

Adaptive Strategies for Bird Survival in Modern Cities

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Abstract: With the acceleration of global urbanization and the expansion of urban environments, the living environment of birds has undergone significant changes. The relationship between birds and urban environment has become an important field of ecological research. Factors such as transportation facilities, noise, and artificial light in cities have affected the diversity, behavior, reproduction, and survival of birds in many ways. This paper focuses on the ecological changes of birds in urban environments and explores the physiological and behavioral changes of birds in cities, the differences in bird species adapting to urban environments, and the survival mechanisms of different bird species in cities. It was found that some birds were able to adapt to urban life by changing their behaviors and utilizing urban resources, while others faced survival challenges. Different bird species coexist in the city through ecological niche differentiation, and their ecological status is relatively affected by changes in the urban environment. This study contributes to an in-depth understanding of the roles and functions of birds in urban ecosystems, provides a theoretical basis for urban biodiversity conservation, and also provides scientific guidance for urban planning and ecological construction in order to realize the harmonious coexistence of cities and birds.

Keywords: Human factors, impacts, urban, ecological

1. Introduction

Looking around the world, urbanization today is growing rapidly at an alarming rate. According to relevant projections, 68% of the world's population will live in cities by 2050. This trend of change is slowly altering wild ecological development. As the main living environment for human beings, it is natural for cities to have fewer opportunities to connect with wildlife. In addition to providing convenience for humans, urbanization has also had a profound impact on biodiversity, and birds are one of the groups of organisms most affected by urbanization.

As one of the important components of the ecosystem, birds make a significant contribution to maintaining the ecology, promoting material circulation and providing abundant nutrients. However, with the rapid development of cities leading to changes in food resources, noise pollution, environmental pollution, artificial light interference, habitat destruction, etc., the living space for birds has been drastically reduced, which poses a great challenge to the survival and reproduction of birds. Therefore, it has become a crucial topic to study how the urban environment affects birds. With the current literature, modern professional teams are focusing on the stage of studying the impacts of cities on birds, such as the behavior, physiological changes and diversity changes of birds[1].

The motivation for doing this dissertation research is to make more people aware of the extent of the harm that urbanization is causing to birds, so that the living space for birds in the city can be better preserved. In the selected literature, the following research methods were mainly used: literature review, field survey, laboratory experiment, Geographic Information System (GIS) technology survey, modeling analysis and so on.

2. Impacts of the urban environment on birds

As one of the largest habitats for human and bird coexistence, cities are affected by artificial structures such as noise, artificial light, traffic, and construction sites. Firstly, various types of noise in cities are important factors affecting the survival of birds. Due to the increase in the number of motor vehicles, traffic noise has become the main source of noise in urban residential areas; Industrial noise refers to factory production noise and construction noise. The two have formed a complex noise environment, which not only affects the quality of life of local residents but also has a significant impact on the survival and reproduction of birds. For example, birds seriously lack information about the location of their prey because of urban noise, making it more difficult for them to catch their prey. At the same time, a large amount of noise also affects the singing time of birds, which indirectly affects the reproductive rhythm and living condition of birds [1].

Secondly, according to surveys, in environments with different artificial light intensities, as the light intensity increases, the duration of some bird songs will shorten, while the frequency of their songs will increase, that is, the pitch will increase. For example, the research team discovered a strong and unique connection between the songs of crested ibis and artificial light at night through detailed recording and analysis of their songs. In areas with more artificial light at night, their songs are shorter and have higher tones. This raises the bird's daily energy loss, causing it to spend more time searching for food. Artificial light can also affect the birds' motivation during the breeding season, reducing reproduction rates [2].

Thirdly, the development of transportation infrastructure is recognized as one of the key drivers of global biodiversity loss. With the increase in traffic flows and the expansion of infrastructure networks on a global scale, pressures on biodiversity are expected to continue to increase in the coming decades. Transportation collisions with birds, the expansion of roads, and polluting gases from road construction all affect the biodiversity of surrounding birds. Transportation infrastructure development is one of the major causes of global biodiversity loss, and studies have shown that bird populations within 1 km of large infrastructures decrease by an average of 20%. Of the 538 SPAs in Sweden, 63% are at least partially and 23% are mostly located in impacted areas; the total area affected is 126,000 ha, which is 4.2% of the total SPA area in the country. There were large variations by biogeographic region, with more severe impacts in the southern (continental) and coastal regions, where 25.8% of the SPA area was located within the impact zone, and where bird populations were predicted to be reduced by 4 - 7%. Birds will be an important indicator in determining their significant impact. The team's investigation of bird conservation in Sweden's Special Protection Areas (SPAs) showed that road and railroad construction, collisions with moving vehicles or aircraft, physical barriers between ecological zones created by roads, and the diffusion of hazardous substances into the environment from vehicle exhaust and factory emissions are the main causes of the decline in bird populations due to transportation and factory construction [3].

