Revista Catalana d'Ornitologia 27:25-30, 2011

Nota Curta / *Short Note*

The Rufous-Collared Sparrow *Zonotrichia capensis* utters higher frequency songs in urban habitats

Paola Laiolo

Literature is increasingly reporting cases of animal species that change their behaviour when dwelling in towns. Common responses in passerines involve singing earlier in the day and varying the physical properties of their songs to reduce the impact of masking traffic noise on communication. In this paper I analyse the song of the Rufous-Collared Sparrow *Zonotrichia capensis*, a widespread passerine inhabiting Central and Southern America. I recorded the songs of 114 males along a rural-urban gradient encompassing open woodland, peripheral and inner garden suburbs in Bahía Blanca, Argentina. By considering the variation present in five frequency parameters, I found that Rufous-Collared Sparrows sang significantly higher pitched songs (with higher minimum frequencies) in suburbs than in rural habitats. This study provides further evidence of birds switching song frequency in urban habitats, as has previously been recorded in several Northern American and European passerines. Since anthropogenic noise is predominantly low in frequency, singing at higher pitches in cities is likely to reduce acoustic interference and maximize signal transmission over distance.

Key words: Rufous-Collared Sparrow, *Zonotrichia capensis*, birdsong, traffic noise, urbanization, Argentina.

Paola Laiolo, *Research Unit of Biodiversity (CSIC, UO, PA), 33071 Oviedo, Spain. paola@ebd.csic.es*

Received: 22.05.11; Accepted: 19.10.11 / Edited by O. Gordo.

Literature on the ecology of urban birds provides several examples of birds responding to the novel acoustic habitat represented by cities (Laiolo 2010). Thanks to a high degree of plasticity in song acquisition and production, many passerines have shifted song frequencies (Slabbekoorn & Peet 2003, Wood & Yezerinac 2006, Bermúdez-Cuamatzin *et al.* 2009), amplitudes (Brumm 2004), timing (Bergen & Abs 1997) and duration (Díaz *et al.* 2011) to reduce the masking impact of urban noise.

By focusing on a natural-urban gradient, I analysed patterns of variation in song frequency in the Rufous-Collared Sparrow *Zonotrichia capensis* in open woodland and garden suburbs in Bahía Blanca, Argentina. Studies of the song of the Rufous-Collared Sparrow provided some of the first evidence of the 'acoustic adaptation hypothesis', whereby acoustic signals are structured to maximize their transmission given the constraints of the environmental acoustics (Nottebohm 1969, Rothstein & Fleischer 1987). Although song adaptation to structurally different natural habitats has received a great deal of attention in this species (Nottebohm 1975, Handford & Lougheed 1991), little information is available on its potential responses to the novel acoustic habitats found in towns. Due to the plasticity and habitat-dependent variation of this species' song (Tubaro *et al.* 1993), I predicted that changes in song parameters may also occur to optimize signal transmission in urban contexts.

Methods

Study species and area

The Rufous-Collared Sparrow is a small territorial songbird inhabiting a wide range of habitats in the Neotropics; it occurs in suburban and periurban areas, although at lower densities than in natural sites (Laiolo 2011). Its song is made up of two distinctive portions: the introductory whistle (the 'theme'), which varies considerably between individuals singing at the same locality, and the terminal 'trill', which is relatively homogeneous over vast areas and within habitats (Nottebohm 1975). Trill characteristics tend to be shared by all birds at one locality; on the other hand, trill differentiation matches major habitat shifts, thereby determining the 'dialect' (i.e. the geographic variant of a species song) uttered by birds (Tubaro *et al.* 1993).

This study was carried out in Bahía Blanca (Buenos Aires province: 38°42'S 62°15'W) in November-December 2006 in the southern Atlantic Argentinean range of the Rufous-Collared Sparrow. The study was designed to encompass a gradient of moderately wooded rural-urban

