

Geographic variation in the acoustic signals of lesser treefrogs *Dendropsophus minutus* (Anura, Hylidae)

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Abstract. Biological sound archives are a major source to investigate geographic variation in animal acoustic signals and their evolutionary drivers. The acoustic signals of anuran species with wide distribution ranges often vary geographically as a result of isolation by distance and climate amongst other factors. We examined whether the acoustic structure of call notes would vary geographically in lesser treefrogs *Dendropsophus minutus* using recordings from bioacoustics repositories. We also tested whether climate (mean annual temperature and annual precipitation) drive geographic variation in those signals. The acoustic distance was unrelated to geographic distance, suggesting that isolation by distance solely cannot explain geographic variation in call structure. Overall, lesser treefrogs uttered call notes with lower frequencies and bandwidths in the west of their range. In addition, frogs produced shorter call notes in hotter, wetter sites and narrow-bandwidth notes in hotter environments. We suggest that frogs produce more calls (not measured here) of shorter durations to maximize transmission and minimize the metabolic costs of calling at high air temperatures. We also suggest that hotter environments favor the propagation of lower-bandwidth calls. This study reinforces the feasibility and power of citizen science and acoustic data repositories for understanding the evolution of anuran acoustic signals.

Keywords. Amphibians; Anurans; Bioacoustics; Vocal behavior; Vocal repertoire.

INTRODUCTION

Biological collections have provided several scientific discoveries that help us to understand aspects of life and the environment (Funk, 2018). Audiovisual archival libraries are collections that have been gaining ground in the scientific community. They provide additional information (e.g., behavioral, acoustic) that cannot be found in museum specimen collections or DNA databases (Toledo *et al.*, 2015b). Through sound archives, it is possible to monitor populations, study taxonomic and evolutionary aspects, and understand the ecological relationships that species have established throughout their life histories (Dena *et al.*, 2020). Notably, bioacoustics is a historical and valuable tool for amphibian taxonomy (Bogert, 1960; Blair, 1963, 1968; review in Köhler *et al.*, 2017), since vocalizations, and consequently acoustic characteristics, vary among different species (Carvalho & Giaretta, 2013; Röhr *et al.*, 2020).

The animal taxa with the highest representation in acoustic libraries are birds, followed by amphibians (Dena *et al.*, 2020). Amphibian anurans emit acoustic signals with different defined social functions, which include species recognition, reproduction, territory defense, and predation avoidance (Haddad, 1995; Wells, 2010; Lemes *et al.*, 2012; Vieira *et al.*, 2016; Guerra *et al.*, 2018). Acoustic signals are of fundamental importance in the life history of these animals, the main form of communication of the species in the group (Wells, 2010; Köhler *et al.*, 2017). Acoustic signals are classified into three categories, according to their social context: reproductive calls, aggressive calls, and defensive calls (against predators) (Toledo *et al.*, 2015a). It is common for the same species to emit three to four variations of calls, presenting different communication strategies, depending on the ecological and social contexts (Guerra *et al.*, 2018). Therefore, it is necessary to use experimental approaches to elucidate the function of each signal type (Guerra *et al.*, 2018).

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The lesser treefrog, *Dendropsophus minutus* (Peters, 1872), is a small hylid with a wide distribution throughout South America, from the plains east of the Andes of Colombia to Argentina, and is one of the most common species in the region (Faivovich *et al.*, 2005; Leivas *et al.*, 2018a; Frost, 2023). Males of the species vocalize in open habitats throughout the year (Vaz-Silva *et al.*, 2020). However, vocal activity peaks during more suitable climatic conditions and increased resource availability (Oliveira *et al.*, 2007; Leivas *et al.*, 2018b; Vaz-Silva *et al.*, 2020). This happens from February to August in Cwa climates (Oliveira *et al.*, 2007), from August to January in Cfb climates (Leivas *et al.*, 2018a), and from December to April in Aw climates (Santos & Oliveira, 2007; Santos *et al.*, 2012; climate classification following Alvares *et al.*, 2013).

The vocal repertoire of lesser treefrogs has three types of notes, designated A, B, and C (Cardoso & Haddad, 1984). These notes can be combined in 16 different ways and their use is influenced by the vocal activity of other males that are nearby and vocalizing (Morais *et al.*, 2012). Note A and note C are usually emitted during reproductive calls of the species, while note B is the main note emitted during aggressive calls (Cardoso & Haddad, 1984; Haddad & Cardoso, 1992; Guerra *et al.*, 2018; Foratto *et al.*, 2021; Hernández-Herrera & Pérez-Mendoza, 2021). Note A is the most produced by lesser treefrogs, both combined with other notes or alone, in different social contexts (Cardoso & Haddad, 1984; Haddad & Cardoso, 1992; Morais *et al.*, 2012). However, because it is a species with complex calls and exhibits a substantial acoustic variation among different populations throughout its geographic distribution, some studies have suggested that *D. minutus* may be a cryptic species complex (e.g., Kaplan, 1994; Köhler, 2000; Gehara *et al.*, 2014).

Acoustic signals play a key role in speciation in highly vocal taxa, such as anurans. These signals are related with the recognition between individuals of the same species and serve as a mechanism for prezygotic isolation (Wells, 2010; Wilkins *et al.*, 2013). It is common to observe, in anuran species with a wide geographic distribution, variations in the acoustic patterns of calls due to the isolation of populations and the effect of local selective pressures (Castellano *et al.*, 2000; Bernal *et al.*, 2005; Tessarolo *et al.*, 2016). One of the patterns of geographical variation is isolation by distance, where geographical distance exerts a strong influence on the variation of acoustic parameters of calls, such as in pulse rate and fundamental frequency (Castellano *et al.*, 2000). Another known pattern is clinal, where acoustic parameters exhibit geographic variation that coincides with a climatic gradient, accompanying, for example, a humidity gradient and seasonality (Bernal *et al.*, 2005). There is also a discrete pattern, where geographic barriers produce divergence among populations. The study by Bernal *et al.* (2005), for example, identified that two populations of the dendrobatid *Rheobates palmatus* (Werner, 1899) living on opposite sides of the Andes showed acoustic differences.

Geographic variation in acoustic characteristics can also be explained by differences in environmental conditions, demographics (e.g., sex ratio), and social

context (Cardoso & Haddad, 1984; Guerra *et al.*, 2018; Foratto *et al.*, 2021; Hernández-Herrera & Pérez-Mendoza, 2021). For example, air temperature is an important environmental variable that can determine geographic variations in calls. In many anuran species, the air temperature has already been documented to affect the temporal parameters of acoustic signals (Morais *et al.*, 2012; Shen *et al.*, 2015). In addition, acoustic parameters that are more temperature-dependent should vary more over short periods and within the same individual (Röhr *et al.*, 2020).

Here, we investigated geographic variation in the acoustic structure of call notes in lesser treefrogs using recordings available in acoustic repositories. We analyzed whether geographic variation in acoustic signals correlates with spatial distance, longitude, latitude, and weather. The wide distribution of this species, the available information about its vocal repertoire, and a relevant number of available recordings are factors that make the species a good model for studying geographical and environmental variations in acoustic signals. This is one of the first studies that evaluates variation in acoustic parameters in notes of the vocal repertoire of anurans using recordings available in acoustic libraries (see also Andreani *et al.*, 2020).

