleutherodactylus* and as a result of that revision, *E. riparius* was described as a new species previously confused with *E. cuneatus*, while *E. sierramaestrae* was considered a synonym of *E. cuneatus*. The authors noted that populations of *E. riparius* from Península de Guanahacabibes (Pinar del Río Province), Ciénaga de Zapata (Matanzas Province), Cayo Coco (Ciego de ávila Province) and localities on the northern slope of Sierra Maestra (Granma Province), differed from typical *E. riparius* and could represent undescribed taxa. We have collected additional material from the Sierra Maestra, and based on morphological and call differences conclude that it represents a new species.

MATERIALS AND METHODS

Measurements were taken with calipers (0.05 mm accuracy) and an ocular micrometer. Frog calls were recorded with a Sony TCM 59V portable cassette recorder and Sony ECM 220 microphone. The acoustic analyses were made with Canary software version 1.2.4 (Cornell University). Signals were digitized at 22050 Hz. Terminology for call parameters follows Duellman and Trueb (1986). Call abbreviations are: DF- dominant frequency; NL- note length, and CR- call rate (calls per minute). Drawings were made using a stereo microscope and a camera lucida. Specimens for skeletal examination were prepared following the clearing and staining method of Dingerkus and Uhler (1977).

Head length (HL) was measured from the posterior edge of tympanum to the snout tip, head width (HW) was taken between the articulation of the jaws, and interorbital distance was taken at the midpoint of the upper eyelid. SVL means snout-vent length. Museum and other zoological collection acronyms are: MNHNCu- Museo Nacional de Historia Natural de Cuba; CZACC- collection of the Instituto de Ecología y Sistemática, La Habana, Cuba; CARE- collection of A. R. Estrada; SBH- S. B. Hedges field serries; LMD- senior author field number series CMST, field number series of Michel Sánchez Torres.

Eleutherodactylus **rivularis,** *new species*
Figs. 1, 2 A - B, 3 A - B.

Holotype.—MNHNCu 843 (original field number MLD 130), an adult male from Río Naguas, La Sierrita (20°06′52″ N, 76° 55′45″ W), 90 m, north slope of Sierra Maestra,

FIG. 1. Adult male (paratype MNHNCu 863, original field number LMD 194) of *Eleutherodactylus rivularis*, n. sp., from Río Yara, Santo Domingo, north slope of Sierra Maestra, Granma Province. SVL 23.4 mm. Photo by Carlos Tallet.

Bartolomé Masó municipality, Granma Province; collected and recorded by Luis M. Díaz and Humberto Cuevas, on February 22, 2000.

Paratypes (N=22).—Males: MNHNCu 844 - 856, with the same data as the holotype (MNHNCu 846 cleared and stained); MNHNCu 842, collected at Santo Domingo, Río Yara, Sierra Maestra, on December 19, 1997 and MNHNCu 863, with the same data but collected by Luis M. Díaz and Pavel Valdés on March 22, 2000. Females: MNHNCu 857 - 862 (MNHNCu 857 cleared and stained), with the same data as the holotype; MNHNCu 864, collected at Santo Domingo, Río Yara, Sierra Maestra, on December 19, 1997; SBH fs 193642, 193689-92, Río Yara, Santo Domingo, 225 m; CARE 1160-161 collected at Río Jibacoa, near Las Mercedes, on January 27, 1997.

Diagnosis.—*Eleutherodactylus rivularis* is a small to medium size species within the Cuban members of the subgenus *Euhyas* (*sensu* Hedges, 1989), with adult males attaining an SVL of 27.5 mm and adult females reaching 31.3 mm. The new species is more closely related to *E. riparius* than to any other Cuban species, by having a W-shaped suprascapular fold, smooth belly, tuberculate dorsum, small digital discs, and riparian habits. It differs from that taxon by its smaller size (maximum SVL is 41.8 mm in *E. riparius*); a more robust body; heels not overlapping when flexed legs are held at right angles to body (overlap in *E. riparius*); vomerine odontophores shorter and at a wider distance (larger and at a narrower distance in *E. riparius*) (Fig. 2 B - D); head wider than long, HW/HL= 1.0 - 1.1 (longer than wide in *E. riparius*, HW/HL= 0.9 - 1.0); more basal webbing on hands; conspicuously enlarged "bean-shaped" supra-axillary glands in a oblique position to sagittal plane, and no dorsolateral folds (enlarged triangular supra-axillary glands in a lateral and parallel position, followed