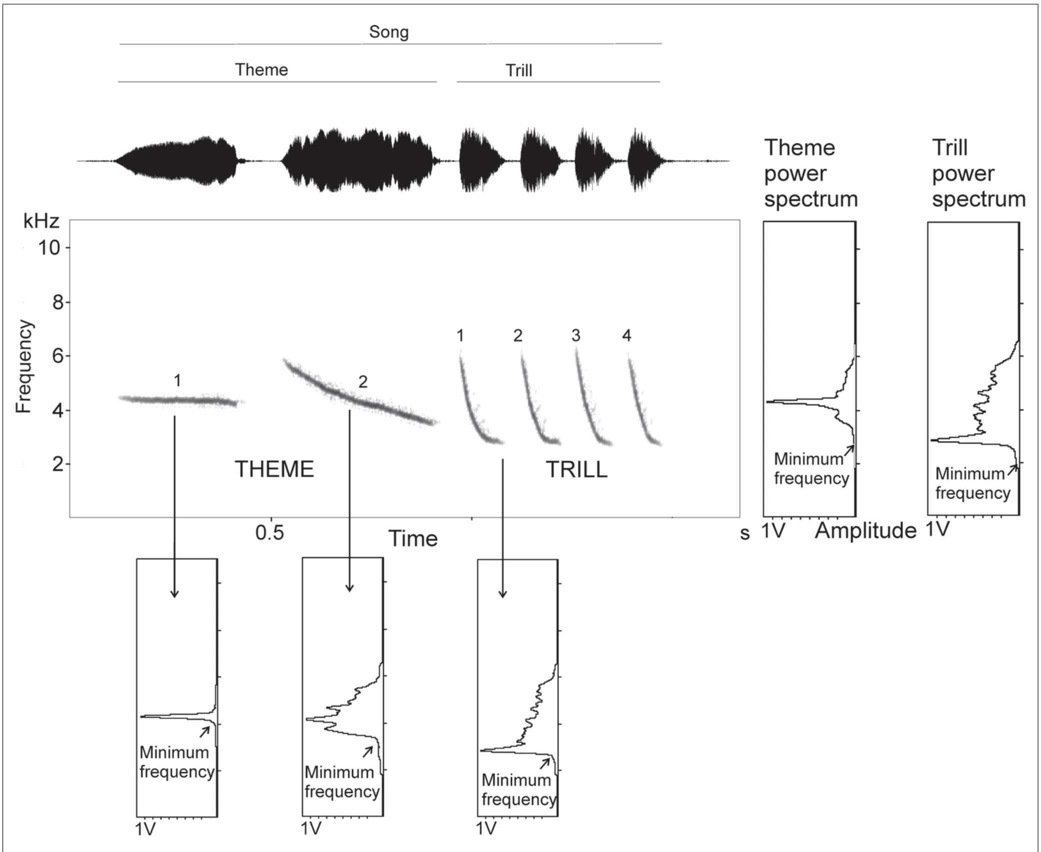

Figure 1. Graphic representation of the song of the Rufous-Collared Sparrow illustrating the acoustic measurements that were taken. Waveform (top), sonogram (left), mean power spectrum of the theme and the trill portions of the song (right) and of syllables 1 and 2 of the theme and 1 of the trill (bottom) are represented. Numbers in the sonogram indicate the syllable of the theme and the trill. Frequency variables were measured with regard to the mean spectra values. Modified from Laiolo (2011).
Representació gràfica del cant del Pardal de Clatell Roig amb una il·lustració de les mesures preses. Forma de l'ona (dalt), sonograma (centre), espectre de potència de les porcions del cant pertanyents al tema i al refilet (dreta) i a la primera i segona síl·laba del tema i la primera del refilet (baix). Els números en el sonograma indiquen la síl·laba del tema i del refilet. Les variables de freqüència van ser mesurades sobre l'espectre mitjà. Modificat després Laiolo (2011).

	Minimum frequency of the whistle		Minimum frequency of the trill		Minimum frequency of the whistle (first syllable)		Minimum frequency of the whistle (second syllable)		Minimum frequency of the trill (first syllable)	
Habitat type	**Mean (kHz)**	**SD**	**Mean (kHz)**	**SD**	**Mean (kHz)**	**SD**	**Mean (kHz)**	**SD**	**Mean (kHz)**	**SD**
Rural areas	2.90	0.35	2.63	0.15	4.10	0.14	3.46	0.43	2.65	0.15
Peripheral suburbs	2.94	0.31	2.85	0.17	4.05	0.16	3.58	0.41	2.90	0.17
Inner suburbs	3.04	0.29	2.92	0.21	4.24	0.20	3.68	0.33	2.94	0.21

Table 1. Means and standard deviations (SD) of Rufous-Collared Sparrow songs along a rural-urban gradient.
Mitjana i desviació estàndard (SD) del cant del Pardal de Clatell Roig al llarg d'un gradient d'urbanització.

habitats, both natural and anthropogenic in origin, in a buffer area with a radius of 5 km from the city centre. Three habitat typologies were considered: (1) rural areas, represented by open woodland remnants located at 2.5–5 km from town fringes and characterized by scattered trees less than 3-m high (Chilean palo verde *Geoffroea decorticans* and *Prosopis caldenia*); (2) peripheral, newly built suburbs with regular rows of houses surrounded by large wooded gardens (but still connected by unpaved roads) in a moderately urbanized environment; and (3) inner suburbs closer to the city centre, with a larger proportion of paved roads and smaller (but older) wooded gardens. Details on habitat structure are provided by Laiolo (2011).

