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Density estimation using camera trap surveys: the random encounter model

J. Marcus Rowcliffe, Chris Carbone, Roland Kays, Bart Kranstauber and Patrick A. Jansen

Abstract

The rate of detection by motion-sensitive camera traps can, in principle, provide information on the abundance of many species of terrestrial vertebrates that are otherwise difficult to survey. The random encounter model provides a means to estimate density from camera trap rates without requiring individual recognition. The method requires that camera traps are deployed at replicated random locations without bait. The concept underlying the model is the extraction of an unbiased density signal from the rate at which a species is photographed by correcting for species-specific movement and camera sensitivity. If the deployments are properly calibrated, it is possible to obtain these parameters directly from camera trapping footage, resulting in a self-contained method that does not require auxiliary information on animal movement or camera performance.

Introduction

The estimation of abundance is a pervasive goal in ecology (Sutherland 2006). The rate of detection by motion-sensitive camera traps can, in principle, provide information on the abundance of many species of terrestrial vertebrates that are otherwise difficult to survey. Where a particular species is more abundant, the rate at which it is captured by camera traps will normally also be higher. All else being equal, photo rates are thus proxies of abundance (Carbone *et al*. 2001).

However, in practice photo rates have not been directly compared across time or space, or between species, because of variation in detectability resulting from differences in other factors, including motion-detector sensitivity, the influence of weather conditions, and the characteristics of the animals and their habitat. In particular, species are more likely to be photographed if they are larger and move further per day, or if more sensitive cameras are used under better conditions. Variation in these factors between species or surveys make raw photo rates poor predictors of absolute animal abundance (Jennelle *et al*. 2002; Sollmann *et al*. 2013). If animals can be individually recognised by unique properties such as coat marks or antlers, mark–recapture analysis can be used to obtain absolute abundance estimates from the photos (Karanth 1995; Royle *et al*. 2009). Unfortunately, this is possible for only a small sub-set of the species that can be recorded by camera traps. Therefore, it