

## Supplementary file

Passive acoustic monitoring and automatic detection of diel patterns and acoustic structure of howler monkey roars

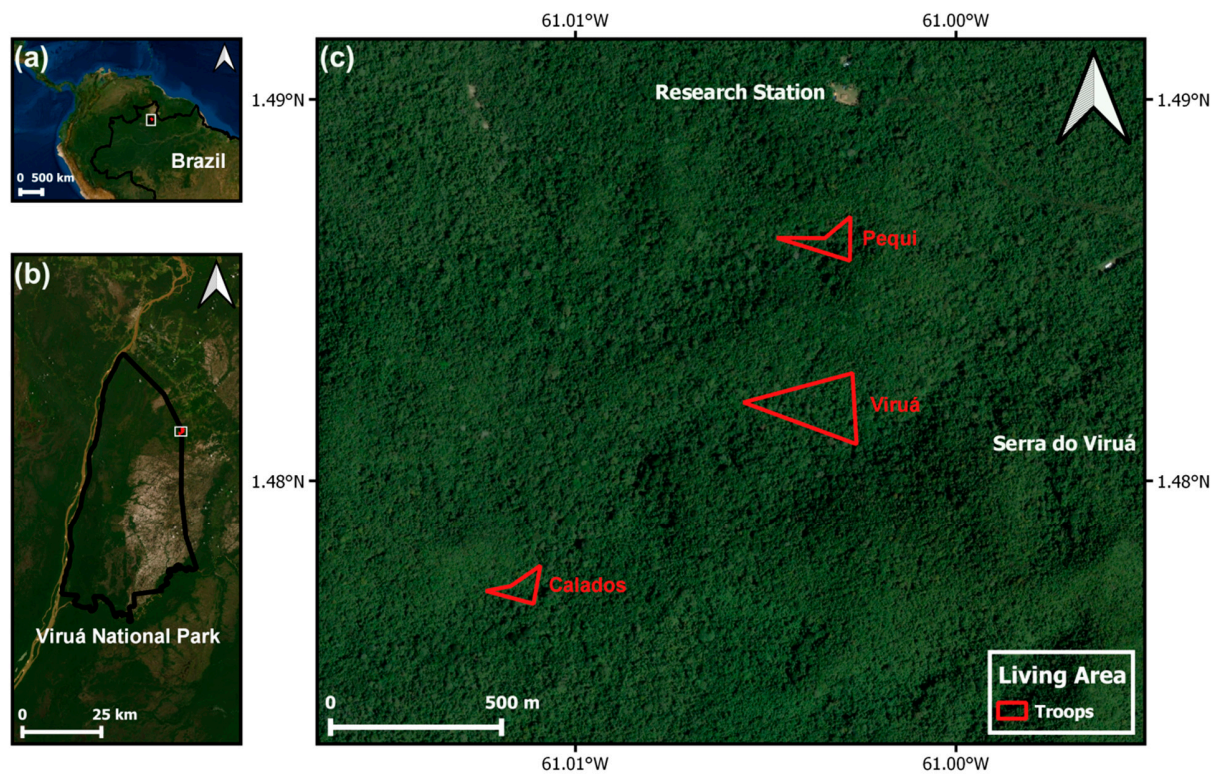
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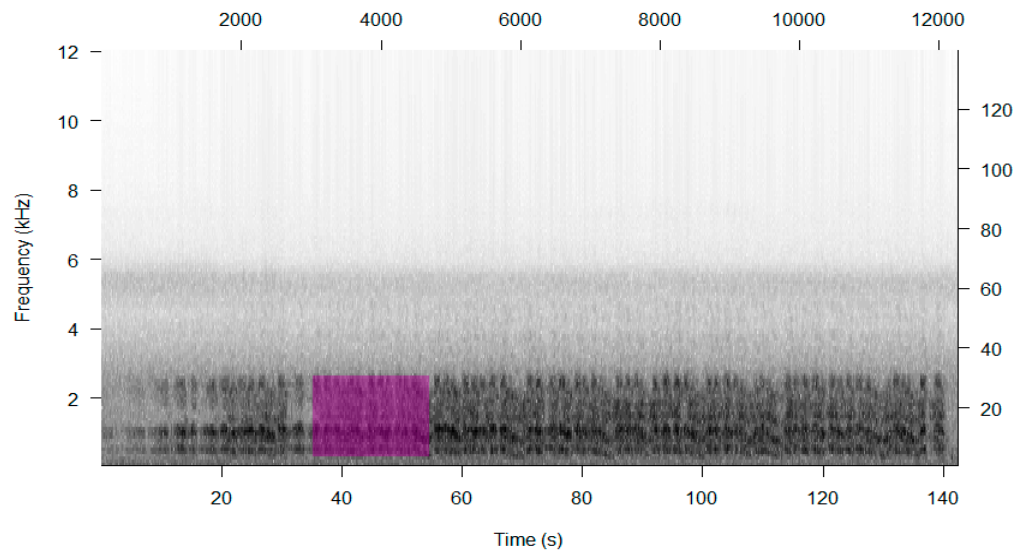
<sup>2</sup>Ecology Department/IMEM "Ramón Margalef", Universidad de Alicante, Alicante, Spain.