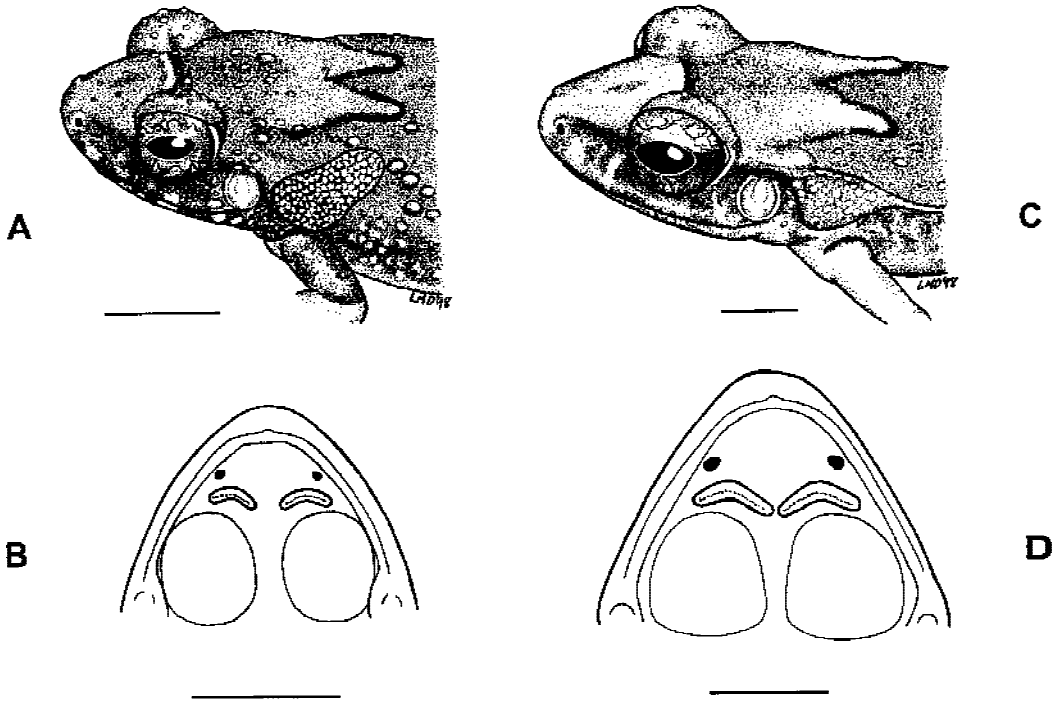

FIG. 2. Comparison of two species of *Eleutherodactylus*. A and C- dorsolateral anterior views showing glands and folds in *Eleutherodactylus rivularis* n. sp. (paratype MNHNCu 864, original field number LMD 159), and *Eleutherodactylus riparius* (MNHNCu 552), respectively. B and D- shape and distance among the vomerine odontophores in *E. rivularis* (B) and *E. riparius* (D), respectively. Scale line equals 5 mm.

by dorsolateral folds in *E. riparius*) (Fig. 2 A - C); calls primarily composed of single notes, mean NL= 17.8 mS, mean DF= 2.3 kHz, mean CR= 32.4 calls/min [In *E. riparius* 1 - 9 notes/call, NL= 79.1 - 197.0 mS, DF= 2.83 - 4.23 kHz, CR= 35 - 158 calls/min].

