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AGGRESSIVE BEHAVIOR OF *RHEOHYLA MIOTYMPANUM* (ANURA: HYLIDAE) IN NORTHERN HIDALGO, MEXICO

CONDUCTA AGRESIVA DE *RHEOHYLA MIOTYMPANUM* (ANURA: HYLIDAE) EN EL NORTE DE HIDALGO, MÉXICO

Lizzeth A. Torres-Hernández[1*], César A. Díaz-Marín[1], Héctor R. Eliosa-León[2], Cinthya Mendoza-Almeralla[1] & Aurelio Ramírez-Bautista[1]

[1]*Laboratorio de Ecología de Poblaciones, Centro de Investigaciones Biológicas, Instituto de Ciencias Básicas e Ingeniería, Universidad Autónoma del Estado de Hidalgo, km 4.5 carretera Pachuca-Tulancingo, 42184, Mineral de La Reforma, Hidalgo, México.*

[2]*Facultad de Ciencias Biológicas, Benemérita Universidad Autónoma de Puebla, Blvd. Valsequillo y Av. San Claudio, Ed. BIO 1 CU, Col. Jardines de San Manuel, 72570, Puebla, Puebla. México.*

**Correspondence: lizzeth.torres97@gmail.com*

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Resumen.– Los anuros se comunican principalmente por medio de cantos, los cuales pueden ser clasificados en tres categorías (reproductivos, defensivos y agresivos) de acuerdo con el contexto social en el que se desarrollen. Los cantos agresivos suelen ser emitidos por los machos para la defensa de recursos (p. ej. sitios de canto y hembras), generalmente acompañados por agresiones físicas. Aquí, reportamos el comportamiento agresivo entre dos machos de *Rheohyla miotympanum*, posiblemente desencadenado por la defensa del sitio donde ocurre el canto y por la oportunidad de amplexo (hembra receptiva, aproximadamente a 80 cm de la escena). Este comportamiento se caracterizó por el contacto físico (lucha) y la emisión de cantos agresivos entre ambos machos. Futuras observaciones conductuales durante los cantos, con evaluaciones de la proximidad y densidad de congéneres, podría contribuir a nuestra comprensión de las principales causas del comportamiento agresivo de los machos de esta y otras especies de anuros.

Palabras clave.–Cantos, machos, pelea, sitios de canto, rana.

Abstract.– Anurans communicate primarily through calls, which can be classified into three categories (reproductive, defensive, and aggressive) according to the social context in which they occur. Aggressive calls are usually produced by males to defend resources (e.g., calling sites and females), generally accompanied by physical aggression. Here, we report aggressive behavior between two *Rheohyla miotympanum* males, possibly triggered by defense of the calling site and for the opportunity for amplexus (receptive female, approximately 80 cm from the scene). This behavior was characterized by physical contact (fight) and the emission of aggressive calls between both males. Future behavioral observations during calls, with the assessment of the proximity and density of conspecifics, could add to our understanding of the main causes related to the male aggressive behavior of this and other anuran species.

keywords.– Calling sites, calls, fight, frog, males.

Bioacoustics studies have been essential to understand the acoustic communication mechanisms used by various biological groups (e.g., anurans, insects, birds, mammals) under different social contexts (Tubaro, 1999). In amphibians, anuran calls are the functional unit of their communications systems (Toledo et al., 2015), and involve different types of behavioral traits (Cocroft & Ryan, 1995; Dapper et al., 2011). Anuran calls can be categorized according to the social context of the signaler and the receiver (intraspecific and interspecific; Bogert, 1960; Wells, 1977a, b; Wells, 1988), and their main function, such as reproductive, defensive, and aggressive calls (Toledo et al., 2015). These latter types of calls are emitted mainly in an intraspecific conflictive context, during close contact or fights among males (Toledo et al., 2015; Köhler et al., 2017), in which they defend their calling sites from nearby conspecifics (Wells, 2007).

