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How to manage hedgerows as effective ecological corridors for mammals: A two-species approach

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ABSTRACT

In European agricultural landscapes, forest fragmentation is one of the most serious threats to wildlife populations viability. Ecological corridors are the management tool used to mitigate the effects of this phenomenon and, in agro-ecosystems, they are traditionally represented by hedgerows. Hedgerows vary dramatically in their internal structure and quality and their effectiveness as corridors depends both on their physical features, such as width and continuity, and internal habitat conditions. Moreover, the ecological requirements related to hedgerow structure are strongly species-specific. In this study, we evaluated which characteristics make a hedgerow suitable for two mammal species sensitive to forest fragmentation at two very different spatial scales: the European Badger and the Hazel Dormouse. The study was carried out in a wide lowland area of northern Italy. Following a stratified cluster sampling design, we surveyed 55 hedgerows. For each hedgerow, we collected both structural and floristic variables and we evaluated how differently they affect hedgerows use by the European Badger and Hazel Dormouse. Our results suggested that, in order to simultaneously increase landscape connectivity for both mammal species, hedgerows should be wide and continuous. Moreover, they should be managed to allow the growth of native species with a complex physical structure in the shrub layer and to promote shrubs development by preventing an excessive tree canopy closure. The information we obtained by this two-species approach provided crucial suggestions for a correct management of hedgerows, which could be used for the conservation of any species with similar ecological requirements and a similar response to fragmentation.

1. Introduction

Forest fragmentation is one of the most important human-induced phenomena threatening the viability of wild populations (Crooks and Soulé, 1999; Fahrig, 2003; Fischer and Lindenmayer, 2007). Fragmentation alters the structure and dynamic of populations, subdividing them into smaller and isolated sub-populations, and making them particularly sensitive to the negative effects of genetic, demographic and environmental stochasticity (Gilpin and Soulé, 1986). This is particularly noticeable in European lowland areas, where natural or semi-natural elements suitable for wildlife, such as woodlands and hedgerows, dramatically decreased during the past decades due to the wide conversion of original habitats to intensively cultivated areas (Arnold, 1983; Darby, 1956; Williams, 2002). One of the management tools designed to mitigate the negative effects of forest fragmentation consists of ecological corridors, i.e. linear structures that could restore and enhance the connectivity among forest remnants (Forman and Gordon, 1986; Šálek et al., 2009). In particular, they should facilitate the gene flow through sub-populations enabling individual dispersal (Červinka et al., 2013; Mech and Hallett, 2001). In lowland agro-ecosystems, ecological corridors are traditionally represented by hedgerows, defined as continuous or closely spaced lines of shrubs and trees. Although the effectiveness of hedgerows and other ecological corridors in mitigating the effect of forest fragmentation has been widely debated over the past two decades (Davies and Pullin, 2007; Tattersall et al., 2002), some authors clearly pointed out their importance in providing shelter, breeding sites and food resources for wildlife (Bennett, 2003; Hilty and Merenlender, 2004). In particular, several studies highlighted that hedgerows could represent not only effective ecological corridors, but also suitable habitats for different species, especially for birds and small mammals (Arnold, 1983; Gelling et al., 2007; Hinsley and Bellamy,

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2000; Laurance and Laurance, 1999; Silva and Prince, 2008; Wolton, 2009). Moreover, recent studies have demonstrated that hedgerows are also preferentially used respect to the agricultural matrix, both as corridors or habitats suitable for feeding and breeding (Hilty and Merenlender, 2004), by several carnivore species, in particular by mustelids (Červinka et al., 2013; Šálek et al., 2009). However, hedgerows can have different origins and structures. They may be residuals of native woodlands or new plantations, and they may suffer different management strategies. This leads to a dramatic dissimilarity in their internal structure and quality (Gelling et al., 2007) and, thus, in their suitability for wildlife. Indeed, the effectiveness of hedgerows as ecological corridors or suitable habitats depends on their structural features, such as width, continuity and internal habitat conditions (Šálek et al., 2009; Silva and Prince, 2008). For examples, poor-quality and discontinuous hedgerows proved detrimental to some farmland birds (Hinsley and Bellamy, 2000) and small mammals (Bright, 1998), while narrow hedgerows without trees seem to be unsuitable for carnivores (Hilty and Merenlender, 2004). Therefore, it is important to define which structural features should be preserved in order to ensure the effectiveness of hedgerows in restoring or enhancing landscape connectivity. Since the ecological requirements related to hedgerow structure are strongly species-specific, it would be appropriate, where possible, to apply a multi-species approach.