Description.—Head wider than long and narrower than body, the length 37 % (35-39) of SVL in males, and 36 % (36-38) in females; snout subacuminate in dorsal view and in profile, overlapping the lower jaw; snout length 18 % (16-20) of SVL in males, and 17 % (16-20) in females; nostrils weakly protuberant, directed dorsolaterally; canthus rostralis rounded and straight in dorsal view; loreal region slightly concave, sloping gradually; lips not distinctively flared; interorbital distance, 0.9-1.4 ($\bar{x}$ = 1.1) times width of upper eyelid, interorbital space with some tubercles; tympanum superficial, with distinct annulus, 49 % (42-59) of eye size in males, and 51 % (46-55) of eye size in females, concealed dorsally by the supratympanic fold and separated from eye by a distance 0.4-0.8 ($\bar{x}$ = 0.58) times its own diameter; enlarged postrictal tubercles present; choanae small, round, not concealed by palatal shelf of maxillary arch; vomerine odontophores present in two arched series, separated by a distance 30-73 % the length of each series; tongue oval, notched behind, posterior two thirds not adherent to floor of mouth; males with sublingual slits; vocal sac submandibular, single and small, sometimes extending onto belly when frogs emit high intensity advertisement calls.

Skin of dorsum tuberculate or pustulose, tubercles differing in size, some enlarged longitudinally; no dorsolateral folds; supra-axillary, inguinal and post-femoral glands well developed; supra-axillary glands "bean-shaped", extending diagonally towards dorsum; skin of venter smooth, with discoidal fold; anal opening not extended in sheath; ulnar tubercles absent; palmar tubercle enlarged, rounded or bifid, larger

than thenar tubercle, which is oval and elevated; supernumerary palmar tubercles very small, rounded; subarticular tubercles of fingers low, oval, and subconical; well defined lateral ridge on fingers, forming discrete basal webbings; fingers III - IV - I - II in order of decreasing length; digital discs small, about 31-54 % tympanum width; hands 26 % (23-28) of SVL in males, and 26 % (22-28) in females; a row of flattened, light colored tubercles along forearm inner margin; heel with small, faintly evident, low tubercles; a row of flattened, light tubercles along outer edge of tarsus, absent in some individuals; inner metatarsal tubercle enlarged, about 1.4-2.2 ($\bar{x}$ = 1.96) times as large as the outer metatarsal tubercle, oval and without keel; supernumerary tubercles small, low, and inconspicuous; subarticular tubercles of toes oval and subconical; toes with a well defined lateral ridge and basal webbing; circumferencial groove bordering distal two thirds of toe pad; heels overlap when flexed legs are held at right angles to sagittal plane; toes IV - III - V - II - I in order of decreasing length.

Measurements are summarized in Table 1.

Color in life: dorsum olive-brown; flanks slightly darker anteriorly, with shades of green; glands with a greenish wash; venter white; throat and chest white or with a reticulate brown pattern that changes during metachrosis; lower jaw reticulated; two vertical bars or a single dark area below the eyes; a faint brown interocular bar; legs with faint brown cross bars; thighs dark-brown anteriorly at angle with body, the inner surface also dark brown but more green-mottled; suprascapular fold dark edged; plantar surface dark brown; toe tips reddish; iris light brown with dark venation.

In alcohol the frogs are almost uniformly gray colored; the flanks are slightly darkened with light dots, and the chest and throat are variably reticulated.

Osteology: This preliminary description is based on two adult specimens (male LMD 156 and female LMD 157, Fig. 3 A,B). Skull wider than long; nasals large and in contact, female with nasals sutured with frontoparietals, not so in the male; frontoparietals well ossified and in contact in the female, separated and with irregular inner borders in the male (Fig. 3 A), gradually expanded posteriorly in both specimens;

TABLE 1. Variation in some measurements of *Eleutherodactylus rivularis*, n. sp. [13 Males (including the holotype) and 7 females; a different sample size is specified in parenthesis]. Values are mean ± SD (in mm).

