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Sounds of the city: The effects of noise on communication in mountain and black-capped chickadees

By

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Abstract

Birds use both songs and calls to communicate and rely heavily on these vocalizations for many purposes, such as attracting mates, defending territories, advertising food sources, etc. However, noise associated with urbanization can interfere with this communication making it more difficult for birds to live and reproduce in urban areas. Interestingly, some bird species are able to adjust the way they sing or call to compensate for urban noise. In particular, because urban noise is generally low in frequency, birds may increase the frequency (pitch) at which they sing, which helps improve audibility. Understanding how species adjust to noise could help predict which species are most at risk from increasing urbanization. We investigated how two closely-related species (mountain chickadees *Poecile gambeli* and black-capped chickadees *Poecile atricapillus*) adjusted the way they sang and called during the dawn chorus (a period of intense vocalizing in the spring, early in the morning) in response to both long-term (chronic) and short-term (acute) exposure to noise. Because mountain and black-capped chickadees differ in how they sing and call, and in how flexible they are in these behaviours (how well individuals can actually change how they sing or call), we expected the two species to adjust to noise in different ways. In this study, we found that both species adjusted their vocalizations in response to long-term noise pollution by increasing the frequencies of their songs. However, in response to short-term noise exposure, the responses of the two species differed and related to their natural vocalizing behaviour. Mountain chickadees are less flexible in their singing, but use both songs and calls during the dawn chorus. As a result, they did not change the way they sang in response to short-term noise exposure, but did change to singing more overall (songs are more audible in noise than calls). In contrast, black-capped chickadees are flexible in their singing, but do not use calls during the dawn chorus. Therefore, in response to short-term, noise exposure, they showed an immediate increase in the frequency at which they sang. However, in both species, only individuals already in noisy areas made these changes, which suggest that the ability to adjust requires previous experience with noisy conditions.

Introduction

Urbanization and communication

Humans have great potential for altering habitats. Through urbanization, resource extraction, and the introduction of invasive species, we have changed the vegetation, physical structure, temperature, and species composition of the landscape. Urbanization results in changes that are both large and long term (McKinney 2006), and can affect animals in a variety of ways, such as: habitat loss and fragmentation, increased competition from new species, increased predation, risk of collisions with vehicles and structures, and exposure to environmental contaminants (Trombulak and Frissell 2000, Chace and Walsh 2006). Thus, urbanization can lead to a loss of biodiversity which, through loss of both resources and ecosystem services, could have severe consequences for society (Cardinale et al. 2012). Less obvious influences of urbanization are its effects on animal communication. Animal signals (the 'package' used to transfer information; Table 1) are easily disrupted by many human activities. For example, we deliberately interfere with the chemical communication of insects by using synthetic pheromones to disrupt mating in pest species (Carde and Minks 1995); we inadvertently

Table 1. Terminology used in studies of bird communication

Term	**Definition**
Signal	The 'package' which is used to transfer information from one individual to another (e.g., song, posture, colour markings, etc.)
Vocalizations	Vocal signals emitted by animals.
Songs	Typically, specific, complex vocalizations usually made by males for territory defence and mate attraction.
Calls	Typically, simple, short, stereotyped vocalizations usually made by both males and females to indicated various things such as predators, food, other individuals, etc.
Masking	When background noise overlaps a signal in the same frequency range, making that signal harder to discern.
Signal-to-noise ratio (SNR)	The ratio of how much signal (information) can be distinguished relative to the amount of background noise. Higher signal- to-noise ratios indicate greater audibility, and less garbling of the message.
Vocal adjustment	Behavioural flexibility in vocalizations. Changes made by birds to their songs or calls, usually in response to differences in the acoustic environment (e.g., ambient noise, etc.).
Behavioural flexibility	How changeable a behaviour is, reflecting the ability of a species to modify particular behaviours to different situations. Flexibility can occur relatively quickly or require longer time frames for adjustment.
Dawn chorus	A period of intense singing at dawn among all males in the population. The males sing to both attract and retain mates as well as to advertise their ownership of a territory. Occurs in the spring before and during the female fertile period.

