

A New Grass Frog from Pine Forests of Western Cuba, and Description of Acoustic and Pattern Variation in *Eleutherodactylus* *varleyi* (Amphibia: Leptodactylidae)

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ABSTRACT.—A new frog of the genus *Eleutherodactylus* is described from pine forests of Alturas de Pizarras del Sur, Province of Pinar del Río, Cuba. It is most closely related to the widely distributed Cuban species *E. varleyi* Dunn, with which it occurs sympatrically, but differs in several morphological and acoustic characters. Variation in the advertisement call and color pattern of *E. varleyi* are described.

INTRODUCTION

The small frog *Eleutherodactylus varleyi* is one of the most widespread anurans in Cuba. The species was described by Dunn (1925) from Soledad, now Jardín Botánico de Cienfuegos, and soon thereafter from other localities throughout the island (Dunn, 1926). Schwartz and Ogren (1956) gave additional information on its distribution and color variation. Schwartz and Henderson (1991) summarized the distributional range, description, and natural history of the species.

Hedges (1989) placed *E. varleyi* and *E. cubanus* Barbour within the *varleyi* group, but Hedges et al. (1995), Estrada and Hedges (1996), and Estrada and Alonso (1997), considered that *E. cubanus* belongs to the *limbatus* group. Schwartz (1958) described *E. phyzelus* from Pinar del Río, placing it within the *dimidiatus* group, but this taxon is considered a synonym of *E. varleyi* (Schwartz and Thomas, 1975; Garrido and Jaume, 1984; Schwartz and Henderson, 1991).

Specimens of *E. varleyi* collected and recorded throughout Cuba exhibit great intra- and inter-population variation in overall pattern and vocalizations. In 1998, an apparently differentiated population of grass frogs, closely related to *E. varleyi*, was

found in the pine forests of Alturas de Pizarras del Sur, Pinar del Río (western Cuba). Although several individuals were heard, only one was caught. At the same time, evidence that the new population occurred sympatrically with *E. varleyi* was obtained. In the summer of 2000, another collection of specimens led us to conclude that in this area *E. varleyi* coexists with an unnamed species inhabiting pinewoods. We describe herein the new taxon and provide additional comments on the acoustic and morphological variation in *E. varleyi*.

METHODS

Measurements were taken with calipers (0.05 mm accuracy) under a microscope and with an ocular micrometer. These abbreviations are used for external features: SVL, snout-vent length; HL, head length (measured from posterior edge of tympanum to snout tip); HW, head width (measured at widest point of head).

Frog calls were recorded with a Sony TCM 59V portable cassette recorder equipped with a Sony ECM 220 microphone, and a Sony WM-D6C cassette recorder with a Sennheiser ME 80 microphone (with amplifier K-3U). Calls were analyzed using Canary software version

1.2.4 (Charif et al., 1995). Signals were digitized at a sampling rate of 22.05 kHz and size of 16 bits. Spectrograms in figures were calculated with fast-Fourier transform (FFT) of 256 points and overlap= 50%, using Hanning windows. Terminology for call parameters follows Duellman and Trueb (1986).

Specimens for skeletal examination were cleared and double stained with Alizarin Red S and Alcian Blue, following Dingerkus and Uhler (1977) for bones and cartilages. Drawings were made using a camera lucida. Museum and other zoological collection acronyms are: MNHNCu, Museo Nacional de Historia Natural de Cuba, Ciudad de La Habana; LMD, field number series of Luis M. Díaz (specimens available at MNHNCu); BSC.H, Herpetological Collection of BIOECO, Museo "Tomás Romay" of Santiago de Cuba, Cuba; MHNH, Museo de Historia Natural "Carlos de La Torre y Huerta" of Holguín, Cuba; CZACC, collection of the Instituto de Ecología y Sistemática (IES), Ciudad de La Habana, Cuba; USNM, U. S. National Museum of Natural History (Smithsonian Institution), Washington D.C.; AMNH, American Museum of Natural History, New York.

Eleutherodactylus adelus, new species

Figs. 1–5

Holotype.—MNHNCu 874 (original field number LMD 224), adult male from Loma del Espejo, Alturas de Pizarras del Sur, Sabanas Llanas, km 41 Carretera de Luis Lazo, 130 m a.s.l., Pinar del Río (about 8 km W Sumidero). Collected by Luis M. Díaz and Antonio Cádiz in August 3, 2000.

Paratopotypes (n = 14).—Males: MNHNCu 877, MHNH 20, and USNM 556156, collected by Luis M. Díaz, Antonio Cádiz and Renier Morejón in July 15–17, 2000; BSC.H 5660, MNHNCu 879–880 (both cleared and stained), and CZACC 5700 with the same data as holotype; MNHNCu 875, collected by Luis M. Díaz in September 6, 1998. Females: MNHNCu 883 and 884 (cleared and stained), USNM 556155, collected by Luis M. Díaz, Antonio Cádiz and Renier Morejón in July 15–17, 2000. Juveniles: MNHNCu 885, with same data as females; MNHNCu 881 and 878 with same data as holotype.

Diagnosis.—A small frog of the subgenus *Euhyas* (*sensu* Hedges, 1989), most closely related to *Eleutherodactylus varleyi*. Both species occur sympatrically, and share a partially areolate venter becoming gradu-

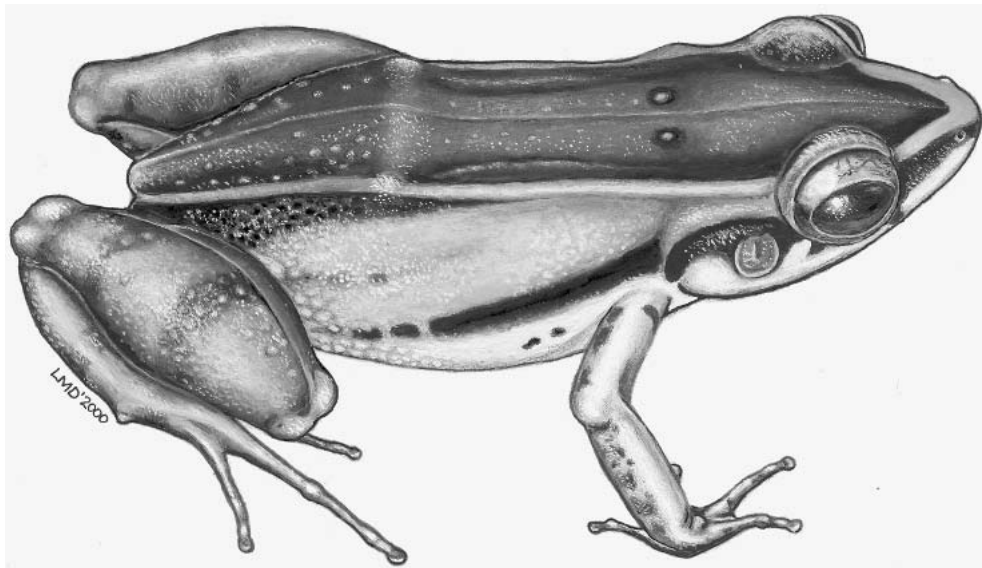


FIG. 1. *Eleutherodactylus adelus* (holotype).

