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Original Investigation

Factors affecting southern water vole (*Arvicola sapidus*) detection and occupancy probabilities in Mediterranean farmland

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ABSTRACT

Failure to detect a species at sites where it is present (i.e. imperfect detection) is known to occur frequently, but this is often disregarded in monitoring programs and metapopulation studies. Here we modelled for the first time the probability of patch occupancy by a threatened small mammal, the southern water vole (*Arvicola sapidus*), while accounting for the probability of detection given occupancy. Based on replicated presence sign surveys conducted in autumn (November–December 2013) and winter (February–March 2014) in a farmland landscape, we used occupancy-detection modelling to test the effects of vegetation, sampling effort, observer experience, and rainfall on detection probability. We then assessed whether occupancy was related to patch size, isolation, vegetation, or presence of water, after correcting for imperfect detection. The mean detection probabilities of water vole signs in autumn (0.71) and winter (0.81) indicated that false absences may be generated in about 20–30% of occupied patches surveyed by a single observer on a single occasion. There was no statistical support for the effects of covariates on detectability. After controlling for imperfect detection, the mean probabilities of occupancy in autumn (0.31) and winter (0.29) were positively related to patch size and presence of water, and negatively so, albeit weakly, to patch isolation. Overall, our study underlined the importance of accounting for imperfect detection in sign surveys of small mammals such as water voles, pointing out the need to use occupancy-detection modelling together with replicate surveys for accurately estimating occupancy and the factors affecting it.

Introduction

Understanding the effects of land-use change on spatially structured populations is an important goal in both wildlife ecology and conservation (e.g. Fischer and Lindenmayer, 2007; Hanski and Ovaskainen, 2000; van Teeffelen et al., 2012). In this context, the metapopulation concept has provided a useful modelling framework by focusing mostly on the occupancy dynamics of habitat patches, while disregarding local population dynamics (e.g. Hanski and Ovaskainen, 2000; MacKenzie et al., 2006; Moilanen, 1999). This common feature to most patch-level occupancy models makes them particularly attractive to estimate metapopulation spatial patterns and temporal dynamics, because they are analytically tractable and require simple presence-absence sampling schemes, which are relatively easy to plan and implement (e.g. Hanski and Ovaskainen, 2000; Moilanen, 1999).

It is now widely acknowledged that accurate estimates of occupancy and the factors affecting it, requires due consideration of the possibility that surveys may fail to detect a species at sites where it is present (i.e. imperfect detection), thereby generating false absences (e.g. MacKenzie et al., 2006). To deal with this problem, detection probability should be accounted for during the modelling process, which requires replicate surveys in at least some sites within a relative short time, during which occupancy status is assumed to be unchanged (e.g. MacKenzie, 2005; MacKenzie and Bailey, 2004; MacKenzie et al., 2006). Although occupancy models

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