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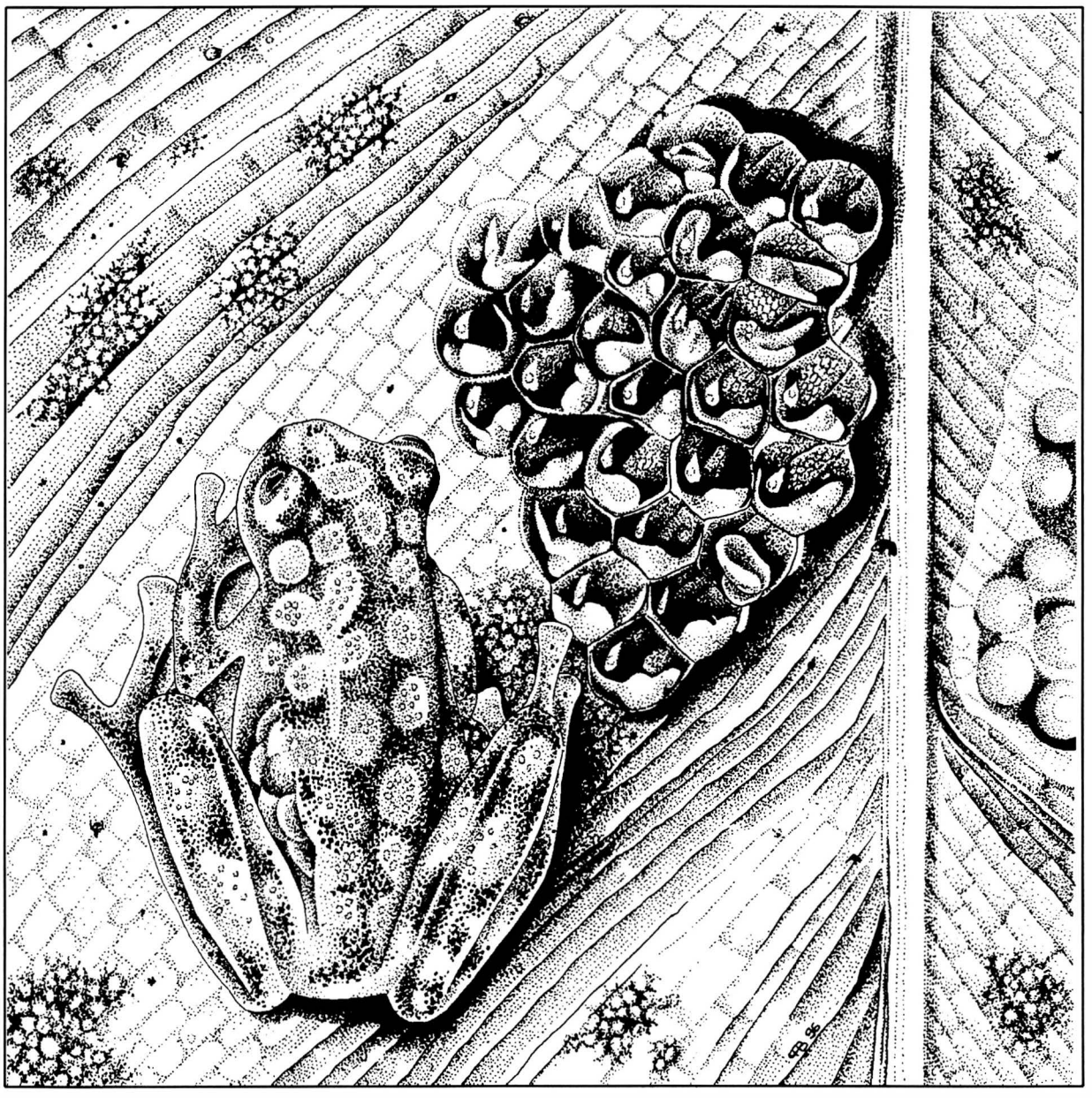

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ADVERTISEMENT CALLS OF THREE GLASS FROGS FROM THE ANDEAN FORESTS (AMPHIBIA: ANURA: CENTROLENIDAE)

RAFAEL MÁRQUEZ[1], IGNACIO DE LA RIVA[2], AND JAIME BOSCH[1]

[1] *Dept. de Ecología Evolutiva; Museo Nacional de Ciencias Naturales; C/ José Gutiérrez Abascal 2. 28006 Madrid, Spain*

[2] *Natural History Museum, The University of Kansas, Lawrence, Kansas 66045-2454, USA*

[2] *Permanent Address: Departamento de Biodiversidad y Biología Evolutiva, Museo Nacional de Ciencias Naturales. C/ José Gutiérrez Abascal 2, 28006 Madrid, Spain*

Centrolenid frogs form a family of anurans that is distributed from Mexico to Argentina, with the highest diversity of species in the Andes of Colombia and Ecuador. New species have been described at a high rate in the last years: 56 species were reported by Duellman (1977), 60 by Frost (1985), 94 by Duellman (1993), and 104 by Wild (1994). Most recent papers on centrolenid frogs deal with alpha-level taxonomy. A noteworthy contribution to the knowledge of the systematics of the family has recently been completed by Ruiz-Carranza & Lynch (1991), whereas Sanchiz & De la Riva (1993) pointed out the need for a reassessment of the consistency of a character that has been always considered as the most important synapomorphy of the family, namely, fusion of tibiale and fibulare.