In this study, we evaluated which internal characteristics make a hedgerow suitable for two mammal species particularly sensitive to fragmentation in northern Italy, the European Badger (*Meles meles*) and the Hazel Dormouse (*Muscardinus avellanarius*). The European Badger is a widespread species considered as least concern by IUCN and it is not so sensitive to fragmentation in areas where agro-ecosystems are composed of forest remnants and open areas (e.g. pasturelands) which form mosaics that may even be favourable to the species (Kruuk, 1989). However, this species is strongly negatively affected by forest loss and fragmentation where the agricultural matrix is characterized by intensive crops (Virgós, 2001, 2002a, 2002b). Particularly, the European Badger has been recognized as one of the species most threatened by forest fragmentation in the agricultural landscapes of northern Italy (Bani et al., 2002). On the other hand, the Hazel Dormouse is a protected species included in the Annex IV of the Habitats Directive (Council Directive 92/43/EEC) and it is widely recognized as a species particularly sensitive to habitat loss and to the disruption of connectivity (Mortelliti et al., 2014). We chose to investigate the ecological requirements of these two species, in terms of structural and floristic characteristics of hedgerows, because of their sensitivity to forest fragmentation at two very different spatial scales (European Badger: 50 km^2 vs Hazel Dormouse: 5 km^2). Indeed, the dispersal magnitude of these two species is strongly different (European Badger: 500 m–8 km, Kowalczyk et al., 2006; Macdonald and Barrett, 1993; Hazel Dormouse: 150 m–300 m, Mortelliti et al., 2012). Moreover, it is well known that both species are particularly linked to hedgerows (Ehlers, 2012; Elliott et al., 2015; O'Brien et al., 2016; Wolton, 2009). Within our study area, it was demonstrated that they perceive hedgerows not only as ecological corridors but also as preferential habitats (Dondina et al. unpublished data). The information provided by this two-species approach could generate important suggestions for favorable management of hedgerows, which might guarantee the conservation of the two target species and, virtually, of any other species

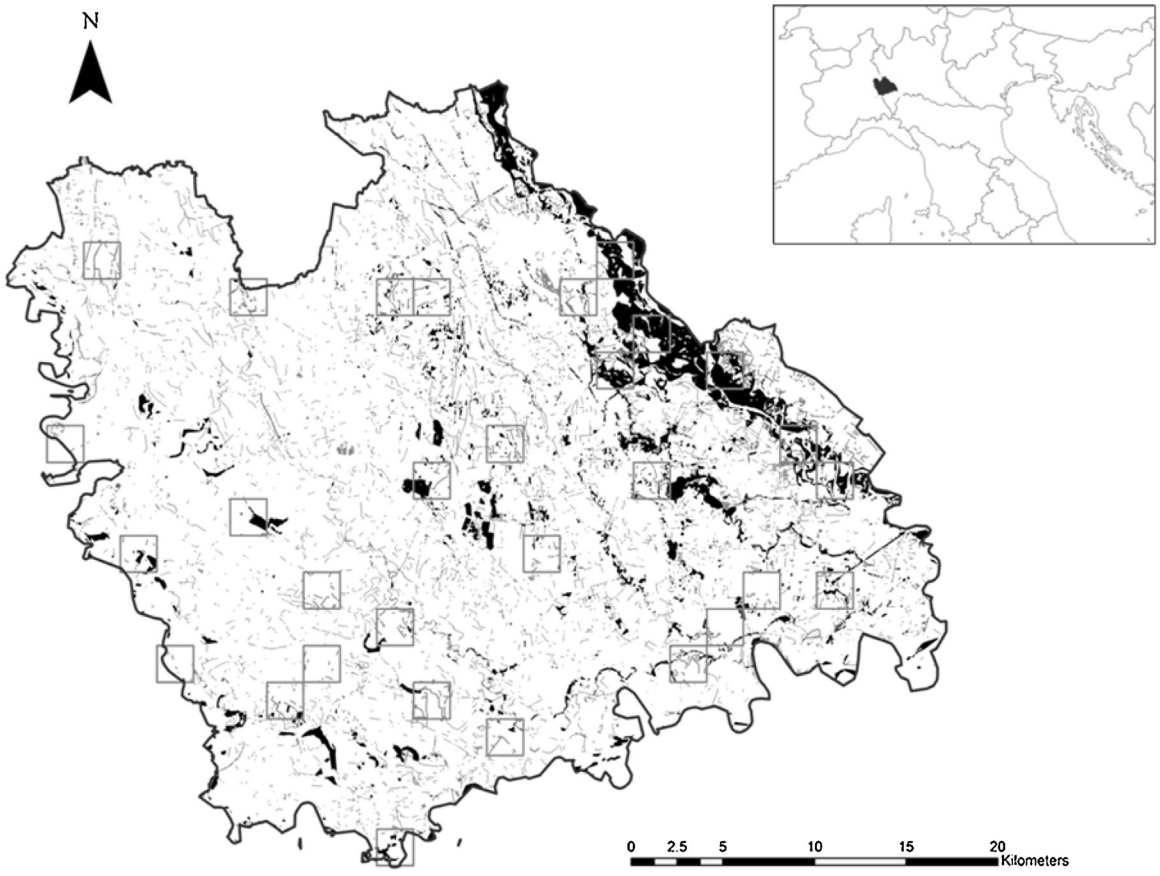

Fig. 1. Study area.
Study area in northern Italy (45°21′N 8°80′E). The gray color represents hedgerows, whereas the black color shows the original broadleaved forest remnants. The gray squares are the 2-km primary sampling units.