Transportation Research Part D 30 (2014) 72–75

Contents lists available at ScienceDirect

Transportation Research Part D

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

Notes and comments

Relationship between traffic noise levels and song perch height in a common passerine bird

Marcin Polak *

Department of Nature Conservation, Institute of Biology and Biochemistry, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland

ARTICLE INFO

Keywords:
Acoustic adaptation
Birdsong
Disturbances
Song-post
Traffic noise

ABSTRACT

The man-made noise is one of the most serious problems that animals living in close contact with humans have to contend with, as it interferes with the transmission of information encoded in acoustic signals sent from emitter to receiver. Birds with their complex songs are particularly vulnerable to anthropogenic noise. This research analyses the selectivity of song posts of the robin *Erithacus rubecula* with respect to a number of habitat parameters and the traffic noise amplitude. The results indicate that the birds take active steps to avoid interference to their vocal communication in the vicinity of busy roads. The males in noisy territories sang from perches located higher above the ground. This is the first report to demonstrate the correlation between song post height and traffic noise levels in a common passerine bird. Very likely, the choice of perches situated higher up in the vegetation improves the robins' auditory perception of neighbouring rivals in an environment polluted by excessive noise levels. The differences in selectivity of song post location between areas with high and low intensities of noise may have serious consequences for the individuals concerned.

Introduction

The increasing pressure of human activities on the natural environment is having a whole range of serious adverse effects on living organisms (Benitez-López et al., 2010). One of the most serious threats resulting from the expansion of infrastructure and industry is omnipresent anthropogenic noise, which may significantly modify the behaviour and certain populational parameters of animals (Forman and Sperling, 2003). Because birds communicate acoustically, they are especially endangered by such noise (Reijnen et al., 1997). Recent studies have shown that man-made noise is indeed having a significant influence on various bird species, reducing their breeding success, hampering the finding of a suitable mate and forcing them to change the bioacoustic parameters of the sounds they emit while singing during the mating season (Slabbekoorn and Peet, 2003; Halfwerk et al., 2012). The difficulties of vocal communication caused by traffic noise would appear to be one of the main problems affecting the birds inhabiting a noise-polluted area (Fuller et al., 2007). Nevertheless, recent work has shown that some bird species can adjust behaviour to a noisy environment and to offset the negative influence of noise bring into play such plastic responses as the Lombard effect, i.e. increasing the amplitude of the song (Brumm, 2004), raising the frequency spectrum of the song (Slabbekoorn and Peet, 2003; McLaughlin and Kunc, 2013), singing at a time of day when noise levels are lower (Fuller et al., 2007) and intensifying the level of vocalisations (Diaz et al., 2011).

During their transmission from source to receiver, acoustic signals are subject to attenuation and distortion (Wiley and Richards, 1978). All year round acoustic communication depends on the effective emission of sounds, auditory perception

* Tel.: +48 081 537 59 71; fax: +48 081 537 59 01.
E-mail address: mpolak@hektor.umcs.lublin.pl

http://dx.doi.org/10.1016/j.trd.2014.05.004

and the extraction of necessary information contained in the signal (Mathevon and Aubin, 1997; Mathevon et al., 2005). From the acoustic signals the receiver has to extract coded information on the identity, motivation and location of the emitter (Dabelsteen et al., 1993; Holland et al., 1998). To maximise the effectiveness of the sounds they transmit, animals should optimise the locations of the spots from which they emit acoustic signals and where auditory perception takes place (Wiley and Richards, 1978). Height differences in woodland between emitter and receiver can significantly affect communication between them (Holland et al., 1998). Behavioural changes while singing may ensue as a result of feedback from a bird's own internal auditory perception and/or feedback from a female or from males in adjacent breeding territories (Halfwerk et al., 2012). Recent experiments have demonstrated that to improve their auditory perception of sounds emitted by their neighbours, birds change the locations of their song posts by selecting tree branches that are farther away from the ground (Mathevon et al., 2005). One way of improving the detection of acoustic signals in a noise-polluted environment is to sing from a song post placed higher up in the vegetation. It is generally thought that high-lying song posts are advantageous to emitters, especially in long-distance communication (Wiley and Richards, 1978). However, singing form higher perches in forest is assumed to have a predation cost. Recent work has shown that these are the canopy parts more exposed to sparrowhawk *Accipiter nisus* attacks (Krams, 2001). To date, however, no field or experimental tests have been carried out to find out whether birds adjust the high heights of their perches in environments exposed to high noise levels (Møller, 2011).

