Biological Conservation 191 (2015) 224–233

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

Opportunities for improving the foraging potential of urban waterways for bats

Paul R. Lintott *, Nils Bunnefeld, Kirsty J. Park

Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, Scotland FK9 4LA, UK

ARTICLE INFO

Article history:
Received 5 February 2015
Received in revised form 9 June 2015
Accepted 26 June 2015
Available online 7 July 2015

Keywords:
Chiroptera
Cryptic species
Fragmentation
Invasive species
Landscape management
River habitat
Urban ecology

ABSTRACT

The rapid rate of urbanisation over the past century has occurred over a relatively small proportion of the earth's surface, yet it has had considerable ecological impact at a global scale. Urban waterways have historically been regarded as a disposable resource for human benefit which has had severe biological consequences. River rehabilitation schemes are attempting to address this; however restoration is frequently undertaken with minimal scientific input and fails to improve biodiversity. Many bat species are strongly associated with aquatic or adjacent riparian habitats but respond negatively to the built environment; however, we know little about the utilisation of urban waterways by bats. We therefore conducted a wide scale, multi-species study that examined how local habitat characteristics and the composition and heterogeneity of the surrounding landscape influence bat presence and activity along urban waterways. We recorded a total of 19,689 bat passes of seven species/genera from 30 urban waterways throughout the U.K. We show that the built environment can negatively affect a variety of species from the riparian zone up to 3 km from a waterway. Additionally, *Myotis* sp. activity was greater in waterways bounded by steep banksides and clear of invasive plant species. We also found differences in the response of two cryptic pipistrelle species to the built environment at multiple spatial scales indicating the difficulties of assessing how adaptable even morphologically similar species are to urbanisation. Beneficial urban waterway rehabilitation schemes for bats require management at multiple spatial scales. At a local scale, retaining a vegetated riparian zone, with a reduction in invasive aquatic plant species, is likely to benefit a variety of taxa. At a landscape scale, our results show that the influence of the built environment can stretch a considerable distance highlighting the necessity for conservation funding to be spent on the implementation of landscape scale environmental improvement schemes which encompass the entire urban matrix.

1. Introduction

The unprecedented rate of urbanisation over the past century has occurred on a small proportion of the earth's terrestrial surface (<3%), yet its ecological footprint is widespread and its impact global (Grimm et al., 2008). Urbanisation can fragment and dramatically modify large parcels of land, often permanently with little chance for recovery (McKinney, 2006). As urban landscapes expand, they influence an increasing proportion of regional, national and global biodiversity (Dearborn and Kark, 2010). Understanding how species respond to the built environment is therefore essential for mitigating and managing urban ecosystems.

Urban waterways have historically been regarded as a disposable resource for human benefit including their modification for flood mitigation, water supply, and use as sinks for pollution (Paul and Meyer, 2001). These alterations have had severe biological consequences creating disturbed ecological systems with water quality problems, highly variable flow regimes and an extremely modified physical habitat (Beavan et al., 2001). However in recent decades, an increasing recognition of the importance of urban greenspace (including urban waterways) for its environmental and human wellbeing benefits has led to efforts to rehabilitate urban waterways (Matsuoka and Kaplan, 2008). Supported by legislation and policy frameworks (e.g. the EU Water Framework Directive (EU Commission, 2000), the Australian Commonwealth Wetlands Policy (EA, 1997), pollution problems and habitat degradation are being addressed for urban waterways and associated surrounding riparian habitat. Despite the fact that urban waterways are frequently recorded as key habitats within the built environment for maintaining biodiversity (e.g. Gaisler et al., 1998), restoration efforts in these habitats have often failed to increase native biodiversity for taxa including fish and benthic macroinvertebrates (Stranko et al., 2012). Many river restoration projects are undertaken with minimal scientific input (Wohl et al., 2005), indicating the need for a greater understanding of species requirements to inform management strategies.

Within fragmented and disturbed landscapes, urban waterways may function as corridors linking fragmented greenspace patches (i.e. woodland, parkland; Bryant, 2006) and connect the urban landscape with surrounding rural habitat. Waterways can therefore improve gene flow between populations, act as migration routes out of urban areas, and facilitate movement throughout the urban matrix whilst avoiding

* Corresponding author.
E-mail address: p.r.lintott@stir.ac.uk (P.R. Lintott).

http://dx.doi.org/10.1016/j.biocon.2015.06.036
0006-3207/

areas of high anthropogenic disturbance (Baschak and Brown, 1995). However, waterways can *also* increase the dispersal of invasive species. For example, Dallimer et al. (2012) found that neophyte richness increased in the direction of water flow along urban rivers. Understanding which local factors (e.g. riparian vegetation characteristics) influence the use of waterways by species is essential in ensuring that native species are able to utilise these ecological corridors to travel within the urban environment. Additionally, there is an increasing emphasis being placed on understanding species distributions within urban areas at a landscape scale (Ignatieva et al., 2011), for example by determining how the surrounding built environment may influence which species are able to access waterways. Examining how best to restore biodiversity in urban rivers and canals therefore requires assessment at multiple spatial scales to examine how species respond to modified waterways and the complexity of the surrounding urban matrix.