MATERIAL AND METHODS

File sorting and call notes selection

The recordings used in this work were made available by the following repositories: (1) Fonoteca Neotropical Jacques Vielliard (FNJV) of the Museu de Zoologia Professor Adão José Cardoso, Universidade Estadual de Campinas (Unicamp), Campinas, Brazil (<https://www2.ib.unicamp.br/fnjv>); (2) herpetological collection of the Museu Nacional of the Universidade Federal do Rio de Janeiro (MNRJ); (3) Coleção de Arquivos Sonoros de Anuros Neotropicais (IF Goiano) (CASAN); and (4) Fonoteca Biológica da Universidade Federal de Pernambuco (FBIOUFPE). The filters used to search the files in FNJV were as follows: Class Amphibia, Order Anura, Family Hylidae, Genus *Dendropsophus*, Species *minutus*, Quality 4 and 5. We performed the search in FNJV on 13 October 2021, which resulted in 73 recordings. We also acquired 10 recordings from MNRJ on 06 June 2023, 5 from CASAN on 25 May 2023, and 1 from FBIOUFPE on 01 June 2023. In total, we obtained 89 recordings from these repositories (Appendix 1: Table S1).

The audio files were made available in .wav format, and we used Adobe Audition CC 2015.0 (Adobe Systems, San Diego, CA, USA) to normalize them to 44.1 kHz (sampling rate) and 16-bit resolution. We use Raven Pro 1.6.1 (K. Lisa Yang Center for Conservation Bioacoustics, 2019) to select, when available, three notes of type A, B, and C (Cardoso & Haddad, 1984), from each recording (Fig. 1). These notes are components of reproductive calls (types A and C) or aggressive calls (type B) (Cardoso & Haddad, 1984), as detailed in the Introduction. We

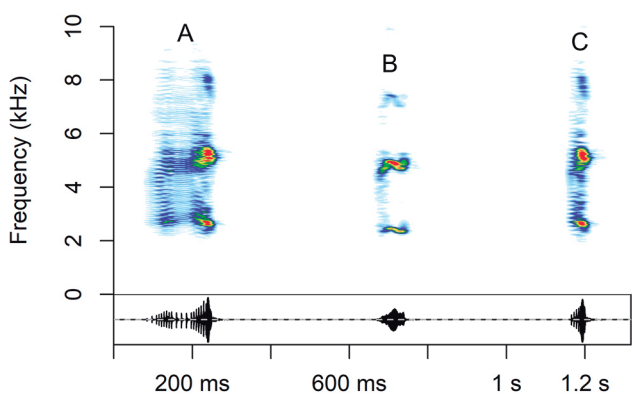


Figure 1. Spectrogram (above) and oscillogram (below) showing the acoustic characteristics of examples of the three note types of the vocal repertoire of *Dendropsophus minutus*. Recording identity: FNJV_13108 (Table S1). Recordingist: Célio Haddad. Coordinates: -47.0697 (longitude), -22.8194 (latitude).

argue that measuring three samples of each note type is sufficient to establish a reliable representation of between-individual acoustic variation (Morais *et al.*, 2012). The note selections were independent of the call type (reproductive, aggressive, or defensive) since most recordings did not have the call type specified in the metadata. The selections were made by only one researcher, and all recordings were standardized before each selection (Hann window type, size 256 samples; Overlap 89.9%; View axes: time scale 2.000 seconds/line, amplitude scale 60000.0 units/line). The 89 audio files resulted in 619 selections of vocalizations, with 250 selections of type A notes (85 recordings), 181 of type B notes (68 recordings), and 188 of type C notes (66 recordings). We could not select any calls from two recordings of lower quality (MNVOC 031_10, MNVOC 046_6). The recordings had a focal individual, so we considered the selections from each recording to come from a single individual.

Variable extraction

All extractions were performed in the R program Version 4.1.1 (R Core Team, 2021). We used the 'Raven' package (Araya-Salas, 2017) to import the note selections performed previously in the Raven program. We used the 'warbler' package (Araya-Salas & Smith-Vidaurre, 2017) to extract the acoustic metrics from the selections (bandwidth 2-18 kHz, window length 256, frequency window length 1024, overlap 90%). We selected six acoustic metrics: note duration (seconds), 25% frequency (kHz; frequency at which the signal is split into two frequency intervals of 25% and 75% energy, respectively), 75% frequency (kHz; frequency at which the signal is split into two frequency intervals of 75% and 25% energy, respectively), bandwidth (kHz; 75% frequency minus the 25% frequency), mean dominant frequency (kHz; mean of the dominant frequency measured across the acoustic signal), and mean peak frequency (kHz; frequency with the highest energy in the mean frequency spectrum). These measurements surpass the requisite criteria for characterizing the acoustic structure of calls from lesser treefrogs (Morais *et al.*, 2012).

After extraction, we took the average of each acoustic metric per recording (individual), as a function of note type. So, the 87 recordings generated 219 data points, 85 for type A notes, 68 for type B, and 66 for type C (Appendix 1: Table S2). All three note types were not always present in the recordings, hence the difference in sample size corresponds to unbalanced renditions of each note type.

The metadata provided by the FNJV and MNRJ did not have the geographic coordinates for all the audio files. Thus, we used the country, state, city, and locality information to estimate the longitude and latitude (decimal degrees) for each recording. The coordinates were least precise when referenced to the municipal seat. This level of precision has been adequate for macroecological studies of acoustic signal variation (García *et al.*, 2018; Lopes & Schunck, 2022). Next, we used the 'raster' (Hijmans, 2020) and 'sp' (Pebesma & Bivand, 2005) packages to download and extract the bioclimatic data from WorldClim (Fick & Hijmans, 2017). Using the coordinates, we extracted the mean annual temperature and annual precipitation for each location for the years 1970-2000. In addition, we used the spatial data made available by the International Union for Conservation of Nature (IUCN, 2021) to create a distribution map of the study species.

Statistical analysis

All statistical analyses were performed in R Version 4.1.1 (R Core Team, 2021). We used the package 'psych' (Revelle, 2021) to perform Principal Component Analysis (PCA, correlation matrix, varimax rotation) of the acoustic metrics. One data point with extreme acoustic values (mean peak frequency > 13 kHz) was removed before the analysis. The variables Note Duration, 25% frequency, and 75% frequency were transformed to natural logarithms before the PCA to make the distribution of these variables closer to a normal distribution. Two components (PC1 and PC2) were retained (eigenvalues > 1 , explained variance $> 75\%$) and explained all the acoustic metrics well, except for Note Duration (Table 1). For this reason, we used PC1, PC2, and Note Duration as dependent variables in subsequent analyses. High values of PC1 represent calls with higher frequencies, while high values of PC2 represent calls with lower minimum frequencies

Table 1. Principal Component Analysis (PCA) summarizing the variance in the acoustic metrics of the call notes ($n = 184$). Eigenvectors (loadings, values $> |0.5|$ highlighted in bold), eigenvalues, and the proportion of variance explained are shown.

	PC1	PC2
Note duration	0.08	-0.43
25% frequency	0.71	-0.63
75% frequency	0.85	0.44
Bandwidth	-0.11	0.96
Mean Dominant Frequency	0.90	-0.31
Mean Peak Frequency	0.78	-0.42
Eigenvalues	2.65	1.97
Proportion of Variance Explained (%)	44	33

and wider bandwidths. We performed a Kruskal-Wallis test to check whether the dependent variables differ as a function of note type since the distributions of the ANOVA residuals did not show normality. If the Kruskal-Wallis test resulted in a $P < 0.05$, we performed Dunn's a posteriori test (P values adjusted by false discovery rates: Benjamini & Hochberg, 1995) to check how note types differed from each other with respect to acoustic parameters.

We used the package 'ade4' (Dray & Dufour, 2007) to perform a Mantel test and check for spatial autocorrelation between acoustic distances of the dependent variables and geographic distance. The Mantel test was performed for each type of note separately. The significance P -values of the Mantel tests were adjusted by the number of tests performed ($n = 9$) using the method of false discovery rates (Benjamini & Hochberg, 1995). We also performed Linear Mixed Models (LMMs) using 'glmmTMB' package to examine if the call traits were related to longitude and latitude (1st model set: dependent variable ~ longitude + latitude) and to mean annual temperature and annual precipitation (2nd model set: dependent variable ~ temperature + precipitation). Note Duration was transformed to natural logarithm for inclusion in the models. Note type and recording identity were included as random intercepts in all models. We opted not to construct individual models to assess the impact of geographic coordinates and weather on the acoustic traits of each note type. This approach avoids decreasing power of our analysis by reducing the sample size by over half for each model, which could potentially yield misleading non-significant results.

