

APPENDIX 1

Vocalizations distinguish the cryptic giant hummingbird species and clarify range limits

Bryce W. Robinson, Ryan J. Zucker, Christopher C. Witt, Thomas Valqui, and Jessie L. Williamson

Includes:

Figure S1

Figure S2

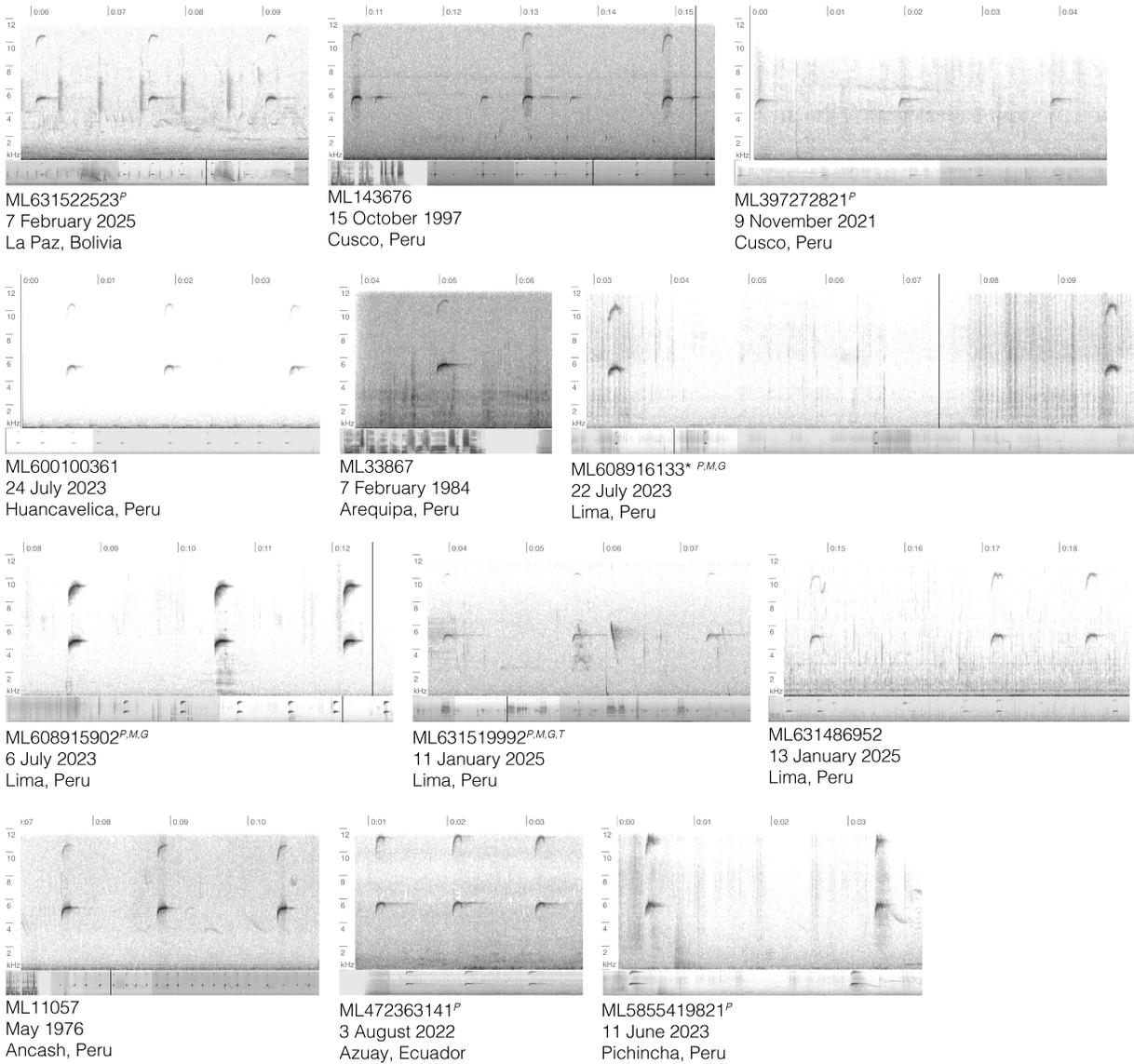
Figure S3

Figure S4

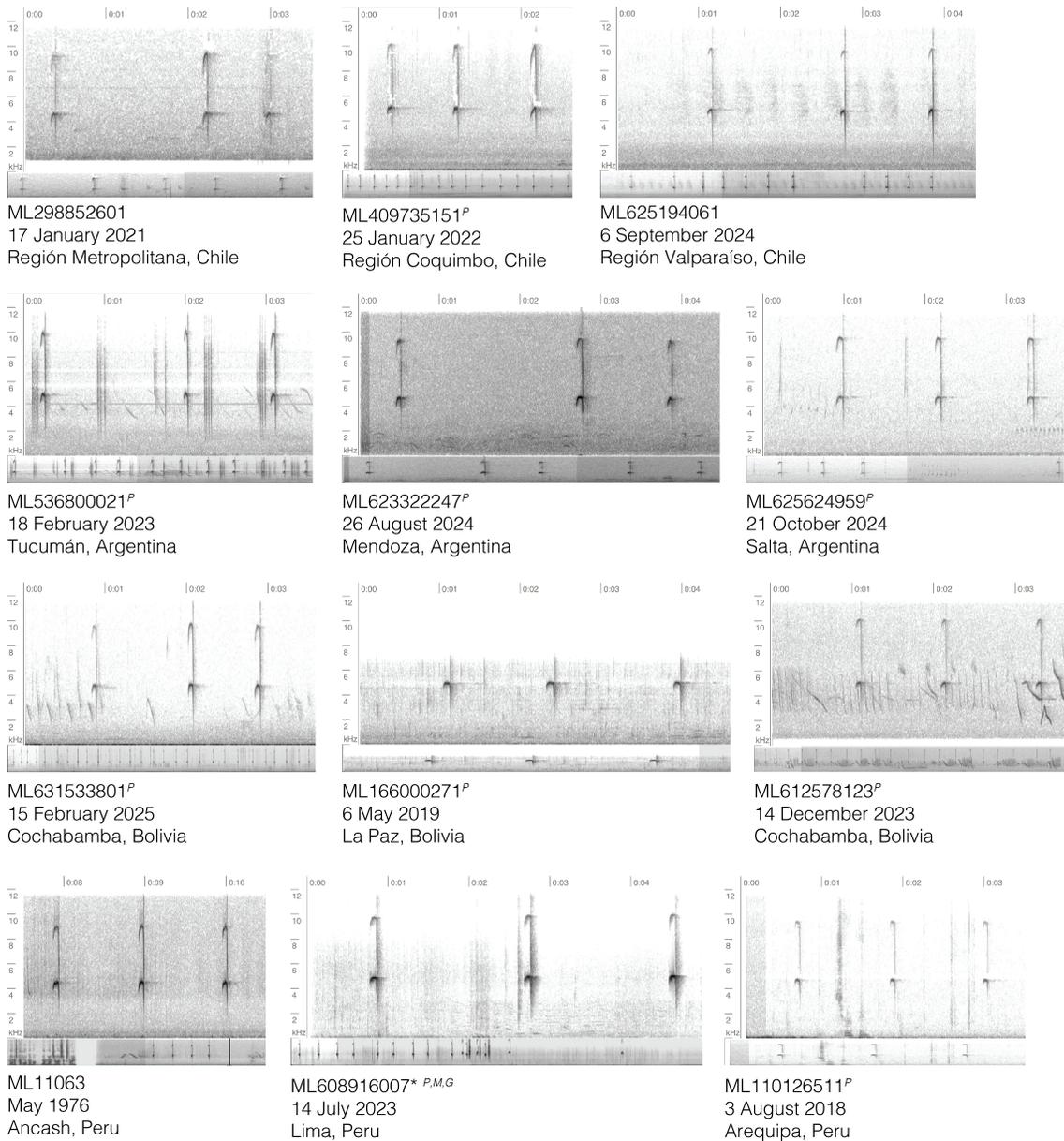
Figure S5

Figure S6

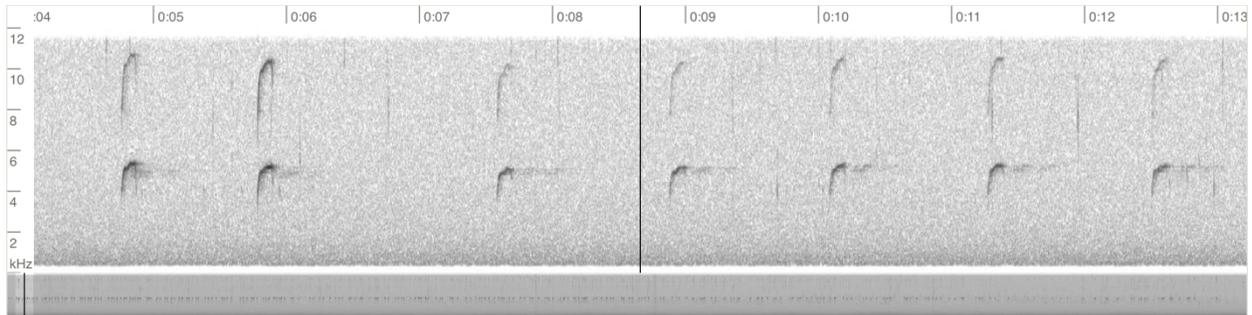
Figure S7



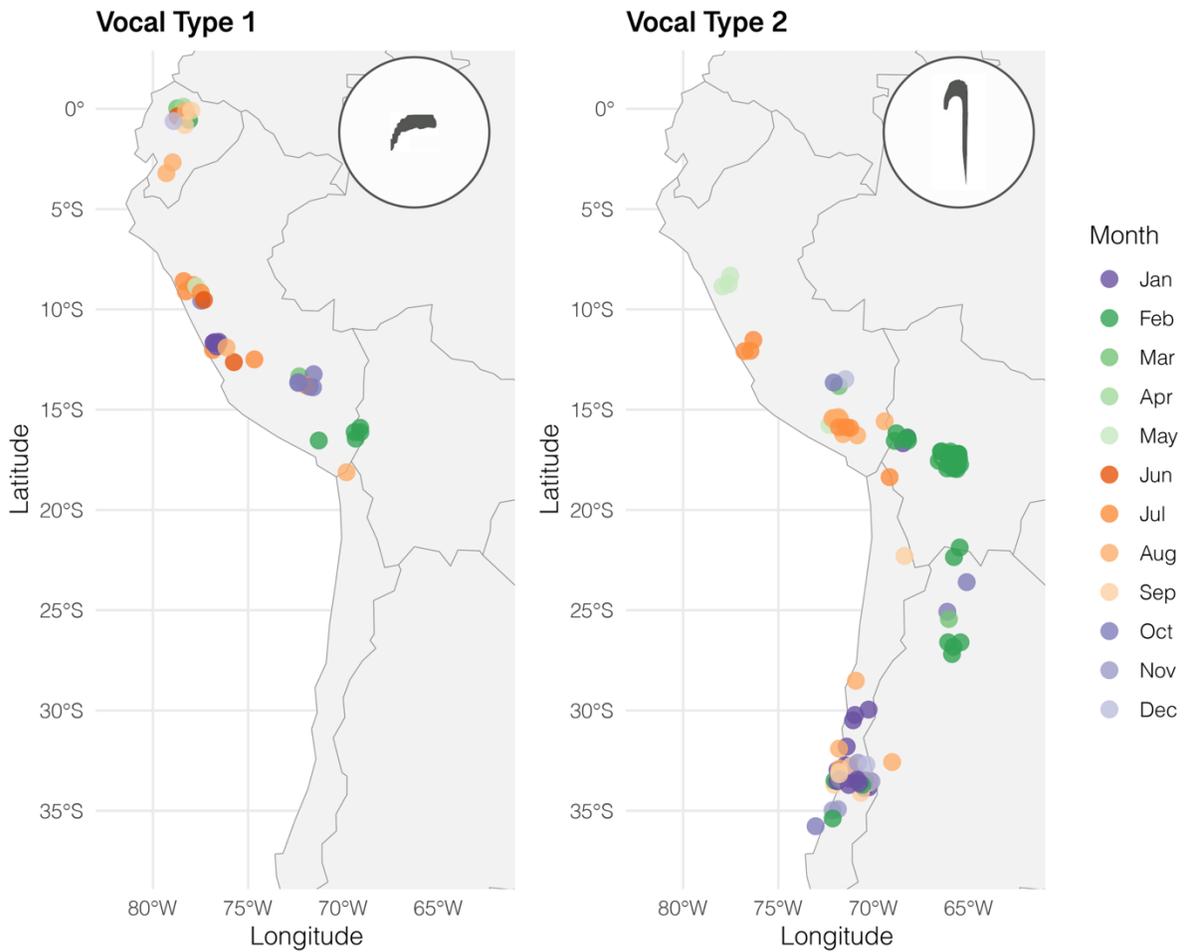
1
2 **Figure S1. Examples of Type 1 giant hummingbird vocalizations from Ecuador, Peru, and**
3 **Bolivia, identified to correspond to the Northern Giant Hummingbird (*Patagona***
4 ***peruviana*).** All screenshots were taken from Macaulay Library (ML) and include individuals
