Strategies of song adaptation to urban noise in the house finch: syllable pitch plasticity or differential syllable use?

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Summary

The influence of ambient noise in shaping birdsong attributes has received much attention lately. Recent work shows that some birds sing higher-pitched songs in noisy areas, which may allow them to avoid acoustic interference; yet it is not clear how this is achieved. Higher-pitched songs may be produced either by using the same syllable types in quiet and noisy areas, but singing them at a higher frequency in the latter (syllable pitch plasticity), or by using different syllable types in silent and in noisy circumstances (differential syllable use). Here we explored both strategies in the Mexico City population of house finch (\textit{Carpodacus mexicanus}), a species known to possess a repertoire of several hundreds of syllable types. Birds produced songs with higher minimum frequencies in noisy than in quiet areas. This was mostly due to the minimum frequency of some syllable types being higher in noisy areas than in quiet locations. Also, males modulated the minimum frequency of the same syllable type during momentary increases of noise. Our results can help explain the high success of house finches at colonizing urban areas, while providing evidence of syllable pitch plasticity.

Keywords: house finch, \textit{Carpodacus mexicanus}, urban noise, birdsong, pitch plasticity.
Introduction

The influence of ambient noise in shaping birdsong attributes has received much attention recently (e.g., Brumm & Todt, 2002; Slabbekoorn & Peet, 2003; Brumm, 2004, 2006; Leader et al., 2005; Brumm & Slater, 2006; Patricelli & Blickley, 2006; Slabbekoorn & den Boer-Visser, 2006; Wood & Yez-erinae, 2006; Fuller et al., 2007). Some of these studies have shown that the song of birds in situations of high levels of noise show particular adaptations to favour signal transmission, such as increase in sound amplitude (Brumm, 2004), number of same song types within a bout before changing to another song type (Brumm & Slater, 2006), and increased minimum song frequency (Slabbekoorn & Peet, 2003; Fernández-Juricic et al., 2005; Wood & Yez-erinae, 2006). With respect to the latter, singing high-pitched songs in noisy areas may lead birds to reduce noise interference. This is because ambient noise, whether naturally produced (e.g., wind) or anthropogenic (e.g., automobile traffic), is commonly composed of low frequencies, with its energy diminishing towards higher frequencies, and certain types of anthropogenic noise like car traffic can easily reach frequencies that overlap with the frequencies of birdsong (e.g., 2 kHz). Therefore, producing songs above these frequencies could prevent noise masking. As birdsong is known to play an important role in sexual selection processes (reviews in Searcy & Anderson, 1986; Catchpole & Slater, 1995; Gil & Gahr, 2002), avoiding noise masking may have important fitness consequences.

Indeed, some studies suggest that noise has negative effects on bird populations. For instance, several studies have found a reduction in density of breeding birds in the proximities of noisy roads and highways (e.g., Reijnen & Foppen, 1994; Reijnen et al., 1996), and a negative association between noise level and bird density (Reijnen et al., 1995). While it is not clear how high noise level may be related to population decline, some data suggest that the latter may be a consequence of noise masking birdsong (Rheindt, 2003), which in turn may impair processes of sexual selection, erode pair preferences (Reijnen & Foppen, 1994; Swaddle & Page, 2007), or disrupt bird vocal communication in general.

Since anthropogenic noise is a widespread phenomenon, particularly strong in or around cities, airports and highways, often reaching levels beyond those allowed by current legislation on public health (especially in big cities), it is important to study whether birds are able to deal with this