

# ***Birds on the Edge: Urban Transport Infrastructure and Its Toll on Avian Communities***

**Haoyuan Xie**

*Guangzhou Dublin International College, South China Agriculture University, Guangzhou, China  
hnxhy@stu.scau.edu.cn*

**Abstract:** The global expansion of transport infrastructure—such as roads, highways, and railways—has emerged as a hallmark of urbanization, enabling economic development while posing significant ecological risks. Birds, as sensitive environmental indicators, are among the most affected wildlife groups, facing habitat fragmentation, behavioral disruption, noise pollution, and accidental mortality. This paper synthesizes findings from highly urbanized countries, including China, France, Italy, and Brazil, to explore how transport infrastructure affects urban bird populations. Key impacts include habitat loss and fragmentation, with certain species like the little bustard experiencing a 60% population decline near high-speed railways. Noise pollution disrupts communication and breeding, especially in vocal species such as the European robin. Behavioral changes in foraging and nesting patterns are observed, with some raptors and omnivorous birds adapting to exploit human-modified environments. However, increased bird mortality from vehicle collisions remains a pressing concern. The study highlights regional disparities in mitigation strategies, noting that while Europe has implemented measures like sound barriers and green corridors, other areas lag behind. To address these gaps, the paper proposes tailored, context-specific solutions that enhance habitat connectivity, reduce noise interference, and integrate modern monitoring tools. By offering a comprehensive overview and practical recommendations, this research underscores the urgency of reconciling infrastructure development with biodiversity conservation, ultimately supporting more sustainable urban ecosystem.

**Keywords:** Traffic infrastructure, urbanization, birds, wildlife conservation.

## **1. Introduction**

The rapid expansion of transport infrastructure, including roads, highways, and railways, has become a signature of urbanization worldwide. While these facilities promote human mobility and economic growth, they also cause ecological consequences that cannot be ignored, particularly for avian population. Birds, as sensitive indicators of environmental change, and profoundly affected by habitat fragmentation, noise pollution, behavioral disruptions, and accidental mortality caused by transport infrastructure. With an estimated 1.75 billion neo-urbanites anticipated by 2030, the pressure on the city ecosystem is expected to intensify, therefore it is necessary to understand and mitigate the negative impacts generated by traffic facility expansion [1].

Globally, research has highlighted the multifaceted effects of transport infrastructure on birds. Studies from highly urbanized countries reveal that habitat loss and fragmentation are among the most significant threats to bird biodiversity [2]. For instance, the construction of high-speed railways

in France has led to a 60% decline in the abundance of female little bustards within a 775-meter zone around the infrastructure [3]. Noise pollution from busy highways, such as Italy's A1 highway, disrupts bird communication and reproduction behaviors, particularly for vocal species like the European robin [4]. Conversely, some species, like omnivorous birds and raptors, exploit transport infrastructure for foraging, demonstrating the complexity of these interactions [5, 6]. However, regional disparities in research and mitigation strategies persist. While Europe and North America have advanced in implementing measures like soundproof panels and wildlife corridors, other regions, including parts of Asia and South America, are still developing context-specific solutions.

This article mainly summarizes the research of countries with high levels of urbanization (mainly from Brazil, China, France, Italy, Poland, Spain, and the United Kingdom), whose urban ecosystems are completely orderly and their transportation infrastructure includes a large amount of transportation. At the same time, it includes different vegetation coverage standards and different environmental conditions (forest roads and urban roads with low plant density). This review integrates current knowledge on the impact of transportation infrastructure on birds, evaluates existing conservation measures, and proposes recommendations for balancing infrastructure development with bird protection. By integrating global insights, this article aims to provide information for policymakers and researchers to promote sustainable coexistence between urbanization and biodiversity. This study employed various evaluation methods, including field surveys of bird mortality rates, behavioral studies on disrupted migration patterns, and spatial modeling of habitat connectivity. The survey further examined real-world case studies, comparing harmful infrastructure impacts with successful mitigation methods such as wildlife crossing and acoustic retrofitting.

