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IMPACT OF ANTHROPOGENIC NOISE AND LIGHT POLLUTION ON URBAN VERTEBRATES COGNITION AND BEHAVIOUR: A REVIEW

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Abstract

Vertebrates are exposed to anthropogenic noise and artificial light at night (ALAN) because of urbanisation, and both can cause changes in information processing, physiological regulation and behaviour. The aim of this review is to discuss the effects of these pollutants on cognition and behaviour in urban vertebrates, including birds, mammals, amphibians and other vertebrates. Biologically critical sounds, such as mating calls, alarm calls, and parent offspring vocalizations, can be masked by anthropogenic sounds. It can also make them more vigilant and less efficient foragers, make it more difficult to sleep and interfere with brain functions like inhibitory control and vocal learning. The effects of light at night include messing up the natural times when it is light and when it is dark controlling the amount of melatonin messing up the body internal clock, when animals are active effects on reproduction how predators and prey interact, how animals find their way sleep problems and how predators and prey deal with each other. Urban animals can change how they look for food how often they are active when they are active where they live and the sounds, they make by being flexible, in their behavior. These changes can cost energy affect their ability to reproduce and impact their thinking. There is growing evidence that noise and light frequently combine in their effect and that they can be additive, antagonistic or synergistic. Birds have been studied most extensively; but for reptiles, amphibians and mammals, there is still important knowledge lacking. Mitigation measures should involve wildlife-sensitive urban design, such as reduction of traffic noise, the provision of dark corridors, shielded and spectrally appropriate lighting and the protection of quiet and dark refuges of habitat.

INTRODUCTION

Urban areas are growing fast. This is changing the way wildlife experiences their surroundings. Animals now face more than losing homes or having their habitats split up. They also deal with noise from cars, construction, planes and bright lights from buildings, streets and the glow in the sky. These things can make it harder for animals to sense what's going on around them understand it and react properly (Shannon et al., 2016; Dominion & Nelson 2015). Human made noise and artificial light at night are big problems. I see how noise messes with the senses that animals need to talk to each other to find their way to spot danger to hunt food to sleep and to breed. The sound

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that noise creates changes the sound of the environment. I notice that artificial light at night or ALAN messes with the dark patterns that animals rely on. Both noise and artificial light at night are common, in cities. Often happen together creating a kind of double trouble for wildlife. Multisensory pollution (Slabbekoorn, 2015; Dominoni et al. 2020).

Recent studies show that most research on noise and animals in cities focuses on birds and mammals. Reptiles and other animal groups get less attention. When scientists do study noise effects they mostly look at how animals behave and how their sounds change. (Terray et al., 2025) In the way research on artificial light, at night shows it affects many things. Like body functions, daily routines, life stages, thinking and reproduction. Across different kinds of animals (Sanders et al., 2021) (Figure 1).