RESULTS

The geographic scope of the analyzed recordings was only a subset of the lesser treefrog's distribution range. Most of the analyzed recordings were from Brazil, particularly the southeast ($n = 63$), followed by the south ($n = 9$), central ($n = 8$), northeast ($n = 3$), and northern regions of the country ($n = 1$) (Fig. 2). There was only one analyzed recording from each of the following countries: Venezuela, Bolivia, and Argentina.

Lesser treefrog's note types differed in duration (Kruskal-Wallis: $\chi^2 = 164.53$, $P < 0.0001$) and some frequency parameters (PC1: $\chi^2 = 2.30$, $P = 0.32$, PC2: $\chi^2 = 56.82$, $P < 0.0001$). Type C note had higher values of PC2 than types A (Teste de Dunn: $Z = 6.14$, $P < 0.0001$) and B ($Z = 6.97$, $P < 0.0001$), whereas types A and B had similar PC2 values ($Z = -1.23$, $P = 0.22$). High PC1 values indicate higher frequency calls, while high PC2 values suggest lower minimum frequencies and wider bandwidths (Table 1). Thus, these results suggest that type C note had wider frequency bandwidth and lower minimum frequency compared with types A and B notes. Type A note was longer than types B ($Z = 6.83$, $P < 0.0001$) and C ($Z = 12.75$, $P < 0.0001$), whereas type C note was shorter than type B note ($Z = -5.63$, $P < 0.0001$).

There was no correlation between acoustic and geographic distances regardless of note type (Mantel tests:

Table 2. Mantel test (9999 repetitions) summarizing the autocorrelations between geographic distance and acoustic distances ($n = 85A$, 67B, 66C). Correlation coefficient (r) values and significance (P) values are shown. The p -values were adjusted for multiple testing considering the false discovery rates method.

Note	Variable	r	P	Adjusted P
Type A	PC1	0.12	0.05	0.21
	PC2	0.06	0.18	0.40
	Note duration	-0.03	0.62	0.62
Type B	PC1	0.15	0.03	0.21
	PC2	0.01	0.38	0.55
	Note duration	-0.001	0.43	0.55
Type C	PC1	-0.02	0.52	0.55
	PC2	0.15	0.07	0.21
	Note duration	-0.03	0.57	0.62

Table 3. Linear mixed models to evaluate the effect of coordinates (latitude and longitude) and climate variables (mean annual temperature [temp] and annual precipitation [prec]) on the acoustic structure of *Dendropsophus minutus* call notes. Note type and recording identity were included as random intercepts in all models. Duration: note duration (log). Significant effects highlighted in bold.

Model	Parameter	β [95% CI]	P
PC1 ~ longitude + latitude	Longitude	0.36 [0.17, 0.55]	< 0.001
	Latitude	-0.02 [-0.22, 0.18]	0.82
PC2 ~ longitude + latitude	Longitude	0.19 [0.04, 0.33]	0.012
	Latitude	-0.08 [-0.23, 0.08]	0.31
Duration ~ longitude + latitude	Longitude	0.07 [-0.02, 0.16]	0.14
	Latitude	-0.07 [-0.17, 0.03]	0.17
PC1 ~ temp + prec	Temperature	-0.18 [-0.39, 0.02]	0.076
	Precipitation	0.02 [-0.19, 0.23]	0.83
PC2 ~ temp + prec	Temperature	-0.16 [-0.31, -0.01]	0.039
	Precipitation	-0.05 [-0.20, 0.11]	0.54
Duration ~ temp + prec	Temperature	-0.16 [-0.25, -0.07]	< 0.001
	Precipitation	-0.12 [-0.21, -0.03]	0.012

Table 2), suggesting that isolation by distance cannot solely explain geographic variation in note acoustics in lesser treefrogs. Linear mixed models showed that frequency (PC1) and bandwidth (PC2) increase with longitude (Table 3, Fig. 3). This suggests that eastern treefrogs produce higher-pitched and wider-bandwidth notes. Moreover, lesser treefrogs uttered notes with wider bandwidths (PC2) in colder sites (Fig. 4A). These anurans also produced longer notes in colder (Fig. 4B) and dryer sites (Fig. 4C). The acoustic features of notes were not related to latitude ($P > 0.10$) (Table 3).

DISCUSSION

Our results suggest that the analyzed acoustic properties of lesser treefrogs' notes, which compose their calls, vary with longitude, mean annual temperature, and annual precipitation. Notes appear to have a higher pitch and wider bandwidth east of the species' range. Notes also seem to have a lower bandwidth at hotter sites and a shorter duration at hotter sites and wetter sites. Con-

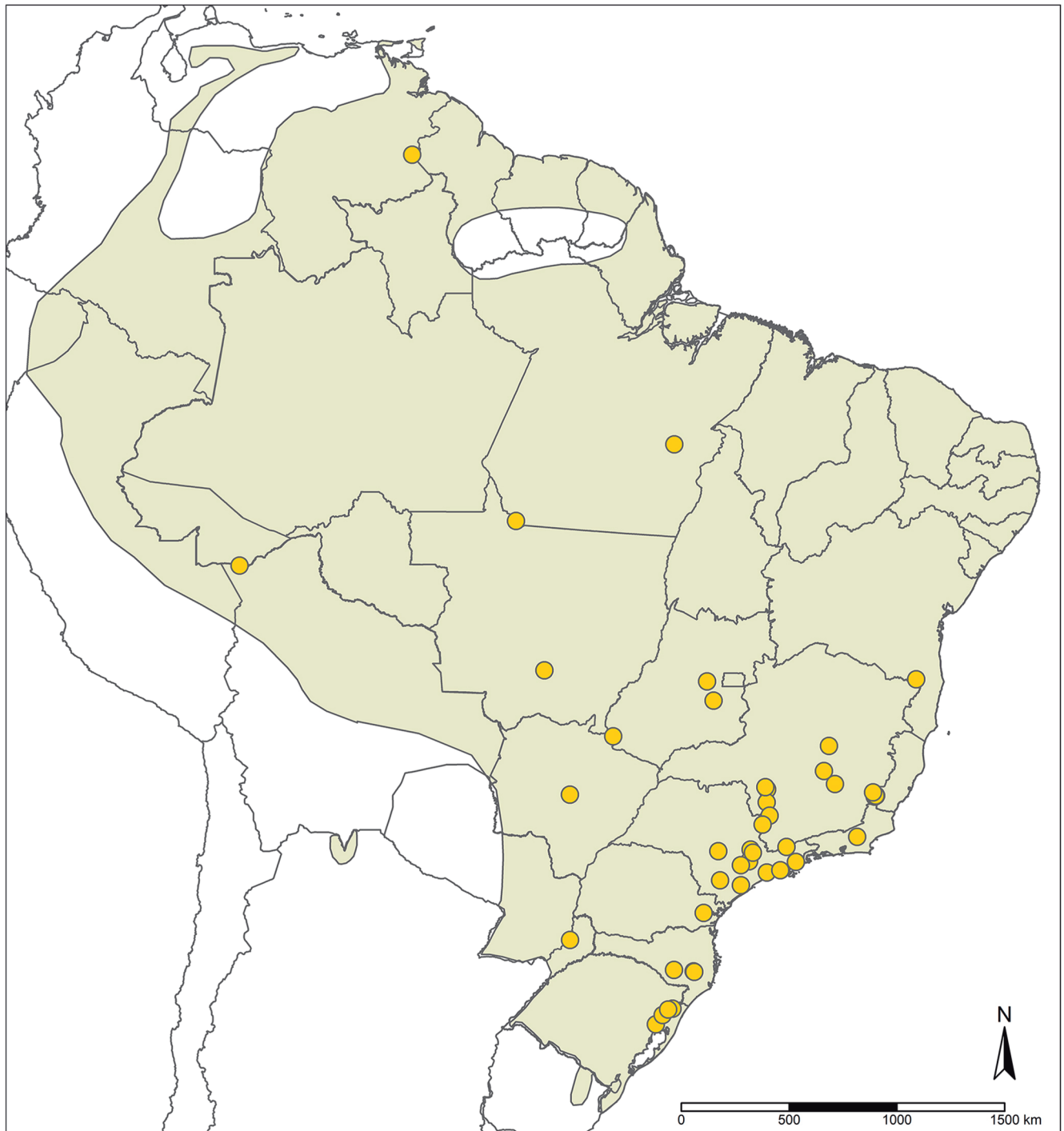


Figure 2. Geographical scope of the sound recordings samples ($n = 87$) of the species *Dendropsophus minutus* in South America. Polygon (beige) represents the entire distribution, according to the spatial data made available by the International Union for Conservation of Nature (IUCN). Dots (yellow) represent the locations where the recordings were made. It is noteworthy that some recordings were made at the same geographical point, but with different individuals.