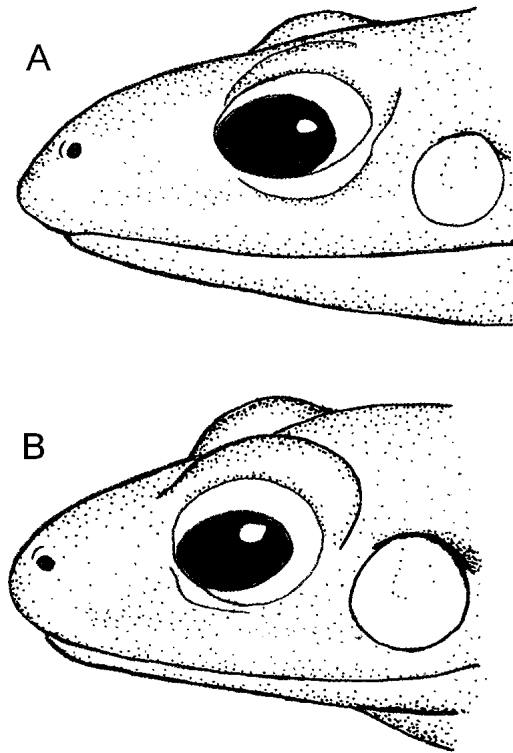


FIG. 2. Snout profile of *Eleutherodactylus adelus* (A) and *E. varleyi* (B). Based on specimens MNHNCu 883 and LMD 241, respectively.

ally smooth toward chest, small digital discs, vomerine odontophores reduced, dorsum with defined folds and tubercles, small glandular areas, small clutch size [three to four eggs in the new species; four in *E. varleyi* (Estrada, 1987)], and terrestrial habits. *Eleutherodactylus adelus* tends to be smaller than *E. varleyi* (mean SVL 11.4 mm males, 14.5 mm females in *E. adelus*; 13.4 mm males, 16.8 mm females in *E. varleyi*; Table 1); has the invariant typical pattern illustrated in Fig. 1; its habitus is more stylized, and its snout has a slightly more acute profile (Fig. 2); a pair of paravertebral folds are extended at middorsum (Fig. 3), which are absent in *E. varleyi*; the alary processes of the hyoid plate are at right angles to sagittal plane while in *E. varleyi* they are angled 40–50° (Fig. 4); advertisement calls are series of chirps uttered in complex assemblages instead of the typical calls of one or two notes of *E. varleyi* (Figs. 5–6).

Description.—Head longer than wide and as wide as or narrower than body, length 40% (37.8–41.7) of SVL in males and 38% (37.8–38.3) in females; snout subacuminate in dorsal view and subacuminate to nearly acute in profile, overlapping lower jaw; snout length 43% (39.3–46.6) of head length in males and 42% (38.7–48.3) in females; nostrils barely protuberant, directed laterally; canthus rostralis rounded and straight in dorsal view; loreal region nearly flat or slightly concave, sloping gradually; lips not flared; interorbital distance 1–2 times width of upper eyelid; no interorbital tubercles; upper eyelid with flat rounded tubercles; tympanum superficial, with distinct annulus, 49% (41.5–58.6) of eye diameter in males, and 52% (50.0–55.5) in females, slightly concealed dorsally by a low supratympanic fold, and separated from eye by a distance equivalent to 24% (12.0–35.0) of own diameter in males and 49% (44.4–52.6) in females; large postrectal tubercles; choanae small, round, not concealed by palatal shelf of maxillary arch; vomerine odontophores short, widely separated and moderately arched, with series of 5–9 barely projected teeth; tongue oval, not notched behind, posterior 1/2 to 3/4 not adherent to floor of mouth; males with sublingual slits; external vocal sac apparently absent.

Skin of dorsum tuberculate, with many tubercles arranged in dorsal and dorsolateral rows; two paravertebral folds at center of dorsum (Figs. 1 and 3); small glandular areas (supraxillary, inguinal, and postfemorals); skin on flanks areolate; skin over tympanic fold with some small tubercles, and thickened; skin of venter areolate, becoming smooth toward chest and throat; discoidal folds evident; anal opening not extended in sheath; ulnar tubercle present, smaller than palmar and thenar tubercles (Fig. 7); palmar tubercle enlarged, rounded, about 2x larger or subequal to thenar; thenar tubercle oval, elevated; supernumerary palmar tubercles present; subarticular tubercles of fingers rounded; lateral ridges on fingers absent; finger length III > IV > II > I; digital discs small, third disc 26% (18.2–42.1) of tympanum width; hands 20%

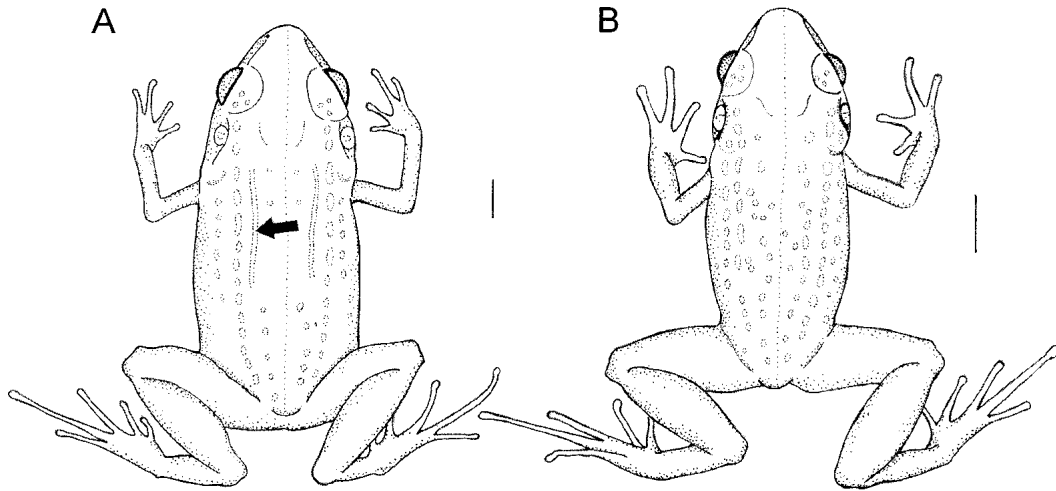


FIG. 3. Dorsal arrangement of tubercles and folds in *Eleutherodactylus adelus* (A) and *E. varleyi* (B). The arrow indicates the paravertebral folds in the new species. Based on black and white photographs of specimens MNHNCu 883 and LMD 231, respectively. Scale bars = 2 mm.

