Mammalian Biology
Zeitschrift für Säugetierkunde
www.elsevier.de/mambio

ORIGINAL INVESTIGATION

Eurasian badger habitat selection in Mediterranean environments: Does scale really matter?

L.M. Rosalino[a,*], Maria J. Santos[a,b,c], P. Beier[c], Margarida Santos-Reis[a]

[a]*Universidade de Lisboa, Faculdade de Ciência, Centro de Biologia Ambiental/Departamento de Biologia Animal, Ed. C2 3° Piso, Campo Grande, 1749-016 Lisboa, Portugal*
[b]*Centre for Environmental Sciences and Education, Physical Sciences Building, Northern Arizona University, P.O. Box 5694, Flagstaff, AZ 86011-5694, USA*
[c]*School of Forestry and Merriam-Powell Center for Environmental Research, Northern Arizona University, Flagstaff, AZ 86011-5018, USA*

Received 20 November 2006; accepted 27 February 2007

Abstract

It is widely believed that spatial scale affects habitat selection, and should influence management options, especially for species with wide geographic distribution or large territories. Eurasian badger habitat selection has been well studied throughout most of its European distribution range, but never at multiple spatial scales. We used compositional analysis to assess habitat selection of Eurasian badgers in southern Portugal at four spatial scales (1, 4, 25, and 100 km^2). We assessed habitat use from setts, latrines and footprints presence, and road kills. Oak woodlands with understorey were selected at all scales, being the most preferred habitat at 3 scales (1, 4, and 100 km^2). Pastures were most selected at the scale of the 25 km^2 cell, but their use was not significantly different from oak woodland with understorey. Shrubs and pastures were also secondly important at the majority of scales. Contrary to findings at northern latitudes, deciduous forests decreased in importance as cell size increased. In the highly humanized and fragmented landscape of southern Portugal, Eurasian badgers are selecting the matrix of oak woodlands interspersed with patches of pastures, shrubs and riparian vegetation. In these oak woodlands, scale does not have a marked effect. Management for badgers should provide, for at least, 30% of oak woodland cover at all scales. Our study illustrates the across-scale importance of maintaining the historically human altered, sustainable and unique landscape and land use system – the *montado*.

Keywords: *Meles meles*; Landscape ecology; *Montado*; Portugal

Introduction

Species rarity, rates of decline, habitat fragmentation, and species–area relationships are all sensitive to the scale at which they are measured, and therefore conservation decision-makers must explicitly consider scale in interpreting them (Hartley and Kunin 2003; Turner and Tjørve 2005). For instance, Schaefer et al. (2000) found that studies conducted at different spatial scales produced markedly different conservation recommendations for caribou (*Rangifer tarandus*). Similarly, in field experiments to understand the role of predation

*Corresponding author. University of Lisbon, Faculty of Sciences, Center of Environmental Biology/Department of Animal Biology, Ed. C2 3° Piso, Campo Grande, 1749-016 Lisboa, Portugal.
E-mail address: lmrosalino@fc.ul.pt (L.M. Rosalino).

1616-5047/$ - see front matter
doi:10.1016/j.mambio.2007.02.004

in natural communities, Englund (1997) concluded that the results of small-scale experiments reflected prey movements, while the results of large-scale experiments were due mainly to predator-related mortality. Moreover, data analysed at different scales could also have divergent interpretation. There is no single natural scale at which ecological phenomena should be studied (Levin 1992); to the extent that biological processes are controlled by dominant physical processes, the scale of these abiotic processes may suggest an appropriate scale for some systems (Turner et al. 1989). The perceptual of human observation can create a biased filter for understanding biological systems (Levin 1992). Many authors advocate a multiscale approach in studies of habitat selection (Powell 1994; Morrison et al. 1998; Aued et al. 2003) but there are few examples in land management and conservation strategies.

Eurasian badgers (*Meles meles* L., 1758) are potentially important species in conservation plans (Schonewald-Cox et al. 1991) because it is one of the largest mustelids in much of its range, is highly area-sensitive (variable home range sizes, e.g. 0.14 km^2 in UK – Cheeseman et al. 1981; 4.46 km^2 in Portugal – Rosalino et al. 2004; 25 km^2 in Poland – Kowalczyk et al. 2003), and has high cultural and esthetic value (e.g. Neal and Cheeseman 1996 state that badger seem to typify the very essence of the countryside). Moreover, Virgós (2001) showed that badgers are sensitive to forest loss or fragmentation in Iberian landscapes.