Characters	Males	Females	Holotype (Male)
Snout-vent length	24.49 ± 2.55	29.42 ± 1.33	23.0
Head width	9.20 ± 0.47	11.25 ± 0.47	8.70
Head length	8.74 ± 0.48	10.68 ± 0.40	8.15
Snout length	4.18 ± 0.36	5.04 ± 0.44	4.10
Upper eyelid width	1.94 ± 0.13	2.35 ± 0.13	1.95
Interocular dist.	1.98 ± 0.18	2.26 ± 0.18	2.10
Tympanum width	1.55 ± 0.23	1.86 ± 0.19	1.30
Tympanum height	1.65 ± 0.15	2.04 ± 0.15	1.50
Internarial dist.	1.88 ± 0.17	2.37 ± 0.18	1.70
Thigh length	11.33 ± 0.75	13.77 ± 0.90	11.50
Shank length	11.67 ± 0.78	14.11 ± 1.09	11.50
Tarsal length	6.77 ± 0.38	8.34 ± 0.52	6.50
Foot length	11.63 ± 0.81	13.85 ± 1.52	10.90
Hand length	6.18 ± 0.42	7.52 ± 0.48	6.10
Eye-tympanum dist.	0.86 ± 0.14	1.12 ± 0.25	1.0
Eye diameter	3.22 ± 0.52	3.68 ± 0.31	4.25
Eye-naris dist.	2.51 ± 0.24	3.10 ± 0.18	2.40
Fingertip (III) width	0.60 ± 0.08 (10)	0.71 ± 0.07 (5)	0.70
Toe tip (IV) width	0.70 ± 0.07 (10)	0.88 ± 0.09 (5)	0.80

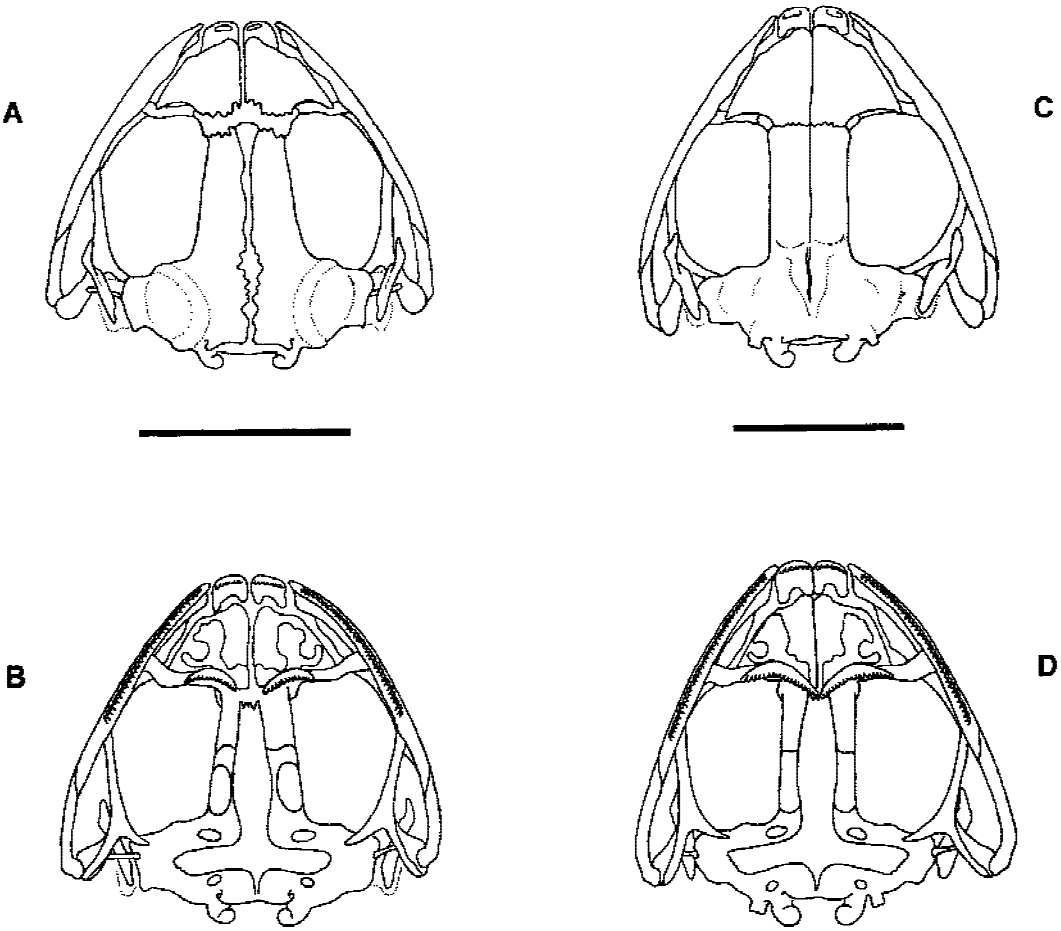

FIG. 3. Skulls of two species of *Eleutherodactylus* showing the most important features. Dorsal views above, ventrals below. A and B- *E. rivularis*, n. sp. (male paratype MNHNCu 846, original field number LMD 157); C and D- *E. riparius* (MNHNCu 511). Scale line equals 5 mm.