5 analyzed in this study. Type 1 vocalizations were not identified from Argentina. An asterisk
6 indicates that an individual was recorded in captivity for ongoing research by the authors.
7 Superscript annotations indicate extended data types collected from the vocalizing individual:
8 *P*=photos; *M*=morphological measurements; *G*=genetic samples, *T*=real-time movement tracking
9 data.



10
 11 **Figure S2. Examples of ‘type 2’ giant hummingbird vocalizations from Chile, Argentina,**
 12 **Bolivia, and Peru identified to correspond to the Southern Giant Hummingbird (*Patagona***
 13 ***gigas*).** Type 2 vocalizations were not identified from Ecuador. All screenshots were taken from
 14 Macaulay Library (ML) and include birds analyzed in this study. An asterisk indicates that an
 15 individual was recorded in captivity for ongoing research by the authors. Superscript annotations
 16 indicate additional data types collected from the vocalizing individual: *P*=photos;
 17 *M*=morphological measurements; *G*=genetic samples.



18
19 **Figure S3. Spectrogram of ML410550051, the only individual in the analyzed data whose**
20 **call type was classified as ‘unknown’.** This individual was recorded on 9 January 2022 in Los
21 Andes, Valparaíso, Chile. The bird was recorded next to a stream and/or environment with
22 dripping water, which can be heard in the background. The bird appears to be vocalizing from
23 inside of a canyon with substantial echo. When listening to the recording, the first two vocal
24 notes (not pictured) sound quite distant from the recordist. The bird then flies close for notes
25 three and four (pictured here as the first two notes), before again flying farther away for the rest
26 of the recording. The file was uploaded as an .mp3 file and the equipment used by the recordist is
27 unknown. It may therefore be plausible that the bird’s vocalizations appear aberrant due to
28 recording quality, background noise, and echo, but this is not confirmed.



