Analysis of Male White-handed Gibbon (Hylobates lar) Songs in Response to Predator Models

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Abstract

White-handed gibbons (Hylobates lar) are lesser apes that produce male-specific codas during territorial song bouts. These codas have previously been classified into three categories, wa, trill, and quaver notes, based on recordings of wild gibbons. The present study aimed to determine sequence variations between H. lar codas in the presence or absence of different predator models. Additionally, phrase frequencies in wild gibbons were analyzed to determine the complexity of the codas. Using Adobe Audition CC 2013.0.2, the minimum and maximum frequencies for each note type were examined. The sequences of notes were visualized as transitional probability diagrams using Graphviz. Single-factor ANOVAs with Tukey’s HSD post-hoc tests compared frequency measurements between groups. The post-hoc tests showed a significant difference in the maximum wa frequency of the duets (p = 0.001) compared to the running tiger model (p = 0.039). This study furthers the understanding of H. lar coda vocalizations by analyzing coda note sequences and frequencies in response to predator presence/absence. Future directions will include analyzing changes to the frequencies of notes over the progression of a song bout and expanding this study to include female-specific calls.

Table 1. Composition of habituated gibbons. The number of codas analyzed from each group are listed. AM = Adult Male, AF = Adult Female, JM = Juvenile Male, JF = Juvenile Female, SAM = Sub-adult Male, SAF = Sub-adult Female, I = Infant.

<table>
<thead>
<tr>
<th>Group</th>
<th>Composition</th>
<th># Coda</th>
<th>% CL</th>
<th>% ST</th>
<th>% RT</th>
<th>Total Coda</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1AM, 1AF, 1JM</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>B</td>
<td>1AM, 1AF, 1SAF</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>1AM, 1AF</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>D</td>
<td>1AM, 1AF, 1JM, 1I</td>
<td>17</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>E</td>
<td>1AM, 1AF, 1JM</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>M</td>
<td>1AM</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>13</td>
</tr>
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<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>O</td>
<td>1AM, 1AF, 3/SAM, 1I</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>S</td>
<td>1AM, 1AF, 1IT</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

Methods

Data Collection

Gibbons from 12 groups were recorded at the Khao Yai National Park in Thailand (Table 1). Recordings were taken at a 44.1 kHz sampling rate using Sony DAT Recorders and Senheisher directional microphones with wind shields (Clarke et al., 2006). Calls were from one of five different experimental setups: 1) duet song bout, 2) clumped leopard (CL) model response, 3) sitting tiger (ST) model response, 4) running tiger (RT) model response, or 5) reticulated python (RP) model response.

Data Analysis

Codas were analyzed in Adobe Audition CC 2013.0.2. Coda note sequences (Figure 1) were determined by characterizing wa (W), trill (T), and quaver (Q) notes at a viewing window of 4.0 s. Elements that did not meet characteristic requirements were coded as “X”. The frequency analysis was completed at a viewing window of 0.5 s. Transitional probabilities were created using a digraph finite state machine code in Graphviz.

Statistical Analysis

Single-factor ANOVAs and Tukey’s HSD post-hoc tests were used to analyze the duration of codas, frequency measurements, and the number of coda notes at the level of 0.05. Bigram transitional probabilities were calculated.

Results

The ANOVA results showed significance between groups for the minimum (F(4, 136) = 3.20, p = 0.005) and maximum (F(4, 136) = 3.99, p = 0.004) wa frequencies across experimental setups. Post-hoc tests revealed significant differences between maximum wa frequencies of the duets (p = 0.008), CL responses (p = 0.014), and RT responses (p = 0.039) compared to the RT responses. The averages for these groups were 1061.87 ± 17.20 Hz (duets), 1053.76 ± 40.74 Hz (CL), 1025.97 ± 77.96 Hz (ST), and 1245.87 ± 49.80 Hz (RT).

Preliminary comparisons of transitional probabilities showed differences between bigrams (Figures 2-6). The quaver-to-quaver transitional probability was highest for ST responses at 0.71, followed by RT responses at 0.69, and the next highest was 0.67 for the CL responses while the lowest probability was 0.31 for the RT responses. ST responses had the highest probability of wa-to-trill transitions at 0.64, which was nearly double the next highest for CL responses at 0.33. Finally, the RT and ST responses both had the lowest wa-to-wa transitional probabilities at 0.36.

Discussion

The significant difference of maximum quaver frequencies in RT responses compared to other groups, CL responses, and ST responses might be attributed to a specific modified predator response that results in a change in the gibbons’ vocal behaviors. Post-predator songs, most common after tiger model presentation, have been noted previously with an increased use of sharp wow notes compared to duets (Clarke et al., 2012). The significant difference between the maximum wa frequency in CL responses compared to both the duets and RT responses might suggest a change in coda complexity. The wa note is typically the highest in frequency, and the overall maximum fundamental frequencies of codas increase over the duration of the calling bouts. This has been attributed to coda complexity (Terlippe et al., 2018). The majority of CL responses came from Groups A and C (Table 1), so there may be combined factors resulting in this difference such as gibbon age or group composition.

Future directions include:

- Analyzing the changes in the frequencies of notes over the progression of a song bout.
- Comparing the number of trill and quaver notes in relation to predator model responses.

Figure 1. Spectrogram of a complete coda from a male in Group D. Exhibited call is from a duet song bout.

Figure 2. Transitional probabilities of the coda note sequence without X notes for wild H. lar duets (n = 95).

Figure 3. Transitional probabilities of the coda note sequence without X notes for wild H. lar responses to the clumped leopard model (n = 24).

Figure 4. Transitional probabilities of the coda note sequence without X notes for wild H. lar responses to the running tiger model (n = 17).

Figure 5. Transitional probabilities of the coda note sequence without X notes for wild H. lar responses to the reticulated python model (n = 11).

Acknowledgements & References

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