interfere with visual communication in fish by decreasing water clarity (Seehausen et al. 1997); and we mask vocal communication in frogs and birds with traffic noise (Slabbekoorn and Peet 2003, Parris et al. 2009). Animals that cannot communicate have difficulties in defending territories, finding food, and finding mates. Thus, interfering with animal communication may affect the survival of a population or species. Vocalizations are the signals used for communication among many bird species; as males use songs to demonstrate their attractiveness and suitability as a mate, as well as their ability and willingness to defend a territory (Table 1). Calls are often used to gather individuals within flocks, and to alert flock mates of potential food sources and predators (Table 1). However they are also used by some species for mate attraction and territory defence. Therefore, if vocalizations cannot be heard, it makes it difficult for birds to find suitable mates and/or defend territories which can lead to lower reproductive success. In the interest of conserving bird species in urban areas it is therefore particularly important to understand how humans interfere with acoustic communication (Rabin and Greene 2002, Warren et al. 2006). Throughout this article we will be using terminology particular to the study of urban noise and bird communication. As such we have provided a table of terminology (Table 1).

Noise interference

Noise in and around urban areas is mostly from vehicular traffic, but in non-urban areas it may arise from other anthropogenic souces: e.g., wind turbines, oil fields, all-terrain vehicles, motorboats or snowmobiles (Chambers 2005, Barber et al. 2010). Noise interferes with communication through masking, which occurs when vocal signals of a given frequency are overlapped by background noise in the same frequency range (Table 1). This decreases the ability to distinguish the signal (songs or calls) relative to the noise (lowers signal-to-noise ratio, SNR; Table 1) and makes the vocalizations more difficult to detect and understand (Klump 1996, Barber et al. 2010). Interestingly, birds can actually respond directly to this interference in a variety of ways. They can avoid noise, either by waiting for noise to decrease (Fuller et al. 2007) or by moving to areas with less noise (Parris and Schneider 2008), or they can repeat signals and use redundancy to reduce the effects of being masked (Brumm and Slater 2006). Birds can also adjust their vocalizations (vocal adjustment; Table 1) to improve the signal-to-noise ratio in noisy conditions. A simple way of increasing signal-to-noise ratio is to sing louder, which is generally known as the Lombard effect (this also results in small increases in frequency; e.g., Brumm 2004, Lowry et al. 2012). Decreasing the frequency overlap between vocalizations and noise is another way of increasing the signal-to-noise ratio, as it reduces masking from background noise. In particular, as urban noise tends to be low-frequency, birds can avoid noise interference by singing at higher frequencies (e.g., Slabbekoorn and Peet 2003, Bermúdez-Cuamatzin et al. 2011). Thus, there are ways that birds can deal with noise interference, but the flexibility to make such behavioural adjustments may vary by species.

Why study vocal adjustment?

Flexible behaviour can help species adapt to urban environments (Sol et al. 2013; Table 1), and vocal adjustment, specifically allows birds to cope with communication challenges. However, not all species are able to adjust their vocalizations (e.g., Hu and Cardoso 2010, Francis et al. 2012), and among those that do, not all have the same degree of flexibility (Francis et al. 2011b). Understanding why some species have this flexibility and others do not can help us understand which species are most likely to successfully colonize and persist in urban areas, and, more importantly, which species will be unable to do so (Slabbekoorn and Ripmeester 2008).

By definition, species in which individuals naturally show variability in their songs, calls, or singing behaviour should be capable of flexibly responding to noise in the environment. Additionally, species which learn their songs generally appear better able to adjust their vocalizations than those that do not (Ríos-Chelén et al. 2012). Species that do not learn their songs sing innate songs, and the songs are rarely different between individuals or populations; as a result, these birds are less likely to be able to adjust their vocalizations in response to noise (but see Francis et al. 2011a). Of species which do learn, some learn continuously and change their songs throughout their life, which permits them to adjust to changing conditions (Patricelli and Blickley 2006). Even in species which only learn when they are young, they learn by listening to neighbouring males. Thus if noise interferes with how they hear a song, they may be more likely to learn parts of a song that are less affected by noise, thus allowing them to develop songs that are better suited to noisy habitats (Patricelli and Blickley 2006). Finally, we may be able to identify species with the potential for vocal adjustment by looking at the amount of vocal variation that naturally occurs among populations (Ríos-Chelén et al. 2012); vocal variation in a population is a indication that vocalizations can change, even if not immediately. Therefore, species in which individuals learn their songs, sing variable songs, or have regional variability in songs, may be better able to adjust their vocalizations when the need arises.