(16.5–22.4) of SVL in males, and 21% (19.2–22.6) in females; heel with small, faint, low tubercles; inner metatarsal tubercle enlarged, subconical and without keel; supernumerary tubercles small and low; subar-

ticular tubercles of toes nearly rounded, some bifid on distal phalanges of third and fourth toes (Fig. 7); palmar and plantar tubercles with light punctuations; toes without lateral ridges; circumferential groove

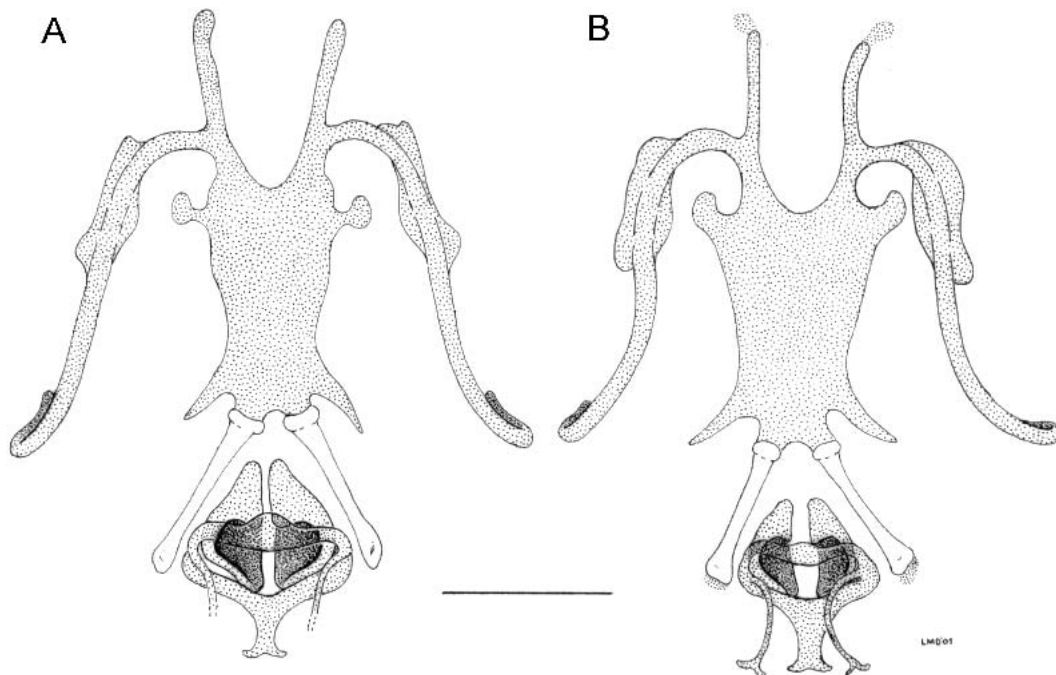


FIG. 4. Hyolaringeal skeleton of (A) *Eleutherodactylus adelus* (MNHNCu 879, and (B) *E. varleyi* (LMD 264).

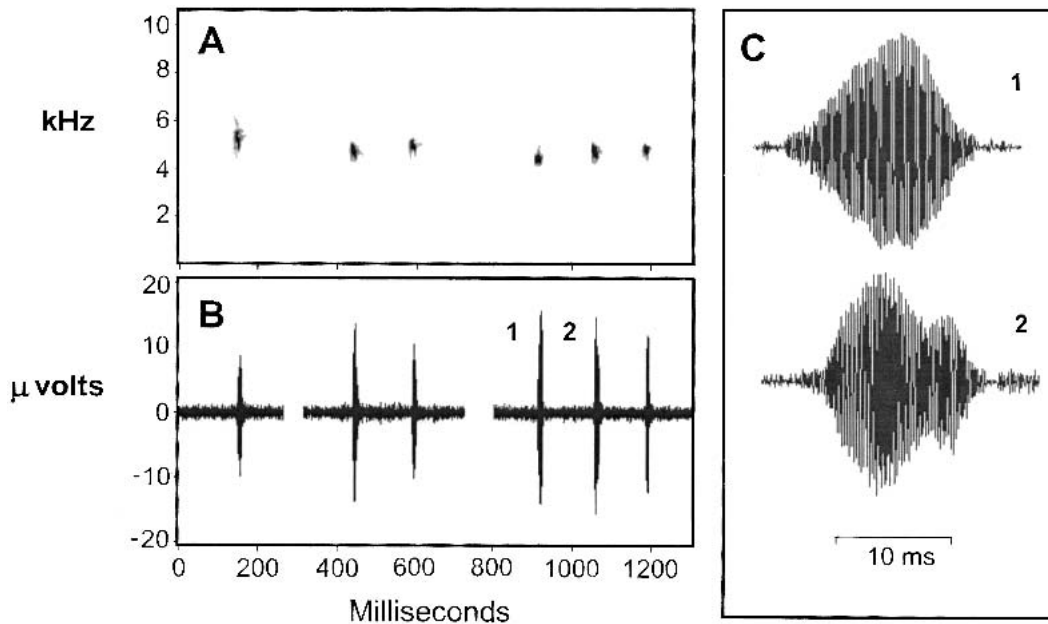


FIG. 5. Spectrogram (A) and waveform (B) of three consecutive different calls of *Eleutherodactylus adelus* (single, two, and three note calls). Gaps in the waveform are unrecorded breaks between different calls. (C) First (1) and second (2) notes of the third call in B, showing amplitude modulation pattern of each signal in more detail. Air temperature was approximately 25° C.

bordering distal 2/3 of toe pad; heels overlap when flexed legs are held at right angles to sagittal plane; toe length $IV > III > V > II > I$. Measurements are summarized in Table 1.

Color in life: Dorsum with a wide longitudinal dark-bordered brown zone that becomes narrow and pointed toward snout and is outlined by narrow light stripes; a suprainguinal black stripe borders light margins of dorsal zone in posterior half of body; two shallow suprascapular tubercles frequently light colored; flanks contrasting light grayish tan, sometimes with a slight green or reddish wash; loreals with a black stripe surrounding snout tip; supratympanic fold conspicuously emphasized in black and followed on flanks by a large black diagonal stripe; postrictal zone light; extremities with moderate to faint brown cross bars; forearms reddish brown; belly greenish or flesh-colored; several specimens with scattered dots on throat, belly and ventral surface of thighs; iris coppery brown above and dark below.

Color in alcohol: Gray and brownish with typical pattern of black stripes.

