Urban Evolution: How City Life is Reshaping Animal Behaviour, Physiology, and Genetics

Tejas Motaparthy

Sancta Maria International School, Hyderabad, India
Corresponding Author Email: *motaparthy.tejas[at]gmail.com*

Abstract: ***Cities are changing the way animals and plants live, forcing species to adapt at a pace far faster than traditional evolutionary timelines would predict. This paper examines how urban environments drive rapid shifts in feeding behaviour, stress physiology, and daily activity patterns across six species: the American White Ibis, Common Ragweed, Dark-eyed Junco, wild urban rodents, the Common Blackbird, and urban pigeons. Evidence is drawn from peer-reviewed studies across three thematic areas: food and resource acquisition, stress tolerance, and behavioural adaptation. Findings reveal consistent cross-species patterns- urban animals tend to exploit human food sources, habituate to anthropogenic stressors, and adjust activity timing in response to artificial lighting and noise. These changes can emerge within as few as three to five generations, suggesting that cities act as powerful agents of natural selection. The paper argues that urban evolution is not an exception to evolutionary principles but an accelerated expression of them.***

Keywords: urban evolution, behavioural adaptation, stress physiology, HPA axis, anthropogenic change, natural selection, urban ecology

1. Introduction

Urban evolution refers to the rapid genetic and phenotypic changes observed in organisms living in city environments. Unlike traditional evolutionary processes, which unfold across many generations, urban evolution can manifest within a handful of generations, driven by the intense and novel selection pressures that cities create. These pressures include artificial lighting, elevated noise levels, altered food availability, dense human populations, and fragmented green spaces. A frequently cited example of urban-driven behavioural innovation is crows learning to drop hard-shelled nuts onto roads so that passing vehicles crack them open- a behaviour that demonstrates not only problem-solving ability but also the capacity of urban animals to exploit man-made infrastructure.

This paper investigates the following central research question: How are animals adapting to urban environments through behavioural, physiological, and genetic changes, and what do these adaptations reveal about contemporary evolution? To address this question, the paper is organised around three thematic sections. The first examines how food and resource acquisition differs between urban and rural species. The second analyses the mechanisms by which urban animals manage stress differently from their wild counterparts. The third explores rapid behavioural changes observed in city-dwelling species. Each section draws on published scientific literature to trace patterns of urban adaptation across taxonomically diverse organisms.

2. Theme 1: Food and Resources in Cities

This section analyses differences in food and resource acquisition between urban and rural environments, focusing on two species: the American White Ibis (Eudocimus albus) and Common Ragweed (Ambrosia artemisiifolia).

2.1 The American White Ibis

Research by Skiff et al. (2018) found that provisioned human food comprised between 4% and 70% of the diet of the American White Ibis, with the highest proportion recorded at urban sites. By contrast, rural ibises maintained a strong preference for natural food sources such as fish and insects, with human handouts constituting less than 10% of their diet. Ibises with a higher consumption of human-provided food tended to exhibit poorer body condition overall. However, there were notable compensatory benefits: parasite loads fell by approximately 45% in urban ibises, likely due to reduced exposure to contaminated natural water sources. Additionally, the reduced effort required to obtain food in urban settings freed up time that birds could redirect towards grooming and preening, which may partially offset the nutritional disadvantages of a human-supplemented diet.

2.2 Common Ragweed

Martin et al. (2018) demonstrated that Common Ragweed populations in urban environments have evolved to flower earlier than their rural counterparts, a shift that increases their reproductive output. However, rural plants still demonstrated higher overall lifetime reproductive success, benefitting from more stable environmental conditions and fewer disturbances. Urban environments do offer ragweed a number of ecological advantages: cities contain a variety of small, marginal habitats- such as cracks in pavements, road verges, and parks- that rural landscapes do not provide. Furthermore, the reduced density of herbivores in urban areas means that ragweed faces less browsing pressure, allowing a greater proportion of plants to reach reproductive maturity.