Despite having the ability to adjust vocalizations to noise, some species may still be at a disadvantage if they are unable to adjust quickly. Urban development is often fast-paced and species that take longer to adjust to the effects of noise pollution may be less successful (or completely unsuccessful) at colonizing and/or persisting in urban spaces than those that demonstrate quick, flexible, vocal responses. While some species may have innate abilities to quickly respond, they may require experience with noisy environments to fine tune this ability. For example, although an individual may have the ability to change its vocalization, it may need to learn how to make adjustments that actually reduce masking from urban noise (e.g., shifting songs up in frequency, rather than down or randomly). However, to date, studies have not looked at how an individual's previous experience with noise might affect how it demonstrates vocal adjustment.

Chickadees

Chickadees are North American members of the Paridae family (chickadees and titmice) in the genus Poecile (Gill et al. 2005). Two of the four common species in Canada, the mountain chickadee (*Poecile gambeli*; Figure 1a) and the black-capped chickadee (*Poecile atricapillus*; Figure 1b) are closely related and both are fairly common in British Columbia, Canada. In general chickadees learn their songs and have three vocalizations: a chick-a-dee call, a whistled song, and a gargle (Hailman and Ficken 1996). From the analysis of recordings of vocalizations which were broadcast through noisy environments and re-recorded, we know that the calls and songs of both species are masked by urban noise (LaZerte et al. 2015), suggesting that vocal adjustment could help reduce masking in noisy environments. Mountain chickadees are found mostly in sub-boreal or Douglas-fir (*Pseudotsuga menziesii*) habitat in the more mountainous regions of southern British Columbia (McCallum et al. 1999), and use a mixture of both whistled songs and chick-a-dee calls in early equal proportions during the dawn chorus (Grava et al. 2013), which is a period of intense singing at dawn in the spring breeding period (Table 1). Finally, mountain chickadees do not alter the frequency of their songs, suggesting that once learned, their songs are static, and cannot be readily changed. In contrast, black-capped chickadees are common throughout most of British Columbia (Foote et al. 2010), and the dominant vocalization they use during the dawn chorus is the species' song (~90% of all vocalizations) with calls used to a much lesser extent. Individual males will adjust the frequency of their songs to match neighbouring males during song contests, referred to as “pitch-matching” (e.g., Ratcliffe and Weisman 1985, Christie et al. 2004). Further, while mountain chickadee songs vary substantially among populations (Grava et al. 2013), black-capped chickadees sing similar songs throughout their range. Interestingly, black-capped chickadees from noisy habitats sing higher frequency songs than those in quiet habitats (Proppe et al. 2011, 2012) and they switch frequencies more quickly if they are overlapped with a small band of noise than if they are not overlapped (Goodwin and Podos 2013). However, there are no studies of how mountain chickadees may adjust to noise. Collectively, this information suggests that in response to urban noise, male mountain chickadees cannot readily change their vocalizations, but may be able to switch between songs and calls, whereas black-capped chickadees may be able to use pitch-shifting. That these two species are closely related, but still show many differences in singing style and variability, makes them a useful system for comparison.

Questions

We explored how anthropogenic noise interferes with communication in mountain and black-capped chickadees. In particular, we asked (1) do these two species adjust to noise, (2) are the mechanisms they use related to their natural vocalizing behaviour, and (3) can they adjust quickly, and do they require experience or familiarity with noise to do so? To address these questions, we conducted a series of experiments on mountain and black-capped chickadees in British Columbia, Canada

Methods

Our studies were conducted in six cities throughout south and central British Columbia. We recorded vocalizations of both mountain and black-capped chickadees during the dawn chorus between 27-March and 23-May during the springs of 2011, 2012 and 2013. Mountain chickadees were recorded predominantly in parts of the province where natural habitat is drier and contains more Douglas-fir: Williams Lake, Kamloops, and Kelowna. Black-capped chickadees were recorded predominantly in Prince George, Quesnel, and Vancouver. Both species were present in all cities with the exception of Vancouver (which had black-capped chickadees, but no mountain chickadees), although in each city one or the other species predominated. Because noise is often associated other features of urbanization (such as buildings, people and other disturbances) we recorded chickadees over a variety of habitats (urban through rural) and in a variety of noise levels (quiet through noisy). This meant that we recorded chickadees in noisy habitats (including both urban and rural sites) and in quiet habitats (again, including both urban and rural sites). This ensured that any effects of noise could be examined independently of habitat. In the lab we used computer software (Avisoft-SASLab Pro v5.2.02 Specht 2012) to determine the frequencies of recorded songs and calls.

