



Tolerance of Auditory Disturbance by an Avian Urban Adapter, the Noisy Miner

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Abstract

Urbanization creates challenges for wildlife, most notably through changes in resource availability and the frequent occurrence of sensory disturbance. Some native species, however, have been able to exploit and thrive in urban environments. Research, in this regard, has mostly focused on the ecological conditions that have allowed such species to prosper. In contrast, less attention has been devoted to evaluating how they cope with human proximity and disturbance. In a field experiment on a successful Australian 'urban adapter', the Noisy miner, *Manorina melanocephala*, we compared tolerance of a loud, startling sound stimulus by urban and rural individuals. We found group size differences between birds occupying urban and rural sites: more urban birds came into the testing area in response to the initial alarm-call playback compared with rural birds. Urban and rural birds also differed significantly in their behavioural response profile to the test sound stimulus. Nearly half (47.5%) of the rural, but only 22.5% of the urban birds took flight and of those that did, only 1 of 9 urban individuals retreated >5 m, compared with 13 of 19 rural birds. About one-third of urban, but only 5% of rural individuals responded to the sound stimulus with aggressive displays. The most frequent response to the stimulus, irrespective of habitat type, was to remain near the sound source and engage in visual surveillance. The high frequency of this response in both urban and rural individuals suggested that most noisy miners were quite 'bold', a temperament trait that is likely to be important in successful urban colonization by birds.

Introduction

Urbanization presents many challenges for wildlife, including changes in the availability of vital resources, such as food and shelter, and frequent sensory disturbances, such as industrial and vehicular noise and pedestrian traffic (Reijnen et al. 1997; Fernández-Juricic & Tellería 2000). However, some native species, often termed 'urban adapters', seem to be 'pre-adapted' to exploit urban conditions and thrive in these highly modified environments (Blair 2004; McKinney 2006; Parsons et al. 2006). Insights

into why such species are able to prosper in cities whilst others fail are important for understanding the capacity of organisms to exploit changing environments (McKinney 2002; Blair 2004; Faeth et al. 2005) and in devising effective management strategies for urban wildlife (Lunney & Burgen 2004; Chace & Walsh 2006; Baker & Harris 2007; Lunney et al. 2008; Chamberlain et al. 2009). Studies of 'urban adapters' have mostly focused on how cities provide their ecological requirements (Chace & Walsh 2006; Lowry & Lill 2007; Croci et al. 2008), with less attention being given to evaluating

how such species are able to cope with human disturbance.

In urban areas, anthropogenic disturbance is usually persistent and frequent (Fuller et al. 2007). For individuals of any species, the cost of ignoring a potentially threatening disturbance must be balanced against the cost of responding, which takes time and energy away from other vital activities and can also be physiologically stressful (Nudds & Bryant 2000; Frid & Dill 2002; Cooper & Frederick 2007; Price 2008). Temperament is likely to be important in enabling species to accommodate to a range of urban stressors (Fraser et al. 2001; Dingemanse et al. 2003). In particular, we might expect members of urban populations to be 'bolder' (defined by Coleman & Wilson (1998) p. 927 as 'the willingness of an individual to take risks, especially in novel situations') and tolerate human disturbance more readily than rural con-specifics who come into contact with humans less often (McDougall et al. 2006). For example, some European and Australian birds that have successfully colonized urban areas have been shown to be less wary of approach by humans than rural con-specifics (Cooke 1980; Rollinson 2003; Møller 2008; Kitchen et al. 2010).