strong maxillary-quadratojugal contact; maxilla eleutherognathine, barely overlapping premaxillae by a toothless flange; pars facialis of maxilla moderately developed, posteriorly a very short process at the level of the palatine, not articulating with the nasal; pars palatina of the premaxillae indented, pars dorsalis vertical; vomers well developed and widely separated medially, partially enclosing internal naris; squamosal slender, the otic ramus with a cartilaginous posterior margin; zygomatic squamosal ramus ofshort and slightly angled; cartilaginous bridge between crista parotica and squamosal; cristae paroticae wider than long; columella visible dorsally; anterior process of epiotic eminence rounded and low, without a bony flange; exoccipital and prootic fused; parasphenoid alae not contacting median rami of pterygoids; cultriform process of parasphenoid long; phalangeal formula of hand 3, 3, 4, 4; formula of foot 3, 3, 4, 5, 4; terminal T-shaped phalanges short, laying at midpoint of the small digital discs; transverse processes of vertebrae unequal in length: III > IV > VII > V > VI > VIII > II (atlas without diapophyses); diapophyses of second vertebra curved anteriorly, those of III and VIII at relatively right angle to column, those of V to VII slightly angled posteriorly; sacral diapophyses barely dilated. Anterior cornu of hyoid with short longitudinal bifurcations at base; alary anterior processes short and

TABLE 2. Statistical values for some call parameters of *Eleutherodactylus rivularis,* n. sp.

Parameters	$\bar{x}$ ± SD	CV (%)
Dominant frequency (kHz)	2.32 ± 0.491	21.15
Calls per minute	32.4 ± 9.2	28.48
Note length (mS)	17.84 ± 10.0	56.07
Int. between notes (mS)	114.89 ± 51.0	44.35
Int. between calls (S)	2.3 ± 1.1	49.78

blunt, posterolateral processes sharpened and directed below; bony posteromedial processes elongate.

Vocalization.—Forty calls from four males were analyzed. The advertisement calls of *E. rivularis* are composed of one (80 % of sample), two (17.5 %) or three (2.5 %) single pulsed notes. Notes show a harmonic structure. The two-note calls begin with a shorter introductory note (NL= 11.8 - 16.5 mS, FD= 2.15 - 2.32 kHz), followed by a longer and higher pitched note (NL= 36.1 - 44.0 mS, FD= 2.58 - 2.75 kHz), with accentuated frequency modulation. Measured acoustic parameters are shown in Table 2. Sonogram and waveform of two calls are shown in Fig. 4. Vouchers are MNHCu 843 (holotype) - 450. Air temperature during recordings was 23.0-24.5° C.

Etymology.—the name *rivularis* derives from the Latin word *rivulus* (small river or stream), and refers to the stream-dwelling habits of the new species.