When these calls are not enough to drive intruders from territories, males often resort to physical aggression in a variety

Figura 1. Macho adulto de *Rheohyla miotympanum* en Chilijapa, Tepehuacán de Guerrero, Hidalgo, México. Foto: César A. Díaz-Marín.
Figure 1. Adult male of *Rheohyla miotympanum* in Chilijapa, Tepehuacán de Guerrero, Hidalgo, Mexico. Photo: César A. Díaz-Marín.

of ways, including jumping on opponents, pushing them from calling sites, or fighting with their forelimbs (intertwined or not; Tunner, 1976; Wells, 1977b; Rodrigues et al., 2003; Wogel et al., 2004).

Here we describe the aggressive behavior of *Rheohyla miotympanum* (Cope, 1863; Fig. 1) in an intraspecific context. This hylid frog is categorized as Least Concern (LC) on the IUCN read list (IUCN, 2023), but it does not have a protection category by national laws NOM-059-SEMARNAT-2010 (SEMARNAT, 2010), and is widely distributed in lowlands (1,000 m a.s.l.) and highlands (2,282 m a.s.l.) of Mexico, from the states of Nuevo León and Coahuila to Hidalgo, Oaxaca, Veracruz, and Chiapas (Frost, 2023). On the 13th of March 2023 at 21:14 h, at Chilijapa, Tepehuacán de Guerrero, Hidalgo, Mexico (21.01547° N, 98.86936° W, WGS84, 1,358 m a.s.l.), after a strong storm of approximately one hour, we were studying the reproductive calls of *R. miotympanum* when we observed an aggressive behavior between two males of this species, through a physical and acoustic confrontation. Hereafter, we consider the resident male as the male perched in the bush at the time of the observation, and the intruder male as the male that arrived at the bush later.

Resident male was perching on a leaf of a bush at a height above the ground of 126.2 cm and at 110.5 cm from the nearest stream, when an intruder male jumped onto the resident male's bush, which caused a physical and acoustic fight (with calls) between both males. The resident male jumped on the dorsum of the intruder male and hit him repeatedly with his hindlimbs, which caused that the intruder male to jump into a near bush. This fight was accompanied by a series of calls from both males. We registered the calls at 48000 Hz sampling frequency, 16-bit resolution and WAVE format with a TASCAM DR-40X digital recorder fitted with two internal unidirectional microphones, placed approximately 30 cm from the males. After the fight, we captured each male and measured their snout-vent length (SVL) and body mass (BM) with a digital caliper (± 0.002 cm precision) and a digital scale (0.1 g precision), respectively.

We obtained acoustics attributes of calls with Raven Pro 1.6.5 software (Bioacoustics Research Program, Cornell Lab of Ornithology, Ithaca, NY), using Hann window, FFT size 2048 and overlap 95%. The seven acoustic attributes were the notes number, two temporal (duration and interval between calls) and four spectral attributes (peak frequency, minimum frequency, maximum frequency, and bandwidth). Subsequently, we