Osteology: Description is based on two males (MNHNCu 879 and 880) and one female (MNHNCu 884). Dorsal and ventral views of skull as in Fig. 8. Skull longer than wide. Nasals well developed, closer anteriorly, separated posteriorly and with sharpened lateral processes; weak contact among nasals and frontoparietals; pars facialis of maxilla low; pars palatina of premaxillae indented, pars dorsalis almost vertical; vomers well developed and separated medially, bearing dentigerous processes and partially enclosing choanae; squamosal slender, otic ramus about 5x longer than zygomatic ramus; squamosomaxillary angle 50°; prootics well ossified, cristae paroticae short and broad, narrowly separated from squamosal; columella visible dorsally; parasphenoid alae poorly expanded and not contacting the median, short rami of pterygoids; parasphenoid alae posteriorly deflected about 105° with respect to cultriform process, which is long and irregularly

TABLE 1. Variation of some measurements (in mm) of *Eleutherodactylus adelus*. Values are $\bar{x} \pm$ SD.

Characters	<i>Eleutherodactylus adelus</i>			<i>Eleutherodactylus varleyi</i>	
	Males (n = 10)	Females (n = 4)	Holotype (Male)	Males (n = 36)	Females (n = 3)
Snout-vent length	11.44 ± 0.442	14.53 ± 0.967	12.15	13.36 ± 1.338	16.77 ± 3.522
Head width	4.17 ± 0.153	4.82 ± 0.437	4.40	4.76 ± 0.574	5.48 ± 1.200
Head length	4.62 ± 0.199	5.53 ± 0.404	4.90	4.73 ± 0.471	5.57 ± 0.939
Snout length	1.97 ± 0.106	2.33 ± 0.491	2.00	1.99 ± 0.231	2.57 ± 0.506
Upper eyelid width	0.85 ± 0.115	1.03 ± 0.104	1.05	1.05 ± 0.137	1.13 ± 0.058
Interocular distance	1.38 ± 0.148	1.73 ± 0.252	1.40	1.43 ± 0.177	1.63 ± 0.351
Tympanum width	1.14 ± 0.109	0.95 ± 0.050	1.30	0.94 ± 0.254	0.75 ± 0.071
Tympanum height	1.06 ± 0.100	1.05 ± 0.087	1.10	1.01 ± 0.243	1.02 ± 0.035
Internarial distance	1.32 ± 0.140	1.63 ± 0.189	1.45	1.23 ± 0.134	1.27 ± 0.035
Thigh length	4.92 ± 0.232	6.28 ± 0.535	4.70	5.54 ± 0.532	5.97 ± 0.701
Shank length	5.31 ± 0.213	7.10 ± 0.132	5.40	5.83 ± 0.476	6.58 ± 0.777
Tarsal length	3.46 ± 0.222	4.65 ± 0.218	3.40	3.83 ± 0.353	4.32 ± 0.653
Foot length	5.70 ± 0.472	6.65 ± 0.180	5.30	5.67 ± 0.691	6.67 ± 0.797
Hand length	2.29 ± 0.158	3.02 ± 0.126	2.00	2.81 ± 0.379	3.35 ± 0.361
Eye-tympanum distance	0.27 ± 0.079	0.47 ± 0.058	0.35	0.41 ± 0.182	0.40 ± 0.000
Eye diameter	1.51 ± 0.127	1.83 ± 0.058	1.45	1.69 ± 0.182	1.87 ± 0.106
Eye-naris distance	1.12 ± 0.071	1.43 ± 0.189	1.20	1.28 ± 0.164	1.47 ± 0.106
Fingertip (III) width	0.27 ± 0.042	0.33 ± 0.058	0.30	0.30 ± 0.072	0.35 ± 0.000
Toetip (IV) width	0.34 ± 0.083	0.38 ± 0.058	0.40	0.35 ± 0.073	0.37 ± 0.106

truncated at level of palatines; phalangeal formula of hand and foot 3,3,4,4 and 3,3,4,5,4; terminal T-shaped phalanges of fingers and toes very short but well expanded laterally; transverse processes of vertebrae unequal: III > IV > II > V ≈ VI ≈ VII ≈ VIII; sacral diapophyses barely dilated; sacrococcygeal articulation bicondylar.

Hyolaringeal skeleton (Fig. 4): hyoid plate more expanded anteriorly; each hyale bearing one slender anterior process; alary processes short and slightly expanded; posterolateral processes sharpened and directed below; bony posteromedial processes elongated; crycoid cartilage complete and dilated ventrally; arytenoid cartilages well separated. Pectoral girdle aciferal, epicoracoids freely overlap.

Vocalization (Fig. 5).—Advertisement calls a series of soft chirps. Chirps (3 to 6 notes) uttered in complex assemblages; one or two note calls more sporadic but always preceding chirps. Call rate 20.6–65.2 (\bar{x} = 46.9, n = 3) per min. Intensity of successive calls variable but following a somewhat predictable pattern. Dominant frequency

(= fundamental): 4.4–5.4 (\bar{x} = 4.8, n = 17) kHz; single note calls usually higher pitched, 5.0–6.3 (\bar{x} = 5.6, n = 3) kHz; notes varying from descendant frequency modulation to no modulation; individual notes generally at slightly different levels of frequency, 4.1 to 5.7 kHz. No harmonic structure. Call durations: single note calls 9.1–14.2 (\bar{x} = 11.6, n = 3) milliseconds; two note calls 143.0–223.5 (\bar{x} = 170.4, n = 7) milliseconds; and three to six note calls 235.7–682.0 (\bar{x} = 383.1, n = 10) milliseconds. Notes duration 5.7–18.2 (\bar{x} = 12.2, n = 51) milliseconds. Note repetition rate 8.8–13.9 (\bar{x} = 10.8, n = 17) per second, note interval 105.2–168.2 (\bar{x} = 137.7, n = 34) milliseconds. Each note modulated, beginning and ending less intense as in mid-note; notes single pulsed or weakly divided in two incomplete pulses (Fig. 5C).

Calling males could not be collected; three individuals were recorded but many were heard, always with the same call pattern. Frogs called during the day and sporadically throughout the night in July and August, being very active after rain. In October 2001 the species called only just after sundown.