versely, we found no significant correlation between acoustic metrics of notes and latitude.

Previous studies found that air temperature is an important driver of variation in anuran calls (Prestwich, 1994). A previous study on geographic variation in call acoustics in the congeneric dwarf treefrog (*Dendropsophus nanus*) (Boulenger, 1889) also found a decrease in advertisement call duration with increasing temperature (Annibale *et al.*, 2020). Call duration in lesser treefrogs living in a temporary pond in central Brazil also decreases with temporal increases in air temperature

(Morais *et al.*, 2012). These studies suggest that higher temperatures tend to reduce the duration of calls and their notes in anurans. However, it is important to note that these previous studies relied on temperature measurements obtained at the time of recordings, whereas our study employed average temperature values across several years. Therefore, our study suggests that call traits (*e.g.*, note rate and duration) might be influenced by climate-based selection extending beyond the individual plasticity in response to fluctuations in air temperature, as proposed in earlier research (Prestwich, 1994; Wells,

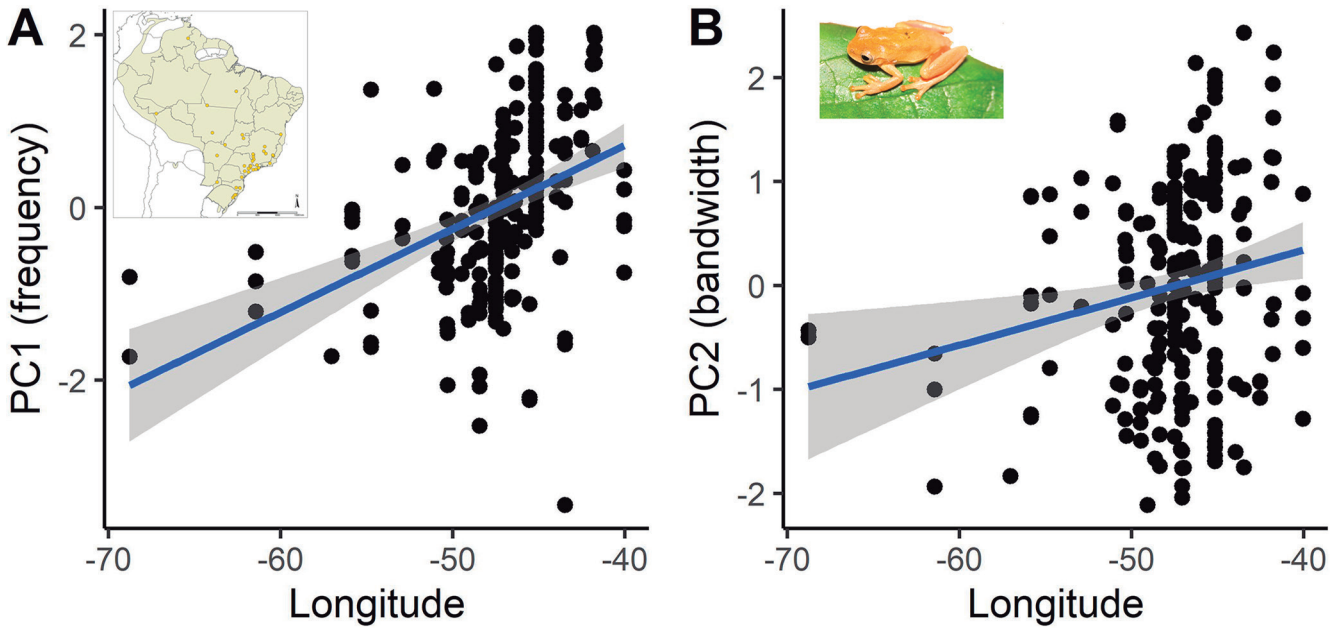


Figure 3. Variation in frequency (PC1) and bandwidth (PC2) of *Dendropsophus minutus* calls as a function of longitude. Mean trend lines and confidence intervals (95%) are shown. Each point represents the average acoustic parameter for each note type on each recording (i.e., individual).

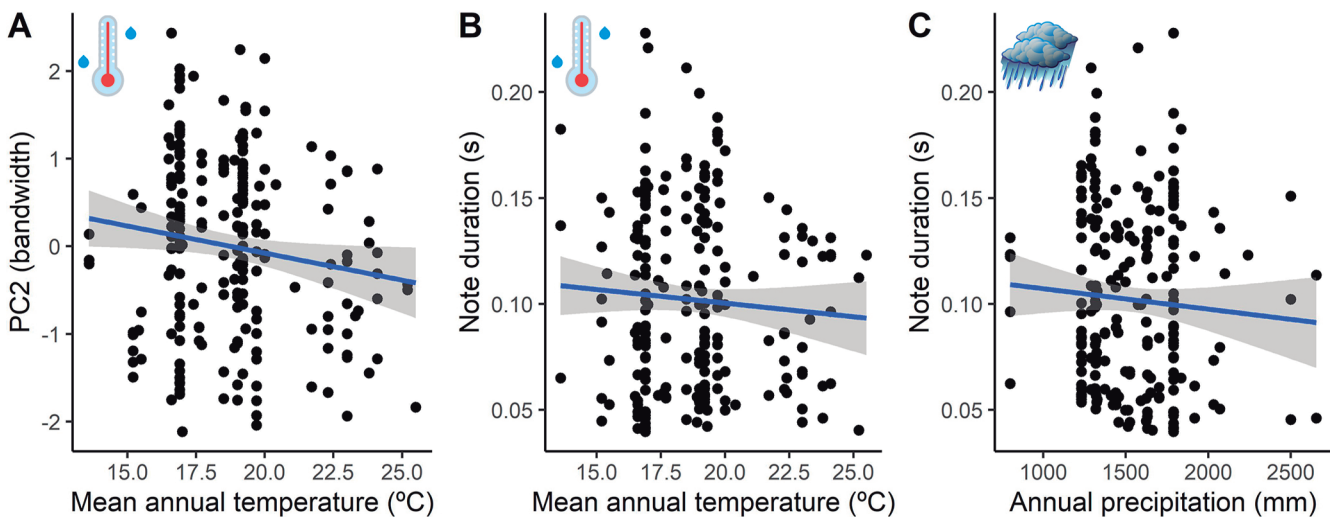


Figure 4. Variation in frequency bandwidth (PC2) and note duration (s) of *Dendropsophus minutus* calls as a function of mean annual temperature and annual precipitation. Mean trend lines and confidence intervals (95%) are shown. Each point represents the average acoustic parameter for each note type on each recording (i.e., individual).

2010; Morais et al., 2012; Llusia et al., 2013a; Annibale et al., 2020).