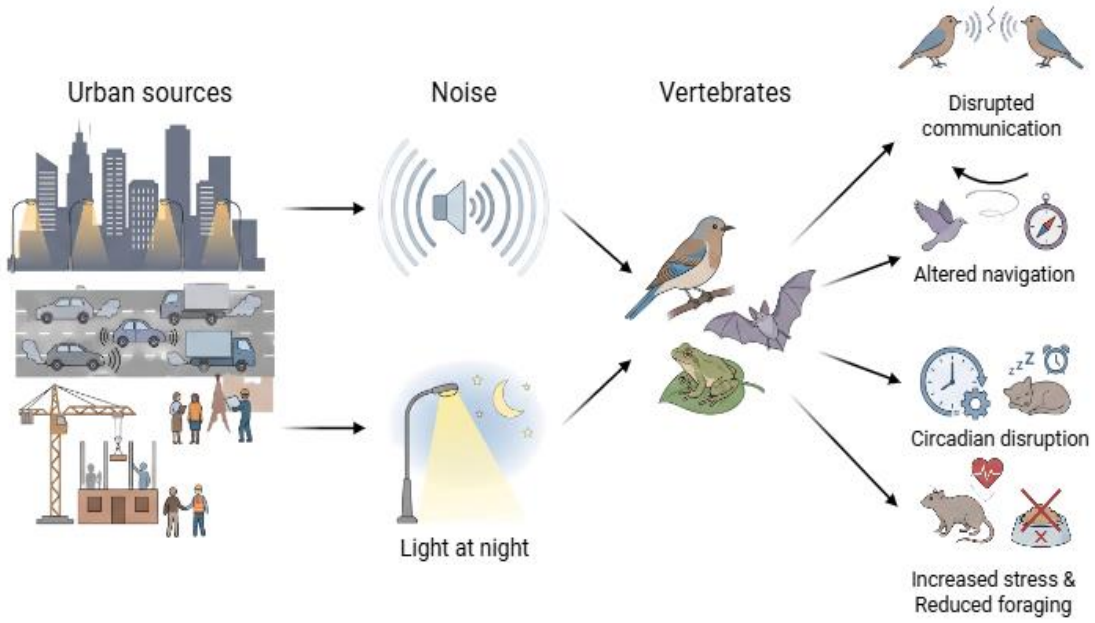


Figure-1: Conceptual framework of anthropogenic noise and ALAN impacts on Vertebrate Behaviour and cognition

Anthropogenic Noise as a Cognitive and Behavioural Stressor

Anthropogenic noise encompasses noise from road, aircraft and railway traffic, industrial noise, construction noise, city noise and leisure noise. Humans made noise is often continuous, unpredictable, low frequency and loud. These properties could make it harder to hear biologically relevant acoustical signals (Barber et al., 2010; Francis & Barber, 2013).

There are several ways in which noise affects vertebrates. First acoustic masking can interfere with communication as background sound blocks the signals making it difficult for the receiver to hear and understand the signals properly. Second, noise can also serve as a distraction, which could distract from foraging or predator detection. Third, prolonged exposure can cause physiological stress and change the response of the endocrine system, which can impact on sleep, immune function and reproduction (Kunc & Schmidt, 2019; Shannon et al., 2016).

Effects on communication

Many vertebrates need to communicate acoustically, particularly birds and amphibians. Songs and calls are used by birds for territory defence, courtship, alarm and social organization. Low-frequency song components may be masked by low-frequency traffic noise, thereby decreasing the ability for signals to be transmitted and received in urban settings (Brumm & Slabbekoorn, 2005; Slabbekoorn & Peet, 2003).

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Responses include increased vocal frequency, amplitude, rate, and/or timing of vocalizations by many species of birds. For instance, great tits and blackbirds in urban areas tend to sing at higher frequencies than those in a rural area. But it's not certain that these changes are adaptive for all situations, since changes in frequency can change the quality of the signal, repertoire structure, or mating success (Nemeth & Brumm, 2010; Zollinger et al., 2012).

There is some evidence from the meta-analysis that anthropogenic noise may have a negative effect on the minimum frequency of terrestrial animal vocalisations, especially in birds. However, these vocal modifications are not seen in all species, and are influenced by species specific vocal constraints, habitat features and temporal dynamics of noise exposure (Duquette et al., 2021)

Effects on vigilance and foraging

Noise may modify the ratio of food collect and predator avoidance. If animals are not able to hear their enemies or alarm signals distinctly, they may increase the need for visual vigilance. If they are less able to hear the approach of the enemy or to hear an alarm signal, they may need to increase their reliance on the visual sense. This can decrease the feeding time and even diminish foraging efficiency (Quinn et al., 2006; Ware et al., 2015). Experimental research in songbirds has demonstrated that human noise can be used to increase vigilance and decrease feeding. Noise exposure in song sparrows led to time spent looking around and less time spent foraging. This suggests that noise might make them more likely to be caught by predators. These kinds of behaviour changes can be very expensive for the birds. This is especially true, during breeding seasons. When they are migrating or living through the winter. These are times when the birds need a lot of energy. Noise may also disrupt information networks among species. Dwarf mongooses, for example, showed reduced ability to use heterospecific alarm calls during anthropogenic noise exposure. Consequently, noise can interfere not only with within-species communication but also with the broader social information systems that support risk assessment and behavioural decision-making (Morris-Drake et al., 2017).

Effects on cognition

Cognition includes attention, memory, learning, stopping impulses making choices and solving problems. Because of extreme fragmentation, distinct food sources, new predator communities, and the presence of humans, these processes are especially critical in urban environments. Some of the cognitive capabilities that enable adaptation to an urban environment can be compromised by noise. Playing the songs of traffic noise was found to reduce inhibitory control in wild-caught black-capped chickadees. Noise did not affect performance in the detour-reaching task performed by birds exposed to traffic noise compared to control birds, indicating that noise affects behavioural regulation and flexible decision making (Templeton et al., 2023) (Figure 2).