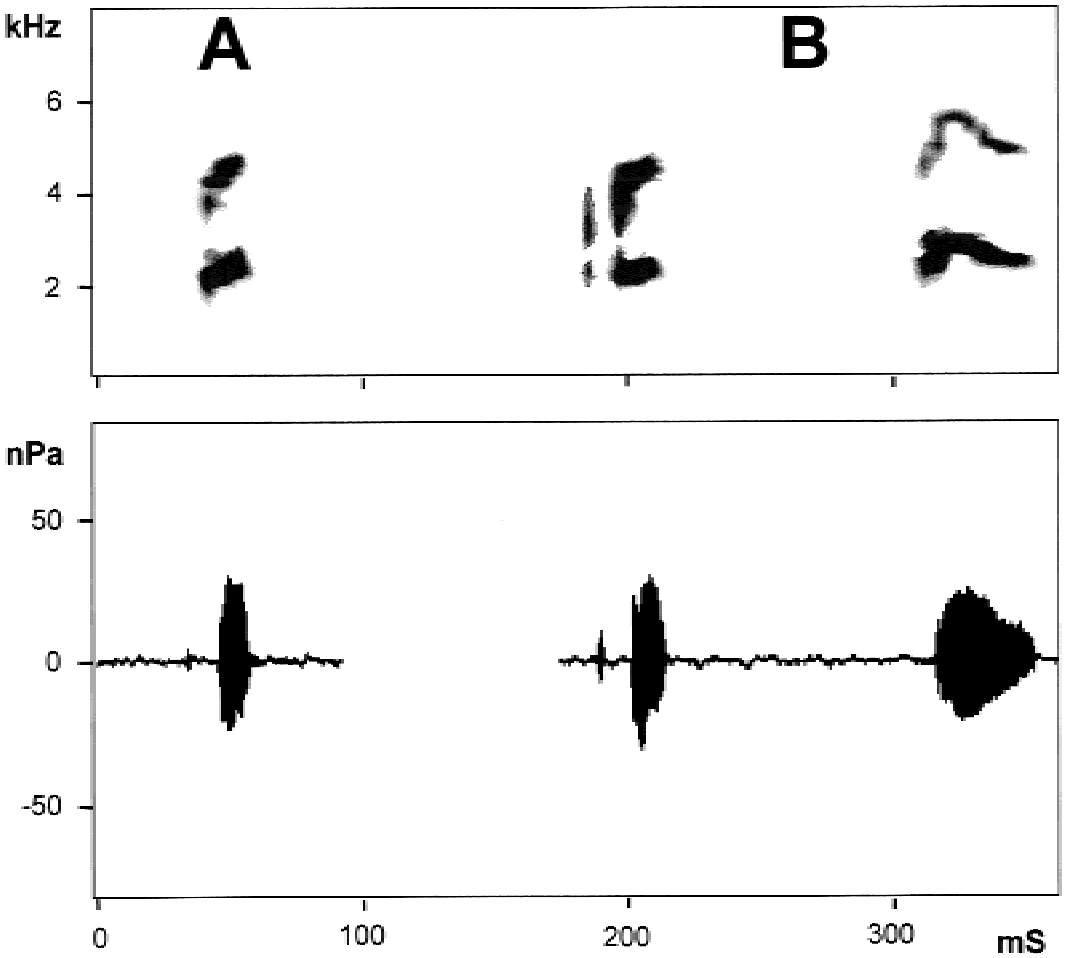

FIG. 4. Sonogram (above) and waveform (below) of two advertisement calls of *Eleutherodactylus rivularis*: A, a single note call and B, two-note call. Air temperature- 24 °C.

