Quantifying habitat-induced degradation of animal sounds: the R package baRulho

Marcelo Araya-Salas, Erin E. Grabarczyk, Marcos Quiroz-Oliva, Adriáan Garcíia-Rodríiguez, Alejandro Rico-Guevara

Animal acoustic signals are shaped by selection to convey information based on their tempo, intensity, and frequency modulation patterns. Across habitats, sound degrades as it propagates over space and through vegetation, exerting strong selection on signal structure. Transmission experiments are designed to quantify changes in signal structure in a given habitat by broadcasting and re-recording animal sounds at increasing distances, which provides a direct means for inferring the strength and direction of selection. We introduce ‘baRuhlho’, an R package designed to facilitate acoustic analysis of sound transmission experiments. The package offers functionality to create synthetic sounds, concatenate sounds into single sound files for playback experiments, time-sync re-recorded sound files, and streamline the quantification of degradation. We highlight package features with a case study testing the effects of habitat, distance, and signal structure on transmission. Simulated pure tone and harmonic signals that varied in frequency and duration were broadcast and re-recorded at five increasing distances in open and closed forest habitats at the Bosque de Tlalpan, Mexico City. As expected, re-recorded signals degraded less in open habitats compared to closed habitats, and signals at higher frequencies degraded faster than signals at lower frequencies. Interestingly, amplitude modulation had little effect on degradation, while frequency modulation seems to rather mitigate it. Compared to other sound analysis programs, baRuhlho generates similar results in a fraction of the time. Furthermore, degradation metrics are less prone to user error due to the automatic detection of re-recorded signals. Overall, this package offers an accessible workflow to quantify patterns of acoustic signal degradation and their role in the evolution of animal communication systems.