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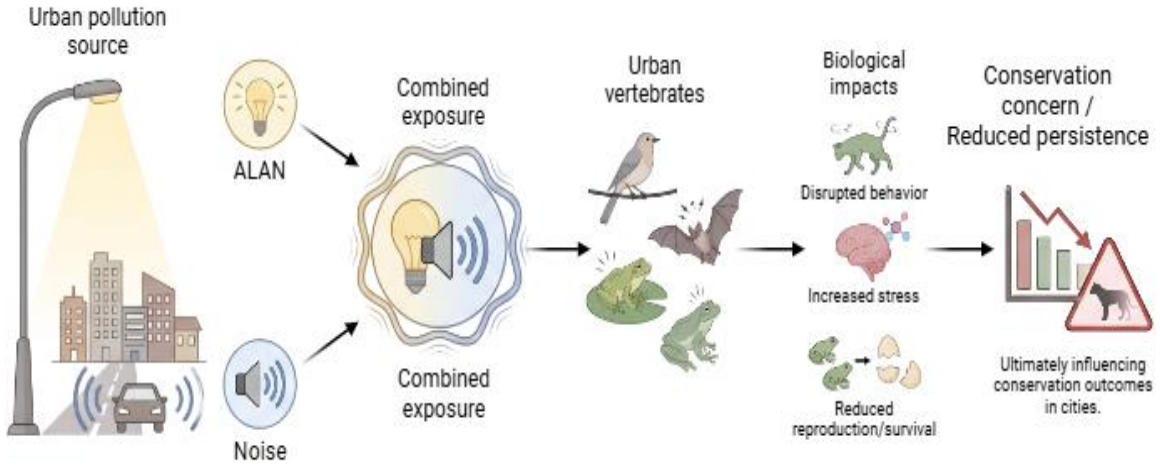


Figure-2: Effect of anthropogenic noise on vertebrate communication and cognition

In zebra finches, traffic noise has also been linked with vocal-learning deficits, indicating that developmental noise exposure may affect the acquisition of learned acoustic signals. However, there is some variability in cognitive outcomes. However, experimental studies conducted with captive Australian magpies revealed no clear effects of playback of urban noise on some cognitive measures, which may depend on species, task type, developmental history and exposure duration (Potvin et al., 2016; Brumm et al., 2021).

Artificial Light at Night and Urban Vertebrate Behaviour

Artificial light, at night includes streetlights and buildings that are lit up. It also includes car headlights and signs that glow. There is a sky above. The natural cycles of light and dark are parts of the environment. The natural cycles of light and dark are parts of the environment. These cycles affect when our body internal clock works, the changing of the seasons sleeping patterns and how animals move around and how they reproduce. ALAN can have a negative effect on these cues and create behaviour and physiological desynchronisation (Gaston et al., 2015; Dominion & Nelson, 2015).

Circadian disruption and sleep

I have noticed that clocks the timekeepers that guide daily cycles of activity, feeding, sleep, hormone levels and body temperature can be affected by light at night. Light, at night can interfere with melatonin. The function of clock genes. When melatonin is disrupted the normal rhythm of clocks may shift and this shift can change activity patterns. Even moderate levels of light can change melatonin levels, and influence sleep related or other behaviours in birds. (Aulsebrook et al., 2018; Dominoni et al., 2013).

When offered the artificial light, free-living great tits also woke early and slept less than birds in dark nest boxes. Since sleep loss has potential cognitive implications; including memory consolidation, learning, attention and behavioural performance; it is important to note (Raap et al., 2015). Artificial light can therefore influence cognition indirectly by reducing the quantity or quality of nocturnal rest.

ALAN is also associated with earlier dawn activity and prolonged daily activity in birds. These shifts may appear beneficial if they create more time for foraging, but they may increase energy expenditure, elevate predation risk, or create mismatches between reproduction and natural food availability (de Jong et al., 2015; Dominoni et al., 2013).

Reproduction and seasonal timing

Seasonal reproduction, in animals is controlled by the length of the day. Light that comes from man-made sources can make the body think that the days are longer. This can affect how animals know when to reproduce. This trick

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speeds up development and breeding-related behaviour. European blackbirds that were exposed to light at night showed earlier reproductive physiology and sang earlier than European blackbirds kept in natural dark conditions (Dominoni et al. 2013).

Earlier breeding is not always beneficial. If reproductive timing becomes disconnected from the peaks, in food availability offspring survival may decline. Artificial illumination can also alter care, mating activity and the timing of reproductive displays (Kempenaers et al., 2010; Russart & Nelson 2018).