To answer our questions, we investigated three measures of vocal adjustment in mountain chickadees (song frequency, call frequency and the proportion of songs vs. calls, as songs travel through noise better than calls, LaZerte et al. 2015) and one measure in black-capped chickadees (song frequency). We then looked at both whether, and over what time scale, chickadees were able to adjust vocalizations in response to noise. First, to investigate whether mountain and black-capped chickadees adjusted their vocalizations in response to longer-term ambient noise, we compared recordings of 5-10 minutes of natural vocalizations among males from habitats with different levels of ambient noise (Mountain n = 51; Black-capped n = 42). Next, to determine how quickly chickadees could adjust their vocalizations and whether prior experience with noise played a role, we exposed singing males to 5 minutes of simulated traffic noise (broadcast at 65 dB(A); Mountain n = 31; Black-capped n = 28). We then observed whether individuals changed their vocalizations during immediate exposure to noise. To test whether prior exposure to noise affected these responses (i.e., birds in already noisy habitats had learned how to correct for sudden increases in noise), we also examined how a male's response changed with local ambient noise conditions.

All analyses were conducted using either linear models or linear mixed models (Gaussian for looking at song and call frequency, and binomial for the proportion of songs vs. calls). When individuals were compared to themselves (for experimental noise exposure) we include male ID as random variable to control for individual differences. As our study takes place across many different regions, we also controlled for potential differences between regions by including region as a random factor in black-capped chickadees and by comparing regions directly in mountain chickadees (for a more detailed look at the differences between regions in mountain chickadees see LaZerte et al. (in prep), or LaZerte 2015).

Results & Discussion

Vocal adjustment and local ambient noise levels

Both mountain and black-capped chickadees clearly showed vocal adjustment; both species sang higher frequency songs as ambient noise levels increased (Figure 1). Although we did not look at the pitch of black-capped chickadee calls,

