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Song Complexity Increases During White-Handed Gibbon (*Hyllobates lar*) Duets

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*All recordings by Thomas Terleph, Sacred Heart University, and Ulrich Reichard, Southern Illinois University, Carbondale. Additional assistance by Suchinda Malaivijitnond, Chulalongkorn University, Thailand.

Abstract

Gibbons are unique among the apes because mated pairs regularly sing in organized duets, and because the male's song phrases increase in complexity during duets and solo bouts. These increases in complexity have not been systematically quantified for any gibbon species. Here we describe and quantify these changes to the male song, from recordings of a wild population of white-handed gibbons (*Hyllobates lar*). We found that the number of notes in male coda phrases increased over the course of song bouts, as did their maximum fundamental frequency. Our analysis of individual syllable types within the coda phrase revealed that male-specific note types, trill and quaver notes, increased in amount and in duration, respectively, within song bouts.

Introduction

We studied male coda phrases as they are more complex in structure, yet at the same time more stereotyped than other male phrases (Geissmann 1993, 1995, Sun et al., 2011). They are produced during song duets with a mate, in close association with her calls (Terleph et al. 2015, 2016), and are thus likely an important component of mutual territorial signaling. We hypothesized that these coda phrases would increase in complexity within bouts, since other less stereotyped male phrases, male solos and duet interlude phrases, have been reported do so (Haimoff 1984, Raemaekers et al. 1984, Schilling 1984, Geissmann 1993, 2000).

Methods

All codas were recorded from a population of 10 wild white-handed gibbons at the Mo Singto—Klong E-Tau long-term research site at Khao Yai National Park, Thailand over four summer field seasons (from 2013-2016) by Drs. Terleph and Ulrich Reichard (Southern Illinois University, Carbondale). Recordings were made with a digital solid-state recorder (Marantz PMD661, Kanagawa, Japan) and a Sennheiser microphone: K6 power module and ME67 recording head and windscreen (Sennheiser Electronic, Wedemark, Germany). Spectrograms were produced using Raven Pro 1.5 Sound Analysis Software (Cornell Lab of Ornithology Bioacoustics Research Program, Ithaca, New York), and all measurements were made from these spectrograms. Coda syllables were analyzed as a function of their position within a song bout (7 coda positions per animal). The measures were: 1) total number of notes per coda, 2) the minimum frequency of each

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coda, 3) the maximum frequency of each coda, 4) the number of trill notes, 5) the duration of quaver syllables, and 6) the number of 'other' notes.

Results

The note count of codas increased over the course of song bouts (Freidman Test Chi-square: 32.4, $p = .00001$), as did their maximum F0 frequency: $F(6, 54) = 10.59$, $p < 0.0001$. The minimum F0 frequency of codas, however, did not change: $F(6, 54) = 1.34$, $p = 0.25$. Our analysis of individual syllable types revealed that the number of trill notes increased throughout song bouts: (Freidman Test Chi-square: 22.3, $p < 0.01$) (Fig 3B), as did the total duration of quaver notes: $F(6, 54) = 2.99$, $p = 0.013$.

Discussion

We do not yet know why these song phrases increase over the course of bouts, but trills and quavers are the only male-specific syllable types in the species' song repertoire, so males potentially advertise their sexual identity by adding these syllables to ongoing duets. Coda frequency also increases throughout a bout, and this variable correlates with androgen levels in the males of this species (Barelli et al 2013). Males may therefore additionally advertise reproductive status primarily during the later parts of duet bouts.