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Effectiveness of corridor vegetation depends on urbanization tolerance of forest birds in central Tokyo, Japan

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ABSTRACT

Vegetation corridors, such as street trees in urban areas, which connect patchy woodland and mitigate habitat isolation, are expected to enhance the persistence of birds in urban landscapes. However, the effectiveness of urban corridors on birds remains equivocal because vegetation corridor is often managed for human use with little consideration of wildlife. Here we compared the effects of three major corridors of varying vegetation structures (trees with a dense understory, trees with a sparse understory, and grassy areas with sparse trees) on the species richness and abundance of birds in 21 wooded patches in the center of Tokyo, Japan, during wintering and breeding seasons. Using generalized linear models and Akaike's information criterion, we found that the effectiveness of corridors depended on the tolerance of birds to urbanization. Urban avoider species, having low tolerance to urbanization, demonstrated lower species richness and abundance in patches close to the corridor with a sparsely vegetated understory as compared with patches close to the understory-richer corridors during winter, although such an effect disappeared during the breeding season. The corridors did not have a significant effect on suburban adapter species with a high tolerance to urbanization. Our results suggest that corridors with scarce understory vegetation may limit the persistence of birds avoiding urban areas.

1. Introduction

Urbanization is rapidly expanding worldwide and is a major threat to biodiversity (Grimm et al., 2008; McKinney, 2002). The environmental effects of urbanization are negative generally because of anthropogenic disturbances, such as intensive modification or development of land into residential, commercial, and agricultural areas, leading to habitat fragmentation across the landscape (Grimm et al., 2008). Although the remnants of woodlots in urban areas experience severe anthropogenic disturbances, they can still function as refuges for some species and thus require appropriate management for biodiversity conservation (Goddard et al., 2010; Hedblom and Söderström, 2008).

Vegetation corridors connect remnant woodland patches and mitigate isolation. The establishment of these corridors is expected to be effective for enhancing urban biodiversity (Ignatieva et al., 2011; Savard et al., 2000) by facilitating the movement of organisms among patches, thereby improving population viability and reducing the chance of population extinction (Beier and Noss, 1998; Brown and Kodric-Brown, 1977). However, the effectiveness of corridors in urban areas remains equivocal (Gilbert-Norton et al., 2010) because corridors, such as greenways, are often managed for optimal human use, which may not meet the habitat requirements of species present in urban areas. Street trees or cycling tracks are potential corridors within urban landscapes that can facilitate wildlife movement; however, the clearance of shrub or understory vegetation in urban corridors is a common management practice to enhance the recreational or aesthetic value of these areas (Hedblom and Söderström, 2008; Heyman, 2010). This management practice has been demonstrated to negatively affect bird species because shrub and understory vegetation frequently provide bird species with food items, refuges, and nesting sites (Heyman, 2010; Katoh, 1996). Corridors with an inappropriate vegetation structure fail to fulfill their intended function as a corridor for wildlife movement and may threaten to function as a sink (Bennett et al., 1994; Hess and Fischer, 2001; Weldon and Haddad, 2005). However, most of the previous studies have tested the effectiveness of corridors for various organisms including birds, small mammals and butterflies by varying their connectivity to habitat patches (Haas,

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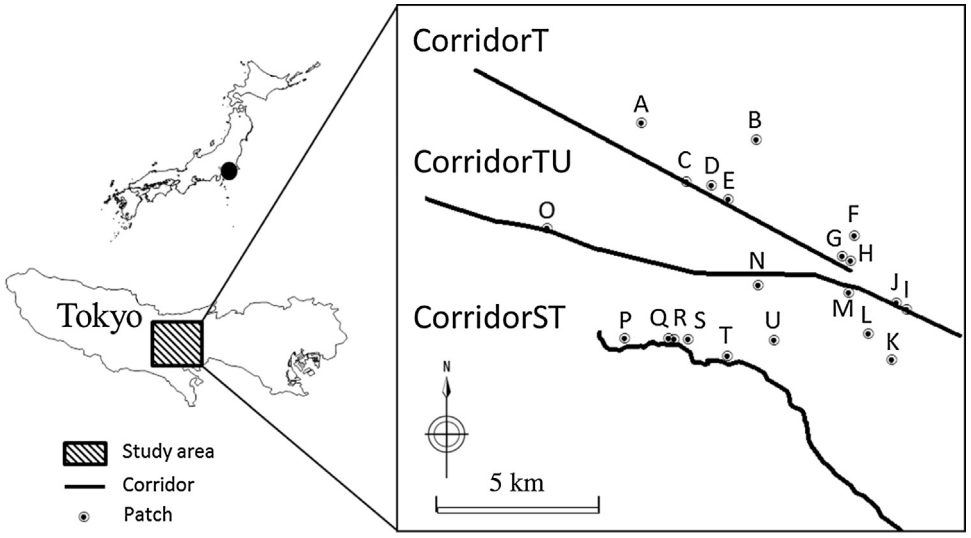

Fig. 1. Map of the locations of small wooded patches and corridors examined in this study.