The Noisy miner, *Manorina melanocephala*, is a large (length 26 cm; mass 70–80 g), communally breeding honeyeater (Meliphagidae), native to eastern and south-eastern Australia (Higgins et al. 2001). Noisy miners exhibit complex, but well-documented, social and aggressive behaviours that are easily observed and quantified (Dow 1977; Grey et al. 1997, 1998; Higgins et al. 2001; Hastings & Beattie 2006; Parsons et al. 2006). They typically inhabit open, grassy woodlands that have often been fragmented and degraded by human activity. However, they have also relatively recently occupied many cities and towns throughout their range, where they exploit natural and human-subsidized food resources and have reached high densities (Low 2002). The aim of the present study was to experimentally investigate whether urban Noisy miners had a higher tolerance of and exhibited 'bolder' behaviour towards, a startling sound stimulus (a loud noise) than rural con-specifics. To our knowledge, this is the first field-based study to use a noise disturbance as a measure of boldness in birds. We wanted a more generalized measure of boldness, rather than one directly associated with humans, such as measuring Flight Initiation Distance (FID) in response to an approaching human, which we felt could be confounded with habituation to humans in urban birds.

Methods

Study Sites and Location of Noisy Miner Colonies




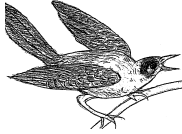
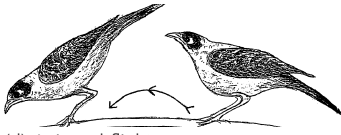
Although Noisy miners can breed at any time of year (Higgins et al. 2001), experimental work was conducted in April–June during the main non-breeding season. A colony was defined as a group of three or more individuals at least 1 km away from any other group of con-specifics. Colonies were found by playing back Noisy miner alarm-calls previously recorded at urban and rural sites (cut-and-pasted into a coherent sequence using Raven Pro Interactive Sound Analysis Software) through a hand-held speaker, as described by Clarke & Oldland (2007). All recordings used for the study were in an uncompressed (i.e. wave) format. The use of uncompressed sound files is important in vocal playback studies to ensure that focal individuals do not perceive the compressed signals differently. Forty urban and 40 rural colonies were tested. Urban colony sites were located in metropolitan Melbourne, Australia (37°50'S, 145°00'E) and included sports fields, playgrounds and public spaces containing a mixture of native and exotic vegetation. Rural sites were in the Central Victorian Goldfields near Maryborough (37°00'S, 143°44'E) and Bendigo (36°40'S, 144°15'E), about 150–165 km north of Melbourne, and incorporated roadside *Eucalyptus* corridors and open *Eucalyptus* woodland in National and State parks.

Experimental Procedure

We conducted a playback experiment to test the response of Noisy miners to a sudden noise disturbance. This was achieved using a speaker attached to the top of an adjustable tripod (set at 1 m height), linked to an Mp3 player via a 10-m connector lead. The tripod was wrapped in army camouflage fabric to reduce its visibility and was positioned centrally to where a colony had previously been located. A sound-level meter (Radio-shack Db 33-4050, Victoria, Australia) was used to ensure that playback amplitude was set at a predetermined level of 80 dB, which is >15 dB above the background sound amplitude averages found in studies measuring urban noise (Brumm 2004; Fuller et al. 2007). When any trial had to be terminated because of inclement weather, passing pedestrians or vehicles, the colony was re-tested a minimum of 2 d after the initial attempt.

To minimize any effects of observer presence, playback and behavioural observations were carried out remotely (observer minimally 10 m from the

Table 1: Categorization of behaviours exhibited by noisy miners on presentation of the startling sound stimulus

Response categories – behaviour	Description
(1) Take flight (a) >5 m (b) <5 m (2) Jump-startle	Focal bird left the immediate area, landing a minimum of 5 m away from its original perching position Departing focal bird landed within 5 m of its original perching position Focal bird took flight in a jump-like manoeuvre directly upwards from its original perching position and landed either back in the original perching position or on the branch <1 m directly above it
	
(3) Visual surveying	Focal bird remained in its original perching position whilst observing its immediate surroundings by turning its head from side-to-side
	
(4) Aggressive/defensive (a) Posturing/Alarm-calling	Focal bird assumed a 'pointed' stance, with the neck stretched out towards the target, the bill held closed, or open if alarm-calling (described by Higgins et al. (2001) as a strong threat behaviour)
	
