Spatial cue-mixture models for estimating bird song rate and population density

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Abstract: Existing methods for the analysis of sound recordings to estimate bird population density rely either on distinguishing individuals or on independent estimates of the per capita song rate, the expected number of songs or other cues produced by one bird during a recording. When several individuals of a species sing simultaneously or sequentially on one recording the assignment of songs to particular individuals is difficult and somewhat subjective. Independent estimation of song rate is also difficult and prone to sampling bias. We show how to avoid these difficulties by analyzing recordings replicated in space using a hierarchical model in which song rate is a latent variable. We derive an expression for the distribution of the number of cues detected at an isolated microphone. Our data are the breeding-season songs of three warbler species in 10-minute recordings at each of 272 forested points in Maryland, USA. We also operated a 4-microphone array for 10 minutes at 66 of these points, allowing us to estimate distance-related sound attenuation and spatial detection probability for songs of these species. We obtained density estimates using either the first song of each putative recorded individual (Dawson and Efford 2009) or the hierarchical model applied to all songs. Results were consistent between the two methods. The best hierarchical model used a negative binomial distribution for the number of songs per bird per recording. The model allows for 'unavailable' birds that do not sing during the recording, corresponding to the zero class of the fitted distribution of songs per individual. The 2-phase design is easily scaled to survey birds across landscapes.

References

Dawson, D.K. and Efford, M.G. (2009) Bird population density estimated from acoustic signals. *Journal of Applied Ecology*, 46:1201–1209.