

konid lizards *Hemidactylus mabouia* and *H. turcicus* (but see Powell et al., 1998) and the turtle *Pelusios subniger*.

Today in the West Indies, inter-island and continent-to-island travel is intense. Airplanes and ships arrive daily from all over the world, but primarily from the USA and, more specifically, from southern Florida. Specifically associated with tourism-related development is the importation of ornamental plants and, concurrently (intentional or not), the wildlife associated with those plants. Recent examples of herpetological introductions, all presumably from Florida, include the snakes *Elaphe guttata* on Grand Cayman (Franz et al. 1987) and *Thamnophis sauritus* and *T. sirtalis* in the Bahamas (Buckner and Franz, 1998a, b), the lizard *Anolis carolinensis* in Anguilla (Eaton et al., in press), and the treefrog discussed herein. Inevitably, some exotic species are established, and a subset of those become epidemic, dramatically altering the composition of an island's flora or fauna, almost always to the detriment of at least some native species.

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LITERATURE CITED

- Buckner, S. D., and R. Franz. 1998a. *Thamnophis sauritus sackenii*. Geographic distribution. Herpetol. Rev. 29:55.
- Buckner, S. D., and R. Franz. 1998b. *Thamnophis sirtalis sirtalis*. Geographic distribution. Herpetol. Rev. 29:55.
- Censky, E. J. 1988. *Geochelone carbonaria* (Reptilia: Testudines) in the West Indies. Florida Sci. 50:108-114.
- Censky, E. J. 1989. *Eleutherodactylus johnstonei* (Saliencia: Leptodactylidae) from Anguilla, West Indies. Carib. J. Sci. 25:229-230.
- Daltry, J. C. 1998. The Anguillian Racer (*Alsophis rijkersmaii*): Findings of the Project Development Visit, April 1998. FFI Carib. Prog., Cambridge, UK. 52 pp.
- Eaton, J. M., K. G. Howard, and R. Powell. In press. *Anolis carolinensis*. Geographic distribution. Herpetol. Rev.
- Franz, R., G. S. Morgan, and J. E. Davies. 1987. Some recent introduction of reptiles in the Cayman Islands, West Indies. Herpetol. Rev. 18:10-11.
- Lazell, J. D., Jr. 1973. The lizard genus *Iguana* in the Lesser Antilles. Bull. Mus. Comp. Zool. 145:1-28.
- MacLean, W. P. 1982. Reptiles and Amphibians of the Virgin Islands. MacMillan, London. vii + 54 pp.
- Meshaka, W. E., Jr. 1993. Hurricane Andrew and the colonization of five invading species in south Florida. Florida Sci. 56:193-201.
- Meshaka, W. E., Jr. 1996. Retreat use by the Cuban Treefrog (*Osteopilus septentrionalis*): Implications for successful colonization in Florida. J. Herpetol. 30:443-445.
- Meshaka, W. E., Jr. 2000. Colonization dynamics in two exotic geckos (*Hemidactylus garnotii* and *H. mabouia*) in Everglades National Park. J. Herpetol. 34:163-168.
- Meshaka, W. E., Jr. In Press. The Cuban Treefrog: Life History of a Successful Colonizing Species. Univ. Press Florida, Gainesville.
- Powell, R., R. J. Passaro, and R. W. Henderson. 1992. Noteworthy herpetological records from Saint [sic] Maarten, Netherlands Antilles. Carib. J. Sci. 28:234-235.
- Powell, R., R. I. Crombie, and H. E. A. Boos. 1998. *Hemidactylus mabouia*. Cat. Amer. Amphib. Rept. (674):1-11.
- Rivero, J. A. 1998. Los Anfibios y Reptiles de Puerto Rico. The Amphibians and Reptiles of Puerto Rico. 2nd ed., rev. Univ. Puerto Rico Press, San Juan. xvi + 510 pp.
- Rouse, I. 1989. Peopling and re-peopling of the West Indies. In C. A. Woods (ed.), Biogeography of the West Indies: Past, Present, and Future, pp. 119-136. Sandhill Crane Press, Inc., Gainesville, Florida.
- Schwartz, A., and R. W. Henderson. 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. xvi + 720 pp.
- Underwood, G. 1962. Reptiles of the eastern Caribbean. Carib. Affairs, new ser. 1:1-192.
- Watters, D. R., E. J. Reitz, D. W. Steadman, and G. K. Pregill. 1984. Vertebrates from archaeological sites on Barbuda, West Indies. Ann. Carnegie Mus. Nat. Hist. 53:383-412.

