Journal for Nature Conservation 27 (2015) 37–43

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.de/jnc

Stealthy at the roadside: Connecting role of roadside hedges and copse for silvicolous, small mammal populations

Jorge A. Encarnação*, Nina I. Becker

Mammalian Ecology Group, Department of Animal Ecology and Systematics, Justus-Liebig-University of Giessen, IFZ – Department of Animal Ecology, Heinrich-Buff-Ring 26, 35392, Giessen, Germany

ARTICLE INFO

Article history:
Received 25 March 2015
Received in revised form 2 June 2015
Accepted 15 June 2015

Keywords:
Muscardinus avellanarius
Dormice
Flagship species
Habitat suitability modelling
Stepping stone habitats
Conservation management

ABSTRACT

An important factor in fragmented habitats is the connectivity between major occurrence areas of a species. Two corridors were modeled between two validated occurrences of *Muscardinus avellanarius* based on a habitat suitability map corrected for recent landscape changes. Especially roadside hedges and copse were identified as connecting landscape elements between woodland habitats occupied by neighboring populations of the hazel dormouse. The two corridors differed in total length (10.9 km vs. 15.5 km) but the longer corridor also had the better mean habitat suitability (0.77 vs. 0.80). The corridor usage was supported by field mapping of species' individuals and traces. On both corridors hazel nuts gnawed open by *M. avellanarius* were found. It can be concluded that roadside hedges and copse with a high tree species diversity, a high proportion of deciduous and mixed forest, and a more open canopy play an important role for conservation management of silvicolous small mammals and improve their habitat connectivity. Therefore, continuous roadside hedges and regular copse as stepping stone habitats should be promoted in environmental planning and landscape preservation. Extensive coppicing of hedges, e.g., at highways due to traffic safety should be avoided to maintain landscape connectivity for small mammals.

1. Introduction

Habitat loss and fragmentation are the main reasons for population declines and lead to a reduced biodiversity (Millennium Ecosystem Assessment, 2005; Rolstad, 1991). Even if habitat loss is the main cause for declines in species richness and populations inter-connected metapopulations have a higher probability of survival on the long run (Begon, Townsend, & Harper, 2005; Pita, Mira, & Beja, 2010). Therefore, the negative effect of habitat fragmentation on population dynamics may be as severe as the consequences of direct habitat loss (Hanski, Alho, & Moilanen, 2000; Lindenmayer & Fischer, 2013). Especially for small mammals, the growing dissection of the landscape restricts their home range and could have a serious impact on common and endangered species (Amler et al., 1999; Fahrig, 2003; Gomes, Ribeiro, & Carretero, 2011; Negro, Novara, Bertolino, & Rolando, 2013). In consequence, one of the main requirements of conservation management in Germany is maintaining and improving habitat connectivity (Blab, 2004; Haapakoski, Sundell, & Ylönen, 2015; Reck & Böttcher, 2005; Zapponi, Del Bianco, Luiselli, Catorci, & Bologna, 2013).

Species distribution and endangerment can be effectively assessed based on habitat-suitability models which permit a scientific statement on the area of suitable habitats of single species (Guisan & Thuiller, 2005). Models have already been proven effective, e.g., for bird species (Brambilla et al., 2009; Gottschalk, Ekschmitt, İsfendiyaroglu, Gem, & Wolters, 2007), insects (Bosso, Rebelo, Garonna, & Russo, 2013), larger mammals (Loe, Bonenfant, Meisingset, & Mysterud, 2011; Zabala, Zuberogoitia, & Martinez-Climent, 2005), bats (Becker & Encarnação, 2012; Russo et al., 2014), and a set of focal species including small mammals (Amici, Geri, & Battisti, 2010; Encarnação et al., 2013). Based on habitat-suitability models the connectivity between habitats was already analyzed for birds (e.g., Santos, Lourenço, Mira, & Beja, 2013), insects (e.g., Binzenhöfer, Schröder, Strauss, Biedermann, & Settele, 2005), larger mammals (e.g., Ferreras, 2001; Poor, Loucks, Jakes, & Urban, 2012; Rodríguez-Soto, Monroy-Vilchis, & Zarco- González, 2013), and bats (e.g., Teixeira et al., 2014), but evidence remains limited for smaller, more elusive, terrestrial mammals (but see Mullins et al., 2015).