The model species in this study was the European robin *Erithacus rubecula*, a species that defends its territory year round (Cramp, 1988). The main function of bird song is to attract a female and to defend a territory. The song is emitted in a frequency range from 2 to 9 kHz, and the repertoire varies widely within and between individuals. Woodland birds often choose certain layers of vegetation from which to sing, which are not necessarily preferred for other activities like foraging (Wiley and Richards, 1978). Robins usually choose song posts located fairly low down, usually 1–3 m above the ground, and they often use the same site, even when plenty of alternative ones are available (Cramp, 1988). Recent studies and experiments have shown that anthropogenic noise has an effect on robin song and individuals can adjust behaviour to a noisy environment (Fuller et al., 2007; McLaughlin and Kunc, 2013; Montague et al., 2013; McMullen et al., 2014). In the present work I studied the selectivity of song posts of the robin in different acoustical conditions. If anthropogenic noise affects perch height selection I predict a positive relationship between background noise levels and song perch height, because birds should sing more from higher song posts to improve their ability to hear other birds singing in neighbouring territories (Dabelsteen et al., 1993; Mathevon et al., 2005).

Methods

The study was carried out from 30th April until 22nd May in 2012 and 2013 in ten forest complexes directly adjacent to different national roads in eastern Poland. The study plots were located near the following villages: Sarny (N 51°34′; E 21°59′), Jaworów (N 51°31′; E 22°2′), Stasin (N 51°12′; E 22°26′), Podkrasne (N 50°50′; E 23°9′), Łopiennik (N 51°1′; E 23°4′), Pikule (N 50°40′; E 22°20′), Zalesie (N 51°22′; E 22°37′), Wandzin (N 51°23′; E 22°38′), Sobieszczany (N 51°2′; E 22°22′), Pułankowice (N 50°57′; E 22°16′). The dominant tree species in these woodlands were scots pine *Pinus sylvestris*, pedunculate oak *Quercus robur* and hornbeam *Carpinus betulus* aged from 56 to 166 years (data from actual forest maps). The intensity of traffic on the road sections investigated was *ca.* 8000–20 000 vehicles in 24 h. To avoid pseudoreplication, each forest complex was checked just once. The observer walked along a transect (randomly chosen from two transects) parallel to the road and 100 m from it. On detecting a singing bird, the observer approached it to record the significant environmental parameters at that song post. A full set of measurements was obtained for 24 singing robins. The location of each song post was logged on a GPS receiver. The level of traffic noise was measured at a height of 1.5 m above the ground during a period of 5 min using a digital sound meter CHY 650 (IEC 651-1979 Type 2, ANSI S1.4-1983 Type 2, JIS C 1502) with A-frequency-weighting and set to the SLOW option. The maximum amplitude of noise recorded during this period was used in the subsequent analysis. The birds chose nine species of trees. Tree and song post heights were measured with a Silva CM 1015/2025 PA (Silva Sweden AB) clinometer accurate to 50 cm (for song posts located up to 20 m above ground level) and to 25 cm (<20 m). To check the robins' tree height preferences, the heights of 116 other trees (selected at random every 200 m along a transect) were measured at all the localities. The structure of the vegetation at every sampling and control point was assessed by use the same methods. The diameter at breast height (DBH) of trees was measured with a tape accurate to 1 cm. The canopy and bush cover were determined in eleven categories: 0 – 0%; 10 – 1–10%; 20 – 11–20%; 30 – 21–30%; 40 – 31–40%; 50 – 51–60%, 60 – 61–70%, 70 – 71–80%, 80 – 81–90%, 90 – 91–99%, 100 – 100% within circle (radius 30 m). The distance of the bird from the road was taken to be the shortest straight-line distance between the tree used as a song post and the centreline of the roadway, as measured by the GPS receiver. The number of tree species among the 30 nearest trees with DBH > 20 cm was counted. Song-post measurements were made throughout the day from 07:35 to 18:50 h. Observations were carried out on weekdays only in rain-free stable weather conditions, at temperatures from 11 to 28 °C, air humidity from 55% to 80% and wind speeds <4 m/s. The means are given together with their standard deviations ± SD.