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The Male and Female Vocalizations of the Cuban Frog *Eleutherodactylus guanahacabibes* (Anura: Leptodactylidae)

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The acoustic emissions of some Cuban *Eleutherodactylus* frogs have been partially characterized during the last decade, with descriptions of new species or

redescriptions of others (Estrada and Hedges, 1996a,b; 1997a-c; 1998; Estrada et al. 1997; Hedges et al., 1992, 1995). *Eleutherodactylus guanahacabibes* Estrada and Novo, an endemic frog from western Cuba, is among the species whose calls remained undescribed.

Female vocalization in anurans within a breeding behavioral context has rarely been documented (Wells, 1977; Duellman and Trueb, 1986). In this paper, various parameters of acoustic emissions from both sexes of *Eleutherodactylus guanahacabibes* are described, with comments on some ecological aspects.

Five males were recorded between August 23 and September 1, 1999, at the localities of Caleta del Piojo and La Bijaica (some 11 km E of Cabo de San Antonio, Península de Guanahacabibes, Pinar del Río Province). Forty calls were analyzed from these males and 13 from a female previously collected at La Bajada on April, 1997, and kept in a terrarium. Calls were recorded with a Sony TCM 59V portable cassette recorder and a Sony ECM 220 microphone placed about 30 cm from the frogs. Vocalizations were studied using Canary 1.2.4 software (Cornell University). Signals were digitized at 22050 Hz. The following parameters were measured using the general terminology proposed by Duellman and Trueb (1986): DF, dominant (carrier) frequency (measured in the power spectrum, filter bandwidth 87.42 Hz, sampling frequency 22.1 Hz.); ND, note duration in milliseconds (mS) measured on the oscillogram, error 0.01 mS; NI, note interval (mS); NRR, note repetition rate (notes per second) and CRR, call repetition rate (calls per minute). Air temperature during recordings ranged from 25 to 26 °C and relative humidity ranged from 90 to 100%. Voucher specimens of the males were deposited in the herpetological collection at Museo Nacional de Historia Natural de Cuba.

Male advertisement call.—The species has a complex insect-like voice. Calls are primarily composed of two single pulsed notes, but a range of 1 to 11 (mean= 2.56) notes was observed. The values for some temporal and spectral characters are shown in Table 1. Typically, the dominant and fundamental frequencies are the same, but in 13 calls (32.5% of the sample) the energy was concentrated in the second harmonic, giving a fundamental frequency of 1.49 to 1.98 (mean= 1.70) kHz. This makes the dominant frequency a more variable parameter. There is no strong frequency modulation, but some notes (N= 11, from 6 different calls) are slightly ascendant or descendant modulated.

Figure 1A shows the waveform and sonogram of a long trill of 9 notes with a gradual decreasing amplitude, as performed by a male (LMD 0115) after hearing its own recorded voice at a close distance (± 50 cm) from the sound source. Other signals in the same figure show male call variation. The intensity of successive calls from a single male is also highly variable (Fig. 1B-C).

Female call.—Although two females were seen and heard calling in captivity during two consecutive years, only one was recorded with proper equipment. Female calls resembled male advertisement calls but were emitted at a lower rate. The dominant and fundamental frequencies are the same in the entire sample. The female had a lower dominant frequency mean value, probably as a consequence of its larger size. Statistical values for female call measurements are compared in Table 1 and a waveform and spectrogram is presented in Fig. 1D. Acoustic emissions of captive females were primarily heard throughout the morning. After calling, the captive females always laid clutches of 5-11 (mean= 8.64) yellowish-white unfertilized eggs.

Ecological notes.—Males call from the ground, rocky limestone surfaces, caves, fallen trunks, and leaves of small palms (*Coccothrinax argentata*) at less than 50 cm from the soil surface. The frogs are associated with almost all kinds of vegetation and habitats in the Peninsula: coastal formations, leaf litter of small swamps, and human rustic houses. Small choruses were heard just after sunset and throughout the night after heavy rains. The closest distance between two calling males was less than a meter in rocky situations. Other species of *Eleutherodactylus* that called sympatrically with *E. guanahacabibes* are *E. atkinsi*, *E. auriculatus*, *E. eileanae*, *E. riparius*, *E. pinarensis*, and *E. varians*. Calls were also recorded for these species.

The voice of *E. guanahacabibes* is somewhat similar to that of *E. planirostris* and *E. tomyi*; two apparently related species from which calls were previously described (Estrada and Hedges, 1997b). Like many other members of the subgenus *Euhyas*, males lack a vocal pouch.

Eleutherodactylus guanahacabibes occurs in many habitats and not only in rocky/cave situations, as argued by Estrada and Novo (1985). However, this frog is clearly specialized to live in that habitat (the most common in the Peninsula), as evidenced by some enlargement of the digital discs. After observing several individuals in the field, it is our impression that *E.*

TABLE 1. Comparative measurements of some parameters of male and female calls of *Eleutherodactylus guanahacabibes*. Dashes indicate missing data.