The prevalence of species within the urban matrix depends on their capacity to survive and adapt to heavily modified landscapes and anthropogenic disturbances. In this regard, although many species of bats (Chiroptera) have adapted to exploit human resources (e.g. insects at artificial light sources; Mathews et al., 2015), the majority of bat species are negatively impacted by urbanisation (Russo and Ancillotto, 2014). The highest rates of bat foraging activity within the urban matrix are often found by waterways due to drinking opportunities and high insect prey concentrations (Li and Wilkins, 2014). Although a substantial volume of work has been conducted in non-urban environments investigating how vegetation characteristics and habitat composition at multiple spatial scales influence bat use of waterways (e.g. Akasaka et al., 2009), relatively little is known about the factors that influence foraging bats along urban waterways.

Within our study area of the U.K. there are 17 bat species, a few of which are strongly associated with aquatic environments. *Myotis daubentonii* is widespread throughout Europe and parts of Asia and is classified as a species of 'Least Concern' by the IUCN Red List of Threatened Species (Stubbe et al., 2008), however its strong association with riverine habitats makes this species particularly vulnerable to changes in river management which may isolate populations or have a severe effect on available foraging habitat (Warren et al., 2000). Langton et al. (2010) found that *M. daubentonii* activity was negatively associated with the percentage of built land in the surrounding 1 km indicating that this species may be negatively impacted by urbanisation.

The two most common species of pipistrelle bat found within the study area, *Pipistrellus pygmaeus* and *Pipistrellus pipistrellus*, are cryptic species with very similar flight morphologies (Jones and Van Parijs, 1993) but different foraging behaviours. In a non-urban setting, Davidson-Watts et al. (2006) found that *P. pygmaeus* preferentially selected riparian habitats over all other habitat types in its core foraging areas, whereas *P. pipistrellus* was more of a generalist, foraging in a wider range of habitats. Little is known of the response of these species to the built environment although Hale et al. (2012) found that *P. pipistrellus* activity at urban ponds peaked with moderate levels of adjacent urban grey space.

This paper addresses how waterway and bank vegetation characteristics and the composition of the riparian zone influence activity levels for a range of bat species/genera. Given their relatively high mobility, we also assess how the wider landscape influence bat activity. Additionally, we examine if two morphologically similar species respond differently to the extent of urban grey space. We use these results to recommend management strategies to protect and improve urban waterways for the benefit of bats.

2. Materials & methods

2.1. Site selection

A total of 30 stretches of urban waterways within the U.K. were identified using digital maps (EDINA, 2013). Stretches of waterway measuring at least 8 km in length, where a minimum of a third of the watercourse was contained within an urban area, were selected (Fig. 1). Urban areas were designated as those where urban cover was the dominant land use within a 1 km grid square as categorised by the UK Land Cover Map 2000. Waterways were selected by latitude, longitude, safety issues (e.g. avoiding stretches of river containing weirs), and degree of urbanisation in the surrounding 1 km using a stratified random sampling method. Sites surveyed on consecutive nights were a minimum of 50 km apart to minimise any bias. Starting points were randomised between sites to ensure there was no spatial bias towards urban or rural areas. Each waterway was surveyed once by a single surveyor. We recognise that a single visit to each waterway provides only a coarse description of local bat activity but here we are interested in the relative influence of waterway characteristics on bat activity which requires that the number of replicates is maximised.

2.2. Vegetation surveys

Daytime vegetation surveys were conducted on the same day as the bat survey to ensure that appropriate vegetative conditions were recorded. A total of 16 point count locations were designated along each waterway, a minimum of 400 m apart. Vegetation characteristics, based upon the Environment Agency's River Habitat Survey (Raven et al., 1998), were recorded at each location (listed in Section 2.6.1).

2.3. Bat surveys

Determining how bats respond to waterway quality and characteristics is difficult given that the vast majority of waterway surveys (e.g. Langton et al., 2010) are conducted bankside which limits surveying to those locations where the bankside is accessible (i.e. missing heavily vegetated areas or stretches of river bounded by private land). We therefore used the technique of surveying by kayak to enable us to record bat activity along entire stretches of waterway through contrasting landscapes.

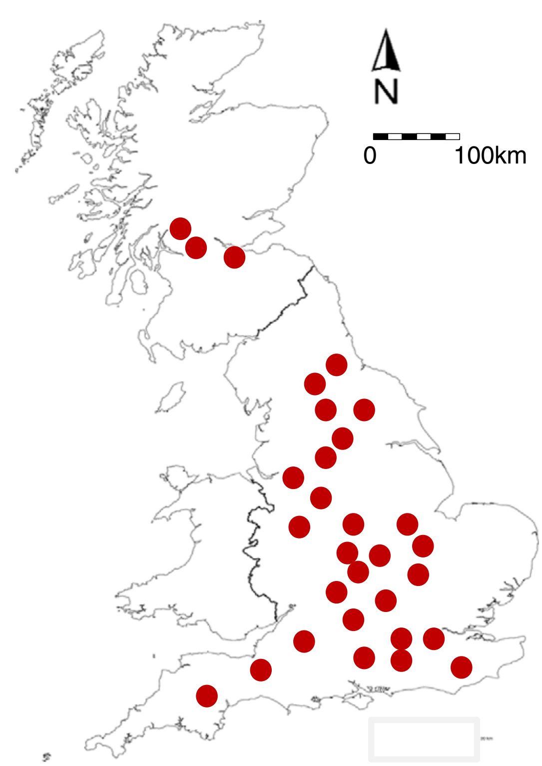

Fig. 1. Surveyed urban waterways across the U.K. Reproduced from Ordnance Survey map data by permission of the Ordnance Survey © Crown copyright 2001.