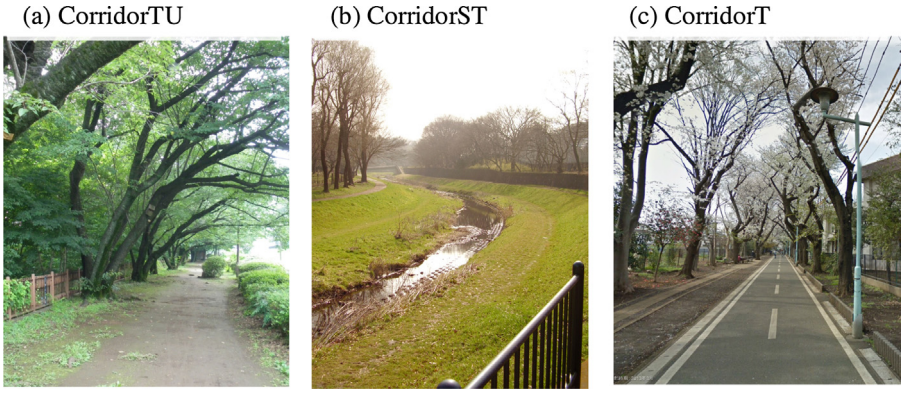

Fig. 2. Typical vegetation structures observed in the three corridors used in this study. CorridorTU is a linear strip of mature broadleaf evergreen/deciduous woods with dense understory vegetation. CorridorST is a riparian corridor along the Nogawa River that is mainly covered with herbaceous vegetation and a few planted trees. CorridorT comprises rows of planted trees (height, approximately 10 m) along both sides of a cycling track with scarce understory vegetation.

1995; Sutcliffe and Thomas, 1996; Tewksbury et al., 2002) and their widths (Andreassen et al., 1996; Haddad, 1999; King et al., 2009), rather than by varying the quality of the corridors (but see Haddad and Tewksbury, 2005).

The present study aimed to compare the effects of three corridors with different vegetation structures on the species richness and total abundance of bird species. Our study areas were located in the center of Tokyo, Japan, and included wooded patches that were connected to or neighboring one of the three corridors, allowing us to overcome the paucity of the study fields of habitats connected to the corridors. We expected the corridors to result in a general increase in the distributions of bird species with a low tolerance to urbanization than those with a high tolerance to urbanization because species that generally avoid urban areas can move only through movement corridors, whereas urban-tolerant species can move through non-vegetated areas (McKinney, 2002). Therefore, we classified the observed bird species into two groups (urban avoiders and suburban adapters; named after McKinney, 2002) according to their tolerances to urbanization and analyzed the different manner in which the species richness and total abundance of each bird species group responded to the corridors, patch areas, and vegetation in those patches. Here we also discuss how our results will contribute to the effective planning of ecological networks with corridors for the conservation of diverse bird species in urban areas.

2. Methods

2.1. Study area

The study area was located in the center of Tokyo, Japan (Fig. 1). A suburban mosaic of residential and commercial land uses dominates central Tokyo, with certain areas utilized for agricultural purposes. In the study area, three extensive corridors that stretch from the east to the west are characterized by their vegetation structures. Each corridor may attract different forest-dwelling bird species to the various wooded patches present in the corridor (Appendix A). The middle corridor (trees with understory vegetation; CorridorTU) comprises a linear strip of 10–20 m width of mature broadleaf evergreen/deciduous woodland with dense understory vegetation growing along an old irrigation canal ("Tamagawa-jousui," built in the middle of the 17th century) (Appendix A) (Fig. 2a). The southern corridor (sparse trees: CorridorST) is a riparian corridor running along the Nogawa River, 5–20 m wide, and mainly covered with herbaceous vegetation and a few planted trees (Appendix A) (Fig. 2b). The northern corridor (trees without understory: CorridorT) comprises lines of planted trees (height, approximately 10 m) along both sides of a cycling track of 10–15-m width (Fig. 2c) with sparse understory vegetation (Appendix A). A total of 21 small wooded patches (<3.0 ha),