Call rate often increases with increasing air temperature in anurans as a result of higher metabolic rate and energy expenditure (Wells, 2010). For example, in chaco treefrogs (*Boana raniceps*) (Cope, 1862), males produce shorter calls, but in greater numbers, as the air temperature increases (Guimarães & Bastos, 2003). Given the recording's limited duration, we could not measure call rates. Yet, we speculate that in warmer temperatures, lesser treefrogs produce shorter notes at a higher rate, optimizing call transmission while conserving energy (Lingnau & Bastos, 2007).

Here, in addition to note duration, note bandwidth (represented by PC2, Table 1), but not note pitch (PC1), decreased with increasing temperature (Fig. 4A). As shown above, air temperature strongly affects the acous-

tics of anuran calls at short (Morais et al., 2012; Llusia et al., 2013a) and possibly at longer time scales (this study). High-pitched sounds attenuate more quickly than low-pitched sounds, i.e., high-pitched sounds lose energy faster as they propagate away from the sound source (Brown & Riede, 2017). Additionally, high temperatures and low humidity favor sound absorption (Snell-Rood, 2012), which impairs sound propagation. We suggest that male lesser treefrogs modulate call bandwidth to optimize signal propagation depending on the air temperature.

The call notes of *D. minutus* were shorter in sites with accumulated annual rainfall greater than 2000mm (Fig. 4D). We already expected that these acoustic signals would vary with precipitation since relative humidity modulates the reproduction of many amphibian species (Aichinger, 1987; Llusia et al., 2013b). Rain noise can mask anuran calls, reduce their acoustic activity (Ospina et al.,

2013), and may thus explain the shorter lesser treefrogs' call notes in wetter sites (Brumm & Slabbekoorn, 2005). Intense solar radiation in the rainy season in southeast Brazil, which covers most of the recording locations (Madruga *et al.*, 2014), increases evaporation and, consequently, heat fluxes. Thus, seasonal matching of hotter temperatures and heavier rainfall may have a combined effect on the occurrence of short call notes in hot and wet environments.

Combined evidence from this and previous studies suggest that individual morphology may also explain geographic variation in calls of *D. minutus*. First, larger males call at a lower pitch in several species from different anuran clades (Gingras *et al.*, 2012). Second, a previous study showed that larger males call at a lower pitch in lesser treefrogs (Morais *et al.*, 2012). Finally, lesser treefrogs are larger in drier regions along a geographic gradient of rainfall seasonality and habitat type, which may be possibly a mechanism to avoid desiccation (Oyamaguchi *et al.*, 2017). These patterns suggest that this species may be smaller and call at a higher pitch in the east of their distribution, where rainfall seasonality is lower than in central Brazil, pending further studies.

We showed that type C notes had a lower pitch than types A and B notes. Males lesser treefrogs utter advertisement calls composed by types A and C notes during the breeding season (Cardoso & Haddad, 1984; Guerra *et al.*, 2018; Foratto *et al.*, 2021). Changes in the production of these acoustic signals such as lowering pitch probably increase male attractiveness to females (Foratto *et al.*, 2021). In contrast, calls including type B note mediates territorial and aggressive interactions. Lesser treefrogs may use the harmonic structure of type B note to assess rivals' fighting ability and aggressive intent, adjusting territorial and aggressive behavior accordingly (Foratto *et al.*, 2021). Further studies could test whether acoustic variation led by geography and bioclimate may result in changes in signaling function within populations. For example, how does call bandwidth mediate aggressive interactions in hot sites, in which call note bandwidths are lower, in comparison with colder sites?

Although there are 14 acoustic libraries containing recordings of amphibians (Köhler *et al.*, 2017), Fonoteca Neotropical Jacques Vielliard (FNJV) has the highest number of recordings of lesser treefrogs at high quality and easy access compared to other libraries. We also obtained additional recordings from three other repositories. Nevertheless, recording availability is strongly biased to southeastern Brazil (Fig. 2) (Toledo *et al.*, 2015b), limiting the representativeness of our results for understanding the geographic variation of lesser treefrog calls. Southeastern Brazil has a diverse climate driven by variations in topography, location, and dynamic aspects of the atmosphere (Minuzzi *et al.*, 2007), which proved to be enough gradient to find a positive correlation between call note acoustics and longitude (Fig. 3). Further studies are needed to evaluate if this pattern holds for a broader geographic range.

We could not assess geographic and contextual variation in note type syntax due to the short recording du-

ration and lack of information about the social context in which frogs were recorded. Lesser treefrogs have a complex vocal repertoire with calls varying in number, frequency, duration, and note type syntax, depending on the social context (Toledo *et al.*, 2015a; Foratto *et al.*, 2021). We urge further recordists to add information on ecology and social context along with the call recordings. This would be the foundation of further studies on geographic variation in call syntax in lesser treefrogs (*e.g.*, Kershenbaum *et al.*, 2012) and shed light on the function of these signals. Finally, the present study highlights the feasibility and importance of citizen science and audio-visual databases to understand the evolution of acoustic signals in anurans.

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APPENDIX 1

Table S1. Acoustic recordings ($n = 89$) of lesser treefrogs (*Dendropsophus minutus*) obtained from acoustic data repositories. Recordings highlighted in bold were not analyzed. The recording underlined was deleted because it exhibits very extreme measurements (e.g., mean peak frequency > 13 kHz). Repositories: Fonoteca Neotropical Jacques Vielliard (FNJV); herpetological collection of the Museu Nacional of the Universidade Federal do Rio de Janeiro (MNRJ); Coleção de Arquivos Sonoros de Anuros Neotropicais (IF Goiano) (CASAN); and Fonoteca Biológica da Universidade Federal de Pernambuco (FBIOUFPE).