Sound recording and analysis

Birds were recorded in their territories during the dawn or dusk song chorus. Recordings were made on analogical cassette tapes using a Sennheiser ME67 microphone and a Sony walkman recorder WM-GX680. I walked nine transects of ca. 1 km in length and recorded 23 Rufous-Collared Sparrows in natural sites (2 transects), 44 in peripheral garden suburbs (4 transects), and 47 in inner garden suburbs (3 transects), totalling 114 birds. Sampled individuals were not marked, but were recorded in their territories during one bout of song on a single visit, thereby avoiding the problems of individual identification. Digitalized songs sampled at 22050 Hz frequency were analysed with Avisoft SASLab Pro 3.91 by Raimund Specht (Berlin), performing a Fast Fourier Transform (FFT length 512, time resolution 8.9 ms, frequency resolution 43 Hz, Window Function: Bartlett). In keeping with Laiolo (2011), who found scarce intra-individual variation in song features, sound measurements were only carried out on one song per bird. I centred this study on several calculations of minimum syllable frequencies, since these are the parameters that mostly overlap low-frequency traffic noise and shift accordingly in urban habitats (Hu & Cardoso 2010). I measured the overall minimum frequencies of the theme and the trill, as well as the minimum frequency of the first two syllables of the theme and of the first syllable of the trill (Figure 1). With the program R.2.12.0, I performed Generalized Linear Mixed Models (GLMM) to test whether minimum frequencies varied between the three habitat types (i.e. rural areas, peripheral and inner suburbs). Transect identity was entered as random factor to control for spatial variation and a normal distribution of errors and an identity link function were used.

Results

Rufous-Collared Sparrows dwelling in suburbs performed songs with significantly higher minimum frequencies in the (a) trill, (b) in the first syllable of the trill and (c) in the second syllable of the whistle than birds inhabiting rural habitats (GLMM: all $t > 4.53$, $P < 0.001$, $n = 114$ individuals from 9 transects; Table 1 and Figure 2). Notably, the syllables that varied in frequency tended to have the lowest pitches (Table 1), i.e. those portions of the song that are most interfered with by urban, low frequency noise.

Discussion

The Rufous-Collared Sparrow utters higher pitched songs in urban habitats than in rural ones; the song syllables or portions that change to the greatest extent are those with the lowest pitch. Signals with low pitches are probably

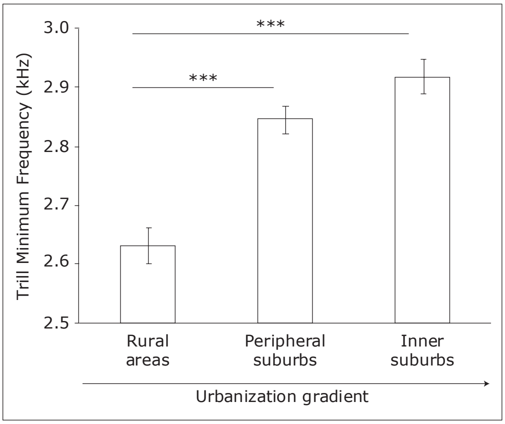

Figure 2. Comparison of the minimum trill frequencies in the song of the Rufous-Collared Sparrow along the rural-urban gradient. Mean values and standard errors are shown. ***P<0.001.
*Comparativa de la freqüència mínima del refilet en el cant del Pardal de Clatell Roig al llarg d'un gradient d'urbanització. Es mostren la mitjana i l'error estàndard. ***P<0.001.*

more masked by urban noise, which tends to be low in frequency (Nemeth & Brumm 2010). The noise from urban traffic and construction activities in towns interferes with the detection and discrimination of signals and song frequency shift is the most common response recorded in urban bird dwellers. Although acoustic changes in urban birds have been associated with aspects of urbanization other than noise (altered densities, food resources, etc.; Nemeth & Brumm 2009, Ripmeester *et al.* 2010, Hamao *et al.* 2011), the pattern of raising song pitch at increasing levels of anthropogenic noise has been observed in other continents (Kight & Swaddle 2011) and in several unrelated passerine species such as Great Tit *Parus major* (Slabbekoorn & Peet 2003), House Finch *Carpodacus mexicanus* (Bermúdez-Cuamatzin *et al.* 2009), Song Sparrow *Melospiza melodia* (Wood & Yezerinak 2006) and Silvereye *Zosterops lateralis* (Potvin *et al.* 2011). Some successful urban dwellers promptly switch song frequencies when noise is experimentally increased (Bermúdez-Cuamatzin *et al.* 2009, 2011; Verzijden *et al.* 2011), a fact that points to learning mechanisms or to a selection for plastic phenotypes in urban environments.