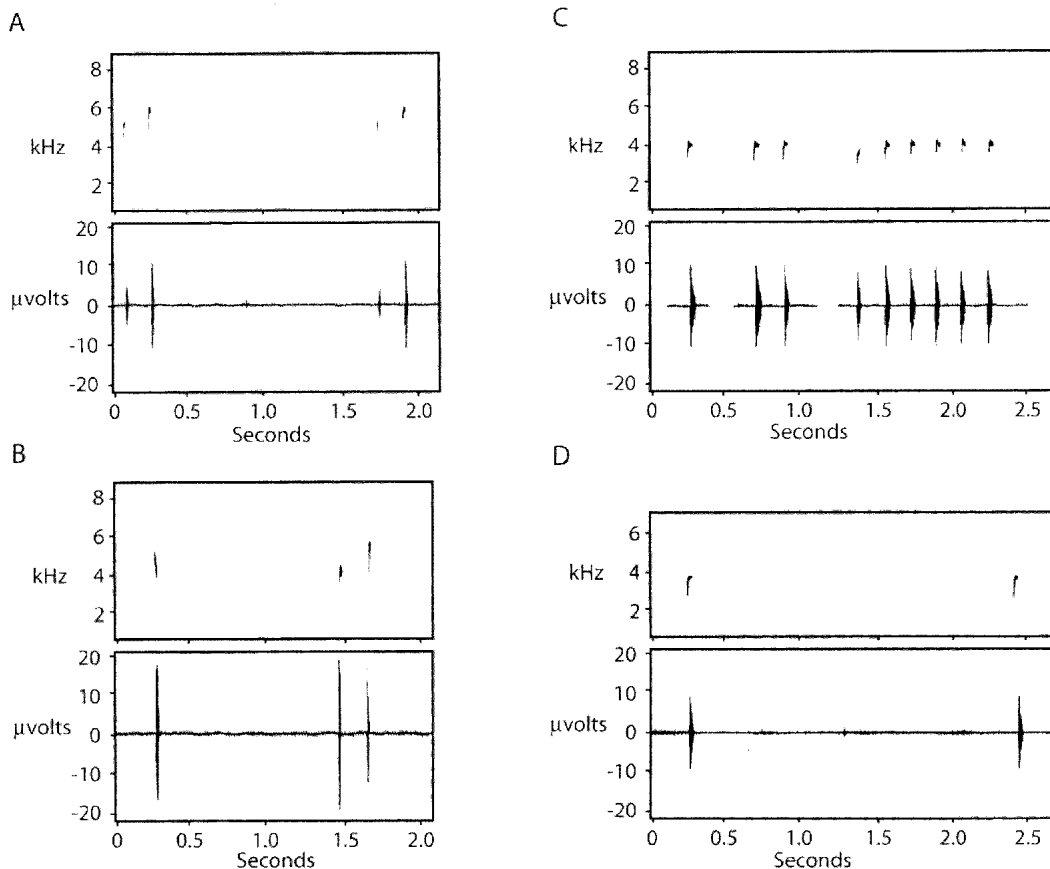


FIG. 6. Spectrograms (above) and waveforms (below) of advertisement calls of *Eleutherodactylus varleyi* from several localities. (A) Jardín Botánico de Cienfuegos (one and two note calls; LMD 269; air temperature, 23°C); (B) Sabanas Llanas, Alturas de Pizarras del Sur, Pinar del Río (one and two note calls; voucher specimen LMD 231; air temperature, 22.5°C); (C) Surroundings of Hotel Zaza, Sancti Spiritus (one, two, and multinote calls; LMD 92; air temperature, 23–24°C); (D) El Muerto, 3 km S of Alegría de Pío, Cabo Cruz, Granma (one note calls; no voucher or temperature data). Gaps in the waveform are unrecorded breaks between different calls.

Distribution (Fig.9).—Known only from the type locality, but it may be common in the pine forests of Alturas de Pizarras del Sur, Pinar del Río Province.

Etymology.—The specific name derives from the Greek word *adelos*, meaning concealed, in allusion to the secretive habits of this frog, which immediately stops calling when approached.

Natural History.—*Eleutherodactylus adelus* occurs in forests of *Pinus tropicalis*. Herbaceous vegetation in this habitat is primarily composed of *Lycopodiella* sp., ferns (*Pteris* sp.), and grass (*Eleocharis* sp.). Soil is acidic and derived from sandstone. The

specimens were collected on the ground after removing the covering vegetation and leaf litter layer. A clutch with three developing eggs (measuring 4.7–5.3 mm) was found directly on the ground, attached to another apparently just-hatched clutch of four eggs (only jelly envelopes remained). An embryo in developmental stage 8 of Townsend and Stewart (1985) hatched in 10 days. Hatchlings measured 3.7–3.8 mm SVL, had a small remnant tail, a yolk reserve (observed through the belly skin), and one egg tooth at the tip of the snout. Overall pattern and color of neonates was almost identical to that of adults.

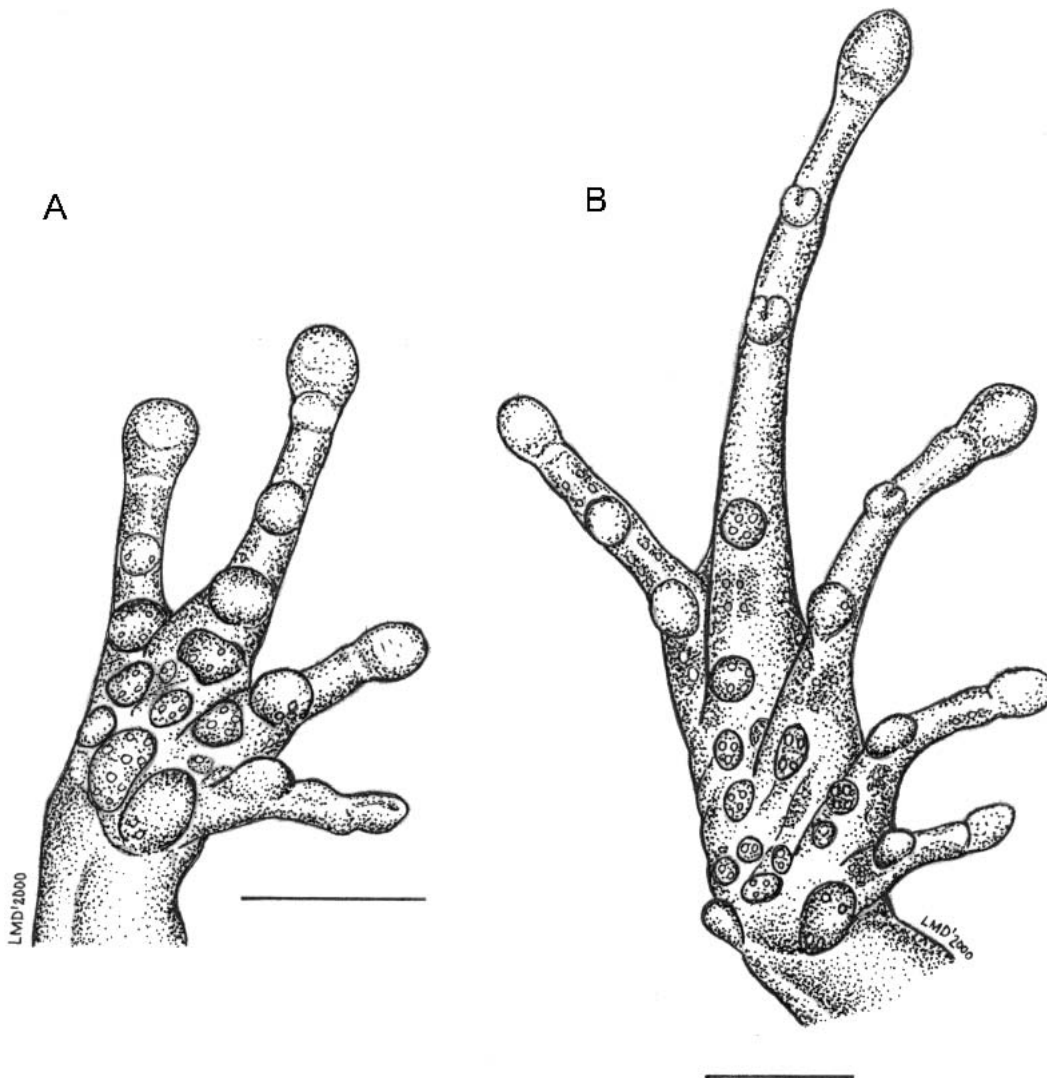


FIG. 7. Hand (A) and foot (B) of *Eleutherodactylus adelus* (MNHNCu 883), in ventral view. Scale bars = 1 mm.