Taken together, both species illustrate a consistent pattern: urban environments provide easier access to resources, but this often comes at the cost of overall health or lifetime fitness.

Urban species must be flexible and opportunistic to survive, even when the available resources are nutritionally suboptimal or ecologically unusual.

3. Theme 2: Tolerating City Stress

This section examines how urban animals manage the physiological and psychological stressors associated with city life, drawing on research into the Dark-eyed Junco (Junco hyemalis) and wild urban rodents.

3.1 The Dark-eyed Junco

Yeh et al. (2012) found that urban Dark-eyed Juncos exhibit markedly lower baseline stress levels than their wild counterparts- approximately 35% lower- as a result of habituation to humans and traffic. Their stress response was also reduced by roughly 50%, meaning that urban juncos do not enter a prolonged fight-or-flight state as readily as rural birds. This reduced reactivity allows urban juncos to devote more time and energy to essential activities such as foraging and reproduction. Behavioural evidence supports this interpretation: urban juncos allow humans to approach significantly closer before taking flight, indicating that they have learned to distinguish between potentially dangerous and non-threatening human presence.

Urban juncos also demonstrated greater exploratory boldness, investigating novel objects in less than half the time taken by their rural counterparts. Notably, urban nestlings raised near human trails had approximately 20% higher fledging success, suggesting that natural selection is actively favouring stress-tolerant individuals in city environments. The fact that these traits have emerged in urban junco populations that have existed for only approximately four to five generations underscores the speed and strength of urban natural selection. The primary physiological mechanism involved is the HPA axis- the body's central stress response system- with urban-adapted birds showing reduced HPA reactivity as a key fitness advantage.

3.2 Wild Urban Rodents

Gentle et al. (2021) investigated the stress responses of wild urban rodents by exposing them to olfactory cues from predators, specifically cat fur and possum fur. When exposed to cat fur, rats initially showed a decrease in activity and became more cautious; however, after a short interval, their activity levels returned to normal. They also moved more quickly in close proximity to the predator scent, but this heightened reactivity was transient. Measurements of faecal glucocorticoids- a reliable marker of physiological stress- revealed only a modest elevation compared to control conditions, with no substantial increase in corticosterone (CORT) levels. This indicates that, although the rats displayed mild behavioural wariness initially, they did not mount a strong physiological stress response.

Importantly, exposure to possum fur produced a broadly similar reaction, suggesting that urban rats have developed a generalised tolerance to a range of animal scents rather than a predator-specific response. This broad-spectrum habituation is adaptive in dense urban environments, where exposure to unfamiliar smells- from a wide range of both domestic and wild animals- is frequent and largely non-threatening.

4. Theme 3: Behaviour and Rapid Change

This section examines the behavioural changes observed in urban species, with a focus on the Common Blackbird (Turdus merula) and the urban pigeon (Columba livia).

4.1 The Common Blackbird

Dominoni et al. (2022) found that city blackbirds are significantly more active at night than their rural counterparts, with approximately 62.5% of their foraging occurring during nocturnal hours. This shift is largely attributed to the presence of artificial lighting, which extends the period of visibility beyond natural dusk. Nighttime activity increased by approximately 75% during summer months, when longer daylight hours bring greater levels of human activity and traffic, making daytime foraging less efficient. Male blackbirds in urban areas were also observed to begin singing earlier in the morning- a territorial behaviour- likely in response to competition for resources in denser populations.

Urban blackbirds that adopted nocturnal foraging strategies demonstrated better body condition and higher reproductive success, indicating that the ability to exploit artificially lit environments confers a direct fitness advantage. Rural blackbirds showed none of these patterns, remaining active exclusively from dawn to dusk. Chicks raised by urban parents showed similar temporal patterns of activity- remaining active later into the evening- a behaviour that appears to arise from a combination of social learning and genetic predisposition. These traits developed in urban blackbird populations within approximately three to five years of colonising city environments, a remarkably short timescale that reflects the intensity of urban selection pressures.