(b) Wing-wave/bill-gape/ Yammer-call	Focal bird flexed its wings at the carpal joints, with the wings held out in a rigidly waving stance accompanied by open bill-gaping and a yammering call (described by Higgins et al. (2001) as a threat display)
	
(c) Forward branch hop	Focal bird took a forward movement along the branch towards the source of the threat in a hop-like movement, with its body in a crouch-like, pointing stance
	
(d) Agitated flight	Focal bird flew in a direct horizontal line above the speaker set-up
(e) Swoop	This is an aggressive, inward flight, not a form of retreat behaviour Focal bird made a direct inward flight low over the speaker set-up in a dive-bomb type manoeuvre

speaker) using the handheld Mp3 player and a pair of binoculars. Dark-coloured clothing was worn at all times. Trials began with playing-back the alarm calls of Noisy miners to attract birds to the speaker using the same recording employed during the initial detection of colonies. The alarm calls were played for 40-s, or until at least three Noisy miners were

perching within 5 m of the speaker. The number of birds that came into the testing area in response to the initial alarm-call playback was recorded as a measure of group size. A focal bird was then selected using a systematic spatial rule (i.e. the second bird in from the left margin of the group). After a 3-s pause, the observer broadcast a recording of either the test

sound or a silent control. The former comprised a loud, hollow-sounding 'bang' made by a large, industrial pressing machine. The behaviour of the focal bird was recorded (as frequencies of occurrence) at the start and conclusion of the 3-s pause to determine whether there were any changes in behaviour prior to presentation of the stimulus or control 'sound' (silence). Observed behaviours shown in response to the sound stimulus or control silence were grouped into several categories (M. Clarke, pers. comm.) described in Table 1. Behaviours (4) (a–e) appeared to be similarly motivated and as such we grouped them together into a single category.

Ethical Note

Noisy miners commonly alarm-call in response to a wide variety of threats under natural conditions (Jurisevic & Sanderson 1994), and similar alarm-calling assays have been used before on this species with no adverse effects (Clarke & Oldland 2007). Initial field trials showed that birds returned to 'relaxed' behaviours <10-s after testing. The study received ethics approval from The Biological Sciences Animal Ethics Committee of Monash University.

Statistical Analyses

A Fisher's exact probability test was used to examine whether there were any significant differences in behavioural response profiles between urban and rural Noisy miners. Two-way Fisher's exact tests were also employed to determine which particular behavioural responses contributed to significant differences between urban and rural colonies. Statistical analyses were conducted with R version 2.2.0 (The R Foundation for Statistical Computing, www.r-project.org/foundation/main.html).

Results

Group sizes of attracted birds (total number of birds present during testing) varied significantly between

Table 2: Proportional and actual occurrence of various behaviours in response to presentation of the startling sound stimulus in focal Noisy miners in urban and rural colonies $n = 40$ birds in each environment

Colony location	Percentage (actual frequency) of response behaviour			
	Take flight	Jump startle	Visual surveying	Aggressive/defensive
Urban	22.5 (9)	15 (6)	32.5 (13)	30 (12)
Rural	47.5 (19)	5 (2)	42.5 (17)	5 (2)

urban and rural sites ($p = 0.001$, $n = 40$ urban and 40 rural sites, Fisher's exact test). Only 5% of rural birds occurred in groups of >10, compared with 35% of urban birds. Rural birds occurred equally often in the two smaller group size categories recorded (<5 and 5–10, both 47.5%), whereas urban birds only occurred in groups of <5 on 22.5% of occasions.

There was a significant difference between urban and rural Noisy miners in their behavioural response profile to the 'startle' stimulus ($p = 0.003$, Fisher's exact test) (Table 2). Nearly half the rural, but only approx. 20% of the urban birds took flight ($p = 0.034$, Fisher's exact test). Flight distance also varied ($p = 0.013$, Fisher's exact test), with only one of nine urban birds fleeing >5 m in response to the 'startle' stimulus, compared with 13 of 19 rural individuals. Aggressive/defensive displays also occurred more frequently in urban than rural individuals; nearly a third of urban, but only 5% of rural individuals exhibited such behaviours ($p = 0.006$, Fisher's exact test). The other two response types ('visual surveying' and 'jump-startle') (Table 1) did not differ ($p > 0.05$) between rural and urban individuals.