29
 30 **Figure S4. Distribution of vocal types 1 and 2 across the Andes and during each month of**
 31 **the year.** Points, colored by month, indicate the localities of the 153 quality-filtered recordings
 32 (see methods) spanning 1976–2025. Recordings were obtained from the Macaulay Library at the
 33 Cornell Lab of Ornithology (<https://www.macaulaylibrary.org/>) and XenoCanto.

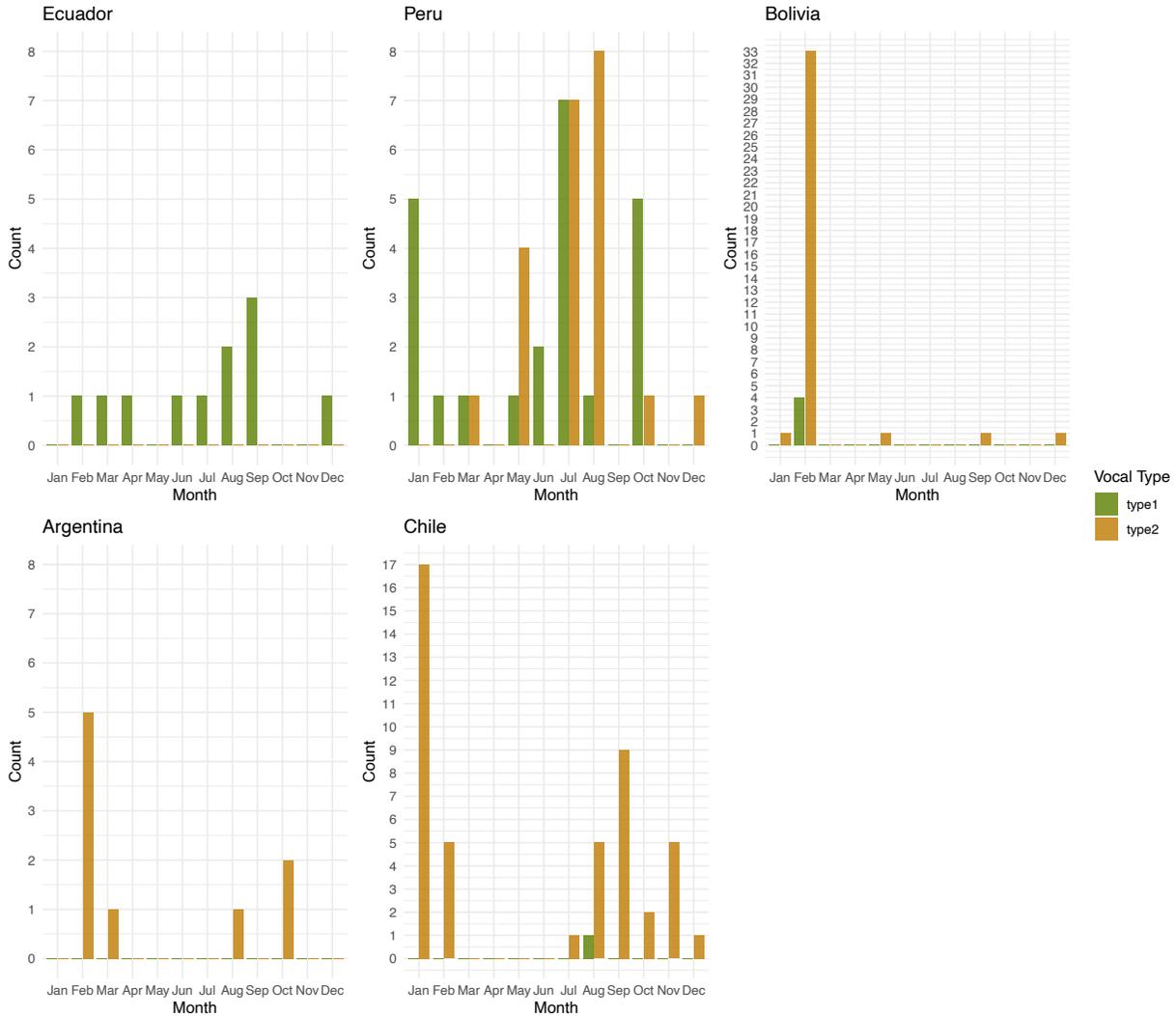


Figure S5. Seasonal occurrence and vocal type frequency by country, from available recordings in Macaulay Library and Xeno-Canto. Note that country-level plots do not account for latitude (see Fig. S4). Type 2 vocalizations have also been recorded from Peru from September (e.g., ML642932325, <https://macaulaylibrary.org/asset/642932325>; 30 September 2025 in Lima, Peru); however, these were not included in the present study, which used publicly available data from any point in the past through 15 February 2025. Enhanced efforts to record the two giant hummingbird species across their ranges will fill in notable sampling gaps and increase our understanding of ecological and evolutionary dynamics.