Recording identity	Repository	Longitude	Latitude	Recordist	Recording identity	Repository	Longitude	Latitude	Recordist
CASAN_062	CASAN	-48.6471	-16.6377	NA	FNJV_33745	FNJV	-45.8106	-23.6761	NA
CASAN_063	CASAN	-48.6471	-16.6377	NA	FNJV_34533	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
CASAN_091	CASAN	-40.0319	-15.7579	NA	FNJV_34534	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
CASAN_092	CASAN	-40.0319	-15.7579	NA	FNJV_34535	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
CASAN_094	CASAN	-40.0319	-15.7579	NA	FNJV_34536	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FBIOUFPE_8_1117	FBIOUFPE	-50.3859	-29.4224	Pedro Simões	FNJV_34540	FNJV	-48.3714	-24.0978	Roseli Foratto & Lucas Forti
FNJV_8703	FNJV	-49.0661	-25.4475	Jacques Vielliard	FNJV_34541	FNJV	-48.3714	-24.0978	Roseli Foratto & Lucas Forti
FNJV_12255	FNJV	-57.0381	-9.18417	Luis Felipe Toledo	FNJV_34542	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13104	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34543	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13106	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34544	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13107	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34545	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13108	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34546	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13109	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34547	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_13110	FNJV	-47.0697	-22.8194	Célio Haddad	FNJV_34551	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30775	FNJV	-46.3675	-20.3283	Adão Cardoso	FNJV_34552	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30776	FNJV	-46.3875	-20.8608	Adão Cardoso	FNJV_34553	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30777	FNJV	-46.5619	-21.7853	Adão Cardoso	FNJV_34554	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30778	FNJV	-46.4458	-20.2317	Adão Cardoso	FNJV_34555	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30783	FNJV	-43.7453	-18.5219	Ivan Sazima	FNJV_34556	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30784	FNJV	-46.3828	-23.7697	Adão Cardoso	FNJV_34557	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30785	FNJV	-50.3264	-27.8178	Adão Cardoso	FNJV_34558	FNJV	-47.4853	-23.4708	Roseli Foratto & Lucas Forti
FNJV_30791	FNJV	-55.8333	-15.3833	Adão Cardoso	FNJV_34559	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30792	FNJV	-55.8333	-15.3833	Adão Cardoso	FNJV_34560	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30794	FNJV	-52.9083	-18.1225	Adão Cardoso	FNJV_34561	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30795	FNJV	-50.3089	-6.00528	Adão Cardoso	FNJV_34562	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30797	FNJV	-61.4498	6.017562	Adão Cardoso	FNJV_34563	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30798	FNJV	-46.2647	-21.4119	Adão Cardoso	FNJV_34564	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30801	FNJV	-42.5403	-22.2931	Adão Cardoso	FNJV_34565	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30803	FNJV	-46.5619	-21.7853	Adão Cardoso	FNJV_34566	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30804	FNJV	-46.5619	-21.7853	Adão Cardoso	FNJV_34567	FNJV	-45.1458	-23.3356	Roseli Foratto & Lucas Forti
FNJV_30806	FNJV	-51.0969	-30.0722	Adão Cardoso	FNJV_36594	FNJV	-41.7377	-20.5812	Camila Zornosa-Torres
FNJV_30810	FNJV	-68.7811	-11.0344	Adão Cardoso	FNJV_37481	FNJV	-54.7531	-20.5381	Matheus Moroti
FNJV_30811	FNJV	-47.1336	-23.3072	Gilda de Andrade	FNJV_40083	FNJV	-41.7961	-20.6202	Camila Zornosa-Torres
FNJV_30813	FNJV	-50.3264	-27.8178	Adão Cardoso	FNJV_40144	FNJV	-41.7601	-20.5815	Victor Augusto
FNJV_30814	FNJV	-50.8064	-29.6869	Adão Cardoso	FNJV_44254	FNJV	-54.7414	-26.5717	NA
FNJV_30815	FNJV	-50.5708	-29.4575	Adão Cardoso	MNVOC005_01	MNRJ	-41.8692	-20.4494	Marcos Bilate
FNJV_30816	FNJV	-47.4831	-24.3017	Adão Cardoso	MNVOC021_02	MNRJ	-43.488	-20.0995	José Pombal-Jr.
FNJV_30817	FNJV	-43.9597	-19.5619	Adão Cardoso	MNVOC031_07	MNRJ	-43.488	-20.0995	José Pombal-Jr.
FNJV_31825	FNJV	-48.4447	-22.8872	Werner Bokermann	MNVOC031_10	MNRJ	-43.488	-20.0995	José Pombal-Jr.
FNJV_31827	FNJV	-48.4447	-22.8872	Werner Bokermann	MNVOC033_03	MNRJ	-43.488	-20.0995	José Pombal-Jr.
FNJV_31830	FNJV	-48.4447	-22.8872	Werner Bokermann	MNVOC034_07	MNRJ	-43.488	-20.0995	José Pombal-Jr.
FNJV_31948	FNJV	-45.5483	-22.7092	Werner Bokermann	MNVOC046_06	MNRJ	-48.9194	-15.8397	Fabio Hepp
FNJV_32526	FNJV	-48.3714	-24.0978	Alexandre Bertolazzi	MNVOC046_08	MNRJ	-48.9194	-15.8397	Fabio Hepp
<u>FNJV_32699</u>	<u>FNJV</u>	<u>-48.7623</u>	<u>-24.2257</u>	<u>Rogério Bastos</u>	MNVOC069_01	MNRJ	-49.4909	-27.8774	Manoela Cardoso
FNJV_33132	FNJV	-46.9725	-22.9456	Alexandre Bertolazzi	MNVOC069_02	MNRJ	-49.4617	-27.8944	Manoela Cardoso

Table S2. Average acoustic measurements of calls from lesser treefrogs (*Dendropsophus minutus*) computed for each note type within each recording (*i.e.*, individual frogs) ($n = 88$ recordings). The note types were categorized as A, B, or C. The acoustic measurements included the duration of each note (measured in seconds), the 25th percentile frequency (measured in kHz; the frequency at which the signal's energy is divided into two intervals containing 25% and 75% of the energy, respectively), the 75th percentile frequency (measured in kHz; the frequency at which the signal's energy is divided into two intervals containing 75% and 25% of the energy, respectively), the bandwidth (measured in kHz; calculated as the difference between the 75th percentile frequency and the 25th percentile frequency), the mean dominant frequency (measured in kHz; the average of the dominant frequencies across the acoustic signal), and the mean peak frequency (measured in kHz; the frequency with the highest energy in the mean frequency spectrum). The recording in bold was deleted because it exhibits very extreme measurements (*e.g.*, mean peak frequency > 13 kHz).

Recording identity	Note type	Note duration (s)	25% frequency	75% frequency	Bandwidth	Mean dominant frequency	Mean peak frequency
CASAN_062	A	0.131	4.119	5.292	1.173	4.674	4.777
CASAN_062	B	0.086	3.609	4.519	0.911	4.394	4.504
CASAN_062	C	0.073	3.841	5.168	1.328	5.076	4.792
CASAN_063	C	0.060	3.308	5.268	1.959	4.083	4.086
CASAN_063	B	0.086	4.292	4.607	0.314	4.568	4.605
CASAN_063	A	0.123	4.169	5.190	1.021	4.701	4.806
CASAN_091	A	0.123	3.717	5.161	1.443	4.938	4.907
CASAN_091	B	0.096	4.003	4.743	0.740	4.580	4.705
CASAN_091	C	0.062	2.721	5.197	2.476	3.932	4.187
CASAN_092	A	0.122	2.924	4.825	1.901	4.410	2.644
CASAN_094	A	0.131	3.542	5.227	1.686	4.675	4.302
FBIOUFPE_8_1117	A	0.143	3.808	4.751	0.943	4.289	4.561
FBIOUFPE_8_1117	C	0.053	2.633	4.774	2.141	3.769	4.561
FBIOUFPE_8_1117	B	0.073	3.089	4.389	1.300	3.975	4.360
FNJV_8703	A	0.221	2.704	4.926	2.222	3.308	2.486
FNJV_8703	B	0.155	4.207	4.453	0.246	4.434	4.388
FNJV_8703	C	0.100	2.524	4.903	2.379	3.463	2.414
FNJV_12255	A	0.123	3.454	4.030	0.577	3.602	3.480
FNJV_13104	C	0.066	2.829	5.512	2.683	4.496	2.659
FNJV_13104	B	0.104	4.668	5.580	0.912	4.985	5.296
FNJV_13104	A	0.177	3.756	5.710	1.954	5.002	4.547
FNJV_13106	A	0.158	4.566	5.736	1.171	5.103	5.051
FNJV_13106	C	0.084	4.227	4.896	0.669	4.565	4.821
FNJV_13106	B	0.098	4.365	4.633	0.268	4.281	4.619
FNJV_13107	B	0.136	4.526	4.666	0.140	4.619	4.648
FNJV_13107	C	0.074	2.908	5.153	2.245	4.067	4.878
FNJV_13107	A	0.162	2.843	5.132	2.289	4.217	4.014
FNJV_13108	B	0.081	4.499	5.006	0.507	4.811	4.979
FNJV_13108	C	0.060	3.814	5.344	1.530	4.580	5.181
FNJV_13108	A	0.188	3.616	5.505	1.890	4.640	5.167
FNJV_13109	A	0.181	4.222	5.332	1.110	4.580	4.648
FNJV_13109	B	0.125	2.259	4.583	2.324	3.614	2.990
FNJV_13110	B	0.101	4.494	4.606	0.113	4.565	4.561
FNJV_13110	A	0.180	4.381	5.011	0.630	4.704	4.835
FNJV_30775	A	0.052	3.434	5.615	2.182	4.747	5.354
FNJV_30776	A	0.117	2.984	5.109	2.126	4.473	4.172
FNJV_30777	C	0.056	2.616	5.010	2.394	4.106	2.428
FNJV_30777	B	0.056	2.608	4.681	2.073	4.599	4.648
FNJV_30777	A	0.160	4.041	5.095	1.054	4.769	4.922
FNJV_30778	A	0.121	2.759	4.896	2.137	3.685	2.673
FNJV_30783	A	0.148	2.825	5.369	2.544	3.711	2.745
FNJV_30784	A	0.114	3.030	5.287	2.258	3.985	3.293
FNJV_30784	B	0.046	3.871	4.877	1.005	4.581	4.777
FNJV_30784	C	0.046	2.709	5.091	2.382	3.962	4.158
FNJV_30785	C	0.052	2.593	4.947	2.353	4.305	4.763
FNJV_30785	A	0.132	3.191	4.975	1.784	3.913	3.898
FNJV_30791	A	0.120	2.980	4.977	1.997	4.271	4.720
FNJV_30791	B	0.068	4.324	4.829	0.505	4.503	4.792