'Controls', which measured the percentage of focal birds that changed their behaviour from pre-to-post 'silence', were conducted for both urban and rural sites. There was a difference in response behaviours between 'control' and 'startle' tests in both urban and rural populations ($p < 0.0001$ in both cases, Fisher's exact test). Only 7.5% (rural) and 15% (urban) of tests involved a change in behaviour between the beginning and end of the 3-s presentation of 'control' silence, whereas 87.5% (rural) and 92.5% (urban) of tests involving broadcasting of the 'startle' stimulus evoked behaviour change.

Discussion

Fleeing from the Sound Stimulus

One key result was that urban Noisy miners were less likely to take flight and exhibited shorter retreat distances than rural con-specifics in response to the startling sound stimulus. Of the focal birds that took flight in urban areas, only one moved from the tree that it occupied at time of testing, whereas the majority of rural birds that took flight relocated to a different tree, indicating that urban birds did not flee just because a 'safe haven' was closer. This finding needs to be tested for other cities colonized by this species, but is consistent with the results of several studies comparing FID in con-specific birds inhabiting high- and low-level disturbance environments

(Cooke 1980; Keller 1989; Walker et al. 2006; Møller 2008; Rollinson 2003; Kitchen et al. 2010). A high level of disturbance-tolerance is likely to be important in successful urban colonization by birds. If urban Noisy miners did not, to some extent, decrease their response to the high levels of human activity and noise in cities, the costs in time deducted from other fitness-enhancing activities (such as feeding) and energy spent on vigilance and fleeing from disturbances would probably be unsustainable (Frid & Dill 2002).

However, the reduced flightiness and shorter retreat distances observed in urban Noisy miners may not necessarily have reflected greater tolerance of the startling sound stimulus. Urban Noisy miners were not only found to be generally less 'flighty' (or 'bolder'), but on average significantly more urban than rural individuals approached the sound source in response to the initial alarm-call playback. Although group size at the time of testing was obviously not an accurate population density measure, we suggest that it probably reflected a trend towards larger colonies in urban than rural habitats. Higher population densities and smaller territories have been correlated with relatively shorter retreat distances from threatening stimuli in urban than rural conspecifics in other bird species (Møller 2008). Long-distance retreat from perceived threats might therefore be avoided because it would frequently result in conflict with neighbouring colonies through territorial incursions. Additionally, urban birds may have been less likely to flee due to perceived 'safety in numbers'. Risk-taking behaviour, for example, has been shown to vary with social context in Great tit, *Parus major*, with certain individuals becoming 'bolder' in the presence of a companion (Van Oers et al. 2005).

Responding Aggressively to the Sound Stimulus

A second key observation was the common occurrence of an aggressive response to the startling sound stimulus by Noisy miners. Studies of other successful avian urban colonisers have also reported the occurrence of aggressive responses to a repeatedly presented, visually perceived threat at the nest (Jones 2008; Levey et al. 2009). However, the present investigation showed that a single, threatening (or alarming) sound stimulus encountered away from the nest was sufficient to elicit an aggressive response in Noisy miners. Moreover, urban individuals exhibited aggressive behaviour significantly more often than rural conspecifics in response to the pre-

sentation of this stimulus. This seemed to indicate a propensity for 'bold' behaviour in these urban birds, especially given that (1) the stimulus did not provide much information that would allow a bird to effectively assess its severity as a threat from a distance and (2) it was not obviously associated with humans, repeated exposure to whom might be expected to lead to habituation in the urban environment. It is not possible to entirely dismiss habituation to 'loud' noise events in the urban environment as the cause of the bolder behaviour shown in response to the test-sound-stimulus by urban Noisy miners. However, rural birds (including those tested in the current study) often inhabit roadside vegetation and, as a result, may experience exposure to passing trucks and other vehicular traffic, which create sporadic loud noise events. Habituation also requires frequent exposure to the stimulus (Evans et al. 2010), in this case a directed 'loud' noise (*sensu* Wiley & Richards 1978), which even in the urban environment seems unlikely for the kind of sound stimulus that we presented. Additionally, habituation cannot account for the more frequent occurrence of aggressive responses observed in urban birds.

