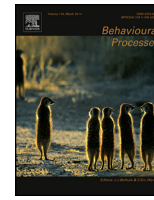
Behavioural Processes 129 (2016) 86–93

Contents lists available at ScienceDirect

Behavioural Processes

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



Low frequency dove coos vary across noise gradients in an urbanized environment

Fengyi Guo[a,b], Timothy C. Bonebrake[a,b], Caroline Dingle[b,*]

[a] School of Biological Sciences, University of Hong Kong, Hong Kong
[b] Department of Earth Sciences, University of Hong Kong, Hong Kong

ARTICLE INFO

Article history:
Received 20 November 2015
Received in revised form 23 May 2016
Accepted 2 June 2016
Available online 3 June 2016

Keywords:
Anthropogenic noise
Columbidae
Coo
Frequency
Signals
Urbanization

ABSTRACT

Urbanization poses a challenge to bird communication due to signal masking by ambient noise and reflective surfaces that lead to signal degradation. Bird species (especially oscines) have been shown to alter their singing behaviour to increase signal efficiency in highly urbanized environments. However, few studies on the effects of noise on song structure have included birds with low frequency vocal signals which may be especially vulnerable to noise pollution due to significant frequency overlap of their signals with traffic noise. We compared the perch coos of spotted doves (*Streptopelia chinensis*), a species with very low frequency vocalizations, in different background noise levels across urban and peri-urban areas in Hong Kong. We documented a 10% upward shift in the minimum frequency of coos of spotted doves across the noise gradient (a relatively small but significant shift), and a reduced maximum frequency in urban habitats with a higher density of built up area. Hong Kong doves had significantly higher minimum and maximum frequencies than doves from throughout their range (from mostly rural sites). Our results indicate that urban species with extremely low sound frequencies such as doves can alter their vocalizations in response to variable urban acoustic environments.

1. Introduction

Acoustic signals play crucial roles in bird communication and convey important information used in territorial defence and mate attraction (Catchpole and Slater, 2003; Collins, 2004). Anthropogenic modifications to the acoustic environment, especially in densely populated urbanized areas, have the potential to affect animal communication in various ways. Low-frequency urban noise from traffic and industry can mask signals (Halfwerk et al., 2011; Rabin and Greene, 2002; Slabbekoorn and Peet, 2003; Warren et al., 2006) while sound reverberation from multiple reflective surfaces might degrade bird signals due to echoes (Warren et al., 2006). In dense urban habitats, sound attenuation by the concrete walls of tall buildings might also limit sound transmission distances (Leader et al., 2005; Parris and McCarthy, 2013; Warren et al., 2006).

A growing body of research has documented a variety of changes in the signals of birds in noisy acoustic environments. One of the most commonly documented responses to urban noise is for birds to sing songs with higher frequencies, presumably to avoid the masking effects of low frequency urban traffic noise (e.g. great tits *Parus major*, Slabbekoorn and Peet, 2003; house finches *Carpodacus mexicanus*, Bermúdez-Cuamatzin et al., 2011; silvereyes *Zosterops lateralis*, Potvin et al., 2011). Other observed responses include amplitude shifts (e.g. common nightingale *Luscinia megarhynchos*, Brumm, 2004), changing song lengths (e.g. house finches *Carpodacus mexicanus* Fernández-Juricic et al., 2005) and increasing the amount of time spent singing (e.g. serins *Serinus serinus* Díaz et al., 2011).

Species vocalizing at low sound frequencies are likely to be more susceptible to the masking effects of noise pollution than those with higher frequencies vocalizations (4–7 kHz) which may not suffer from the masking effects of urban noise (Hu and Cardoso, 2009; Rheindt, 2003; Slabbekoorn, 2013; Slabbekoorn and Ripmeester, 2008, but see Moiron et al., 2015). Species with intermediate minimum signal frequencies (1.5–4 kHz) have been shown to be capable of adjusting their signal frequencies to minimize the impact of overlap with anthropogenic noise (Hu and Cardoso, 2010; Parris and Schneider, 2009). Species vocalizing at very low frequencies (below 1 kHz), however, will have a high proportion of their signals masked by low frequency background noise. For such species, it could be difficult to shift the frequencies of their songs sufficiently to overcome the masking effect of urban noise, and thus these species might require the adoption of other non-frequency

* Corresponding author at: Department of Earth Sciences, James Lee Science Building, University of Hong Kong, Pokfulam Road, Hong Kong.
E-mail address: cdingle@hku.hk (C. Dingle).