Movement, migration, and habitat selection

Many nocturnal migrants rely on cues and Earth's magnetic field to find their way. Artificial lighting can attract birds make them confused or pull them into groups, near bright lights, which raises the risk of crashes. ALAN may also affect when and where migratory birds stop how they time their migration and the places they choose to live (Van Doren et al., 2017; Cabrera-Cruz et al., 2018).

Lighting can block the path of mammals. Some bat species are sensitive to light and could reduce habitat connectivity by avoiding commuting routes and foraging grounds when they are illuminated. Conversely, some opportunistic bats might approach lights due to insect concentrations around lights, indicating that the responses are species dependent and related to the foraging strategy (Stone et al., 2015; Azam et al., 2015).

Behavioural Adaptations to Sensory Pollution

Urban vertebrates are behaviourally flexible with respect to noise and ALAN. Birds can change the pitch of their song. They can also change how loud it is. They can decide how long they keep singing. Mammals might choose times to be active. They pick the parts of the day. Amphibians can change when they call. These changes might help them survive in the term, but they don't fix the long-term problems caused by noise and light. For example, birds might start singing in areas with lots of light. Frogs might change how they call or how loud they are when traffic noise is around. These changes can help them be heard better now but they also use more energy. It can also change how they interact with mates, rivals, predators or prey. (Kempenaers et al., 2010; Halfwerk et al. 2019)

Just because a species can live in a city doesn't mean it's doing well. Even animals that are still common, in cities might have trouble sleeping have babies struggle to communicate or be stressed all the time. On the other hand, community structure and biodiversity may be changed by the disappearance of highly sensitive species due to noise or light (Francis et al., 2009; McClure et al., 2013).

Combined Effects of Noise and Light Pollution

Noise and ALAN typically go hand in hand in urban settings but have been significantly researched individually. This reduces understanding as both pollutants can impact activity timing, communication, endocrine regulation, vigilance and predator – prey interactions. They may have additive, antagonistic or synergistic effects (Halfwerk & Jerem, 2021).

The experimental study of the great tits led to the conclusion that ALAN and continuous noise had an interactive effect on activity patterns. The total and night-time activity effects of combined exposures were larger than those expected from the individual exposures. This shows that the impact of urban sensory pollution on the environment cannot be judged only by taking into account a single stressor. A field experiment with camera traps showed that light and noise affected the richness, turnover and foraging activity of vertebrates at the community level. Cumulative richness went down because of noise. It went up when light was present (on the spatial scale analysed) (Willems et al. 2022). This shows that sensory pollutants, like noise and light can change not how a single animal behaves but also how many kinds of species live together and how they interact with each other. A systematic review told me that only a small number of studies have really looked at how ALAN and anthropogenic noise work together though they often appear together. Most of the papers focus on birds, which shows we need research that looks at many species over long time periods (Halfwerk & Jerem 2021).

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Implications for Conservation and Urban Planning

The reduction of pollution must be part of the idea of protecting urban biodiversity. Every city should think about how to lower the noise and visual mess that harms nature. Noise mitigation techniques can involve traffic calming, noiseless road surfaces, vegetation buffers, and/or limiting noise from construction activities during breeding seasons and maintaining quiet habitat refuges. However, vegetation alone may not be sufficient for low frequency traffic noise reduction and planning should focus on sound reduction at the source (Barber et al., 2010; Francis & Barber, 2013).

The emphasis for light mitigation should be to use lighting where it is needed, to reduce the intensity of light, to direct light down, to shield light fixtures, to avoid unnecessary lighting for all night, and to select spectra that do not cause as much ecological disturbance. The use of warm coloured lights and the reduction of short-wavelength emissions may be less disruptive for some wildlife, but this varies by taxon and should be considered on a case-by-case basis (Longcore & Rich, 2004; Gaston et al., 2012).

Conclusion

Cities create changes, in the environment through human-made noise and artificial light at night. This noise can stop animals from communicating. It becomes harder for them to pay attention to what's happening around them when they are trying to find food. This can also change the way they process and handle information. Even simple brain activities, like focusing on things and learning from noises can be affected. Artificial light, at night can disrupt their routines. It changes when they are awake when they reproduce, when they travel and where they decide to live. It can also disrupt their sleep cycles and internal body clocks. Some animals, in cities can adapt their behavior. Doing so might cost them extra energy. It could harm their health. Reduce their chances of having babies. Noise and light often happen together. When they do their effects can combine in complicated ways that are not just simple addition. Future studies should look at these issues over periods across many different species and, in real city environments. They should focus on how these factors affect thinking, survival and how animal populations grow or shrink over time.

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