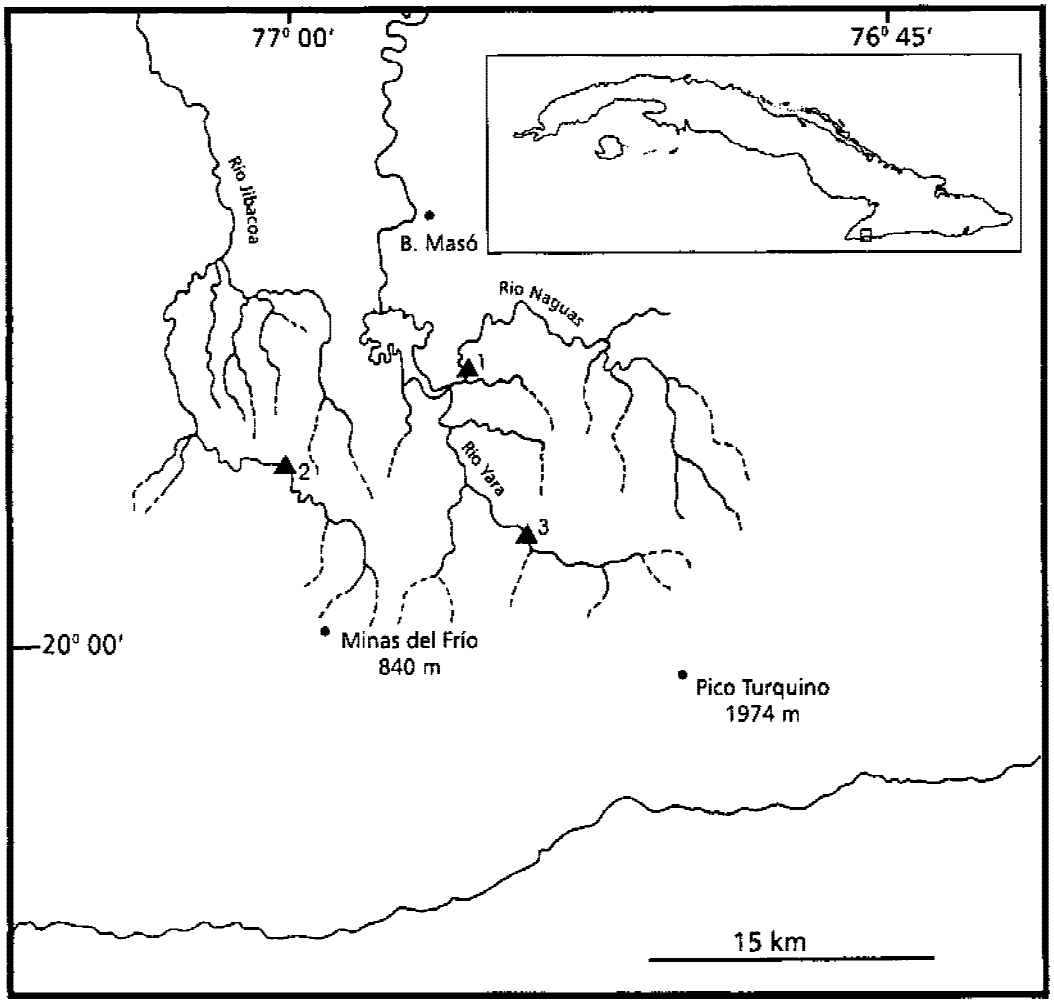

FIG. 5. Distribution of *Eleutherodactylus rivularis*, n. sp, in eastern Cuba. Localities are: 1- La Sierrita (Type-locality), 2- Las Mercedes, and 3- Santo Domingo.

Distribution (Fig. 5).—*E. rivularis* is known from montane streams at three localities on the north slope of Sierra Maestra (B. Masó municipality, Granma Province): Río Naguas, La Sierrita (90 m, type locality); Río Yara, Santo Domingo (240 m), and Río Jibacoa, Caney de Las Mercedes (80 m).

Natural History.—The new species occurs along streams with grassy margins. The primary vegetation along the streams is *Cyperus* sp. All localities from which the species is known have high human disturbance. Frogs began to call at dusk after 1800 h but one individual was heard in mid-morning. Males call mainly from river beaches of sand and pebbles, but also from emerging rocks. Distance among closest calling males was 1-4 m. While calling, males extend a small submandibular vocal sac, sometimes expanding onto the belly. A total of 18 specimens (12 calling males and 6 females) were collected within a 10 m^2 area. Most females have enlarged follicles or oviducal eggs on each side of body, at least in December and February. On February 23, 2000, a clutch of 42 eggs was found at Las Mercedes, 4 m from the edge of the Jibacoa river. Eggs were laid in an excavated hole (length - width 22.3 × 20.8 mm; depth, 14.3 mm) under a piece of cloth

and moss sheaths; the place received direct sunlight at midday. A single egg was moldy and dead. The nest temperature was 25 °C at 11:15 am. Egg diameter (measured in situ) was 4.2-4.6 mm ($\bar{x}$=4.4, N=11). Young hatched throughout the day and showed the same coloration, enlarged glands, and suprascapular fold of adults. Froglets hatched with a SVL of 5.0-5.6 ($\bar{x}$=5.2, N=7) mm and had a remnant tail, a single pointed egg tooth on the snout, and a prominent yolk reserve. Feces from five collected specimens contained spiders [Lycosidae (*Pirata* sp.), Tetragnathidae (*Tetragnatha laboriosa*)], ants, beetles (Tenebrionidae, Staphylinidae and undetermined taxa), flies, and sand (possibly swallowed with prey).