The following anurans occur with *E. adelus*: *Bufo* (*Peltophryne*) *fustiger* Schwartz, *B. longinasus longinasus* (Stejneger), *Eleutherodactylus auriculatus* (Cope), *E. atkinsi atkinsi* Dunn, *E. eileenae* Dunn, *E. goini* Schwartz, *E. planirostris* (Cope), *E. riparius* Estrada and Hedges, *E. varleyi* Dunn, *E. zugii zugii* Schwartz, *Osteopilus septentrionalis* (Duméril and Bibron), and *Rana catesbeiana* Shaw.

DISCUSSION

Eleutherodactylus adelus and *E. varleyi* are sympatric at the type locality, where individuals of both species were collected a few

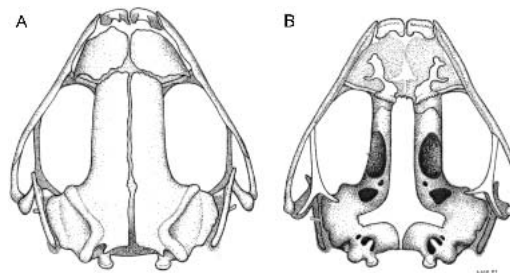


FIG. 8. Skull of *Eleutherodactylus adelus* (MNHNCu 879) in dorsal (A) and ventral (B) views. Scale bar = 1 mm.

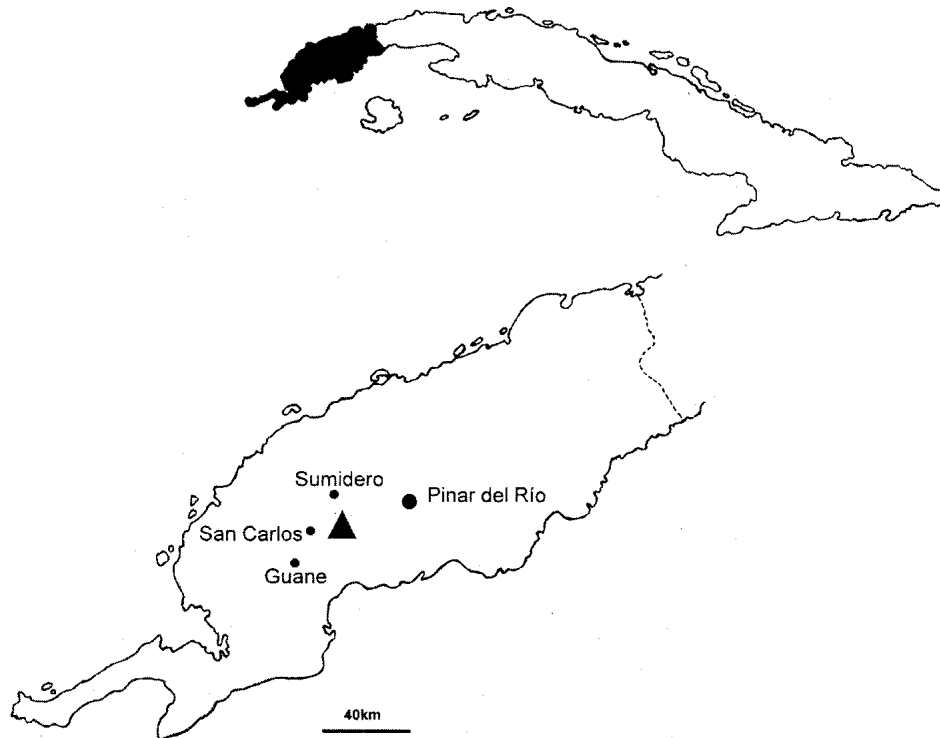


FIG. 9. Distribution of *Eleutherodactylus adelus* (black triangle) in western Cuba.

meters apart. The two species seemed to vocalize at different times: *E. adelus* was primarily diurnal (heard sporadically during night) while *E. varleyi* was more nocturnal. Calling sites also appeared to differ: *E. varleyi* called from grass or low plant leaves, often in an exposed position, while *E. adelus* called from concealed locations under leaf litter and grass.

Eleutherodactylus varleyi shows geographic call variation (Fig. 6) but its call has not been adequately described. We have noted two typical patterns of advertisement calls. The first pattern comprises relatively soft calls of two notes ("tuc-tic") broadcast at different levels of frequency (see Table 2); the average note difference in frequency is 0.68 ± 0.320 kHz ($\bar{x} \pm SD$) for individuals from Sabanas Llanas, Pinar del Río, and 1.12 ± 0.399 kHz for individuals from Jardín Botánico de Cienfuegos; usually, the second note has an ascendant frequency modulation, while the first may be indistinctly "inverted U-shaped", descen-

dant or ascendant modulated (not shown); note interval is 118.3–216.9 ms; single note calls are also emitted, but at a lower rate, having indistinctly lower (3.6–3.9 kHz) or higher (4.5–5.8 kHz) frequency values. Calls with three to four notes are inserted sporadically, possibly carrying a territorial message, or the two-note calls are produced in groups frequently introduced by single notes. The interval between calls is 0.8–8.4 s. This call pattern was recorded or heard by us at Sabanas Llanas (Pinar del Río Province), Soroa (Pinar del Río), La Habana Province, Los Hondones in Ciénaga de Zapata (Matanzas), Jardín Botánico de Cienfuegos (the type locality of *E. varleyi*) and Rolo Monterrey, Moa (Holguín). The second pattern consists of loud, more metallic calls ("pic"), composed primarily by single notes, sometimes two. There are also sporadic trains with 3–7 notes (possibly territorial calls). In the two note calls, the first note has a lower dominant frequency (3.7–4.0 kHz) than the second (4.0–4.1 kHz);

TABLE 2. Variation of some acoustic parameters in *Eleutherodactylus varleyi*. Values are ranges; mode (notes per call) or means and sample sizes are in parentheses. Roman numeral indicates note number.