Results

The average distance between the song-post tree and the roadway centreline was 115.5 ± 61.5 m (15–233 m, $n = 24$, Table 1). 38% of all tested robins sang in close proximity to the roads (<100 m). The level of traffic noise in the robin

Table 1
The environmental variables obtained at song posts ($n = 24$).

Parameter	Mean ± SD	Minimum	Maximum
Height of the song post above ground (m)	14.1 ± 5.0	6.6	25.5
Level of traffic noise (dB)	58.9 ± 8.1	41.0	74.2
Distance from road (m)	115.5 ± 61.5	15	233
Tree height (m)	20.6 ± 4.6	13.0	28.0
Tree DBH (cm)	93.7 ± 48.9	21	216
Tree canopy cover (%)	62.5 ± 30.8	10	100
Shrub cover (%)	27.1 ± 25.8	0	100
Number of tree species	2.7 ± 1.0	1	5

territories studied varied from 41.0 to 74.2 dB (mean = 58.9 ± 8.1 dB, $n = 24$). The heights of song posts above ground level differed widely in the population under study, from 6.6 to 25.5 m (mean = 14.1 ± 5.0 m, $n = 24$). The differences between the heights of the trees that birds selected as song posts (mean = 20.6 ± 4.6 m, 13.0–28.0 m, $n = 24$) and of randomly selected trees growing in the study area were not statistically significant (mean = 20.8 ± 5.1 m, 6.0–30.0 m, $n = 116$; $t = -0.10$, df = 138; $p = 0.92$). The analysis showed that the only parameters significantly correlated with the song perch height were the level of traffic noise ($r = 0.44$, $p < 0.05$, $n = 24$) and tree height ($r = 0.49$, $p < 0.05$, $n = 24$). In breeding territories subject to high amplitudes of noise robins sang from posts located higher above the ground (Fig. 1).

Discussion

The results of this work indicate a hitherto undescribed relationship between song perch height and anthropogenic background noise levels. This is in agreement with the results obtained by researchers in other robin's population (McLaughlin and Kunc, 2013), which showed a gradual behavioural change in response to increasing background noise levels. At my study area in places located close to busy roads and exposed to high intensities of noise, robins chose song posts located high above the ground. Analysis showed that birds in the study plots preferred trees of a similar height. But within the several forest storeys in territories exposed to a high amplitude of noise, birds chose song posts located higher up in the tree canopy. The structure of the vegetation had no significant influence on the vertical selectivity of song posts in robins. The positions of emitter and receiver with respect to various elements of the immediate environment to a large extent determine the effectiveness of sound transmission between them (Wiley and Richards, 1978). Recent experiments have shown that birds sing more from higher song posts to improve their ability to hear other birds singing in neighbouring territories than to intensify the propagation of their own song (Dabelsteen et al., 1993; Mathevon et al., 2005). The receiver has to extract two basic pieces of information from acoustic signals: the distance and the direction from which the song of a neighbouring rival is coming (Holland et al., 1998). Experiments have shown that on hearing a rival's distorted song, wrens *Troglodytes troglodytes* choose song posts at greater heights to hear that song better (Mathevon and Aubin, 1997). Blackbirds *Turdus merula* in vocal communication with their neighbouring rivals gain an advantage from higher-lying song posts mainly as recipients of information encoded in the song, rather than as emitters, despite the greater level of background noise at those heights (Dabelsteen et al., 1993). A change in song post location as a result of experimentally induced noise was demonstrated in