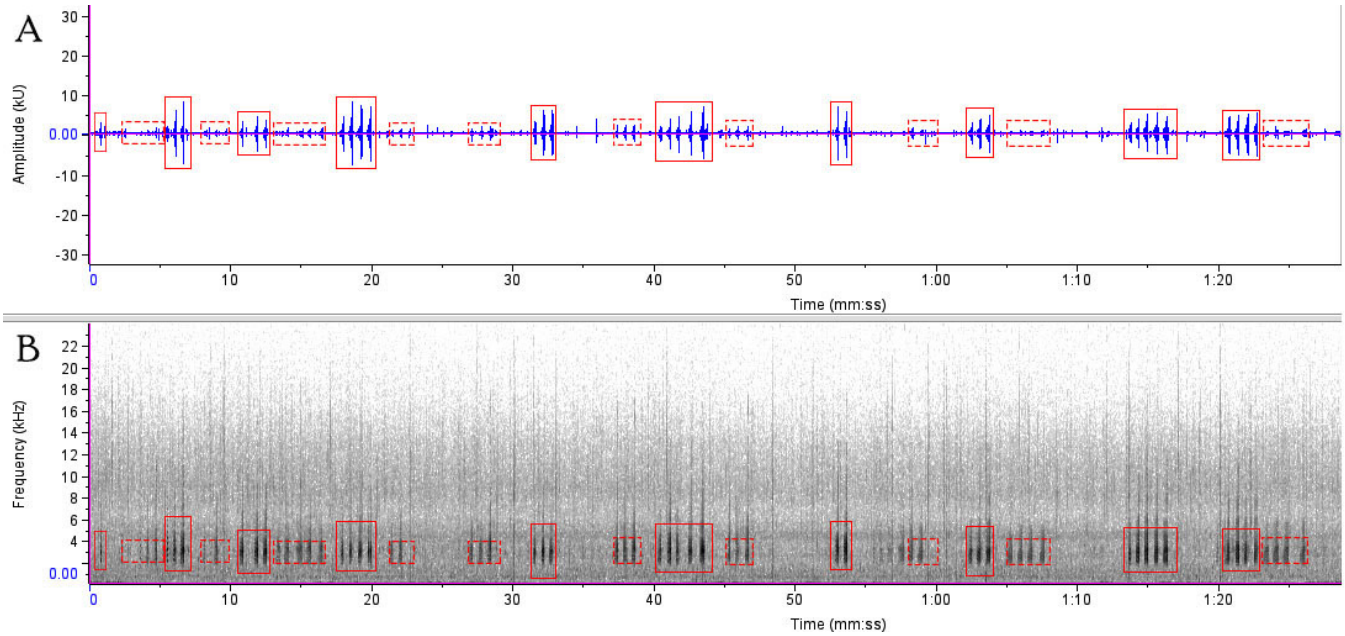

Figura 2. Oscilograma (A) y espectograma (B) del canto territorial entre dos machos de *Rheohyla miotympanum*. La línea roja continua corresponde al macho residente, y la línea roja discontinua corresponde al macho intruso.

Figure 2. Oscillogram (A) and spectrogram (B) of the territorial call between two *Rheohyla miotympanum* males. The solid red line corresponds to the resident male and the red dashed line corresponds to the intruder male.

performed Wilcoxon tests (Zar, 2010) to determine possible differences between males in acoustic attributes. All statistical analyses were performed in R software (v. 4.3.1, R Core Team, 2023), using the plotrix and ggplot2 packages. Results are presented as means ± SE unless indicated otherwise.

The acoustic interaction lasted 1.28 min (MZFC-HEC4467, Fonoteca de Anfibios, Universidad Nacional Autónoma de México) and was composed of 20 calls, 10 from each male (Fig. 2). The notes number and the temporal attributes of the calls (duration and interval between calls) showed no significant statistical differences between the two types of males (resident and intruder; Table 1), while peak frequency (W = 76, P = 0.05), minimum frequency (W = 22, P = 0.04), maximum frequency (W = 100, P = 0.0002), and bandwidth (W = 100, P= 0.0002) showed significant differences, although the variation in peak frequency was marginal.

The means of the three spectral attributes (peak frequency, maximum frequency, and bandwidth) were higher in the calls of the intruder male than in those of the resident male (Fig. 3A-C), while the minimum frequency was higher in the calls of

Tabla 1. Estadística descriptiva de los atributos acústicos similares del macho residente e intruso de *Rheohyla miotympanum*. Los parámetros de la prueba de Wilcoxon se muestran para las comparaciones de atributos entre machos.

Table 1. Descriptive statistics of the similar acoustic attributes of the resident and intruder male of *Rheohyla miotympanum*. Wilcoxon test parameters are also shown for attribute comparisons between males.

Male	Notes number	Duration (s)	Interval between calls (s)
Resident	3.3 ± 0.40	1.76 ± 0.30	7.16 ± 0.93
Intruder	3.4 ± 0.34	2.02 ± 0.29	7.07 ± 1.33
	W = 51, P = 0.97	W = 56, P = 0.68	W = 39, P = 0.93