Many of these small mammals are legally protected (Temple & Terry, 2007, 2009) and the Member States of the European Union are obliged to find regional conservation objectives to contribute

* Corresponding author.
E-mail addresses: J.Encarnacao@bio.uni-giessen.de (J.A. Encarnação), Nina.I.Becker@bio.uni-giessen.de (N.I. Becker).

http://dx.doi.org/10.1016/j.jnc.2015.06.003

to their protection (Louette et al., 2011). However, the voluntary migration of small mammals within potential corridors from one habitat patch to another is often methodically difficult to proof due to their elusive and nocturnal way of life and the limited number of migrating individuals (Büchner, 2008; Mortelliti, Santarelli, Sozio, Fagiani, & Boitani, 2013). The assessment of habitat connectivity is especially important in the case of forest-dwelling mammals because the loss and fragmentation of forests is a frequent and serious change of the landscape. However, fragmented forest patches can be connected with hedges and copse (Bright & Morris, 1996; Capizzi, Battistini, & Amori, 2002; Davies & Pullin, 2007) which are very important for an effective conservation management of small mammals (Bright & MacPherson, 2002; Sabino-Marques & Mira, 2011). While it is known that roadside hedges and copse might be suitable habitat for small mammals (Ascensão, Clevenger, Grilo, Filipe, & Santos-Reis, 2012; Sabino-Marques & Mira, 2011) their role as connecting elements and/or stepping stones for these species needs to be elucidated.

This study assesses if connectivity analysis to identify corridors between occupied patches of small, elusive mammals based on habitat suitability maps is a suitable tool for landscape planning and assessment. If a habitat remains usable for a metapopulation depends on the connectivity between occupied patches. If fragmented areas with major occurrences of a species are still connected by corridors species can compensate habitat loss by, e.g., movement to other areas (Gilbert-Norton, Wilson, Stevens, & Beard, 2010; Taylor, Fahrig, Henein, & Merriam, 1993). Therefore, this study tests the applicability of habitat suitability maps to analyze the connecting function of roadside hedges and copse as corridor and stepping stone habitats between two major occurrence patches of *Muscardinus avellanarius*, an endangered, silvicolous, and elusive small mammal.

2. Materials and methods

2.1. Study area

The study site has a dimension of approx. 3 km × 10 km (Fig. 1a–c) and is located in the south-western part of the City Gießen (Hesse, Germany). It contains urban areas (20.5%), agriculture (41.0%), forest (28.6%), hedges (7.1%), and water areas (2.8%) (Fig. 1b). Highways, roads and railways with adjacent hedges cross the study area mainly in east-west orientation (Fig. 1c). Three occurrences of *M. avellanarius* were documented in deciduous forests within the official monitoring program in the years 2002–2012 (Büchner, 2010). Two records are located at the western end, and one at the eastern end of the study site in a distance of 9.1 km (Fig. 1a). A roadside copse (approx. 600 m × 400 m, 16.8 ha) is located in the center of the study area and is nearby roadside hedges. The copse has a gappy canopy cover, medium age of about 50 years, and high plant species diversity (trees, shrubs and herbs). The field permit was granted by the Regional Council Giessen.