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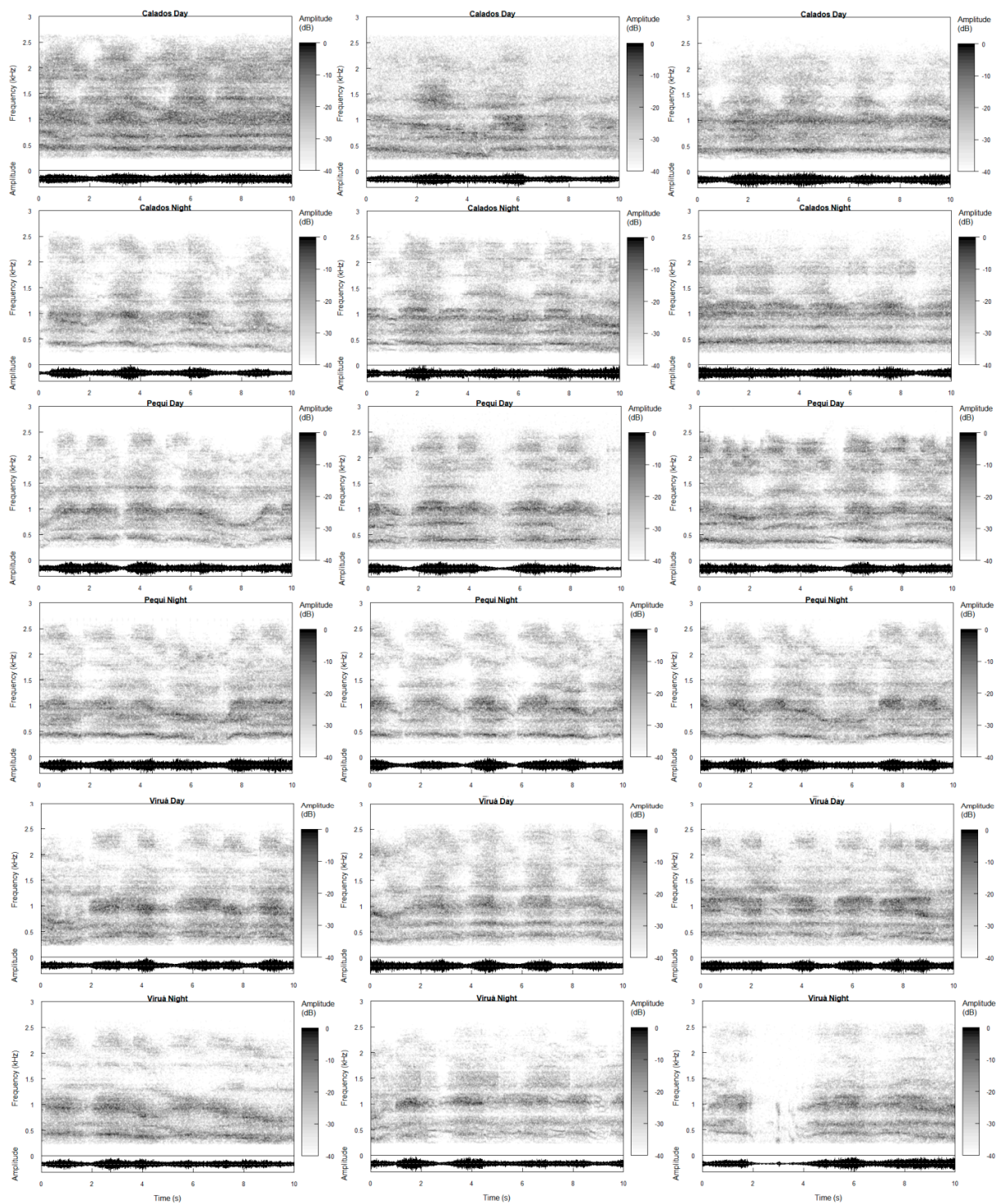
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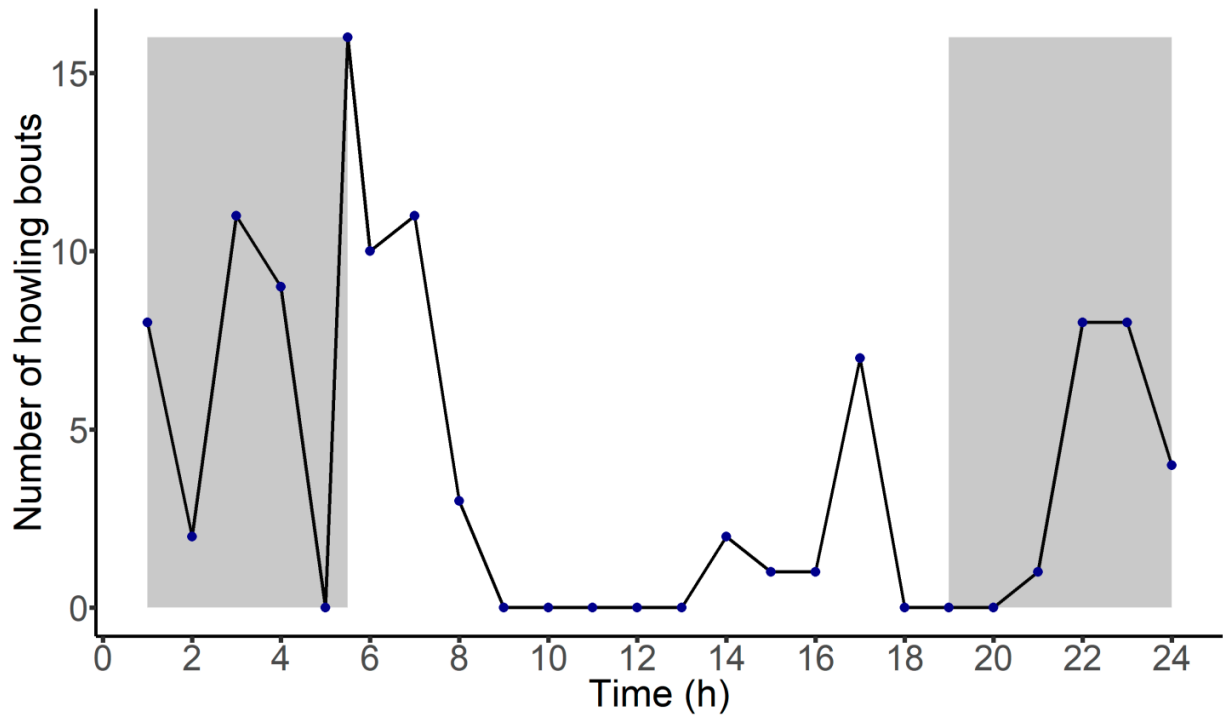
**Figure S1.** Study area (a) in Brazil, (b) in Viruá National Park, and (c) the location of the three Guianan red howler groups surveyed.



