



Original research article

Extensive distribution models of the harvest mouse (*Micromys minutus*) in different landscapes

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ABSTRACT

Grasslands in Japan are decreasing in area and becoming increasingly fragmented. To understand how this will affect grassland organisms, it is important to predict species distributions on a landscape scale. Large-scale models are well suited to identifying potential habitats on a regional scale, but the applicability of such models across different landscapes is not clear. In previous studies of the harvest mouse (*Micromys minutus*), local-scale species distribution models (SDMs) have been devised for some areas; however, no studies have compared the applicability of such models between different landscapes. Here, we construct an extensive SDM fitted to two districts of western Japan as well as local models for each district. We also verified the accuracy of these extensive models and the transferability to local models. Extensive models using different landscapes for harvest mice yielded acceptable predictions. Rice paddies and forest areas within a 500m radius and perennial grassland habitats were favored as the predictors of mouse presence in the extensive model. Additionally, it became clear that local models had no transferability to other ranges. In the district with significant amounts of grassland (e.g., rural area), mice preferred larger patches sizes and perennial plant types; however, in the district with fewer grasslands (e.g., urban area), mice initially preferred a larger amount of grassland within a 500-m radius, regardless of patch size. Thus, habitat selection by harvest mice differed between rural and urban areas. These results demonstrate that not only patch quality but also the landscape around the habitat patch are important for habitat selection by the harvest mouse, especially in urban areas with limited grasslands

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1. Introduction

The harvest mouse *Micromys minutus* (Pallas, 1771) is a grassland species found in Europe, Russia, China, Korea, and Japan (Aplin et al., 2008). It is included on some local red lists in Japan and is a Biodiversity Action Plan species in England (The Biodiversity Reporting Information Group, 2007). Harvest mice favor tall grassland habitats such as riverbeds, marshes, pasture, and abandoned farmland (Harris, 1979; Hata, 2011), which provides the grass they need for nest construction. In Japan, forests are the most common natural biotope owing to the warm and humid climate, while large-scale grasslands are scarce and flood plains have been converted to rice fields or urban space. The total grassland area of Japan is 387,000 ha, comprising only about 1% of the country's total land area (Ministry of Agriculture, Forestry and Fisheries of Japan, 2005). Moreover, most of these grasslands are semi-natural surrounding farmland which are decreasing as a result of changes in

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agricultural practices, land regeneration, and farmland consolidation. This is considered the main factor endangering the harvest mouse in Japan.

The home range of a harvest mouse is reported to be around 400 m² (Trout, 1978). At the landscape scale, a population therefore includes the home ranges of multiple individuals. Although it is unclear what conditions favor the establishment of a stable population, it is known that harvest mouse distribution is affected by the landscape within a 500 m radius (Sawabe and Natuhara, 2015). This means that the fragmented and dispersed nature of grasslands in Japan places a crucial limitation on harvest mouse persistence, and it is therefore important to evaluate habitat suitability in isolated grassland areas. Previous studies have also demonstrated the influence of surrounding environment, such as rice paddy fields, crop fields, or forest, on the distribution of harvest mice (Hata and Natuhara, 2006; Kuroda and Katsuno, 2006; Sawabe and Natuhara, 2015).

The species distribution model (SDM) is a numerical tool that combines observations of species occurrence or abundance with environmental estimates (Elith and Leathwick, 2009). As Ueno and Kurihara (2015) have pointed out, predictions of suitable habitats on a large scale are important for biological conservation, in addition to knowledge of spatial applicability and differences in the distribution characteristics of each species by district. Additionally, transferability to other ranges is an important feature of SDMs (Randin et al., 2006). An SDM commonly assumes that the species is at equilibrium in the occupied area and that sufficient sampling has been carried out along environmental gradients (Elith and Leathwick, 2009). Thus, there is a possibility that a restricted model cannot be accurately applied to other areas with different environments. Species distribution models are traditionally evaluated within one district; therefore, their transferability has rarely been assessed (Randin et al., 2006). Our previous study examined harvest mouse distribution patterns using an SDM based on the presence/absence data in Osaka, Japan (Sawabe and Natuhara, 2015); however, its transferability has not been examined elsewhere. Moreover there are no common models that have fitted two districts for the harvest mouse.

To address this gap in our understanding of the distribution of the threatened harvest mouse in Japan, we develop an extensive model based on field data that can be confidently applied across a larger geographical scale and range of habitats, and also develop local models for each of the two districts sampled. Furthermore, we verify the accuracy of the extensive model, as well as the transferability of the local models. In addition, we discuss the differences in distribution characteristics by district.

2. Methods

2.1. Study area and field survey

The study was carried out in two districts, Shiga and Osaka, that have similar terrain but differ in their landscape structure and extent of urbanization. In the Shiga district, the study area (5 km × 38 km) was located in a rural area in the southeast of the Shiga Prefecture (Fig. 1). The northwestern part of study area comprised lake shore and plains, while the southeastern part was hilly and contained farmland, urban area, and forest. In the Osaka district the study area (3 km × 13 km) was in the southwestern part of Osaka Prefecture and included a city of one million people (Fig. 1). The study area also contained coastline along Osaka Bay and plains in the northwest, and hills in the southeast.

At the Shiga site, harvest mice nests were observed at 104 study sites from September to November in 2014. Every study site consisted of a grassland patch containing nesting plants. We unified the area of grasslands more than 200 m² in both districts. At each study site, a 30 min search was carried out by two people (as described previously in Sawabe and Natuhara, 2015) and the number of nests and dominant plants were recorded. For the Osaka site, we used available presence/absence data collected at 47 study sites between July and August, 2006 (Sawabe and Natuhara, 2015).

2.2. Landscape and habitat elements

We used six explanatory variables to predict the presence/absence of harvest mice (Table 1). We analyzed landscape composition within a buffer zone using a 1/25,000 vegetation map (Ministry of the Environment, Biodiversity Center of Japan, 2008) and aerial photographs (Shiga Prefecture Shooting and Geographical Survey Institute) using ArcGIS (ArcGIS version 10.0, ESRI, Redlands, CA, USA). We quantified the landscape surrounding the study sites in terms of the proportions of total area within 500 m of the center of the study site with a given type of land cover. This 500 m radius has previously been estimated to capture variation biologically relevant to habit use in harvest mice (Sawabe and Natuhara, 2015). The analyzed landscapes (land cover type) were rice paddy, crop field, forest, and grassland. In addition, we used the patch size and dominant plant type of each study site as predictors. Dominant plants were categorized into three types: nesting plants (perennial grasses), nesting plants (annual grasses) and non-nesting plants (Kuroe et al., 2007; Sawabe et al., 2005). Subsequently, 70 grasslands from Shiga and 18 grasslands from Osaka were categorized as perennial nesting plants, 12 grasslands from Shiga and 9 grasslands from Osaka were categorized as annual nesting plants, and 22 grasslands from Shiga and 20 grasslands from Osaka were classified as non-nesting plants.

In addition, for comparing the extensive model and the local models, using a χ -square test of land covers of the total area within all buffers in the two districts, we confirmed that the landscape compositions differ between two the districts. Land covers were categorized into rice paddy, crop field, forest, grassland, and “other”. “Other” contained urban areas, open water, and developed land.

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