2.2. Study species

We chose the hazel dormouse (*M. avellanarius*) as a model species. The hazel dormouse has been assigned 'least concern' status by the IUCN Red List of Threatened Species and is listed in annex IV of the Habitats Directive (Temple & Terry, 2007, 2009). It occurs in small population densities (Juškaitis, 2005) and requires well networked forests as it avoids open land (Bright & Morris, 1990, 1991; Mortelliti et al., 2013; Ramakers, Dorenbosch, & Foppen, 2014; Sozio et al., 2015; Trout, Brooks, Rudlin, & Neil, 2012). Habitats should have a high plant-species diversity with various deciduous trees and shrubs (Juškaitis & Remeisis, 2007) since *M. avellanarius* needs seeds with high caloric but low tannin content to cover high energy expenditure during the active season (Pretzlaff, Rau, & Dausmann, 2014) and to build fat reserves for hibernation (Ancillotto, Sozio, & Mortelliti, 2014). It is highly vulnerable to habitat fragmentation (Büchner, 2008; Zapponi et al., 2013) as it moves arboreally among branches (Di Cerbo & Biancardi, 2013) in 2–5 m height avoiding the floor (Bright, 1998; Bright & Morris, 1991). Thus a widened forest trail or broadened meadow strip like for a ski-piste in winter can already be a crossing barrier for *M. avellanarius* (Bright, 1998; Negro et al., 2013). The mortality in the hazel dormouse is high during summer and probably linked to predation in more open areas (Juškaitis, 2014). In the Red Lists for Germany and Hesse, a long-term population decline of unknown extent is assumed for the hazel dormouse (Büchner et al., 2010; Meinig, Boye, & Hutterer, 2009).

2.3. Datasets for habitat suitability mapping

The records for the dormouse underlying the habitat suitability map for connectivity analysis originate from three data sources. Presence data of *M. avellanarius* were collected based on the usage of nest boxes within an official monitoring program (Hessen Forst FENA, Forest Inventory and Nature Conservation Agency of Hesse) and species-specific bite marks in hazel nuts (Bright, Morris, & Mitchell-Jones, 2006) within a voluntary monitoring program (Great Nut Hunt) on the initiative of the NABU Landesverband Hessen e. V. (Hesse branch of the German Society for Nature Conservation). Occurrence data were supplemented by own records with nest tube records and bite marks in hazel nuts (Becker & Encarnação, 2015). We chose null samples of the voluntary monitoring program, i.e., sites where hazel nuts were collected but none were opened by *M. avellanarius* as absence points for the model as these presence/absence models are more robust and realistic (Becker & Encarnação, 2015). Data were filtered for their actuality (2007–2015), spatial accuracy (±50 m), distance to presence points (min 800 m), and to other absence points (min 200 m). Distances were chosen to prevent both spatial clustering and underrepresentation of very suitable areas. In summary, the overall data set for habitat suitability analysis contains each 52 presence points and null samples of *M. avellanarius* in Middle Hesse.

Environmental variables were chosen based on the ecology of the hazel dormouse (Bright & Morris, 1990, 1996; Juškaitis, 2008; Reiners, Nöding, & Encarnação, 2012). Freely available data of climate (Hijmans, Cameron, SParra, Jones, P& Jarvis, 2005), elevation (German Federal Agency for Cartography and Geodesy, 2010), and landscape (Official Topographical Cartographic Information System (ATKIS), Hessian State Office of Land Management and Geological Information, HVBG, 2011) were used. All landscape data were rastered at a resolution of 25 × 25 m. To account for spatial inaccuracy in point and continuous landscape data focal statistics were calculated over a neighborhood of 100 m (ArcMap Version 10.1, ESRI Inc., Redlands). The distance was chosen as *M. avellanarius* is normally not found more than 100 m away from its nest (Bright & Morris, 1991). For categorized landscape data the percentage of occurrence and the diversity (Interspersion and Juxtaposition Index (IJI), Shannon's Diversity Index (SHDI)) around 100 m of the point (Fragstats 4.1) was considered in the analysis. For a comparison of different modeling techniques for *M. avellanarius* please see Becker and Encarnação (2015).

2.4. Modeling and mapping

The habitat suitability map underlying the connectivity analysis was based on a boosted regression tree (BRT) model and was implemented in the statistical program R (R Development Core Team, 2011) with the gbm libraries (Ridgeway, 2006) and