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Urban land use does not limit weaver bird movements between wetlands in Cape Town, South Africa

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ABSTRACT

Urbanisation often has profound impacts on ecological processes. Management of these impacts is central to urban conservation efforts. We used data from 6591 individually ringed weaver birds from 42 ringing locations to investigate the influence that the urban matrix, as well as patch isolation, size and quality, had on weaver bird movement between ringing locations in Cape Town, a growing city within a global biodiversity hotspot. Distance-based linear models revealed that proximity to other sites was the dominant predictor of weaver movement while the site variables (wetland size and bird abundance) had a limited and inconclusive influence. Once the variation explained by the proximity and site variables had been accounted for, the composition of the surrounding urban matrix, the length of the least cost path between wetlands, and the presence of rivers as potential movement corridors (measured at three spatial scales) all had little influence on weaver movement. Analysis of the weaver bird movement-wetland network using social network analysis showed that the network is simple, clustered, and non-random, with relatively high vulnerability to node loss and some indication of preferential attachment (i.e., increased use of more used sites). Since proximity (site isolation) is the dominant influence on weaver movements, and the network is already sparse, further wetland loss is likely to reduce population viability. Our results match the predictions of classical theory and suggest that patch management will matter more for wetland passerines than matrix management.

1. Introduction

The earth's human population has recently, and for the first time in history, crossed the point at which more people live in cities than in the countryside. It is predicted that the area of urban land use surrounding protected areas and biodiversity hotspots will increase from 450 000 km^2 in 2000 to 1 440 000 ± 65 000 km^2 in 2030 (Güneralp and Seto, 2013). The ongoing global rural to urban transition carries both opportunities and challenges for conservation efforts. Viewed through the lens of ecosystem goods and services, urban human communities typically derive many of their ecosystem services (e.g., food, fibre, water) from areas outside the city limits (Jansson et al., 1999; Sanderson et al., 2002). As a result, cities in industrialised nations have historically prioritised other forms of service – such as infrastructure, housing, and waste disposal – over ecosystem services. This trend has resulted in a gradual separation of people and nature, and a loss of awareness of the impacts of human consumption on ecosystems, even as cities have developed ecological footprints that have impacts far beyond their own geographic extents (Cumming et al., 2014).

Over the last few decades there has been a backlash against the 'concrete jungle' notion of cities, with increasing recognition that (1) ecological communities inside cities can provide a wide range of important services (e.g., relating to air and water quality, thermoregulation, and cultural services) that can have strong impacts on human well-being; (2) it is possible for urban areas to make contributions to the conservation of rare and endangered species (Pickett et al., 2008); and (3) it is possible for cities to retain a diversity of commoner species that perform basic ecological functions, such as nitrogen fixation and seed dispersal, that contribute to the continued functioning of urban ecosystems. In the city of Cape Town and the adjacent Cape Peninsula, for example, there are 158 endemic plant species, of which >41% are IUCN Red Data Book listed. Here, pockets of remaining lowland acid Sand Fynbos vegetation within Cape Town are home to several endangered

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species that are found nowhere else (Helme and Trinder-Smith, 2006). These species are supported by a diverse ensemble of commoner but possibly more ecologically important indigenous plants and animals.

As conservation efforts seek to both maintain viable populations of native species in cities and improve the delivery of ecosystem goods and services to the human community, one of the central questions facing conservation-minded urban planners and managers is that of how to maintain essential ecological processes between patches of habitat that exist in a matrix that contains high densities of people, vehicles, and human-built structures. Hong et al. (2013), for example, addressed this concern by proposing an ecological network based on the movements of urban birds in Seoul, South Korea, that would improve habitat connectivity in a highly urbanised area. Although animal movements between habitat patches and the influence of the matrix on these movements have been central topics of study in island biogeography and landscape ecology for over 40 years (MacArthur and Wilson, 1967), many gaps remain in our understanding of how animals use urban environments. One such gap concerns passerine birds in urban wetlands. Small passerines are often numerous at urban wetlands, and may perform a variety of important ecological functions (Sekercioglu, 2010), but their small size and relatively high mobility make them difficult study targets for traditional tracking approaches. Sustainable management of urban wetlands, which can be thought of as islands in a sea of land, must consider the ecological processes that connect wetlands and hence depends on an understanding of the relevance of the urban matrix for species that disperse (and provide ecological connections) between wetlands under natural conditions. In this paper we explore the ways in which wetland-dwelling passerine bird species are influenced by urbanisation.