Recording identity	Note type	Note duration (s)	25% frequency	75% frequency	Bandwidth	Mean dominant frequency	Mean peak frequency
FNVJ_30791	C	0.044	2.695	4.956	2.261	3.987	3.178
FNVJ_30792	B	0.067	4.326	4.837	0.511	4.271	4.792
FNVJ_30792	C	0.044	2.694	4.965	2.271	4.111	3.178
FNVJ_30792	A	0.132	2.991	4.974	1.983	4.529	4.749
FNVJ_30794	B	0.065	2.483	4.912	2.429	4.360	4.057
FNVJ_30794	C	0.058	2.794	5.285	2.491	4.135	3.394
FNVJ_30794	A	0.145	3.993	5.641	1.647	4.554	4.100
FNVJ_30795	A	0.122	3.215	4.153	0.938	3.789	3.754
FNVJ_30795	C	0.046	2.348	4.212	1.864	3.652	3.999
FNVJ_30795	B	0.061	2.117	4.186	2.069	3.521	2.068
FNVJ_30797	C	0.051	3.494	4.586	1.093	4.195	4.446
FNVJ_30797	B	0.080	3.898	4.124	0.226	3.989	4.129
FNVJ_30797	A	0.136	3.340	4.591	1.251	3.859	4.143
FNVJ_30798	A	0.110	3.432	6.599	3.167	5.303	5.181
FNVJ_30798	C	0.050	3.093	6.368	3.276	4.617	4.086
FNVJ_30798	B	0.068	4.824	6.030	1.206	5.203	4.979
FNVJ_30801	B	0.108	4.420	5.358	0.939	5.046	5.282
FNVJ_30801	C	0.058	5.051	5.525	0.474	5.265	5.253
FNVJ_30801	A	0.154	4.569	5.462	0.893	5.035	4.950
FNVJ_30803	B	0.084	2.457	4.894	2.437	3.738	4.878
FNVJ_30803	C	0.061	2.528	5.038	2.509	3.362	2.500
FNVJ_30803	A	0.144	2.681	5.268	2.587	3.079	2.529
FNVJ_30804	A	0.134	3.991	5.483	1.493	4.782	5.109
FNVJ_30806	C	0.044	2.888	5.341	2.453	4.724	5.109
FNVJ_30806	B	0.056	4.685	5.084	0.400	4.972	5.037
FNVJ_30806	A	0.134	4.372	5.859	1.487	5.238	5.570
FNVJ_30810	A	0.112	2.941	4.504	1.563	3.257	2.169
FNVJ_30810	C	0.040	3.408	4.532	1.124	3.807	4.172
FNVJ_30811	C	0.051	3.194	5.274	2.081	4.704	4.850
FNVJ_30811	B	0.072	4.778	4.922	0.145	4.849	4.893
FNVJ_30811	A	0.109	4.600	5.328	0.728	5.037	5.022
FNVJ_30813	B	0.089	2.348	4.695	2.347	3.706	4.648
FNVJ_30813	C	0.054	2.615	4.811	2.196	3.247	2.342
FNVJ_30813	A	0.137	3.020	5.049	2.029	4.057	2.472
FNVJ_30814	A	0.138	4.290	5.345	1.055	4.922	5.066
FNVJ_30814	C	0.042	2.771	5.486	2.715	3.205	2.745
FNVJ_30814	B	0.050	2.681	5.445	2.764	3.038	2.673
FNVJ_30815	A	0.114	3.139	4.453	1.314	4.196	4.460
FNVJ_30816	A	0.113	4.973	6.141	1.169	5.136	5.830
FNVJ_30817	A	0.150	4.358	5.416	1.058	4.959	4.994
FNVJ_30817	C	0.057	2.821	5.387	2.566	4.588	3.480
FNVJ_30817	B	0.083	4.785	4.966	0.181	4.864	4.922
FNVJ_31825	A	0.126	3.027	4.639	1.612	4.032	4.042
FNVJ_31825	B	0.077	2.782	4.778	1.996	3.859	3.019
FNVJ_31825	C	0.054	2.777	4.607	1.830	3.721	2.688
FNVJ_31827	A	0.145	2.499	4.443	1.944	2.721	2.428
FNVJ_31827	B	0.100	3.062	4.473	1.411	3.784	3.697
FNVJ_31827	C	0.074	2.412	4.542	2.130	2.698	2.399
FNVJ_31830	A	0.199	2.475	3.981	1.506	2.895	2.472
FNVJ_31948	C	0.065	2.382	4.305	1.923	2.670	2.371
FNVJ_31948	B	0.137	2.275	4.450	2.175	3.799	4.432
FNVJ_31948	A	0.182	2.382	4.447	2.065	2.512	2.356
FNVJ_32526	B	0.165	4.489	5.794	1.305	4.341	4.518
FNVJ_32526	A	0.211	4.643	5.373	0.729	4.908	4.950
FNVJ_32699	B	0.142	7.695	13.256	5.561	11.136	13.252
FNVJ_33132	C	0.060	3.325	5.007	1.682	4.675	4.936
FNVJ_33132	A	0.155	3.587	5.214	1.627	4.771	4.994