DISCUSSION

Eleutherodactylus rivularis is similar to *E. riparius* being a member of the riparian ecomorph (*sensu* Hedges, 1989) in Cuba (Estrada and Hedges, 1998). Besides the other diagnostic differences noted above for these two species, *E. riparius* is more variable in color pattern, with some mottled, striped, or almost plain colored individuals. Estrada and Hedges (1998) illustrated and noted call differences among some populations of *E. riparius*, including *E. rivularis*. Choruses of *E. riparius* begin and stop suddenly, while *E. rivularis* usually calls over longer periods of time. Preliminary osteological comparisons reveal that the frontoparietals of *E. riparius* are straight versus gradually expanded posteriorly in *E. rivularis*, and that *E. riparius* has two squarish posterior prootic processes which are absent in *E. rivularis* (Fig. 3).

Eleutherodactylus cuneatus and *E. turquinensis* comprise another pair of closely related (and sympatric) species with riparian habits. They differ from *E. rivularis* and *E. riparius* in being larger, in lacking a suprascapular fold (there are tubercles and a W-shaped dark pattern of pigmentation in many individuals), lacking enlarged glandular areas, having well developed digital discs, and in having a primarily single-note advertisement call emitted as a mew or whistle (Hedges et al., 1995, L.M.D., pers. obs.). *Eleutherodactylus turquinensis* has a small, inconspicuous, flattened vocal pouch which is absent in *E. cuneatus*.

Eleutherodactylus cuneatus is sympatric with *E. rivularis* at Santo Domingo (Río Yara) and with *E. riparius* at Cerro Las Tinajitas (Holguín Province), San Roman in Songo La Maya municipality (Guantánamo Province) and Arroyón, San Antonio del Sur (Guantánamo). In Granma Province, *E. riparius* is known from Manzanillo (about 96 Km NW of La Sierrita, type locality of *E. rivularis*) (Schwartz and Henderson, 1991; Estrada and Hedges, 1998).

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APPENDIX I
ADDITIONAL SPECIMENS EXAMINED

Eleutherodactylus riparius (N=36).—**Pinar del Río**: MNHNCu 672 (Holotype), Soroa, Candelaria, Sierra del Rosario; LMD 113 - 114, Caleta del Piojo, Península de Guanahacabibes; LMD 119, La Biajaca, Península de Guanahacabibes; MNHNCu 248 and 367, Río Taco-Taco, Rangel; MNHNCu 551-553, Resolladero del Río Majagua, Majagua-Cantera; MNHNCu 554, Resolladero del Río Majagua, Majagua-Cantera (cleared and stained); LMD 219-220, Cabrillas, Alturas Pizarrosas del Sur; CMST 42 - 49, El Cacho, Los Palacios; CMST 51 - 52, 56 - 57, 59 - 60, Estación Forestal, Viñales; CMST 208 - 219, "La Pastora", Consolación del Sur. **Ciudad de La Habana**: CMST 174 - 179, Río Quibú, Marianao; CMST 202 - 204, Parque Metropolitano, Boyeros. **Isla de la Juventud**: LMD 58, La Jungla de Jones; LMD 60-62, Los Indios. **Matanzas**: LMD 82 and 85, Canal de Soplillar, Los Hondones, Ciénaga de Zapata; LMD 200, Arroyo Corrales, 14 km E of Jaguey Grande. **Villa Clara**: MNHNCu 509, 510, 512, Río Jibacoa; MNHNCu 511, Río Jibacoa (cleared and stained). **Cienfuegos**: MNHNCu 527-529, Río Caonao, La Caleta, Cumanayagua. **Sancti Spíritus**: MNHNCu 480-483, 485, Río Ceibabo; LMD 93, Hotel Zaza. **Guantánamo**: LMD 195-198, San Roman, Songo La Maya; MNHNCu 326, Río Arroyón, San Antonio del Sur.