http://dx.doi.org/10.1016/j.beproc.2016.06.002
0376-6357/

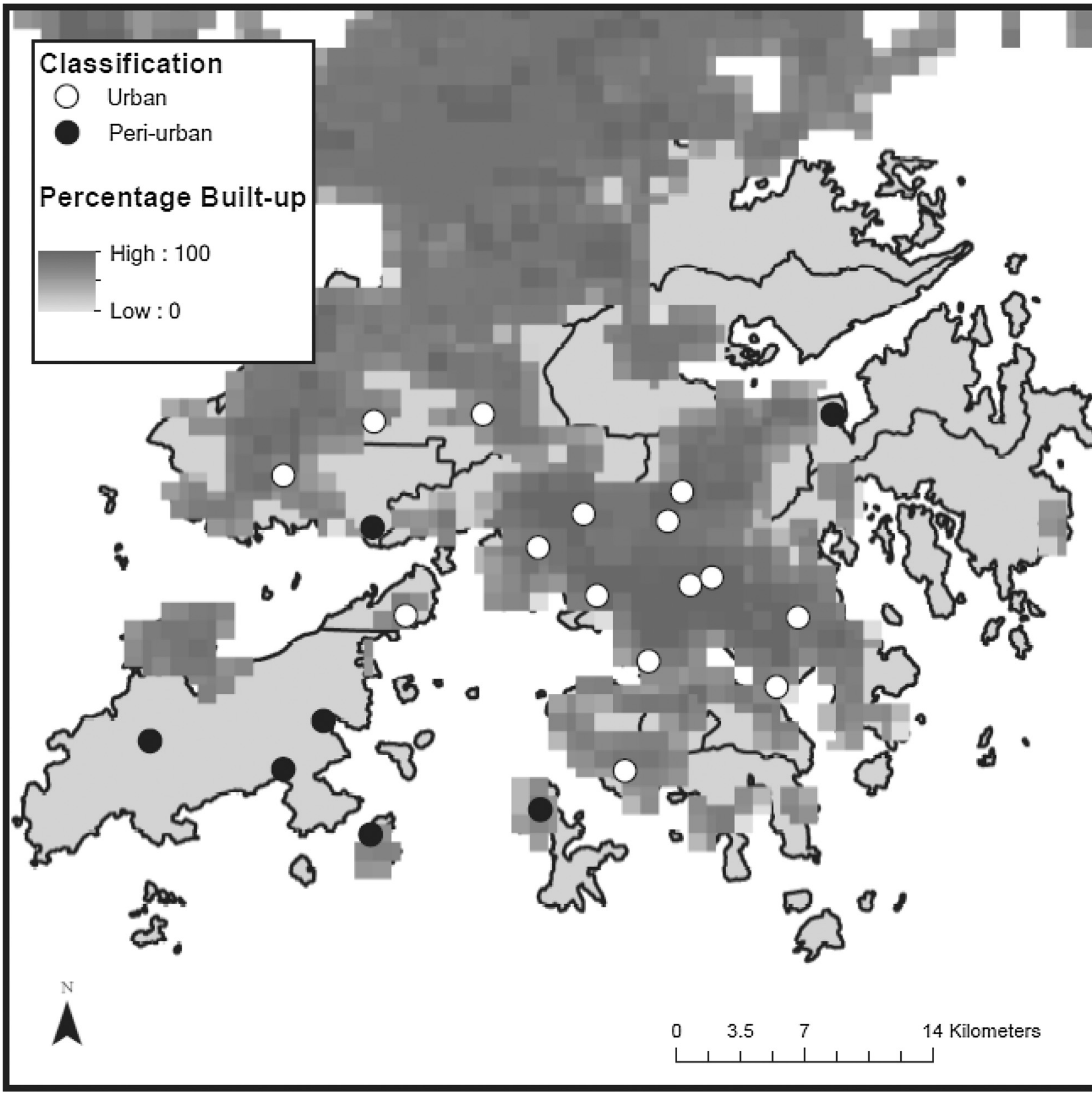


Fig. 1. Map indicating the location of the 22 sampling sites used in this study. (10 of the original 32 sites were not included due to small sample sizes.) Black dots in dark grey areas represent urban sites in dense built-up areas, and white dots represent peri-urban sites in open areas like shrublands and farmlands.

vocal adjustments (Francis et al., 2011; Hu and Cardoso, 2010). In a model predicting the decrease in active space of avian signals in noisy areas, Parris and McCarthy (2013) concluded that birds with frequencies around 1.5 kHz should benefit most from frequency shifts and thus should be more likely to switch to higher frequencies in noisy urban areas. The Parris and McCarthy (2013) model applies well to available data on oscine passerines, but the model is so far untested with birds of frequencies lower than 1.5 kHz. Hu and Cardoso (2010) found that only three out of nine bird species with song or call frequencies lower than 1.5 kHz showed significant increases in minimum frequency in their vocalizations in noisy urban areas. The species with the lowest frequencies (pied currawong *Strepera graculina*: F_{min} = 0.55 kHz, Australian magpie *Gymnorhina tibicen*: F_{min} = 0.61 kHz, and grey butcherbird *Cracticus torquatus*: F_{min} = 0.75 kHz) did not show any significant shift at all. It therefore remains unclear how non-passerine species with very low frequency signals respond to noise in urban areas and what the consequences might be for their success in these novel environments.

Doves (family *Columbidae*) are abundant residents of many cities and seem to have successfully adapted to urban environments (Chace and Walsh, 2006). The dominant frequencies of urban anthropogenic noise strongly overlap with the low frequencies of dove coos which are used for both long-range (perch coo) and short-range (bow coo) communication (de Kort and ten Cate, 2004; Patricelli and Blickley, 2006; Rheindt, 2003). This signal masking seems to contradict their apparent success in urban environments (Slabbekoorn et al., 1999; Viney et al., 2005). Non-oscine species like doves are traditionally thought to be incapable of significantly changing the acoustic features of their signals through behavioural modification (Patricelli and Blickley, 2006), and thus they might suffer more than oscines from anthropogenic impacts such as