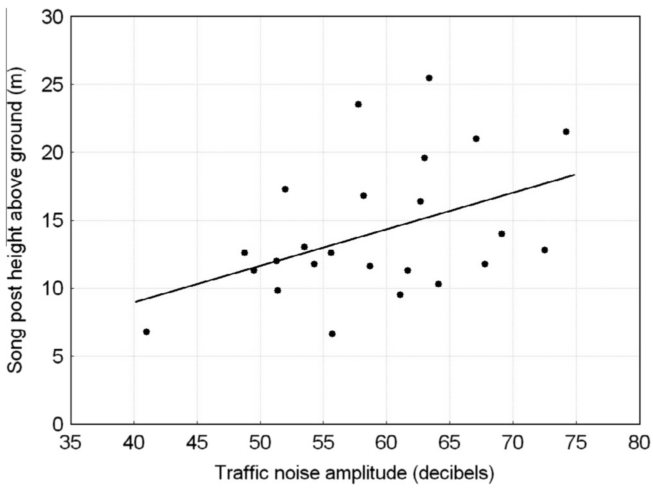

Fig. 1. Relationship between song-post height above ground and ambient noise in robins singing near busy roads ($r^2 = 0.19$, $r = 0.44$, $p = 0.034$, $y = -1.8015 + 0.2705 * x$, $n = 24$).

a population of great tits *Parus major*, where males, because of impaired perception of feedback from incubating females, selected song posts closer to the nest (Halfwerk et al., 2012).

This study shows a strict relationship between noise levels and the song perch height. Nonetheless, this dependence is correlational and I cannot rule out the influence of other factors that I did not assess in this study and which could have modified the song-post height preferences. Another explanation for the choice of higher-lying song posts in robins could be the active modification of the size and range of the so-called sound shadow (Wiley and Richards, 1978). This occurs beneath a sound source close to the ground, and especially when under thermal inversion conditions. An alternative explanation of the observed pattern is possibility that birds may sing from higher positions in the vegetation to avoid predation by cats (Møller, 2011). Recent studies indicate high penetration of habitats around built-up areas by domestic predators in central Poland, however cats were much more active at night than daytime (Krauze-Gryz et al., 2012).

The choice of higher perches in the vegetation in the vicinity of roads with high traffic noise levels may have serious consequences for the adaptation and fitness of the individual birds concerned, as they may be exposing themselves to a greater risk of predation (Krams, 2001). On the other hand high-lying song posts offer a good view of the surroundings and may facilitate the timely detection of and escape from a predator, particularly a land mammal (Møller, 2011). In temperate climate zones high-lying song posts have a more severe microclimate with lower temperatures and stronger winds, which may raise the costs of thermoregulation while singing (Ward and Slater, 2005). In view of the costs entailed by vocal communication in the higher-lying storeys of the vegetation, some authors (Møller et al., 2005) suggest that sexual selection may favour males using exposed song posts, as they may be preferred by females.

Conclusions

These findings show, to my knowledge for the first time, the relationship between increasing noise levels and changes in song perch height in a common passerine bird. At study sites the robins in noisy territories sang from perches located higher above the ground.

Acknowledgement

I am grateful to Hansjoerg P. Kunc and an anonymous referee for valuable comments and suggestions.