This medium-sized carnivore, often described as a generalist in terms of food and habitat (Neal and Cheeseman 1996; Revilla and Palomares 2002; Virgós 2002), occurs throughout almost all Eurasia, including the island of Crete and Rodhes, ranging from the British islands to Japan (Neal and Cheeseman 1996; Mitchell-Jones et al. 1999). Habitat selection studies have been conducted in some areas of its European distribution range (e.g. Brøseth et al. 1997; Revilla et al. 2000; Good et al. 2001; Rosalino et al. 2004; Rosalino et al. 2005b), especially in the UK (e.g. Kruuk et al. 1979; da Silva et al. 1993; Feore and Montgomery 1999). However, to our knowledge, no previous studies on Eurasian badgers consider effects of spatial scale. Although, Jepsen et al. (2005) did not investigate scale effect on badgers, they suggest that local terrain and habitat features were more important for the choice of sett sites (burrow systems, which provide shelter during the day and can be used for breeding) than larger-scale environmental characteristics.

In this study, we investigate if habitat selection patterns by badgers in Mediterranean landscapes vary with the scale of analysis (e.g. 1, 4, 25, and 100 km^2 grids), and how such variation might affect conservation strategies and land management policies.

Because the proportions of landscape units vary with scale, and because the animal unit of analysis also changes (e.g., individual, social group, population) with scale, we hypothesised that habitat use patterns should differ across scales.

Material and methods

Scale is a measure of two factors: grain and extent. While the finest level of resolution (or smallest interval in an observation set) determines grain, the total area sampled (or range over which observations at a particular grain are made) establishes extent (Gergel and Turner 2002; Hay et al. 2001). Our study focused on the effect of grain. We divided our analysis into four overlapping levels of resolution or grain (1, 4, 25, and 100 km^2).

Study area

We studied habitat use by badgers in the regions of Alentejo and Algarve (centroid = 38°03′N, 08°07′W; ca. 35,000 km^2), Southern Portugal (Fig. 1). The landscape reflects the Mediterranean climate, with variations determined by proximity to the Atlantic coast, altitude, aspect and geological features. The dominant plant communities derive from the progressive degradation of the pristine forests dominated by oaks, and are characterized by the existence of sclerophylous and evergreen trees, cork oak (*Quercus suber*) and holm oak (*Quercus ilex*) (Rivas-Martínez 1975). These Mediterranean woodlands, known in Portugal as *montados* and in Spain as *dehesas*, form the major remaining wood-pasture system of Europe (Diáz et al. 1997; Makhzoumi 1997; Grove and Rackham 2003) and the dominant landscape in south Iberia. The study area comprised several different habitats which, for analytical purposes, were clustered into more or less homogeneous groups: oak woodlands with understorey (35%), oak woodlands without understorey (3%), shrubland (rockroses, *Cistus* spp.; kermes oak, *Quercus coccifera*; brooms *Genista* spp.; heaths, *Erica* spp., without trees) (10%), other deciduous trees (1%), eucalyptus plantations, *Eucalyptus* sp. (4%), conifers plantations (2%), orchards and olive yards (13%), pastures (30%), water systems (1%), and others (1%).

In the *montados*, four main rural activities (cork extraction, wood gathering, livestock husbandry, and agriculture) are pursued simultaneously in a single space where, nevertheless, high biodiversity levels are maintained (Blondel and Aronson 1999; Plieninger et al. 2003). These systems are characterised by the combination of an open tree cover of cork and/or holm oaks in variable densities, with a rotation of cultures, grazing and fallow (Pinto-Correia 1993). Cork and holm *montados* have an almost allopatric distribution, with cork oak being better adapted to higher humidity, flourishing either under strong oceanic influence or where local factors contribute to a more humid climate, and holm oak to dry conditions (Pinto-Correia 2000). The different landscape structure across *montado* range, results from the variation in tree and understorey (e.g. *Cistus* spp., *Genista* spp., *Lavandula* spp., *Erica* spp.) composition and density, agriculture and forestry practices (e.g. wheat production, cork extraction), grazing species (e.g. pig, sheep, goat, cattle) and intensity.