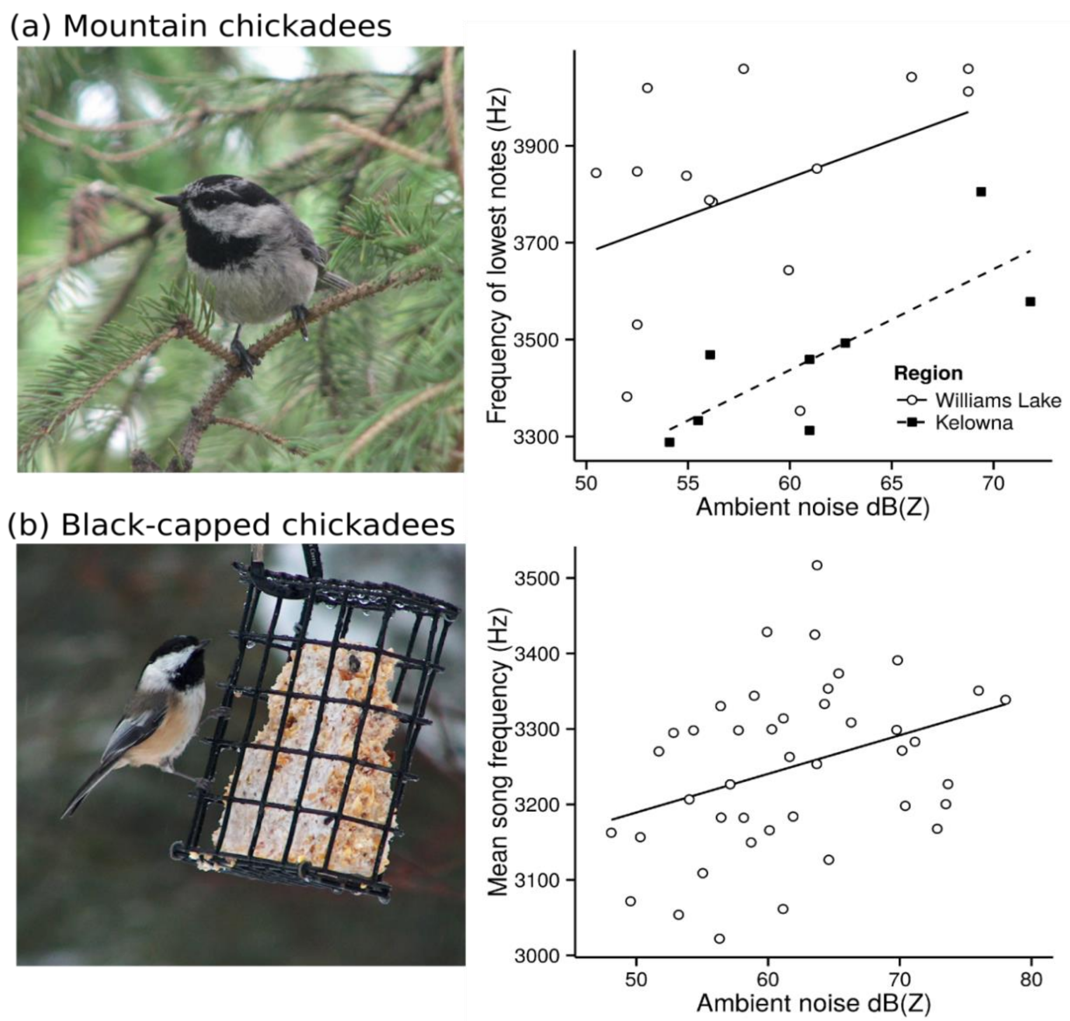

Figure 1. (a) Mountain chickadees in Williams Lake and Kelowna (but not in Kamloops) sang songs with higher low-frequency notes as ambient noise levels increased. (b) Throughout their range black-capped chickadees sang higher frequency songs as ambient noise levels increased.

we found no increase in the pitch of mountain chickadee calls as local ambient noise increased, matching findings in Carolina chickadees (*Poecile carolinensis*, Grace and Anderson 2014).

Ability to adjust quickly and the role of familiarity with noise

Both species also showed rapid (immediate) flexibility in response to experimental noise exposure, but in very different ways. When exposed to noise, mountain chickadees used higher frequency calls (Figure 2a) and switched to singing more than calling (Figure 2b). That mountain chickadees increased the frequency of their calls in response to experimental noise, but not in locally-noisy areas, suggests that flexibility in call frequency may be a very short-term response. Switching from calls to songs improves audibility in noise by both increasing tonality of vocalizations (which other studies have suggested helps penetrate noise; e.g., red-winged blackbirds *Agelaius phoeniceus*, Hanna et al. 2011), as well as by increasing the minimum frequencies (to avoid masking by low-frequency traffic noise; e.g., chaffinches *Fringilla coelebs*, Verzijden et al. 2010, house finches *Carpodacus mexicanus* Bermúdez-Cuamatzin et al. 2011).

In contrast, black-capped chickadees used a completely different mechanism of adjusting to ambient noise. Immediate flexibility in black-capped chickadees has been observed in response to fluctuating traffic noise (Proppe et al. 2011), but here we found evidence that black-capped chickadees used their natural ’pitch-shifting’ ability as a mechanism to adjust overall frequency use during the chorus; they immediately shifted their songs to higher frequencies in response to experimental noise (Figure 3), and this response was greatest in their lower-frequency songs. This suggests that they aren't shifting all songs higher, but are singing more of their high-frequency songs. While in response to noise other species may selectively sing higher frequency song types from their repertoires (Halfwerk and Slabbekoorn 2009, Luther and Baptista 2010), to our knowledge, black-capped chickadees are the only species to use pitch-shifting as a mechanism to avoid masking.

