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Towards a full map of drumming signals in European woodpeckers

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Europe is home to eleven species of woodpeckers. Some barely drum (Picus viridis, P. sharpei, Jynx torquilla, Dendrocopos medius), some use drumming as their primary signal for territory defense and mate attraction (D. major, D. syriacus, D. leucotos, Picoides tridactylus) and others resort to a combination of drums and calls. The territorial drumming rolls are loud signals and carry species markers; they are adequate signals for long-range advertising. They are not however the only intentional signals woodpeckers produce with their bills. Others exist for which documentation is scarce. There is *soft drumming* in the form of quieter drumming rolls, and there are slower, shorter bouts known as *tapping*. All are used in close communication between breeding partners. Ritualized tapping has multiple variants, for example demonstrative tapping, which is associated with nest showing early in the breeding season, and nest relief tapping, which occurs at changeover during excavation or brooding.

The present work aims to analyze drumming and tapping recordings gathered from multiple sources: Xeno-Canto, a recording station deployed in Belgium (2016) and in Luxemburg (2017), and a large sound collection assembled by co-author Kyle Turner during his travels throughout Europe starting in 2002. We present t-SNE maps and statistics on the temporal structure of drums and taps. Mapping our database was facilitated by algorithms that automate the calculation of drumming parameters and species identification. This represents an advance towards a full description of drumming in European woodpeckers, and a first characterization of soft drumming, demonstrative tapping and nest relief tapping. The database also informs us on a possible evolution of woodpecker signals from low-complexity taps towards identity-carrying drums, and for some species towards the abandon of drumming in favor of vocalizations.

Additionally, we recorded a wide array of misunderstood signals (e.g., mixtures of drums and taps) and interspecific communication.

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