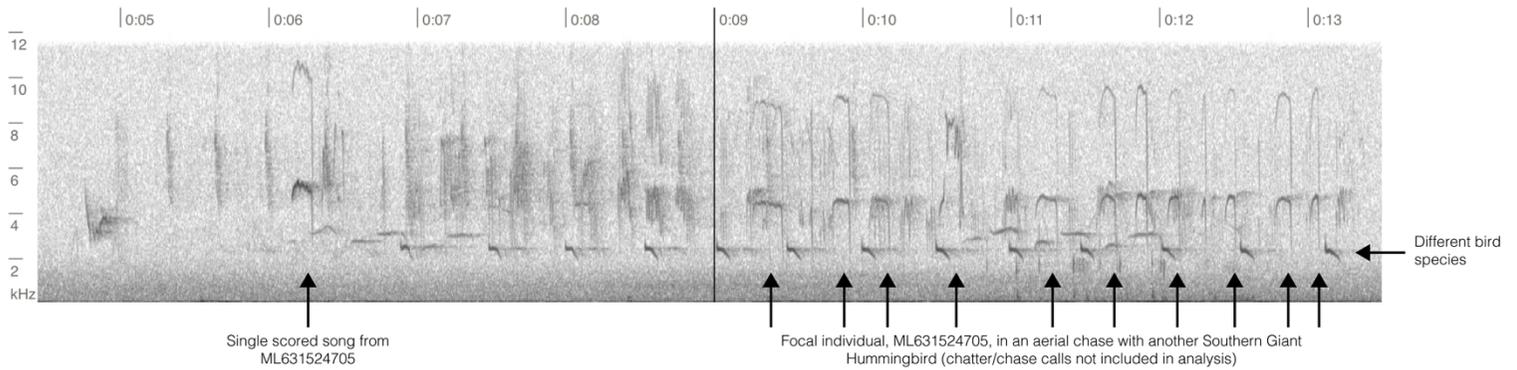


Figure S6. Excerpt of spectrogram of ML631524705, one of two individuals that misidentified by the LDA model of vocal traits. The individual in question is a Southern Giant Hummingbird that was misidentified as a Northern Giant Hummingbird, recorded on 12 February 2025 in Cochabamba, Bolivia by [AUTHOR]. Only one vocalization was scored for this individual; during scoring, [AUTHOR] noted that the song appeared modulated (note “wavy” top loop of typical Southern candy cane shape). In the rest of the recording, this individual can be heard fighting with a second Southern Giant Hummingbird in an aerial chase. [AUTHOR] observed the focal individual, as well as the individual it fought, for an extended period and additionally took diagnostic plumage and molt photos. All data support the ID of Southern Giant Hummingbird. The ML record is available at: <https://ebird.org/checklist/S213020346>.