Information on the natural history, ecology, and other aspects of most species of centrolenids is extremely scarce. The area of bioacoustics is one such poorly studied area. Unlike other Neotropical groups of anurans for which more comprehensive information on vocalizations is available, next to nothing is known on centrolenids. In general, their calls are high frequency notes. This has been related to the small size of these frogs and also to the fact that this kind of sound is suitable for propagation in the environment where these frogs primarily occur, namely, streams surrounded by dense plant cover (Richards & Wiley, 1980; Wells & Schwartz, 1982).

Syntopically occurring species of glass frogs may have generally similar external appearances and often they have to be identified on the basis of a combination of characters. The great species-specificity of the vocalizations in anurans (for a review of this subject, see Duellman & Trueb, 1986), makes the descriptions of the advertisement calls, useful tools for recognising different species. Accurate descriptions of the advertisement calls of centrolenid frogs are only available for a handful of species (Barrio, 1968; Starrett & Savage, 1973; Heyer, 1978, 1985; Greer & Wells, 1980; Haddad, Andrade & Cardoso, 1988; Cadle & McDiarmid, 1990; Heyer, *et al.*, 1990; Ibáñez, 1993; Señaris & Ayarzagüena, 1993). In this study we contribute to the knowledge of the centrolenids of Bolivia and Ecuador by describing the previously unknown advertisement calls of three species, in addition to providing notes on their calling behaviour and distribution.

Recordings were obtained by the second author from 1987 to 1990. Recording equipment included either a Sony WM D6C or a Sanyo M1120 tape recorder and a Sennheiser Me 80 directional microphone. We present a representative audiospectrogram and oscillogram for a selected 2.5 sec recording segment for each species. A longer recording (20-60 secs.) was analysed when available to generate numerical information on the spectral and temporal characteristics of the sounds. Recordings were processed with a digital signal analysis system based on an Apple Macintosh. The sounds were digitized and edited at a sampling frequency of 44.1 KHz and 16 bit resolution with 'Sound Tools' hardware and software. Signalyze software was used to obtain numerical information and to generate audiospectrograms and oscillograms. Frequency information was obtained through fast Fourier transform (FFT) (width, 1024 points). The terminology used for the description of the advertisement calls follows Heyer *et al.* (1990). Unless specified, classification and nomenclature of the species follow Frost (1985).

Seven different call characteristics were recorded. The variables considered were: note duration, fundamental frequency, dominant frequency, other frequency with substantial energy, number of pulses per note, pulse rate (pulses per second), and change in dominant frequency (dominant frequency at the end of the note minus dominant frequency at the beginning of the note). Collected individuals of *Cochranella bejaranoi* and of *Hyalinobatrachium bergeri* were deposited in the Centro de Estudios Tropicales, Sevilla, Spain, and/or in the Museo de Historia Natural "Noel Kempff Mercado", Santa Cruz de la Sierra, Bolivia. No specimens were collected in Ecuador.

Centrolene ballux (Duellman & Burrowes, 1989) occurs in cloud forests on the Pacific versant of the Andes, Departamento de Nariño, Colombia, to the Provincia de Pichincha, Ecuador (Duellman & Burrowes, 1989). The advertisement call of *C. ballux* was recorded in Las Palmeras, ca. 1400 m, Pichincha, Ecuador (00° 17' S / 78° 45' W). The air temperature during the recording session was approximately 20°C. Males called at night, perched on large leaves of riparian trees at about 2 m. above ground. The call was emitted sporadically. The call was a single, relatively short note (n=2, mean duration 374.5 ms, SD 70, range 328.5-420.4) with 7-9 pulses (not 100% amplitude

modulated), the first 4-5 being repeated at short, regular intervals, and the last three pulses being emitted at longer intervals (mean pulses per second 21.4, SD 0.1, range 21.3-21.4) (Fig. 1A). The dominant frequency was high (mean dominant frequency at peak amplitude 4833 Hz, SD 209, range 4685-4981) and the call had an upwards frequency sweep (mean increase + 454 Hz, SD 14, range 444-464). The animals recorded were calling in the near vicinity of a fast flowing stream that produced a loud white noise below 4000 Hz. The frequency band occupied by the call was right above the noise band of the stream (filtered out in Fig. 1). *Hyla carnifex* called simultaneously at the same place.