We used an unusually intensive data set of ringing recaptures of wetland-associated weaver birds (Ploceidae) to quantify weaver movements between 42 ringing locations in Cape Town. Weaver birds are colonial breeders that frequently move among habitat patches (when not breeding; breeding males are territorial) and often associate themselves with aspects of the human environment for food and nesting sites. Since these species are mobile and are not known to be particularly sensitive to human presence, they are a good model species for understanding the movements of small urban passerines.

We expected weaver bird movements to be strongly affected by landscape geometry, such as proximity to other sites, as well as by the nature of the land use surrounding habitat patches. More specifically, we asked (1) Is the movement of weaver birds into and out of a site influenced by site proximity, the features of the site itself (“site variables”), and/or the nature of the matrix and the presence of rivers surrounding the site? (2) Is weaver movement *between* sites influenced by the potential costs associated with moving through a heterogeneous urban matrix, or is it simply driven by the geographic separation of sites? And (3) what are the network-level properties of weaver bird movements, and what conservation implications do these properties have? The answers to these questions have strong relevance for the conservation of urban wetlands and associated passerine species.

2. Materials and methods

2.1. Study area and species

Cape Town has a population of 3.74 million people and covers an area of 2455 km^2 (Fig. 1). The city falls within a global biodiversity hotspot, the Cape Floristic Region (CFR), which, in terms of total area, is also the world’s smallest floral kingdom. It boasts exceptionally high plant diversity and endemism. The weaver bird family (Ploceidae) consists of 116 species of weavers, widow birds, queleas and bishops that are distributed throughout most of sub-Saharan Africa, South East Asia and the Indian Ocean islands (Fry and Keith, 2004). The four weaver species resident in Cape Town are the Cape Weaver (*Ploceus capensis*, Linnaeus 1766), Southern Masked Weaver (*Ploceus velatus*, Vieillot 1819), Yellow Bishop (*Euplectes capensis*, Linnaeus 1766) and Southern Red Bishop (*Euplectes orix*, Linnaeus 1758). All four are polygynous breeders that often nest near permanent inland water bodies and river courses (Hockey et al., 2005). Because they have similar habitat requirements in Cape Town (i.e., vegetation near wetlands) and dispersal strategies, and because we were interested in deriving general principles for urban wetland passerine conservation, we grouped them together as “weavers” for the majority of the analyses. To test whether differences between weaver species were relevant for our conclusions, we also ran the same analyses on the two most intensively sampled species, Cape Weaver and Southern Masked Weaver.

2.2. Data collection

Weaver movement data were collected by the South African Bird Ringing Unit (SAFRING; see http://safring.adu.org.za/) from January 2007 to September 2013 at ringing locations across greater Cape Town. Birds were captured in the early morning using mist nets and ringed (banded) with unique metal rings. Data were obtained from 42 ringing locations over 31 individual wetlands (several larger wetlands had more than one ringing location) (Appendix 1). Although most sizable wetlands in Cape Town have almost certainly been used by weavers at some stage, it was not always possible to sample all of them mostly due to accessibility issues. Our sample of 42 ringing sites from 31 wetlands offers a good representation of Cape Town’s wetland system. The northernmost site was at Rietvlei, in Blouberg, and the southernmost site, 35 km from Rietvlei, was at the Bokram river wetland in Kommetjie (Fig. 1). The data set included 7862 entries from 6591 individual weaver birds, with 1271 recapture records from 1033 individual birds. The study sites included the majority of wetlands in greater Cape Town.

To provide comparative information on relative weaver abundance, one 30-min bird count was conducted between 6am and 9am at each site during November 2013. Counts included all birds within a 150 m radius of the mist-netting site, yielding values for the total number of all birds counted and the total number of weavers counted.

2.3. Statistical analysis

We analysed the data to address (1) the influence of the matrix immediately around each wetland; (2) the influence of the matrix along pathways between wetlands; and (3) the properties of the movement network as a whole. In addition to analysing the movements of the four species as a group, we also investigated whether the Cape Weaver and the Southern Masked Weaver showed differing responses to the urban landscape and wetland configuration, by running analyses on these species separately. Sample sizes were insufficient to run analyses on all four species individually.

2.3.1. Influence of the surrounding matrix

This analysis addressed the question of whether the matrix around each ringing location explained a significant proportion of variance in the amount of weaver movement into and out of each site, based purely on recaptures. To correct for differences in sampling effort between sites, we divided the number of movements into or out of the site by the number of birds caught at each site