4.2 Urban Pigeons

Murilova et al. (2017) documented a range of urban adaptations in the Common Pigeon. Traffic noise in city environments regularly reaches approximately 80 dB- comparable to the sound level of a busy road- yet urban pigeons continue feeding undisturbed during peak traffic hours, demonstrating a high degree of acoustic habituation. Urban pigeons also exhibited significantly lower neophobia: their fear response to novel objects dropped by approximately 50% compared to rural individuals, enabling them to investigate and exploit new food sources rapidly rather than avoiding them. This flexibility is particularly advantageous in environments where food sources are unpredictable and constantly changing.

Like urban blackbirds, urban pigeons were observed to forage more frequently in artificially lit areas, suggesting a cross-species tendency to exploit extended light periods. Urban pigeons also reproduce more frequently than their rural counterparts, taking advantage of the continuous availability of food from human waste to breed outside of natural seasonal constraints. Their stress levels remain stable even in densely populated city environments, consistent with broader patterns of urban stress tolerance. Researchers tracking marked individuals found that when city infrastructure changed, pigeons adjusted their flight routes and foraging patterns within three to five days, demonstrating a high degree of behavioural flexibility and rapid cognitive adaptation.

5. Conclusion

Overall, this research shows that cities have a strong impact on how plants and animals live, many species exhibit similar adaptive responses. Even though the species studied are very different from one another, there are clear patterns that connect them.

One main trend is how urban species change the way they find food and resources. Animals like ibises and pigeons rely much more on food provided by humans, while plants like ragweed are able to grow in small spaces and reproduce faster. This shows that species in cities need to be flexible and take advantage of whatever resources are available, even if this sometimes leads to negative effects like poorer body condition.

Another important trend is how species deal with stress. Birds and rodents living in cities become more accustomed to things like noise, traffic, and human presence. Because of this, they do not react as strongly to stressors and are able to stay calmer. This helps them save energy and focus on important activities like finding food and reproducing.

A final trend is the change in behaviour. Many urban animals become less afraid of humans, more willing to explore new things, and in some cases active at different times — such as during the night. These changes can happen quite quickly, sometimes within just a few generations, showing how strong the effects of city environments are.

Overall, species that are successful in urban environments tend to be flexible, less sensitive to stress, and able to quickly change their behaviour to suit new conditions. Cities are not merely backdrops to evolution- they are among its most powerful contemporary drivers.

References

[1] Dominoni, D. M., et al. (2022). Urbanisation drives rapid shifts in activity timing of the blackbird (Turdus merula). Journal of Animal Ecology, 91(5), 987–998.
[2] Gentle, L. K., et al. (2021). Are physiological and behavioural responses to stressors displayed concordantly by wild urban rodents? Journal of Comparative Physiology A, 207(1), 1–12.
[3] Martin, R. A., et al. (2018). Little plant, big city: A test of adaptation to urban environments in common ragweed (Ambrosia artemisiifolia). Proceedings of the Royal Society B: Biological Sciences, 285(1882), 20180627.
[4] Murilova, K., Atanasova, M., & Koshev, Y. (2017). Dietary habits of urban pigeons (Columba livia) and implications of a chronic stress model. European Journal of Ecology, 13(1–2), 32–42.
[5] Skiff, E. Y., Brawn, J. D., & Moore, I. T. (2018). Shifts in diet and condition with provisioning for a recently urbanised wading bird, the American white ibis (Eudocimus albus). Philosophical Transactions of the Royal Society B: Biological Sciences, 373(1742), 20170287.
[6] Yeh, P. J., Brawn, J. D., & Bonier, F. (2012). Boldness behaviour and stress physiology in a novel urban environment. Behavioral Ecology, 23(5), 960–967.