Although song plasticity may help explain the successful colonization of cities by many songbirds, it has recently been shown that anthropogenic noise can have fitness consequences in urban dwellers. A decrease in reproductive success in individuals that breed in noisy areas has been found in the Great Tit, a bird common in urban green areas (Halfwerk *et al.* 2011a). In this species, the use of low-frequency songs by males is related to female fertility and sexual fidelity, yet high-pitch songs carry better in noisy environments (Halfwerk *et al.* 2011b). Thus, males singing high frequency songs in the noisiest environments may be less attractive to mates or less effective in avoiding territorial intrusions (Slabbekoorn & Ripmeester 2008).

All in all, this study provides a further example of a species that changes the properties of its song, namely minimum syllable frequencies, in an urban environment. The Rufous-Collared Sparrow is known to adapt its song for transmission in environments with different acoustics. Urban habitats thus constitute a novel challenge in this context that appears to be successfully resolved by this species.

Ackowledgements

Field work in Argentina was supported by Canal Sur Andalucía and the Estación Biológica de Doñana (CSIC). I am grateful to O. Gordo and two anonymous referees for providing useful suggestions to a former version of the manuscript.

Resum

El Pardal de Clatell Roig *Zonotrichia capensis* té un cant més agut en habitats urbans

Hi ha un nombre cada cop més gran d'espècies animals en les quals s'ha demostrat que han canviat el seu comportament quan viuen a les ciutats. Dos canvis típics observats en passeriformes són el fet que canten més d'hora al matí i la variació de les seves propietats físiques amb l'objectiu de reduir l'efecte del soroll del trànsit en la comunicació. En aquest estudi es va analitzar el cant del Pardal de Clatell Roig, un passeriforme molt comú arreu d'Amèrica Central i del Sud. Es va enregistrar el cant de 114 mascles al llarg d'un gradient rural-urbà que incloïa boscos oberts i jardins, tant de la perifèria com del centre dels barris als afores de Bahia Blanca, Argentina. Mitjançant l'estudi de la variació en cinc paràmetres de freqüència dels cants, es va trobar que el Pardal de Clatell Roig va cantar significativament

amb tons més aguts (freqüències mínimes més altes) quan viu a les zones urbanes. Aquest estudi proporciona més evidències sobre els canvis en l'espectre de freqüència del cant dels ocells en hàbitats urbans, com ja s'ha vist en d'altres passeriformes nord-americans i europeus. Ja que el soroll antropogènic és predominantment de baixa freqüència, en cantar en tons més aguts es reduirien les interferències i es maximitzaria la transmissió de senyals en la distància dintre de les ciutats.

Resumen

El Chingolo Común *Zonotrichia capensis* muestra un canto más agudo en hábitats urbanos

Existe un número creciente de especies animales en las que se han demostrado cambios de comportamiento al vivir en las ciudades. Dos respuestas típicas observadas en paseriformes son el canto más temprano por la mañana y la variación de sus propiedades físicas con objeto de reducir el enmascaramiento del ruido del tráfico en la comunicación. En este estudio se analizó el canto del Chingolo Común, un paseriforme muy común de América Central y del Sur. Se registró el canto de 114 machos a lo largo de un gradiente rural-urbano que abarcó bosques abiertos y jardines, tanto de la periferia como en el centro de los barrios de las afueras de Bahía Blanca, Argentina. Al estudiar la variación en cinco parámetros de frecuencia de los cantos, se encontró que el Chingolo Común cantó significativamente con tonos más agudos (frecuencias mínimas más altas) cuando vivía en las zonas urbanas. Este estudio proporciona más evidencias sobre los cambios en el espectro de frecuencia de los cantos de las aves en hábitats urbanos, tal y como ya se ha visto en diversos paseriformes norteamericanos y europeos. Puesto que el ruido antropogénico es predominantemente de baja frecuencia, al cantar en tonos más agudos se reducirían las interferencias y se maximizaría la transmisión de señales en la distancia dentro de las ciudades.

References

Bergen, F. & Abs, M. 1997. Etho-ecological study of the singing activity of the blue tit (*Parus caeruleus*) great tit (*Parus major*), and chaffinch (*Fringilla coelebs*). *J. Ornithol.* 138: 451–467.