References

Benitez-López, A., Alkemade, R., Verweij, P.A., 2010. The impacts of roads and other infrastructure on mammal and bird populations: a meta-analysis. Biol. Conserv. 143, 1307–1316.
Brumm, H., 2004. The impact of environmental noise on song amplitude in a territorial bird. J. Anim. Ecol. 73, 434–440.
Cramp, S., 1988. The birds of the Western Palearctic. Tyrant Flycatchers to Thrushes, vol. 5. Oxford University Press, Oxford.
Dabelsteen, T., Larsen, O.N., Pedersen, S.B., 1993. Habitat-induced degradation of sound signals: quantifying the effects of communication sounds and bird location on blur ratio, excess attenuation, and signal-to-noise ratio in blackbird song. J. Acoust. Soc. Am. 93, 2206–2220.
Diaz, M., Parra, A., Gallardo, C., 2011. Serins respond to anthropogenic noise by increasing vocal activity. Behav. Ecol. 22, 332–336.
Forman, R.T., Sperling, D., 2003. Road Ecology: Science and Solutions. Island Press, Washington.
Fuller, R.A., Warren, P.H., Gaston, K.J., 2007. Daytime noise predicts nocturnal singing in urban robins. Biol. Lett. 3, 368–370.
Halfwerk, W., Bot, S., Slabbekoorn, H., 2012. Male great tit song perch selection in response to noise-dependent female feedback. Funct. Ecol. 26, 1339–1347.
Holland, J., Dabelsteen, T., Pedersen, S.B., 1998. Degradation of wren *Troglodytes troglodytes* song: implications for information transfer and ranking. J. Acoust. Soc. Am. 103, 2154–2166.
Krams, I., 2001. Perch selection by singing Chaffinches: a better view of surroundings and the risk of predation. Behav. Ecol. 12, 295–300.
Krauze-Gryz, D., Gryz, J.B., Goszczyński, J., Chylarecki, P., Żmihorski, M., 2012. The good, the bad, and the ugly: space use and intraguild interactions among three opportunistic predators – cat (*Felis catus*), dog (*Canis lupus familiaris*), and red fox (*Vulpes vulpes*) – under human pressure. Can. J. Zool. 90, 1402–1413.
Mathevon, N., Aubin, T., 1997. Reaction to conspecific degraded song by the wren *Troglodytes troglodytes*: territorial response and choice of song post. Behav. Process. 39, 77–84.
Mathevon, N., Dabelsteen, T., Blumenrath, S.H., 2005. Are high perches in the blackcap *Sylvia atricapilla* song or listening posts? A sound transmission study. J. Acoust. Soc. Am. 117, 442–449.
McLaughlin, K.E., Kunc, H.P., 2013. Experimentally increased noise levels change spatial and singing behaviour. Biol. Lett. 9, 20120771.
McMullen, H., Schmidt, R., Kunc, H.P., 2014. Anthropogenic noise affects vocal interactions. Behav. Process. 103, 125–128.
Møller, A.P., 2011. Song post height in relation to predator diversity and urbanization. Ethology 117, 529–538.
Møller, A.P., Nielsen, J.T., Garamszegi, L.Z., 2005. Song post exposure, song features, and predation risk. Behav. Ecol. 17, 155–163.
Montague, M.J., Danek-Gontard, M., Kunc, H.P., 2013. Phenotypic plasticity affects the response of a sexually selected trait to antropogenic noise. Behav. Ecol. 24, 343–348.
Reijnen, R., Foppen, R., Veenbaas, G., 1997. Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. Biodivers. Conserv. 6, 567–581.
Slabbekoorn, H., Peet, M., 2003. Birds sing at a higher pitch in urban noise. Nature 424, 267.
Ward, S., Slater, P.J., 2005. Raised termoregulatory costs at exposed song posts increase the energetic cost of singing for willow warblers *Phylloscopus trochilus*. J. Avian Biol. 36, 280–286.
Wiley, R.H., Richards, D.G., 1978. Physical constraints on acoustic communication in the atmosphere: implications for the evolution of animal vocalizations. Behav. Ecol. Sociobiol 3, 69–94.