A novel finding in these studies is that these quick

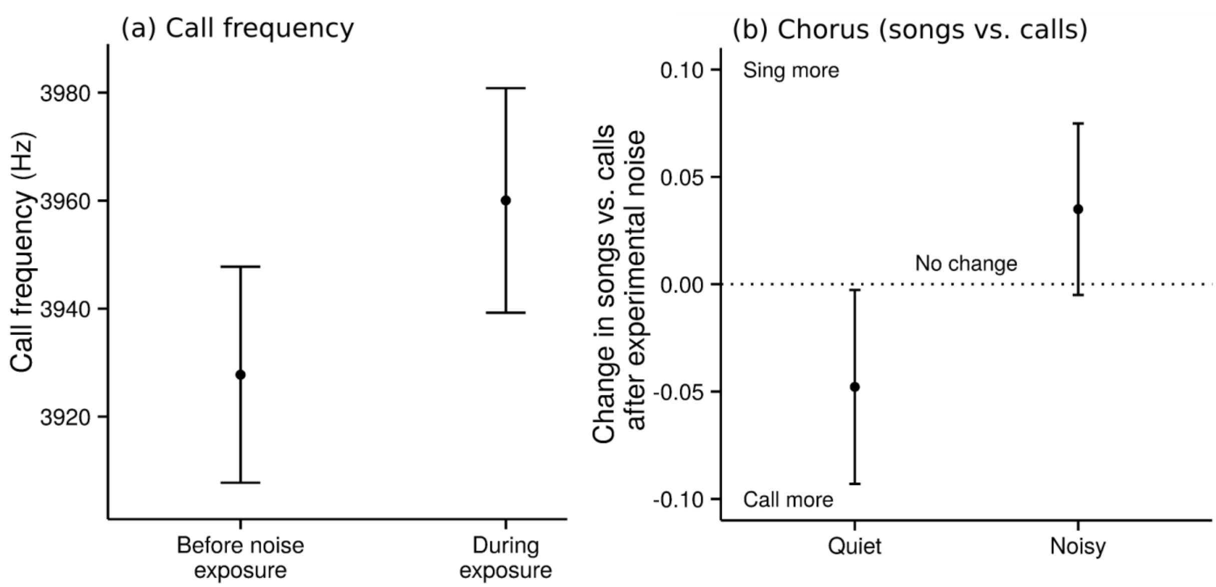

Figure 2. In response to experimental noise, mountain chickadees (a) increased the frequency of their calls, and (b) in noisy areas sang more and called less compared to males responding to experimental noise in quiet areas.

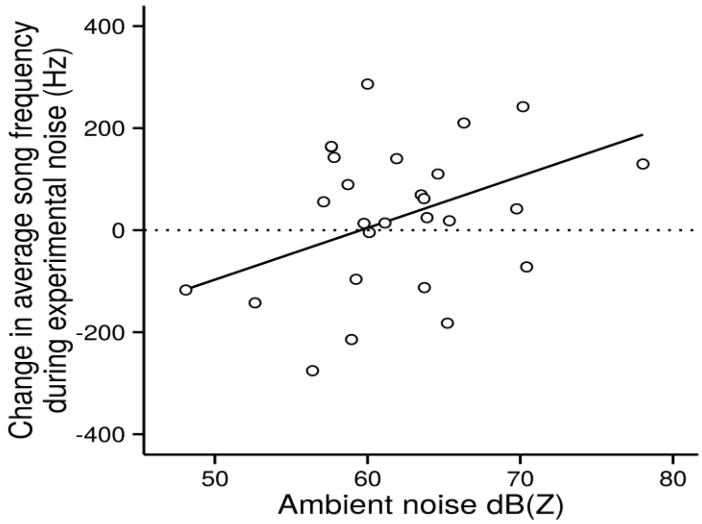

Figure 3. For black-capped chickadees, in response to experimental noise, changes in song frequency increased with ambient noise.

adjustments made in response to experimental noise in both species was also related to actual ambient noise levels; meaning that in noisy areas, individuals adjusted their vocalizations in a manner that could reduce masking, whereas in quiet areas they did not. Given that juvenile dispersal among populations is probably high (Weise and Meyer 1979), it is likely that this appropriate vocal flexibility is a learned response rather than an evolved response as a result of longer-term exposure to high levels of ambient noise (longer than our 5-min exposure, at least). Therefore, these findings support the idea that learning may play a large role in the ability of bird species to reduce masking in anthropogenic noise (Ríos-Chelén et al. 2012). Future studies investigating how quickly these changes come about would be useful for confirming whether these patterns result from developmental flexibility (i.e. learned as a young bird when developing their songs), or an intermediate period of familiarization (i.e. learned as an adult over hours, days, weeks, etc.).