	Males				Female			
	X	SD	CV (%)	N	X	SD	CV (%)	N
DF	2.397	0.525	21.919	40	2.026	0.143	7.064	13
ND	11.419	4.245	37.175	40	8.870	3.288	37.038	13
NI	56.887	13.351	23.469	40	38.673	12.855	33.241	13
NRR	32.667	26.162	80.087	40	37.683	13.345	35.413	13
CRR	30.384	17.288	56.898	5	6.061	—	—	1

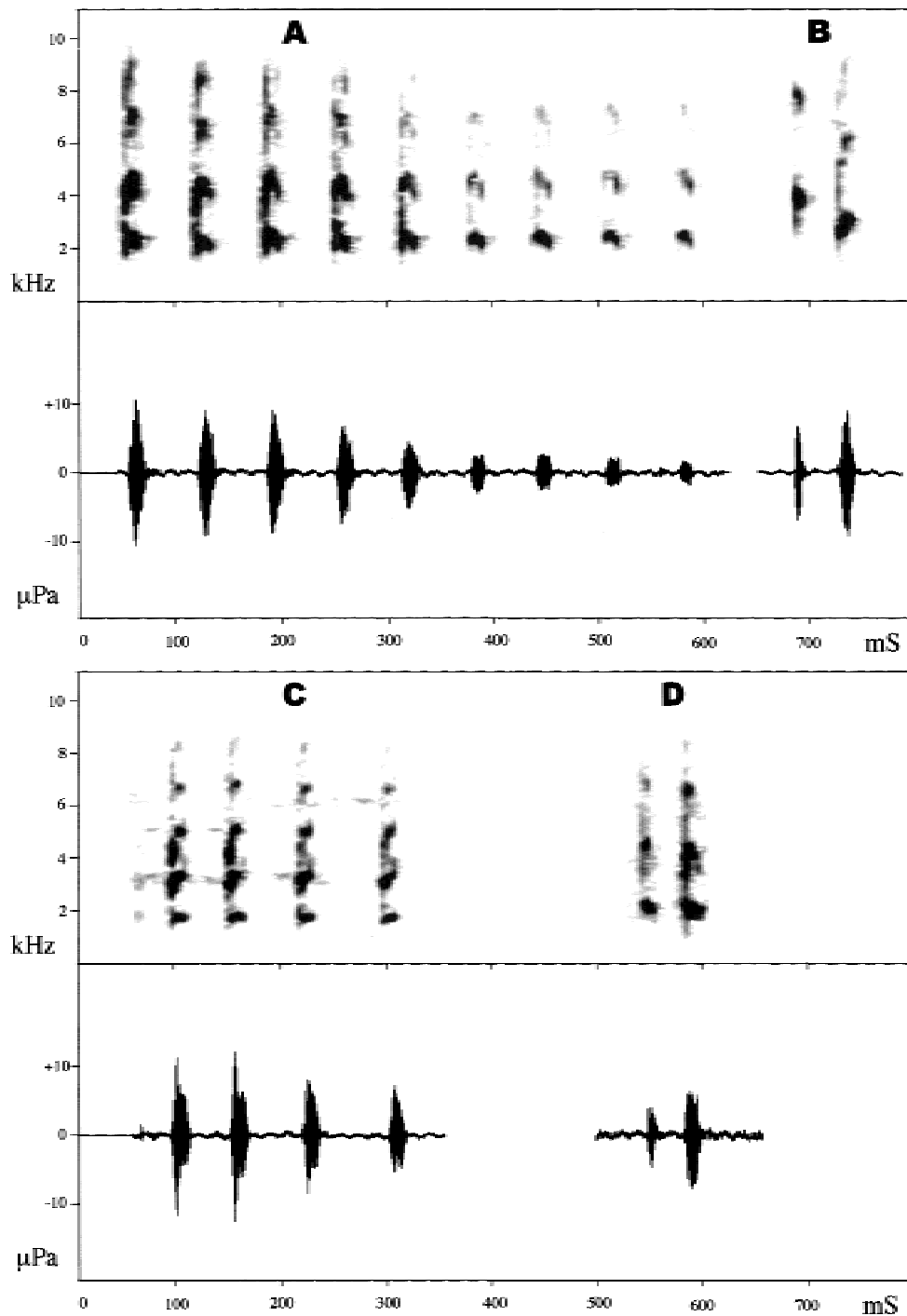


FIG. 1. Calls of *Eleutherodactylus guanahacabibes* (sonograms above, waveforms below). A- A long trill (9 notes). B- Male two note call. C- A four notes trill. D- Female two note call.

guanahacabibes is more opportunistic than other taxa of rock/cave ecomorphs (sensu Hedges, 1989).