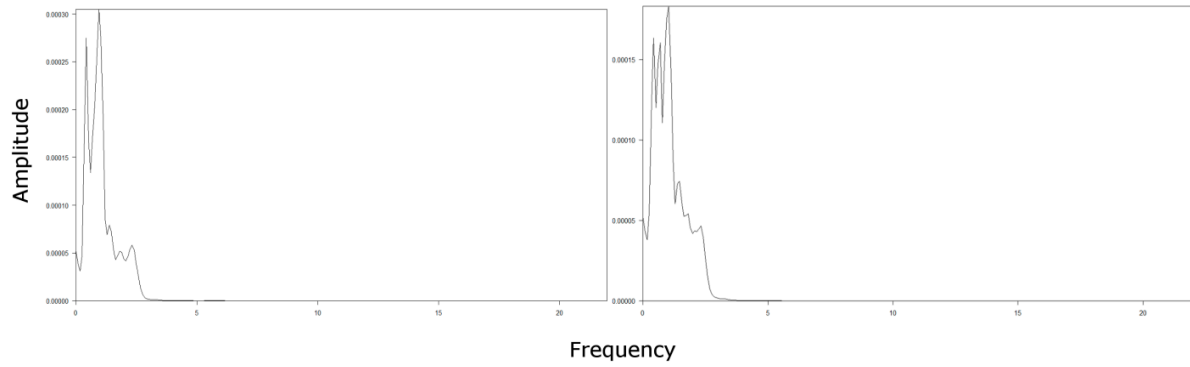
**Figure S2.** Template (purple shaded area) used in the automatic classification to detect howling bouts of the Guianan red howler monkey.