Consequences for mountain and black-capped chickadees

Implications for colonization of urban areas

Despite their relatedness, mountain and black-capped chickadees clearly have different mechanisms for adjusting their vocalizations to noise and they react to noise in different ways. Black-capped chickadees can use pitch-shifting to adjust their songs during noisy conditions, and seem extremely well suited to urban noise. In contrast, while mountain chickadees do adjust to noise, their mechanisms seem unlikely to be as quick (they did not quickly adjust song frequency in response to experimental noise) or as effective; males cannot sing more than 100% songs, and even if they switched to singing only, previous studies suggest that mountain chickadee songs are still negatively affected by noise, even if they are not as affected as calls (LaZerte et al. 2015). These differences may partially explain why black-capped chickadees are generally more common in urban environments than mountain chickadees (see E-bird analysis from LaZerte 2015 for more details), although habitat is likely influential as well.

Despite these drawbacks, however, mountain chickadees are able to adjust their vocalizations, and do colonize and persist in the edges of urban areas. In contrast, some species do not adjust their vocalizations, but instead avoid noise altogether. For example, grey flycatchers (*Empidonax wrightii*) avoid noise by leaving noisy habitats (Francis et al. 2011a), and European robins (*Erithacus rubecula*) increase the amount of time spent singing at night, which is a time when urban noise is low (Fuller et al. 2007). Therefore, the ability to adjust vocalizations in mountain chickadees may permit them to colonize and persist in urban areas, even if not as effectively as black-capped chickadees. That mountain and black-capped chickadees are so closely related, yet show very different abilities and mechanisms of vocal adjustment, suggests that learning styles and vocal behaviour are better predictors of vocal adjustment than evolutionary relatedness.

Potential consequences on reproduction

Colonization of and persistence in urban areas, however, is not evidence that populations are healthy. Often urban areas may result in ecological traps (Pulliam 1988, Schlaepfer et al. 2002). Ecological traps occur when there is a mismatch between the quality of a habitat and the cues used by animals when deciding which habitat to settle in. This often results in animals settling in poor quality habitats. For example, birds may be attracted to urban landscapes by food resources, such as bird feeders. However, once settled, they may experience a lack of other resources (e.g., nest sites, food with which to provision young) or may find it difficult to secure good quality mates. In the context of chickadee communication, adjusting how one vocalizes may improve audibility in noise, but may also counter signals that evolved to give females information about males. This is the case in the southern brown tree frogs (*Litoria ewingii*). These frogs increase the frequency of their calls in traffic noise. Females, however, prefer low-frequency calls, as the lower the frequency, the larger the male, which equates with higher perceived male quality in many amphibians (Parris et al. 2009). Thus, increasing call frequency in response to noise may render males unattractive to females, or may reduce the ability of females to choose among males of differing quality. To date there is little evidence that vocal adjustments actually result in greater reproductive success, and it is entirely possible that they result in trade-offs or even in a loss of reproduction (Read et al. 2013).

While there is no evidence that female mountain or black-capped chickadees prefer low-frequency songs over high-frequency songs, there are other metrics that may be affected by vocal adjustment. For example, while it is not clear why mountain chickadees use both songs and calls during the dawn chorus, there is some speculation that calls may be directed towards their current mates (females) whereas songs are long-range signals directed towards neighbouring males (or other females; McCallum et al. 1999). Therefore, in noisy conditions, males that switch to songs from calls may be reducing communication with their mates. This may have consequences on extra-pair mating behaviour or even on how long mates stay together. Similarly, although black-capped chickadees use a different mechanism of vocal adjustment, vocal changes may also affect the information sent by the signal. Pitch-matching in black-capped chickadees (shifting song frequency to match that of a neighbouring male) functions to signal to neighbours that a challenge is directed specifically at them, but the pitch-shifted songs also contain information on dominance, which may be used by females to assess male quality (Otter et al. 2002, Christie et al. 2004). If male black-capped chickadees are constrained to avoid their lower frequency songs due to masking from anthropogenic noise, they are also constrained to pitch-shift within a smaller range, perhaps making it more difficult to demonstrate their abilities. Further, there is evidence that lower frequency songs are actually better at indicating male dominance than higher frequency songs (Christie et al. 2004). Therefore, although female black-capped chickadees do not prefer low-frequency songs, if males use more high-frequency songs as a result of vocal adjustment, females may be less able to assess male quality.