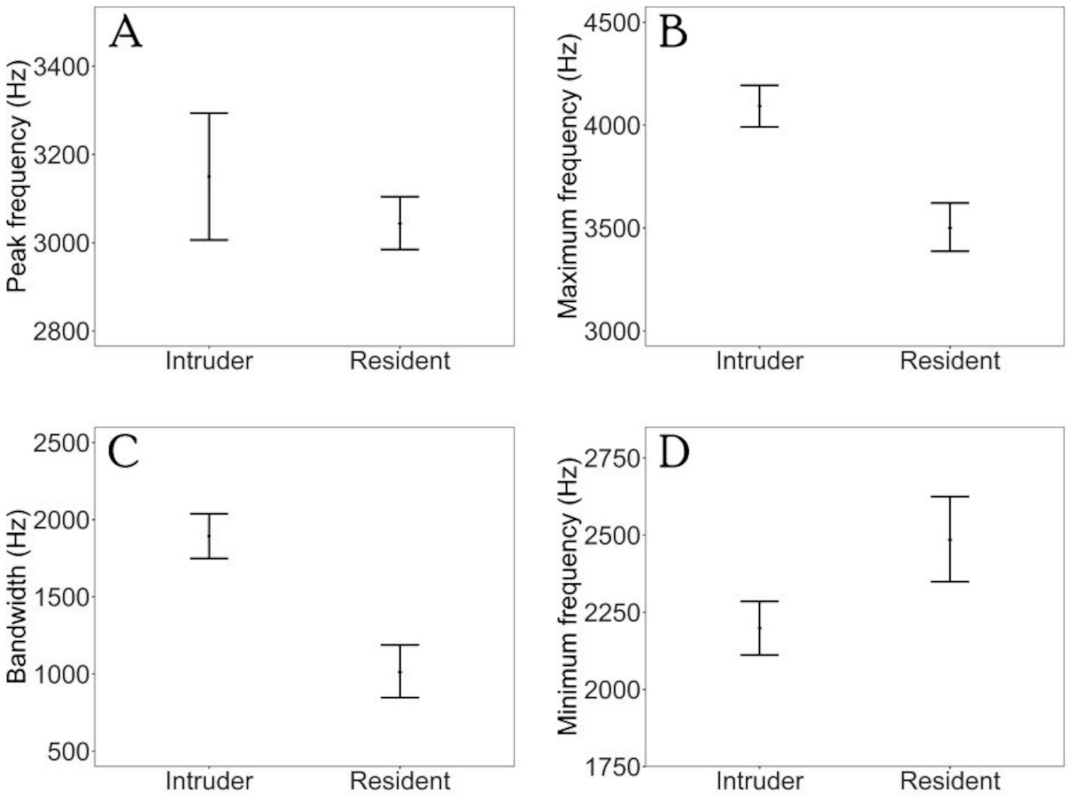

Figura 3. Variación en frecuencia dominante (A), frecuencia máxima (B), ancho de banda (C), y frecuencia mínima (D) entre el macho intruso y residente de *Rheohyla miotympanum*. Las barras de error representan intervalos de confianza al 95%.

Figure 3. Variation in peak frequency (A), maximum frequency (B), bandwidth (C), and minimum frequency (D) between the intruder and resident male of *Rheohyla miotympanum*. Error bars represent 95% confidence intervals.

the resident male than in those of the resident male (Fig. 3D). Despite these results, in this fight the resident male won (i.e., kept his perch site), which was slightly larger (SVL: 29.20 mm) and heavier (1.4 g) than the intruder male (SVL: 29.01 mm, BM: 1.2 g).

This observation suggests that males of *R. miotympanum* actively choose and defend (acoustically and physically) a perch site with specific characteristics (e.g., height above ground and near to stream), where they can attract mates. Therefore, according to Toledo et al. (2015), it is possible to subcategorize this aggressive call as territorial, due to the defense of the perch site, and fighting, due to physical contact between both males. In this hylid species, males are generally more abundant than females, so this territorial behavior may occur not only for the defense of calling sites but also for other resources, such as the limited number of receptive females during the reproductive season.

In the study area, approximately 80 cm away from these males, we found a female with visible eggs in her ventral cavity, indicating that she was probably reproductively mature and receptive. Future studies of the calling behavior of this and other anuran species with behavioral observations of calling individuals and assessment of the proximity and density of conspecifics (females and males) in a specific area could to determine the main causes of aggressive behavior (e.g., calling sites, feeding, females, acoustic space).

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