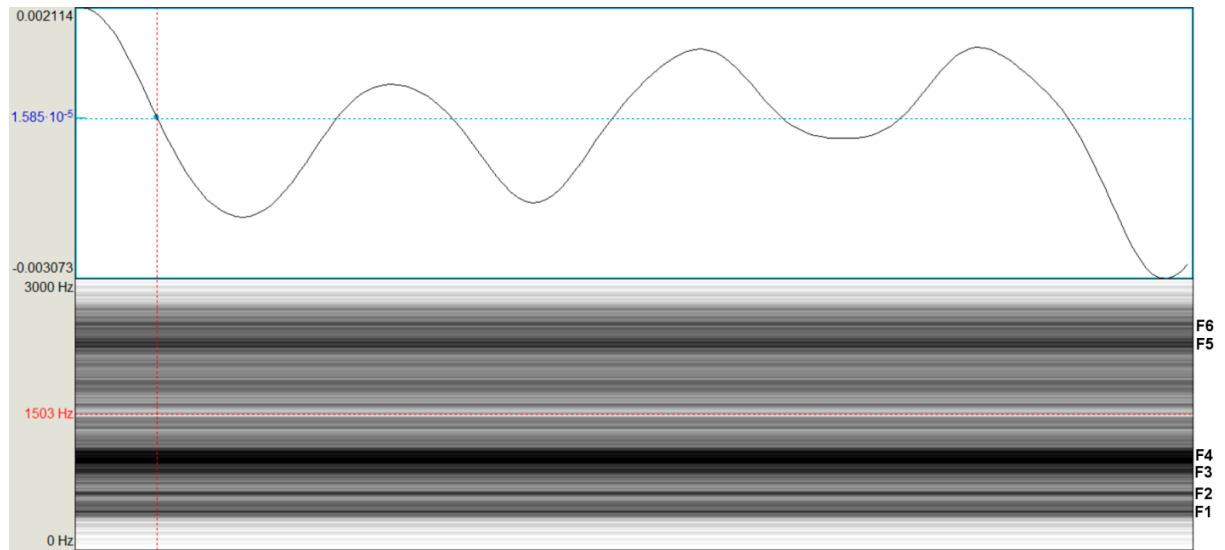
**Figure S3.** Examples of nocturnal and diurnal howling bouts from each studied group. 10 s clips of different recordings are shown with a windows length of 4012 points.