Cochranella bejaranoi (Cannatella, 1980) is a Bolivian endemic occurring in cloud forests of the Amazonian Andean slopes. Previously known only from the type locality (51.8 km SW Villa Tunari; Cannatella, 1980) and a nearby locality (De la Riva, 1990), it has now also been found at Sehuencas, 2300 m, Departamento de Cochabamba (17° 29' S / 64° 16' W), several localities in the La Siberia region (boundary between the departments of Cochabamba and Santa Cruz), and La Yunga, 2000 m, Departamento de Santa Cruz (18° 06' S / 63° 54' W). Advertisement calls of male *C. bejaranoi* were recorded in La Siberia, Río Chua Kocha, Provincia de Carrasco, Departamento de Cochabamba, 2000 m (17° 47' S / 64° 42' W). Air temperature at the time of recording was 14°C. Males called while perched on stems of understorey vegetation (such as ferns), near streams, at approximately 1.5 m. above the ground. Isolated males called at night, the calls being repeated at long (up to several minutes), irregular intervals. The call (Fig. 1B) was a sequence of 6-7 pulses the first six being repeated at regular intervals (mean interval 9 ms), and the last one being more separated (mean interval 42 ms) (mean pulses per second 33.3). Mean call duration was 202.3 ms (n=4, SD 9.3, range 189.1-210.6). The mean dominant frequency was of 4039 Hz (SD 103, range 3887-4113), and the call increased slightly in dominant frequency (mean increase + 168 Hz, SD 23, range 373-505).

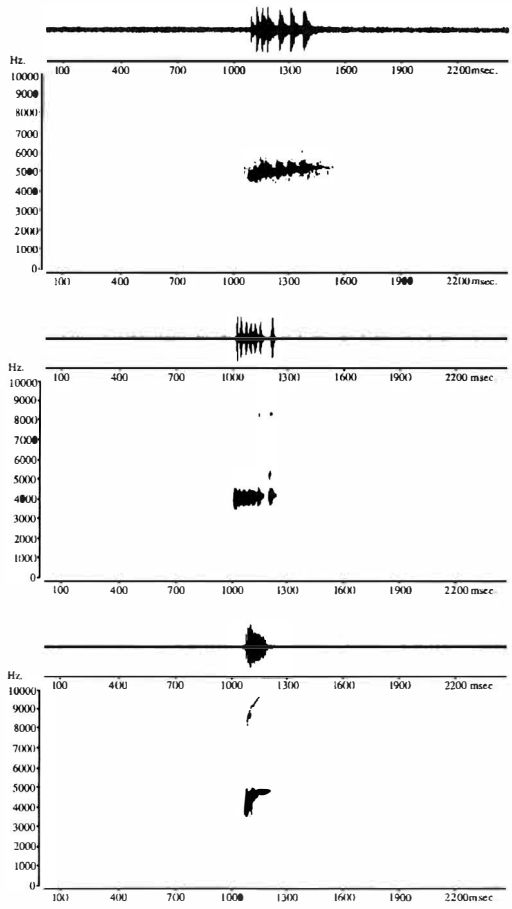

FIG. 1. Audiospectrograms and ocillograms of a 2.5 s section of a characteristic advertisement call. A, *Centrolene ballux*; B, *Cochranella bejaranoi*; C, *Hyalinobatrachium bergeri*. Note that the ordinate for the oscillogram is relative and linear, and therefore a scale is not provided.

Hyalinobatrachium bergeri (Cannatella, 1980) occurs in forests on the Andean Amazonian slopes, from the Departamento de Cuzco, Perú, to the Departamento de Santa Cruz, Bolivia. Although initially reported exclusively as a cloud forest-inhabiting species ranging from 1700-1890 m (Cannatella, 1980), we found it in Bolivia at the foot of the mountains, at localities as low as 300 m. a. s. l., such as in Paractito, department of Cochabamba (17° 01' S / 65° 27' W), and in Amboró National Park, department of Santa Cruz. Additionally, Emmons (1991) reported the species at 13 km W Ixiamas, Department of La Paz. Recordings were obtained at Río Cheyo, 700 m, Amboró National Park, Province Ichilo, Department of Santa Cruz, Bolivia (18° 40' S / 63° 35' W). Males called at night from the underside of the leaves of riparian trees at about 2.5 m above ground. Air temperature at the time of recording was 19°C. The call (Fig. 1C) was a short note (n=15, mean duration 151.4 ms, SD 21.6, range 125.5-169.4), with a mean dominant frequency at peak amplitude of 4495 Hz (SD 74, range 4402-4558), and a marked upwards (logarithmic) frequency sweep (mean increase + 449 Hz, SD 61, range 373-505). A well-tuned second harmonic showed substantial power of 9149 Hz (SD 158, range 8925-9268). No other anuran species could be heard concomitantly.

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