These findings inform an evaluation of practical mitigation strategies, ranging from structural solutions to policy interventions, all aimed at reconciling urban development with avian conservation. Ultimately, this research translates scientific insights into actionable policy recommendations for bird-friendly urban design, emphasizing the need for adaptive management and public engagement. By bridging ecological research with urban planning imperatives, our framework seeks to foster sustainable infrastructure development that safeguards avian biodiversity while accommodating societal needs, with future research directions identified to address emerging challenges in this evolving field.

## **2. The multiple effects of transportation infrastructure on birds**

### **2.1. Relationship between transport infrastructure and birds**

During the last century, human societies have experienced enormous development. The increasing level of urbanization has caused great changes to the original ecological environment. Approximately 1.75 billion neo-urbanites are estimated to enter cities no later than 2030 worldwide, and nearly half of the increase occurs in cities that have no more than 500,000 people [1]. Under this scenario, more transport infrastructure needs to be constructed to fulfill the traffic demand of the growing city. Most of the time, roads and highways, no matter whether urban or suburban, would worsen habitat loss and fragmentation, which is considered a main factor of loss in biodiversity [2]. Additionally, busy traffic also gives rise to noise and the accidental killing of animals.

Birds are common in both urban and suburban. However, they are largely affected by human activities. For example, threats occur to farmland birds in Western Europe due to land artificialization, which is considered the second-largest reason for their shrinking population [3]. Because of the sensitivity to environmental changes, birds are important indicators of how infrastructure expansion affects the local environment. Transportation infrastructure has affected urban birds in many ways, including changing their habitats, acting as a noise source.

## 2.2. The effects of transportation infrastructure on birds

### 2.2.1. The effect of transportation infrastructure on urban birds by altering habitats

The influence that transport infrastructure has on bird habitat may occur throughout the construction of the traffic line, and last for years. A high-speed railway (HSR) line in France began to be built in 2013 and took a total of 4 years to complete. It goes through a specially protected breeding area for female little bustards. The special protected area is separated into several small, disconnected fragments by urban areas. A study showed that the changes in the area of favorable nesting habitats for little bustards varied along with different periods of the HSR construction and the distance to the HSR [3]. A special method that focuses on the variation of time and distance was adopted by the researchers. It indicated that the favorable nesting habitats for little bustards showed a V-shape variation in 3 stages of the HSR construction (before construction, the year 2012, 0.42% of the study area; during construction, the year 2016, 0.22%; after construction, the year 2020, 0.44%). Meanwhile, the female little bustard abundance strongly decreased in proximity to the HSR and reduced by about 60% in a 775m zone around the HSR.

Detailed research offered a more precise understanding of these effects, considering the type of road, environmental effects, and feeding guild association [6]. Results showed that negative effects of roads are often related to highly-frequented roads with higher original tree cover. The reason for this could be explained by bird species in such a low-artificialization environment cannot adapt to sharp changes in the original habitats, due to the road effects being less significant in habitats with more open space at the beginning. It is interesting to introduce foraging to the consideration of road effects on birds. Svenja et al. found that roads positively impacted omnivorous birds [6]. These omnivorous birds, for example, ravens (*Corvus corax*), are capable of adjusting their diets to varying environments, hence they can make full use of the sources in habitats. However, the sample size was so small that contingency could happen. In spite of this, a new research idea could be proposed, that is to say, the research could be focused on the exact species of birds that own different habits.

### 2.2.2. The effect of transportation infrastructure as a noise source on birds

Noise is expected to expel birds, especially for those who are more vocalized, and those who are in breeding seasons. Species density declines when getting closer to the origin of noise pollution [4]. The research site was near the A1, which is one of the highways with the largest traffic in Italy. Research data indicated bird abundance grows along with the trend getting distant from the origin of disturbance, and the peak occurred in the center of the research site. For birds that vocalize more, getting faraway from noise sources benefits their correct communication for behaviors like escaping from predators, and consequently with their reproduction strategies. For example, the European robin (*Erithacus rubecula*) shows higher frequency in moving away from the noise sources and changing their singing when exposed to a high background noise environment. The influence is stronger on breeding birds because of the need to complete their breeding cycle when the higher frequency of singing conveys information like meeting mates, defending territory, and parent-offspring communication. One possible reason for this is, that more energy is cost to support higher volume and higher frequency of singing, hence birds are supposed to consume more food, then rising numbers of foraging occurs [7]. This mechanism indirectly increases birds' risk of facing predators and accidental kill.