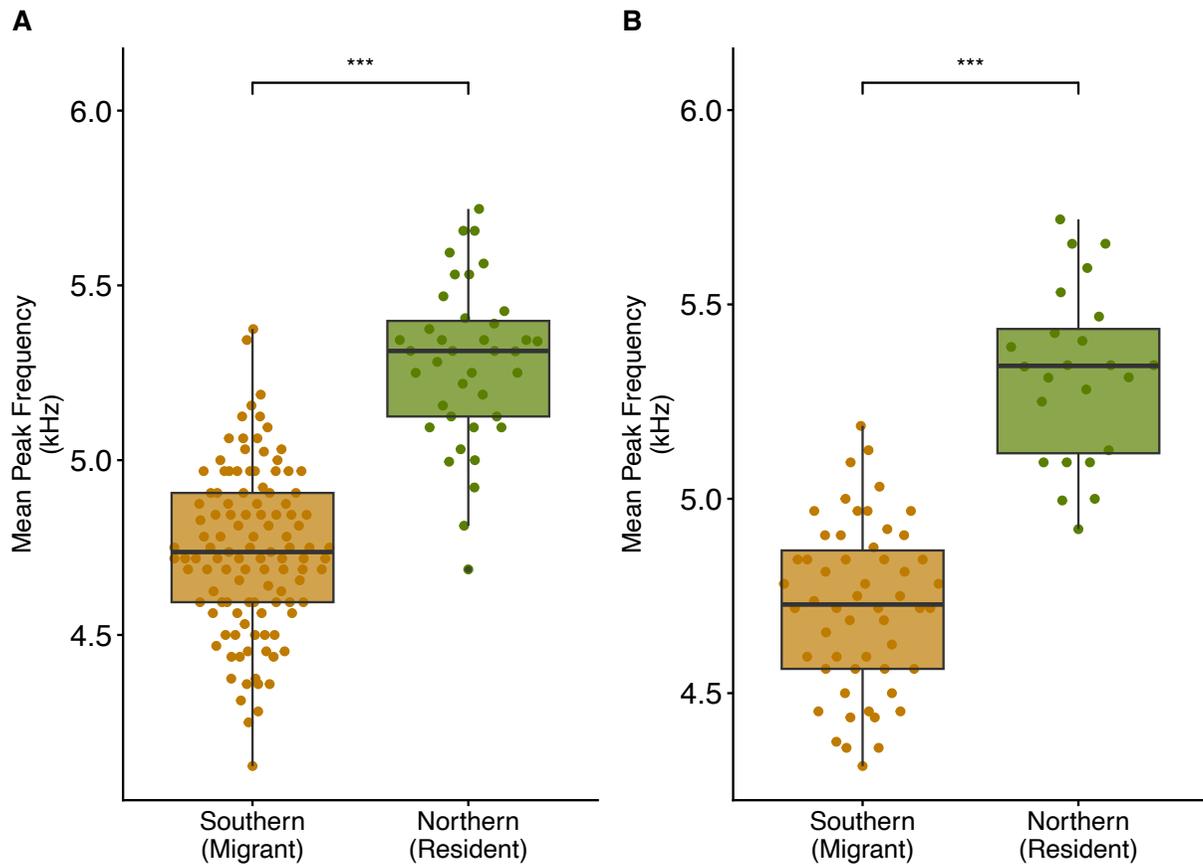


Figure S7. Peak frequencies (kHz) of vocalizations of Northern and Southern Giant Hummingbirds differ significantly. **A** Mean peak frequency differs significantly in the full annual range dataset ($n=113$ Southern, $n=39$ Northern). Peak frequency was 1.1x higher in Northern than Southern Giant Hummingbirds ($p < 2.2 \times 10^{-16}$, t -test). **B** Mean peak frequency also differs significantly in the breeding range only dataset ($n=53$ Southern, $n=24$ Northern). In these comparisons, peak frequency was 1.1x higher in Northern than Southern Giant Hummingbirds ($p < 3.2 \times 10^{-14}$, t -test). In both panels, box plot horizontal lines indicate median values. Each point is a mean vocal value from a single individual. Peak frequency results are analogous to maximum frequency results.