Population	Notes per call	Call duration (ms)	Note rate (notes/second)	Call rate (calls/minute)	Dominant frequency (kHz)
Pinar del Rio: Sabanas Llanas.	1-3 (2)	I: 18.3-25.3 (21.5, n = 8) II: 190-232 (203, n = 13) III: 295-316 (306, n = 2)	8.6-12.5 (9.9, n = 15)	16.8-21.5 (n = 2)	I: 3.8-5.1 (4.5, n = 8) II: 4.9-5.6 (5.2, n = 13)
Cienfuegos: Jardín Botánico (type locality).	1-2 (2)	I: 13.1-22.8 (19.3, n = 3) II: 172-235 (204, n = 26)	8.5-11.6 (9.8, n = 26)	13.8-24.1 (18.7, n = 3)	I: 3.9-5.5 (4.5, n = 3) II: 3.9-5.9 (5.6, n = 26)
Sancti Spiritus: Hotel Zaza.	1-7 (1)	I: 31.7-37.0 (35.0, n = 8) II: 218-252 (232, n = 4) VI-VII: 872-1100 (990, n = 5)	5.4-9.2 (7.4, n = 13)	36.8-38.5 (n = 2)	I: 3.4-4.1 (3.9, n = 7)
Granma: Cabo Cruz.	1-3 (1)	I: 20.7-33.7 (27.7, n = 20) II-III: 242-578 (345, n = 8)	5.2-9.1 (7.1, n = 8)	23.6-38.9 (30.6, n = 3)	I: 3.5-4.1 (3.8, n = 19)
Santiago de Cuba: Airport.	1	I: 9.1-22.7 (16.6, n = 10)	Not applicable	41.7 (n = 1)	I: 3.3-3.6 (3.5, n = 10)
Guantánamo: San Rafael, Yateras.	1-2 (1)	I: 16.4-34.8 (28.5, n = 26) II: 242-278 (259, n = 4)	7.2-8.2 (7.7, n = 4)	23.3-35.4 (n = 2)	I: 3.5-3.8 (3.7, n = 10)

notes of very long calls (lasting about 1 s), as emitted by frogs from Hotel Zaza in Sancti Spiritus Province, are at different levels of frequency, beginning lower (3.3–3.4 kHz) and rising up to 4.2 kHz (Fig. 6C); average note difference in frequency 0.33 ± 0.293 kHz in males from Zaza, Sancti Spiritus, and 0.26 ± 0.069 kHz in those from Yateras, Guantánamo; notes interval 160.4–295.6 ms. Each signal has a fast rising “hook-shaped” or “inverted L-shaped” patterns of frequency modulation (not shown). Call interval is 1.1–4.7 s. Frogs with this type of call have been heard or recorded by us at Corralillo (Villa Clara Province), surroundings of Hotel Zaza (Sancti Spiritus), Sierra de Cubitas, Najasa (Camagüey), Cabo Cruz (Granma), Manzanillo (Granma), surroundings of the Santiago de Cuba City, La Gran Piedra

(Santiago de Cuba), and Yateras (Guantánamo).

Choruses of these call patterns sound quite different, so it is probable that other cryptic species remain under the name of *E. varleyi*. Audiospectrograms and waveforms of different calls at several localities are shown in Fig. 6. Variations of some temporal and spectral call parameters of *E. varleyi* are summarized in Table 2.

Eleutherodactylus varleyi shows great intra- and inter-population color pattern variation (Fig. 10) compared to the typical and diagnostic pattern of *E. adelus*. Most populations of *E. varleyi* are polymorphic regarding color pattern while others are relatively homogeneous. The color patterns illustrated in Fig. 10 were the most representative in the series (see Appendix I). Specimens collected sympatrically

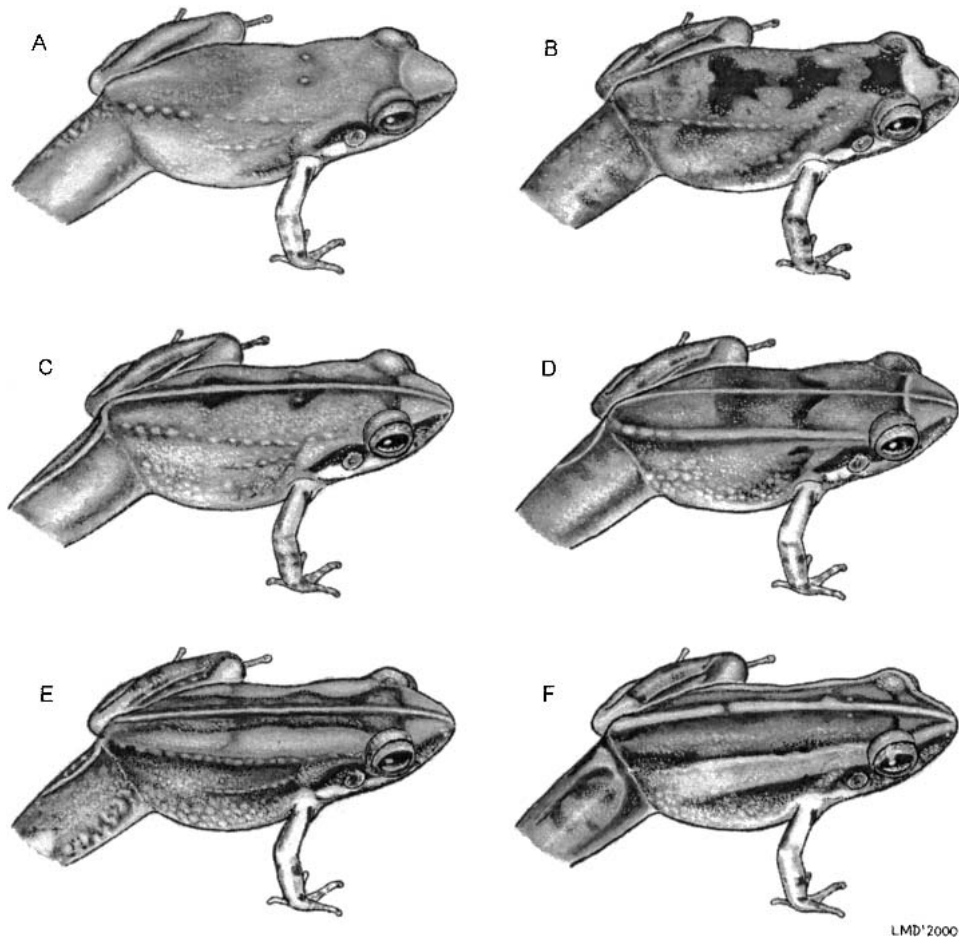


FIG. 10. Representation of different patterns of *Eleutherodactylus varleyi*. Voucher specimens are in parentheses (see their localities in Appendix I). (A) Barely evident suprascapular chevron and a "diamond-like" blotch at middorsum (LMD 231); (B) Contrasting dark triangular or "diamond-like" blotches on dorsum, shades of different colors and a conspicuous interorbital figure (LMD 233); (C) Dark bordered vertebral hairline (LMD 259); (D) Dorsolateral narrow stripes, suprascapular chevron and "diamond-like" or squarish blotch at middorsum (LMD 270); (E) Broad paravertebral light stripes and a vertebral hairline, flanks darken (LMD 240); (F) A vertebral light stripe, pale lateral zones and dark underflanks (LMD 249).

with *E. adelus* have patterns A and E (Fig. 10). Overall body coloration is light greenish brown, gray, tan, and grayish brown to dark brown; some individuals have a reddish wash; flanks may be distinctively darker than dorsum in individuals with pattern E, sometimes with a greenish or purplish wash. Stripes may be tan colored, light reddish-brown or orange-brown. Inguinal glandular areas are frequently green, yellow, or orange. Extremities may be cross-banded. Thighs are vividly orange only in specimens from

Mil Cumbres, Sierra del Rosario, Pinar del Río Province (voucher specimen LMD 432).