Recording identity	Note type	Note duration (s)	25% frequency	75% frequency	Bandwidth	Mean dominant frequency	Mean peak frequency
FNJV_33132	B	0.108	4.622	4.863	0.241	5.187	4.864
FNJV_33745	C	0.045	2.946	5.719	2.773	3.078	2.918
FNJV_33745	A	0.151	3.116	5.756	2.641	3.698	2.933
FNJV_33745	B	0.102	2.759	5.508	2.749	4.525	4.107
FNJV_34533	A	0.143	3.004	5.497	2.494	4.315	2.644
FNJV_34533	B	0.085	2.515	4.971	2.455	3.742	2.515
FNJV_34533	C	0.062	2.716	5.280	2.564	3.830	2.673
FNJV_34534	B	0.073	2.533	5.031	2.497	3.739	2.529
FNJV_34534	C	0.055	2.722	5.300	2.578	3.595	2.702
FNJV_34534	A	0.138	3.000	5.574	2.574	4.392	2.688
FNJV_34535	A	0.150	2.840	4.834	1.995	4.272	3.207
FNJV_34535	B	0.087	3.833	4.460	0.627	4.322	4.432
FNJV_34535	C	0.054	2.509	4.764	2.255	4.092	3.898
FNJV_34536	A	0.165	2.857	4.761	1.904	4.326	3.927
FNJV_34536	C	0.057	2.493	4.741	2.249	3.880	4.648
FNJV_34536	B	0.084	3.060	4.489	1.429	4.308	4.446
FNJV_34540	A	0.169	3.154	5.029	1.875	4.557	4.979
FNJV_34540	B	0.097	3.049	4.892	1.843	4.068	4.071
FNJV_34540	C	0.060	2.755	5.236	2.481	3.834	5.037
FNJV_34541	B	0.109	4.469	4.765	0.296	4.687	4.749
FNJV_34541	C	0.074	2.732	5.249	2.518	3.648	3.423
FNJV_34541	A	0.140	2.628	4.943	2.314	3.748	2.515
FNJV_34542	A	0.228	4.095	5.658	1.564	4.943	5.541
FNJV_34542	B	0.122	5.197	5.564	0.367	5.595	5.469
FNJV_34542	C	0.086	3.843	5.564	1.721	4.723	5.469
FNJV_34543	A	0.174	3.209	5.743	2.534	4.808	5.599
FNJV_34543	B	0.130	5.298	5.548	0.250	5.299	5.484
FNJV_34543	C	0.074	2.979	5.588	2.609	4.716	5.383
FNJV_34544	B	0.117	4.778	5.536	0.757	5.274	5.512
FNJV_34544	C	0.081	2.912	5.489	2.576	4.342	5.397
FNJV_34545	A	0.190	3.068	5.490	2.422	4.852	5.282
FNJV_34545	C	0.059	2.854	5.522	2.668	3.748	3.567
FNJV_34545	B	0.083	5.083	5.200	0.117	5.078	5.167
FNJV_34546	C	0.068	2.888	5.534	2.646	4.430	4.489
FNJV_34546	B	0.105	5.100	5.214	0.114	5.145	5.181
FNJV_34546	A	0.140	3.146	5.505	2.359	5.077	5.231
FNJV_34547	A	0.163	3.080	5.547	2.467	4.931	5.239
FNJV_34547	B	0.097	5.089	5.218	0.129	5.161	5.224
FNJV_34547	C	0.064	2.853	5.516	2.664	3.959	2.673
FNJV_34551	B	0.095	3.061	4.845	1.783	3.954	3.999
FNJV_34551	A	0.162	2.977	5.078	2.101	4.321	5.037
FNJV_34551	C	0.056	2.679	5.115	2.436	3.674	3.408
FNJV_34552	B	0.076	2.489	4.979	2.490	3.349	2.486
FNJV_34552	C	0.057	2.737	5.365	2.628	3.875	2.616
FNJV_34552	A	0.160	3.026	5.353	2.327	4.702	5.239
FNJV_34553	C	0.055	2.609	5.085	2.476	3.173	2.544
FNJV_34553	A	0.160	3.056	4.838	1.782	4.668	4.806
FNJV_34553	B	0.081	2.400	4.784	2.384	4.355	3.985
FNJV_34554	B	0.081	2.368	4.734	2.366	3.645	2.356
FNJV_34554	A	0.138	2.931	4.876	1.945	4.187	4.864
FNJV_34554	C	0.056	2.552	4.926	2.374	3.628	3.250
FNJV_34555	C	0.060	2.450	4.896	2.446	3.647	2.399
FNJV_34555	A	0.140	2.882	4.875	1.993	4.229	4.547
FNJV_34555	B	0.087	2.371	4.728	2.357	3.871	3.134
FNJV_34556	A	0.116	2.763	4.887	2.124	4.060	2.616
FNJV_34557	A	0.131	2.775	4.891	2.116	4.051	2.659
FNJV_34558	A	0.153	2.771	4.846	2.075	3.729	2.673

Recording identity	Note type	Note duration (s)	25% frequency	75% frequency	Bandwidth	Mean dominant frequency	Mean peak frequency
FNUV_34558	B	0.100	2.369	4.740	2.371	3.757	2.356
FNUV_34558	C	0.068	2.616	4.918	2.302	3.274	2.659
FNUV_34559	A	0.155	4.865	5.955	1.091	5.493	5.685
FNUV_34560	B	0.128	5.367	5.777	0.410	5.526	5.772
FNUV_34560	C	0.041	3.641	6.210	2.568	5.652	5.930
FNUV_34560	A	0.152	3.995	6.259	2.263	5.754	5.685
FNUV_34561	C	0.042	3.187	6.092	2.905	5.073	3.913
FNUV_34561	A	0.149	3.849	5.901	2.052	5.607	5.757
FNUV_34561	B	0.102	3.313	5.812	2.499	4.729	4.777
FNUV_34562	A	0.146	3.805	5.909	2.104	5.368	5.858
FNUV_34562	C	0.049	4.232	5.840	1.608	5.257	5.440
FNUV_34562	B	0.122	4.134	5.722	1.588	5.433	5.729
FNUV_34563	A	0.151	3.200	5.948	2.748	3.635	3.062
FNUV_34563	B	0.086	2.907	5.802	2.895	4.527	3.884
FNUV_34563	C	0.040	3.047	5.982	2.934	3.778	2.976
FNUV_34564	C	0.044	3.056	6.094	3.038	3.903	3.062
FNUV_34564	B	0.090	2.916	5.843	2.928	4.666	5.844
FNUV_34564	A	0.157	3.171	5.983	2.813	3.830	3.048
FNUV_34565	B	0.080	2.882	5.777	2.895	4.308	3.855
FNUV_34565	A	0.155	3.118	5.923	2.805	3.582	3.048
FNUV_34565	C	0.049	3.035	6.017	2.982	3.761	3.062
FNUV_34566	C	0.047	5.124	6.306	1.182	5.448	5.642
FNUV_34566	A	0.140	4.964	5.945	0.981	5.362	5.570
FNUV_34566	B	0.089	5.043	5.256	0.213	5.117	5.253
FNUV_34567	C	0.049	4.922	6.133	1.211	5.460	5.585
FNUV_34567	A	0.147	5.014	5.915	0.901	5.295	5.570
FNUV_34567	B	0.075	4.479	5.352	0.872	5.178	5.296
FNUV_36594	A	0.140	4.071	6.868	2.797	5.460	4.360
FNUV_36594	B	0.106	4.960	6.291	1.331	5.619	5.066
FNUV_36594	C	0.055	3.449	6.807	3.358	4.774	4.446
FNUV_37481	A	0.093	4.987	5.779	0.792	5.381	5.296
FNUV_40083	C	0.057	3.689	6.820	3.131	4.563	5.296
FNUV_40083	B	0.111	5.190	6.149	0.958	5.863	5.887
FNUV_40144	A	0.114	3.557	6.612	3.055	4.794	3.365
FNUV_44254	C	0.054	2.546	4.885	2.338	3.370	2.500
FNUV_44254	A	0.172	2.669	4.733	2.064	2.926	2.644
FNUV_44254	B	0.100	2.335	4.663	2.328	3.357	2.313
MNVOC005_01	B	0.086	4.666	5.944	1.278	5.378	5.945
MNVOC005_01	C	0.056	3.469	6.060	2.592	4.985	4.922
MNVOC005_01	A	0.131	3.548	6.158	2.610	4.391	3.365
MNVOC021_02	A	0.123	2.675	4.829	2.154	2.677	2.702
MNVOC021_02	B	0.080	2.547	4.959	2.412	2.612	2.529
MNVOC021_02	C	0.049	2.531	3.184	0.653	2.705	2.659
MNVOC031_07	A	0.134	4.794	5.625	0.830	5.311	5.008
MNVOC033_03	A	0.153	3.866	5.849	1.984	5.081	5.757
MNVOC033_03	B	0.067	3.647	5.726	2.079	4.885	5.570
MNVOC033_03	C	0.047	3.554	5.884	2.330	4.630	3.754
MNVOC034_07	A	0.131	3.331	5.353	2.023	4.925	5.152
MNVOC034_07	B	0.083	2.655	5.244	2.589	3.998	5.195
MNVOC034_07	C	0.041	2.865	6.218	3.353	3.819	2.731
MNVOC046_08	A	0.130	4.067	5.310	1.243	4.827	4.907
MNVOC069_01	A	0.150	4.383	5.117	0.734	4.580	4.576
MNVOC069_01	B	0.102	3.628	4.549	0.922	3.968	4.244
MNVOC069_01	C	0.055	4.305	4.908	0.603	4.671	4.561
MNVOC069_02	A	0.127	4.451	5.372	0.921	4.659	4.936
MNVOC069_02	B	0.092	4.307	4.761	0.454	4.249	4.705
MNVOC069_02	C	0.045	2.952	5.073	2.120	3.798	4.907