Our bioacoustical work is descriptive and preliminary because we cannot demonstrate the role of the advertisement call complexity of *E. guanahacabibes* in a wider behavioral context. However, it seems that at least the more intense male trills have an accentuated territorial function, as performed by males approaching the sound source after stimulation by their own voice recordings. Longer calls (by addition of notes) have a more intense territorial function in other species of frogs (Pengilly, 1971; Arak, 1983; Stewart and Rand, 1991).

Vocal emissions in anuran females associated with breeding activity are known only for two species, *Alytes obstetricans* and *Tomodactylus angustidigitorum* (Wells, 1977; Duellman and Trueb, 1986). In the Mexican leptodactylid *T. angustidigitorum*, females answer male advertisement calls with their own vocalizations (Dixon, 1957). Stewart and Rand (1991) reported aggressive calls in females of the Puerto Rican *Eleutherodactylus coqui* defending retreat sites. Our observation indicate that females of *E. guanahacabibes* vocalize during an advanced pregnant condition, maybe "declaring" their state and receptivity to males. Males of *T. angustidigitorum* switch calls from peeps to a trill as females approach (Dixon, 1957). Unfortunately, we observed female behavior without males available. Further observations will help explain inter-sex communication in *E. guanahacabibes* during breeding.

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LITERATURE CITED

- Arak, A. 1983. Vocal interaction, call matching and territoriality in Sri Lankan treefrog, *Phyllautus leucorhinus* (Racophoridae). *Anim. Behav.* 31: 292-302.
- Dixon, J. R. 1957. Geographic variation and distribution of the genus *Tomodactylus* in Mexico. *Texas J. Sci.* 9: 379-409.
- Duellman, W., and L. Trueb. 1986. *Biology of Amphibians*. The Johns Hopkins University Press. 670 pp.
- Estrada, A. R., and B. S. Hedges. 1996a. A new frog of the genus *Eleutherodactylus* from eastern Cuba (Anura: Leptodactylidae). *Herpetologica* 52(3): 435-439.
- Estrada, A. R., and B. S. Hedges. 1996b. At the lower size limit in tetrapods. A new diminutive frog of the genus *Eleutherodactylus* from Cuba (Anura: Leptodactylidae). *Copeia* 1996 (4): 852-859.
- Estrada, A. R., and B. S. Hedges. 1997a. Nueva especie de *Eleutherodactylus* (Anura: Leptodactylidae) del macizo Sagua—Baracoa, Cuba. *Carib. J. Sci.* 33(3-4): 222-226.
- Estrada, A. R., and B. S. Hedges. 1997b. A new species of frog from the Meseta de Cabo Cruz, Eastern Cuba (Leptodactylidae: *Eleutherodactylus*). *Carib. J. Sci.* 33(3-4): 227-232.
- Estrada, A. R., and B. S. Hedges. 1997c. A new species of frog from Sierra Maestra, Cuba (Leptodactylidae, *Eleutherodactylus*). *J. Herpetol.* 31(3): 364-368.
- Estrada, A. R., and B. S. Hedges. 1998. Sistemática de las ranas ribereñas de Cuba (Leptodactylidae: *Eleutherodactylus*) con la descripción de una especie nueva. *Carib. J. Sci.* 33(3-4): 218-230.
- Estrada, A. R., and J. Novo. 1985. Nueva especie de *Eleutherodactylus* del grupo *ricordi* (Anura: Leptodactylidae) del occidente de Cuba. *Poeyana* 303: 1-10.
- Estrada, A. R., L. M. Díaz, and A. Rodríguez. 1997. Nueva especie de *Eleutherodactylus* (Anura: Leptodactylidae) del litoral norte de La Habana, Cuba. *Rev. Esp. Herp.* 1997 (11): 19-24.
- 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*. p. 305-370. Sandhill Crane Press, Gainesville, Florida.
- Hedges, S. B., A. R. Estrada, and R. Thomas. 1992. Three new species of *Eleutherodactylus* from eastern Cuba, with notes on vocalizations of other species (Anura: Leptodactylidae). *Herpetol. Monogr.*: 68-83.
- Hedges, S. B., L. González, and A. R. Estrada. 1995. Rediscovery of the Cuban frog *Eleutherodactylus cubanus* and *Eleutherodactylus turquinensis* (Anura: Leptodactylidae). *Carib. J. Sci.* 31(3-4): 327-332.
- Pengilly, R. K. 1971. Calling and associate behavior of some species of *Pseudophryne* (Anura: Leptodactylidae). *J. Zool.* 163: 73-92.
- 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.
- Stewart, M., and S. Rand. 1991. Vocalizations and the defense of retreat sites by male and female frogs, *Eleutherodactylus coqui*. *Copeia*, 1991 (4): 1013-1024.
- Wells, K. D. 1977. The courtship of frogs. In D. H. Taylor and S. I. Guttman (eds.), *The Reproductive Biology of Amphibians*, pp. 233-262. Plenum Press, New York.