The Origin of Boldness in Urban Noisy Miners

If, as our study suggests, suburbia contained 'bolder' Noisy miners than the nearby rural environment, there are two ways in which this might have occurred. First, individuals that initially colonized Melbourne may have been inherently bolder than those that did not. These birds would therefore naturally have been better equipped to persist and thrive in the disturbance-rich urban environment, with further selection then possibly enhancing this boldness. Second, learning may also have been important, with birds habituating to a new set of potentially threatening stimuli within the urban environment. Research on a single urban and a nearby rural population of European blackbirds, *Turdus merula*, in Germany found no evidence of genetic differentiation between adult urban and rural individuals, but disparities in breeding density, length of the daytime activity period and 'tameness' suggested that there was sufficient phenotypic (behavioural) plasticity in this species to facilitate urban colonization (Partecke et al. 2006a). However, other comparative studies with European blackbirds suggest that differences between populations may be subject to some level of genetic control (Partecke et al. 2006b; Partecke & Gwinner 2007). More recently, a study

by Møller (2008) demonstrated that variation in relative FID of urban populations of successful urban adapter bird species in Europe was predicted by the estimated number of generations since urbanization, suggesting that genetic adaptation had occurred. A recent study investigating behavioural traits in urban and rural populations of male Song sparrows *Melospiza melodia* identified a correlation between 'boldness' and territorial aggression; urban birds were 'bolder' and more territorial than rural conspecifics, suggesting that urban 'boldness' may be part of a behavioural syndrome (Evans et al. 2010). Heritable differences in risk-taking and exploratory behaviour demonstrated in hand-reared Great tits also seem to suggest the existence of avian 'personalities' (Van Oers et al. 2004). To determine what process is driving the divergence between urban and rural Noisy miners' responses to a startling sound stimulus, future studies might investigate whether there is genetic differentiation between city and country birds, and whether there is any evidence of a behavioural syndrome in this species manifested in stable, correlated differences (Sih et al. 2004) in 'boldness' and aggression among individuals.

Responding with Visual Surveillance to the Sound Stimulus

The third key finding in the present study was that 'visual surveying', in which a Noisy miner visually monitored its surroundings whilst remaining in the immediate vicinity of the sound stimulus' origin (Table 1), was the most common response by urban individuals and very common in rural birds. Of all the responses observed, it should have been the most cost-effective if it was adaptive, because of its presumed relatively small energy expenditure. The frequent occurrence of this response in both urban and rural individuals seemed to indicate that most Noisy miners in the study had a 'bold' temperament. Sirot (2007) described a 'bold' bird as being alert for some time when disturbed and only taking flight if the threat actually proved to be a predatory attack. Our finding may therefore indicate that there is a behavioural pre-disposition to inhabit urban environments in the Noisy miner, stemming from a naturally high tolerance of sensory disturbance (i.e. boldness), although a comparison of the relative frequency of the visual surveillance or similar responses to this kind of sound stimulus in other urban adapters and 'avoiders' (McKinney 2002) would be required to reach this conclusion unequivocally. Another apparent manifestation of boldness in Noisy

miners is their tendency to react aggressively to a wide range of bird species and some mammals (e.g. domestic dogs) that do not appear to pose a competitive or predatory threat (Dow 1977) and even to their own mirror image (A. Lill, unpubl. data). If boldness is inherent in Noisy miners, an intriguing, unanswered question is what the adaptive value of this trait might have been in the species' original natural habitat.

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