Bermúdez-Cuamatzin, E., Ríos-Chelén, A.A., Gil D. & Macías Garcia, C. 2009. Strategies of song adaptation to urban noise in the house finch: syllable pitch plasticity or differential syllable use? *Behaviour* 146: 1269–1286

Bermúdez-Cuamatzin, E., Ríos-Chelén, A.A., Gil D. & Macías Garcia, C. 2011. Experimental evidence for real-time song frequency shift in response to urban noise in a passerine bird. *Biol. Lett.* 7: 36–38

Brumm, H. 2004. The impact of environmental noise on song amplitude in a territorial bird. *J. Anim. Ecol*. 73: 434–440.

Díaz, M., Parra A. & Gallardo, C. 2011. Serins respond to anthropogenic noise by increasing vocal activity. *Behav. Ecol.* doi: 10.1093/beheco/arq210.

Kight, C.R. & Swaddle, J.P. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. *Ecol. Lett.* doi: 10.1111/j.1461-0248.2011.01664.x

Halfwerk, W., Bot, S. Buikx, J. van der Velde, M. Komdeur, J. ten Cate, C. & Slabbekoorn, H. 2011a. Low-frequency songs lose their potency in noisy urban conditions. *P. Natl. Acad. Sci. USA* 108: 14549–14554.

Halfwerk, W., Holleman, L., Lessells, K. & Slabbekoorn, H. 2011b. Negative impact of traffic noise on avian reproductive success. *J. Applied Ecol.* 48: 210–219

Hamao, S., Watanabe, M., & Mori, Y. 2011. Urban noise and male density affect songs in the great tit *Parus major*. *Ethol. Ecol. Evol.* 23: 111–119.

Handford, P. & Lougheed, S. 1991. Variation in duration and frequency characters in the song of the rufous-collared sparrow, *Zonotrichia capensis*, with respect to habitat, trill dialects and body size. *Condor* 93: 644–658.

Hu, Y. & Cardoso, G.C. 2010. Which birds adjust the frequency of vocalizations in urban noise? *Anim. Behav.* 79: 863–867.

Laiolo, P. 2010. The emerging significance of bioacoustics in animal species conservation. *Biol. Conserv.* 143: 1635–1645

Laiolo, P. 2011. Homogenization of birdsong along a natural-urban gradient in Argentina. *Ethol. Ecol. Evol.* 23: 274–287.

Nemeth E. & Brumm ,H. 2010. Birds and anthropogenic noise: are urban songs adaptive? *Am. Nat.* 176: 465–475.

Nemeth, E. & Brumm, H. 2009. Blackbirds sing higher-pitched songs in cities: adaptation to habitat acoustics or side-effect of urbanization? *Anim. Behav.* 78: 637–641.

Nottebohm, **F.** 1969. The song of the chingolo, *Zonotrichia capensis*, in Argentina: description and evaluation of a system of dialects. *Condor* 71: 299–315.

Nottebohm, F. 1975. Continental patterns of song variability in *Zonotrichia capensis*: some possible ecological correlates. *Am. Nat.* 109: 605–624.

Potvin, D.A, Parris, K.M. & Mulder, R.A. 2011. Geographically pervasive effects of urban noise on frequency and syllable rate of songs and calls in silvereyes (*Zosterops lateralis*). *Proc. R. Soc. B* 278: 2464–2469.

Ripmeester, E.A.P., Kok, J.S., van Rijssel, J.C. & Slabbekoorn, H. 2010. Habitat-related birdsong divergence: a multi-level study on the influence of territory density and ambient noise in European blackbirds. *Behav. Ecol. Sociobiol.* 64: 409–418.

Rothstein, S.I. & Fleischer, R.C. 1987. Vocal dialects and their possible relation to honest status signalling in the brown-headed cowbird. *Condor* 89: 1–23.

Slabbekoorn, H. & Peet, M. 2003. Birds sing at a higher pitch in urban noise – great tits hit the high notes to ensure that their mating calls are heard above the city's din. *Nature* 424: 267–267.

Slabbekoorn, H. & Ripmeester, E.A.P. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. *Mol. Ecol.* 17: 72–83.

Tubaro, P.L., Segura, E.T. & Handford, P. 1993. Geographic variation in the song of the rufous-collared sparrow in eastern Argentina. *Condor*. 95: 588–595.

Verzijden, M. N., Ripmeester, E. A. P., Ohms, V. R., Snelderwaard, P. & Slabbekoorn H. 2010. Immediate spectral flexibility in singing chiffchaffs during experimental exposure to highway noise. *J. Exp. Biol.* 213: 2575–2581.

Wood, W. E. & Yezerinak, S. M. 2006. Song sparrow (*Melospiza melodia*) song varies with urban noise. *Auk* 123: 650–659.