### 2.2.3. The effect of transportation infrastructure on birds by changing behavior

#### 2.2.3.1. Foraging behavior

Birds are facing new challenges because of the growth of transport infrastructure. In order to avoid being eliminated by the changing environment, birds need quick response to harness their niche, which requires birds to change their consistent behaviours [8]. Despite transport infrastructure adversely affecting birds in general, some positive impacts emerge due to the existence of traffic lines. Bird population growth of some species was observed in the United Kingdom [9]. Sophia et al. tested 75 species in the UK, and 19% of these species were positively affected by the traffic lines near the research sites [9]. The reasons for the increases could be, birds being attracted to the surface of the road to seek food, gravel, or warmth. This hypothesis is proved in the later research. Pawel et al. mentioned that transport infrastructure offered an open foraging site for birds like common buzzards (*Buteo buteo*), black kites (*Milvus migrans*), and kestrels (*Falco tinnunculus*) [5]. The phenomenon is more significant in winter, as the snow cover on the road surface is thinner than other foraging sites, and road kill to other birds offers more opportunities to gain food. Pawel et al. carried out their research in north-eastern Poland, finding out that buzzards would spend more time foraging along the expressway than in the farmland, and they are more likely to frequently change their hunting sites along the traffic lines instead of in farmland [5]. This could be explained in the perspective of different energy outputs for hunting in farmland and traffic lines. The farmland landscape provided single trees and offer high sites, while either side of the traffic line were equipped with fences, offering medium-height sites. When hunting from the medium-height site, buzzards were able to gain a better view of roadsides with its low vegetation, and rapid reflection for the prey. Considering these characteristics, using expressways as foraging sites reduces buzzards' energy spent on hunting to a minimal level. This is especially helpful in winter, when more energy should be used to defend against low temperatures, alternatively, birds may die of hypothermia.

For those omnivorous birds who have smaller body sizes, for example, corvids (*Corvidae*), starlings (*Sturnidae*), and thrushes (*Dumetella Carolinensis*), green areas aside from the traffic line are good foraging sites with few pedestrians and wind proof performance. Additionally, some extra sources of food are available on these sites. For example, passengers may feed jackdaws (*Corvus monedula*) and feral pigeons (*Columbidae*), and litter that is left by passengers could also sources of food [10].

#### 2.2.3.2. Nesting behavior

Nesting behaviour is one of the determining factors for whether birds can flourish in the environment [11]. A study reported that birds with larger bodies in urban tend to exploit higher trees for nesting [11]. This is partly because this vegetation provides abundant food (fruits, flowers, and insects) and nesting resources for birds. This is able to help them escape from noises. Those with smaller bodies, tend to occupy lower green belts surrounding the streets, which also defend them from predators. The mechanism behind changes in nesting behavior is complex. It is interwoven with factors like food sources, noise, habitat connectivity, vegetation density, et al [7, 11, 12]. Unexpected consequences in migratory birds were also reported in China, indicating that migratory birds may be blocked from their nesting sites due to the construction of the highways, and further prevent them from completing the breeding cycle [7, 12].

### 2.2.4. Transport infrastructure affects birds by accidentally killing birds

Birds are under increasing pressure from accidental killing caused by roads and railways [13]. Clara et al. carried out research in Europe, and reviewed the higher rate of road collision in birds [13]. More

than 100,000 birds are projected to be killed by traffic, ranging in about 10% of Europe. Factors that contribute to the increasing roadkill rate include body weight, population density, life expectancy, and age of maturity. Research in Spain counted 66 railway trips and found that the mortality of birds was estimated at 60.5 birds per km per year and 26.1 birds per km per year on two different sections of the railway [14]. The delayed reaction, along with the restricted capacity of birds to make their response in the face of high-speed trains was an explanation for these accidental kills.