3. Changes in natural habitats of birds

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4. Birds' adaptive strategies to these changes

4.1. Changes in birds' foraging time

It was found that urban bird diversity decreased with increasing urbanization, and in highly urbanized areas, bird species richness decreased by about 30% - 50% compared to natural areas. Meanwhile, there was a positive correlation between tree diversity and predation attempts on artificial prey, with birds making 20% - 30% more predation attempts on artificial prey in urban areas with high tree diversity than in areas with low tree diversity. It can be indirectly inferred that when bird diversity decreases and the distribution of food resources changes, birds will adjust their foraging time in order to obtain sufficient food. For example, in areas with reduced food resources, birds may spend time resting or doing other activities to forage for food, increasing the length of time spent foraging, possibly from 4 - 5 hours to 6 - 7 hours per day [4].

Artificial light pollution can also affect the amount of time birds spend foraging. For every 10 lux increase in light intensity, the onset of dawn singing in blackbirds was advanced by an average of 3 - 8 minutes. Since singing and foraging behaviors are closely related, foraging time may be advanced when singing time is advanced, e.g., a blackbird that would otherwise start foraging 30 - 40 minutes after singing may start foraging 20 - 30 minutes after singing in order to replenish the missing energy for the next activity and song [5].

An experiment was conducted with Purple Cliff Swallow chicks, which were exposed to green or white LED light (5 lux) from hatching to nest departure, with a control group of natural ambient light. Results showed that chicks exposed to white light weighed about 5 - 10 g more than controls at 20 or 22 days of age. Nest departure was delayed by 1.54 ± 0.37 days (95% confidence interval 0.80 - 2.28), and the date of departure from the roost was 2.84 ± 1.00 days (95% confidence interval 0.88 - 4.81) later than in the control group. From the changes in chick growth and development and activity time, it can be hypothesized that foraging time may have been affected. For example, the delay in nest departure resulted in a longer foraging time in the nest, and what was originally 3-4 times per day in the nest for 15-20 minutes per session may have increased to 4-5 times per day for 20-25 minutes per session in order to satisfy the energy requirements of their growth and development[6]. Thus, it is evident that the main reason for birds to change their foraging time is the need to find food in time to meet their energy requirements for the day, but factors such as artificial light sources and anthropogenic hunting are having a slow impact.

4.2. Changes in bird singing

In terms of bird behavior, the investigation found that European blackbirds sang significantly earlier under the synergistic effect of noise and artificial light. The combined effect of noise and light pollution was most pronounced at the beginning of the breeding season, i.e., as noise intensity increased, the effect of light pollution on European blackbirds became more pronounced. It was noted that the effect of light pollution on the onset of blackbird singing was 1.5 times stronger in areas with 70 dB noise compared to areas with 50 dB noise and was more pronounced at the end of the season when the effect was elevated to 3.8 times[5]. Meanwhile, certain birds have increased their singing amplitude and frequency in response to complex noise environments. A related study found that the minimum frequency of the song of the White Crested Bunting in San Francisco, U.S.A., increased between 1969 and 2005 because of increasing traffic noise. In addition, some birds are also called

earlier, such as the thrush in the city center of Leipzig, Germany, which is called five hours earlier than the thrush in nature to avoid the peak noise hours[1].

Artificial light sources can also affect bird song. For example, a team of researchers studying the Vireo found that an increase in artificial light significantly increased the pitch of the Vireo's song when the environment was low in noise (43-54 dB [A]) and low in temperature (12-15°C). The positive effect of artificial light on song pitch was also more pronounced during periods close to the new moon, when moonlight is less disruptive to ambient nighttime light, making artificial light a key factor in the song of the Vermilion Pachyderm[7]. They adapted to this change in light by increasing their pitch. These phenomena suggest that birds are making adaptive changes to urban life, but such changes may also bring potential problems such as high energy loss[8].

4.3. Changes in stationing in the city

Ecologically, factors such as noise during urbanization have led to some functional traits receiving negative impressions and altering the structure of bird communities. The number of noise-sensitive bird species decreases, while the relative increase of species with better adaptive ability reduces the species diversity of bird communities. In terms of foraging behavior, urban noise interferes with birds' search for food. As noise masks the acoustic cues emitted by prey, it is difficult for birds to accurately perceive the location of food, making it more difficult for urban chicks to obtain food and affecting their survival and growth [9].