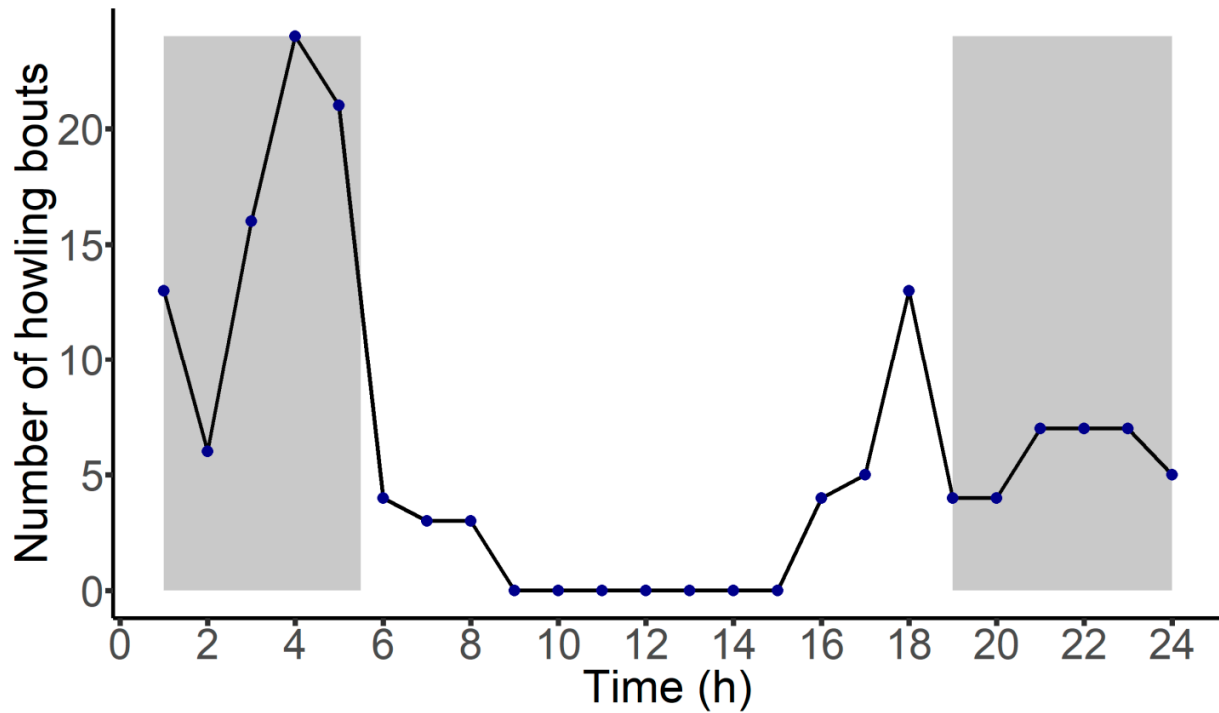
**Figure S4.** Temporal distribution of the 102 howling bouts used in our acoustic analysis. Data were collected from February to April 2018. The graph starts at 0100 h and ends at 2400 h. The gray shaded areas indicate nocturnal hours (1900 h to 0529 h) based on nautical twilight. Between 0500 h and 0600 h the graph is subdivided in a half hour interval to accommodate 16 howling bouts made after 0529 h.



**Figure S5.** Example of a diurnal (left pane) and nocturnal (right pane) background noise from recordings used in our analysis. Amplitude is in decibels and was calculated through the mean frequency spectrum of 1s clips of silence from immediately before and after 30 howling bouts belonging to the 102 howling bouts we analyzed the acoustic structure.



**Figure S6.** Example of a spectrogram built in Praat software showing how the formants were extracted for all howling bouts used in this study. Formants are labeled F1 to F6.



**Figure S7.** Diel vocal behavior of the Guianan red howler monkey in Viruá National Park, Roraima, Brazil. Diel pattern is expressed as the total number of howling bouts (all groups pooled) detected per recording hour. This graph was built with our manual validation dataset (146 howling bouts total) consisting of 10 days of annotated recordings from the three howler groups studied. The graph starts at 0100 h and ends at 2400 h. The gray shaded areas indicate nocturnal hours (1900 h to 0529 h) based on nautical twilight.