### **3. Recommendations of traffic construction based on bird protection**

#### **3.1. Moderate bird conservation practices**

Although there are multiple adverse consequences that traffic facilities have on birds, it should be noticed that birds are highly active animals. Compared to other terrestrial vertebrates, birds show higher dispersal activity, therefore the traffic effects may not be as serious as predicted and hence the exact practices are supposed to be formulated according to the specific situation in the region, instead of copying experience of other regions or taking overprotective measures, and it is irresponsible to ignore the necessity of bird protection [8].

#### **3.2. Possible ways to protect birds**

##### **3.2.1. Increasing bird habitat connectivity in various approaches**

Since habitat loss and disconnection are the most important contributors to bird biodiversity loss, more efforts need to be put into these fields, especially in regions that are rarely disturbed by infrastructure in the original environment [2, 3, 6, 15]. Simple methods include setting slow sign and animal passages [12]. An interesting practice from Brazil is to implement a temporary ban on the streets. This aims to provide recreational and leisure courts for citizens, yet the birds also benefit from the closing time: 86 species of birds are observed in a 14km range traffic line during every Sunday's highway closing time [11].

##### **3.2.2. Equipping anti-noise equipment alongside the infrastructures**

Considering the negative effects that noises have on birds, it is necessary to set up anti-noise equipment like soundproof panels alongside the traffic lines. As noted by Ester et al., anti-noise panels are able to attenuate noise pollution of 5-15dB, which represents a large scale of diminishing on hearing as the decibel scale is calculated in logarithm form [4]. An extra benefit that the panels bring about is to mitigate visual stimulation from the traffic, since the street lights and car headlights are also altering birds [7]. This would help birds to travel between different habitats, and exploit the available sources better.

##### **3.2.3. Developing different mathematic models to evaluate regional traffic effects**

Based on the recorded data, Ana et al. developed "a form of dose-effect relationship" aiming to calculate the region's sensitivity to the traffic construction [15]. This provides an idea to combine the previous documents with modern technology (e.g. the Geographic Information System, GIS) to create a database, and help to monitor bird activity. The data collected and analyzed by the database could be provided to researchers and policymakers to support further research and make adaptive countermeasures.

## 4. Conclusion

Transport infrastructure represents a fundamental component of contemporary urban development, yet it simultaneously poses significant threats to urban biodiversity, particularly to bird populations. As cities continue to expand and integrate complex networks of roads, highways, and railways, the ecological consequences for avian communities have become increasingly pronounced. This paper consolidates current knowledge on the multifaceted impacts of transport infrastructure—such as habitat fragmentation, noise pollution, behavioral alterations, and elevated mortality—highlighting both the breadth and depth of these challenges across diverse global contexts. The research underscores the ecological significance of urban birds as sensitive bioindicators, whose responses can reflect broader environmental changes. By examining case studies from countries including China, France, Italy, and Brazil, this study reveals both universal patterns and region-specific outcomes, providing a valuable comparative framework. Moreover, it identifies and evaluates a range of mitigation strategies, from green corridors and acoustic barriers to species-specific behavioral adaptations, emphasizing the necessity of context-sensitive, interdisciplinary approaches to urban planning and conservation. However, the study is not without limitations. Data heterogeneity across regions and inconsistent monitoring efforts together limits the scope of cross-comparative analyses. Furthermore, the current review primarily focuses on direct impacts, such as noise and collision mortality, and does not fully explore the interactions with factors like climate change, pollution, and invasive species, which may exacerbate the vulnerability of urban bird populations. Future research should prioritize long-term, multi-scalar studies employing advanced technologies such as remote sensing, bioacoustics, and GPS tracking to capture dynamic species responses over time. Investigations into taxon-specific sensitivities and adaptive capacities will also be critical for developing more effective conservation strategies. Importantly, fostering collaboration among ecologists, urban planners, engineers, and policymakers is essential to integrate ecological principles into infrastructure design from the outset. In conclusion, reconciling the demands of transport infrastructure development with the imperative of biodiversity conservation remains a central challenge of sustainable urbanization. This study contributes to a growing body of literature advocating for ecologically informed planning, and it offers a foundation for future efforts aimed at promoting coexistence between human development and urban wildlife. As cities continue to grow, embedding conservation within the framework of infrastructure design will be vital to ensuring the resilience and ecological integrity of urban ecosystems.

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