5. Physiological adaptations

5.1. Evolution of traits adapted to inner cities

First, birds become bolder. Some birds that were originally more wary of humans and vehicles become accustomed to human activities and traffic noise in urban environments and become more tolerant of humans and vehicles. They will forage and nest closer to human settlements and traffic roads, no longer avoiding them as readily as they would in their natural environment. Second, birds may gradually evolve their auditory systems in response to noise disturbances in cities, increasing their sensitivity to specific frequencies of sound in order to better communicate and forage in noisy urban environments. The type and quality of food in urban environments are different from those in natural environments, and the digestive systems of some birds may also undergo adaptive changes to better digest food in cities, for example, the digestive system of birds to food scraps discarded by human beings or the fruits of artificially grown plants in cities. Third, urban birds have changed the way they select and utilize habitats. They are no longer limited to traditional natural habitats, but are able to utilize artificial buildings, parks, green spaces and other environments in cities. For example, some birds, such as sparrows, build their nests under the eaves of houses, which protects them from storms, increases their height to avoid predators, and improves the survival rate of their young[1].

5.2. Changes in body structure

Physiologically, noise, as a stressor, affects the stress response of birds, while plasma corticosterone hormone (CORT) is secreted level is an important indicator of the reproductive aggressiveness of birds. Elevated levels of CORT inhibit the secretion and release of gonadal hormones, leading to slow gonadal development, affecting the maturation of gametes, and decreasing the ability to reproduce in birds. High levels of CORT can even make birds less interested in breeding activities and reduce behaviors such as courtship and nesting. In addition, fluctuations in CORT levels may also affect behaviors such as bird brooding, leading to reduced parental care of chicks, which in turn affects chick survival[10].

Regarding the impacts of artificial lighting on urban birds, physiologically, the survey team investigated six urban bird species (American crow, North American woodpecker, house sparrow, red-tailed hawk, great horned owl, and American mockingbird). Dark-light vision was estimated by measuring the eye geometry of the specimens, i.e., using the inner diameter of the scleral ring to reflect the size of the cornea, measuring the distance from a specific point on the orbital rim to the contralateral point as the transverse diameter, and calculating the ratio of the corneal diameter to the transverse diameter. In terms of the role of artificial light on bird physiology, over the past 75 - 100 years, dark light vision has tended to increase in house sparrows and great horned owls, while it has decreased in red-tailed hawks and American crows. These results suggest that artificial light may act as a natural selection on the sensory abilities of urban birds. Different bird species responded differently to artificial light and thus underwent adaptive changes. For example, the increase in dark-light vision in House Sparrows and Great Horned Owls may be due to better adaptation to nocturnal activities in artificial light environments, while the decrease in dark-light vision in Red-tailed Hawks and American Crows may be due to ecological niches that do not require enhanced dark-light vision[8].

6. Conclusion

In the era of rapid urban development, the complex relationship between birds and the urban environment has become a key topic of ecological research. In this study, we analyzed the ecological performance of birds in urban areas. It was found that the adaptive ability of different bird species to the urban environment varied significantly. Some birds with high disturbance tolerance and good use of artificial resources, such as sparrows and pigeons, were relatively stable or increased in number in the city, indicating that these birds are good at making behavioral and physiological adaptations in time to cope with the consequences of urban expansion, and that they are capable of surviving in the city in the future, while some birds that are very demanding in terms of habitat and food are faced with a complex relationship with the urban environment, which has become a key issue in ecological research. On the other hand, some birds that are very demanding on habitat and food are facing problems such as habitat loss, food shortage, diversity reduction, etc., and their populations are declining significantly, which indicates that these birds are not good at surviving in cities, and they will have serious impacts in the context of future urbanization and expansion, which will have an impact on the biosphere. At the same time, different bird species can effectively reduce interspecific competition and achieve coexistence in urban areas through ecological niche differentiation and differences in foraging, nesting and activity time. This paper helps us to understand the survival conditions and mechanisms of birds in urban ecosystems, and provides a scientific basis for urban biodiversity conservation. However, there are some limitations in this paper, such as some of the studies did not fully consider the synergistic effects of multiple environmental factors, the studies on some rare birds and new birds in the city were not comprehensive and in-depth enough, and they lacked future prediction, and their understanding of their needs and challenges in urban environments was limited. In the future, we can focus on the adaptation strategies of birds under the influence of multiple factors to strengthen the protection of urban birds, and we should explore how to optimize urban planning to create a more favorable urban ecological environment for the survival and reproduction of birds, and promote the conservation and development of urban biodiversity.

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