Schwartz (1958) illustrated the holotype of *Eleutherodactylus phyzelus* (= *E. varleyi*), which is quite similar to pattern E of our Fig. 10. One of us (SBH) examined this specimen and determined that it has most of external characters and proportions of typical *E. varleyi*, justifying the continued recognition of *E. phyzelus* as a synonym of *E. varleyi*. Therefore, *E. adelus* is not a synonym of *E. phyzelus*.

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LITERATURE CITED

- Charif, R. A., S. Mitchell, and C. W. Clark. 1995. *Canary 1.2 User's Manual*. Cornell Laboratory of Ornithology, Ithaca, New York, 229 pp.
- Dingerkus, G., and L. D. Uhler. 1977. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. *Stain Tech.* 52:229–232.
- Duellman, W., and L. Trueb. 1986. *Biology of Amphibians*. McGraw-Hill, New York, N. Y., 670 pp.
- Dunn, E. R. 1925. New frogs from Cuba. *Occ. Pap. Boston Soc. Nat. Hist.* 5:163–164.
- Dunn, E. R. 1926. Additional frogs from Cuba. *Occ. Pap. Boston Soc. Nat. Hist.* 5:209–215.
- Estrada, A. R. 1987. Los nidos terrestres de dos especies de anfibios cubanos del género *Eleutherodactylus* (Anura: Leptodactylidae). *Poeyana* (352):1–9.
- Estrada, A. R., and R. Alonso. 1997. Nueva especie del grupo *limbatus* (Leptodactylidae: *Eleutherodactylus*) de la región oriental de Cuba. *Carib. J. Sci.* 33:41–44.
- Estrada, A., and S. B. Hedges. 1996. At the lower size limit in tetrapods. A new diminutive frog of the genus *Eleutherodactylus* from Cuba (Anura: Leptodactylidae). *Copeia* 1996:852–859.
- Garrido, O. H., and M. L. Jaume. 1984. Catálogo descriptivo de los anfibios y reptiles de Cuba. Doñana, *Acta Vert.* 11(2):5–128.
- Hedges, S. B. 1989. Evolution and biogeography of West Indian frogs of the genus *Eleutherodactylus*; slow evolving loci and the major groups. In C. A. Woods (Ed.), *Biogeography of the West Indies: Past, Present and Future*, pp. 305–370, Sandhill Crane Press, Gainesville, Florida.
- Hedges, S. B., L. González, and A. R. Estrada. 1995. Rediscovery of the Cuban frogs *Eleutherodactylus cubanus* and *Eleutherodactylus turquinensis* (Anura: Leptodactylidae). *Carib. J. Sci.* 31:327–332.
- Schwartz, A. 1958. Four new frogs of the genus *Eleutherodactylus* (Anura: Leptodactylidae) from Cuba. *Amer. Mus. Novitates* (1873):1–20.
- Schwartz, A. and L. H. Ogren. 1956. A collection of Reptiles and Amphibians from Cuba, with descriptions of two new forms. *Herpetologica* 12:94.
- Schwartz, A., and R. Henderson. 1991. *Amphibians and Reptiles of The West Indies: Descriptions, Distributions and Natural History*. University of Florida Press, Gainesville, Florida, 720 pp.
- Schwartz, A., and R. Thomas. 1975. A check-list of West Indian Amphibians and Reptiles. *Carnegie Mus. Nat. Hist. Spec. Publ.* 1:1–216.
- Townsend, D. S., and M. M. Stewart. 1985. Direct development in *Eleutherodactylus coqui* (Anura: Leptodactylidae): a staging table. *Copeia* 1985:423–436.

APPENDIX 1. ADDITIONAL SPECIMENS EXAMINED

Eleutherodactylus varleyi (n = 87).—**Pinar del Río:** LMD 231, 232, 240–245 (242 and 244, are cleared and stained specimens), Sabanas Llanas, Alturas de Pizarras del Sur; MNHNCu 613, Cueva Cheta, Majagua Canteras; LMD 432, Mil Cumbres, Sierra del Rosario. **La Habana:** MNHNCu 250, Madruga; LMD 276–278, Peñas Blancas. **Ciudad de La Habana:** CZACC jar 309 (a single specimen without number), Atabey, Playa. **Isla de la Juventud:** LMD 249 and 250, Río Itabo, Los Indios; CZACC jar 311 (18 specimens without individual numbers), Hotel Colony, Siguanea. **Villa Clara:** LMD 246, Pueblo de Corralillo; LMD 247 and 248, Placetas. **Cienfuegos:** LMD 251–269 (254, 258, 261, and 264, are cleared and stained specimens), Jardín Botánico de Cienfuegos. **Sancti Spiritus:** LMD 90, 92, 97 and 98, surroundings of Hotel Zaza. **Camagüey:** LMD 6, 9 and 10, Hoyo de Bonet, Sierra de Cubitas; BSC.H 2370–71, Las Cruces, 6 km ESE of Ciudad de Camagüey.

Guantánamo: MNHNCu 329, La Muni-
ción; MNHNCu 330, Arroyón, San Antonio
del Sur; LMD 270–272, San Rafael, Yateras;
LMD 408–411, Piedra La Vela, Ojito de
Agua, Yateras. **Santiago de Cuba:** LMD
273–274, surroundings of the Airport of
Santiago de Cuba; LMD 310–312, 392, La
Gran Piedra; BSC.H 2349, El Olimpo, 4.5
km WNW of La Gran Piedra; BSC.H 2476–
80, La Tabla, Tercer Frente, Sierra Maestra.
Granma: BSC.H 659, Alegría de Pío,
Niquero, Cabo Cruz; LMD 233, Margins of
Río Jiguaní, Jiguaní.

Eleutherodactylus phyzelus (= *E. varleyi*):
AMNH 59832 (Holotype), 4.4 miles NE of
San Vicente, Pinar del Río Province.