Other chickadee species

Two other chickadee species common to British Columbia are the chestnut-backed (*Poecile rufuscens)* and boreal (*Parus hudsonicus*) chickadees. These two species form the brown-headed chickadee clade, and, with the grey-headed chickadee (*Poecile cinctus*), form the sister group to the black-headed clade (which includes mountain and black-capped chickadees; Gill et al. 2005). Of particular interest is the fact that neither chestnut-backed or boreal chickadees use songs during the dawn chorus; they only use calls (Hailman et al. 1994). We hypothesized that mountain chickadees may be less able to adjust to anthropogenic noise, due, at least in part, to the fact that they use calls during their dawn chorus, which do not transmit as well as songs. It is therefore possible that chestnut-backed and boreal chickadees would be even more negatively affected by anthropogenic noise. Chestnut-backed chickadees are quite common in sub-urban areas in Vancouver and on Vancouver Island, but whether they selectively avoid noisy areas is unknown. An informal scan of E-Bird (http://ebird.org, an online site where people can report where and when they have sighted different bird species) reveals that while boreal chickadees are not common in urban areas, they have been observed numerous times in the Greater Toronto Area, Montreal, Quebec, and Halifax (to name a few cities). Therefore, future studies addressing whether or how these two species deal with noise would yield further insight into the mechanisms of vocal adjustment and the consequences of anthropogenic noise on different chickadee species.

Overall Conclusions

We found evidence that two closely related species adjust to noise in different ways and that even quick, or immediate, responses to noise may depend on previous experience with noisy conditions. Beside specific implications for this field of study, these findings have broader implications for conservation issues, and in extension, for society in general.

Our findings suggest that, with at least these two chickadee species, we can predict how well a species can adjust to anthropogenic noise by considering its ability to learn, vocal variability, and natural singing styles. This may apply to other species as well. Better assessment of a species' vulnerability to urbanization will help conservationists foresee problems before they arise, and hopefully help mitigate them, thus preventing species homogenization and preserving species richness and diversity (Proppe et al. 2013). However, an important finding of these studies is that even immediate responses to noise may be the product of a longer-term exposure to ambient noise. Thus immediate flexibility may not be as immediate as previously thought, and even species which demonstrate immediate flexibility may take longer than expected to adjust their vocalizations to noisy conditions. Further, it is important to note that we still do not know whether vocal adjustment interferes with communication in other ways.

Although this work has implications for conservation, at first glance, the findings of our study may not appear of interest to society in general. However, the more difficult it is for birds to colonize and/or persist in urban landscapes, the fewer birds will be found in these landscapes, and this loss will have an effect on society. First of all, the loss of biodiversity is an increasingly troubling problem which can negatively affect sociaty (through the loss of resources, loss of ecosystem services, etc.; Cardinale et al. 2012). Although it is easy to dismiss the ecological value of birds, they are a part of the ecosystem and the loss of populations and species will affect ecosystems as a whole. For example, songbirds are typically insectivorous and important regulators of insect populations. While our studies would suggest this may only seem to be a problem in urban areas, more and more people are living in urban areas and the amount of urbanization in the world is only increasing (United Nations, Department of Economic and Social Affairs, Population Division 2012), suggesting this problem will affect more and more people. Second, having different species in urban areas helps to promote conservation and awareness of nature and the environment in general (McKinney 2006). This is important for helping to stem the global loss of biodiversity. Finally, the presence of nature in our cities is highly valued (e.g., Chiesura 2004), and simply speaking, people enjoy bird song and other natural sounds and find them relaxing (Yang and Kang 2005, Alvarsson et al. 2010). While this is perhaps not a profound reason for conservation, improvements to mental well-being should not be underrated.

In Silent Spring (1962), Rachael Carson pointed out that birds should be viewed as common property to be seen, heard and enjoyed by all. Although Carson introduced this idea as part of her argument against bird fatalities from excessive pesticide use, today, the principle remains the same. Birds are a commonly held property, and society as a whole shares the responsibility of ensuring that we do not lose them.

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