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Predicting and Customizing Development of Bird-Building Collision Prevention Measures in China Based on Research in North America

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Abstract:

With the development of urbanization, bird collisions with buildings have become increasingly frequent, resulting in significant bird deaths worldwide each year. In North America, hundreds of millions of birds die annually from collisions with buildings. The risks posed by building collisions have already jeopardized bird species diversity. Bird collisions are particularly common during migratory periods. Fatalities from bird-window collisions have a significant impact on ecosystems. Researchers in North America have conducted extensive research and experimentally validated bird collision prevention measures in various regions, which can effectively reduce avian mortality rates from collisions with buildings. While precise national statistics are lacking in China, existing research indicates that a significant number of birds also die from collisions with buildings. However, relevant research is limited in China and there is a lack of effective mitigation strategies. Therefore, this paper aims to develop bird collisions prevention measures applicable to Chinese avian populations, drawing on existing research on bird collisions in North America and incorporating it into existing research in China.

Keywords: Bird-building collision; bird-window collision; avian ecology; avian conservation.

1. Introduction

Bird collisions represent a significant anthropogenic threat to avian populations. The issue of bird strikes is severe on a global scale. In North America alone, over one billion birds die annually due to collisions with human-made structures [1]. During flight, birds often struggle to detect and avoid obstacles due to their limited visual field and relatively low visual resolution [2]. Some factors can have an impact on bird collisions, for example, species, weather and seasonality, surroundings and types of construction

[1]. The risks posed by bird-building collisions impact the bird species diversity, huge migratory bird species and endangered species died from bird collisions [2]. Large numbers of birds dying from bird collisions will disrupt the ecological balance.

North America has the most papers on bird collision prevention in the world [3]. Bird-friendly windows reduce the chance of bird collisions by the patterns on the windows [4]. Birds are attracted to artificial lights at night, leading to bird collision. Using blinking lights and red lights can reduce the attraction of birds and thus reduce bird strikes [5]. These bird collision prevention measures implemented in North America have effectively mitigated the incidence of bird collisions.

China occupies a critically important position along the East Asian-Australasian Flyway, supporting vast populations of migratory birds. The country's rapid urbanization has led to the extensive use of glass facades and severe levels of light pollution at night. These factors are likely to exacerbate bird collision risks. However, research on bird strikes in China remains extremely limited, with only a handful of studies addressing this issue [3]. This illustrates that currently China do not put their focus on the study of bird collision and how to prevent such incidents, showing a missing space for further study.

Therefore, the factors associated with bird-building collisions will be examined. The analysis will consider collision prevention measures proposed by North American studies alongside existing research on bird collision prevention in China. This examination aims to project future developments in bird collision mitigation strategies for China and to propose specific measures for future implementation.

2. Factors Influencing Bird-Building Collisions

In the background of global urbanization, fatalities of bird populations caused by collisions with human-made structures have witnessed a dramatic increase. Among all the artificial structures, collisions with buildings are the most common and serious cases of avian mortality from collisions [1]. Collisions happen due to the inability of birds to recognize and avoid certain obstacles, especially reflective and transparent surfaces. Birds fly directly towards and then collide with the windows. Various factors that affect bird-building collisions have been investigated in the last few decades. Given that certain natural factors such as season, migratory flyways and species can never be altered, we focus exclusively on the impact of anthropogenic factors that can be mitigated by prevention measures.

2.1 Building Features

As the main size-related factor, building height significantly contributes to the frequency of bird-building collisions [1]. It has been proved that bird-building collisions occur more frequently on high-rise buildings exceeding four stories than on low-rise residential buildings. Except for building height, Riding et al. conducted an experiment to investigate the impact of the height, length and shape of the exterior surfaces of buildings [6]. The experiment showed that exterior surfaces with larger areas or concave shapes are more likely to cause bird-building collisions. Furthermore, the effect of building size is underestimated as it is inversely proportional to the degree of urbanization. Bird-building collision mortality is strongly corelated with an interaction effect between building size and regional urbanization [3].

2.2 Artificial Lighting

Artificial lighting in urban areas leads to most cases of birds colliding with buildings at night. The area of windows lighted and proportion of glass lighted are two crucial variables that affect bird-building collisions [7]. Artificial lighting is highly attractive to migrating birds and can change the behavior of birds, causing deviation of the original direction they were flying. The experiment carried out by concluded that Illuminated structures tend to attract migrating birds at night, especially under adverse weather conditions that limit navigational abilities [5].

2.3 Window Features

Windows are the direct causes of avian fatalities from collisions with buildings. The proportion of glass area has a positive effect to the colliding frequency [1,8]. Larger amounts of glass exposed to the surroundings lead to an increase in reflected images, which confuses the bird and causes collision. The lighting area of a building also depends on its glass area during nighttime [7]. Besides, glass type affects the likelihood of birds colliding with buildings as well.

2.4 Surrounding Vegetation and Greenspaces

In the visions of birds, it is the surrounding environment of the building reflected by the glass that causes collisions with the building. The study of Gelb & Delacretaz have found that birds collide most frequently with the parts of the glass surface that reflect vegetation outside the building [8]. Bird-building collisions are influenced by the development in the immediate vicinity of a building instead of the distance to vegetated areas. The vegetation within 50 meters from the building significantly affect the number of colliding individuals [1].

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3. Measures to Prevent Bird-Building Collisions Based on Studies in North America

Field research and experiments conducted in the United States and Canada have informed the development of prevention measures. Many North American cities have employed a range of strategies to prevent bird-building collisions. There are also some proposed measures that have not yet been translated into practical application. These measures can be categorized into two types: the first involves retrofitting existing buildings, and the second focuses on introducing new bird-friendly designs to the buildings yet to be constructed.

3.1 Treatments for Existing Buildings

3.1.1 Window Marking

Window marking is the most representative short-term measure to prevent bird-building collisions, different types of visual markers help birds to detect glass and avoid collisions. Marking can be either stripes or dots with different directions, sizes and colors. Rössler et al. have carried out experiments to test more types of markers with different patterns and shapes, which were all shown to be resultful [4]. Due to the low cost and high efficacy, window markers were first adopted on buildings with a high risk of bird collisions.

3.1.2 Ultraviolet (UV) signals

The use of UV signals is by far the most doable solution by maintaining the visual properties humans desire while converting clear and reflective panes into detectable barriers for birds to avoid. UV signals are used in the form of alternating UV-reflecting and UV-absorbing elements separated by the same intervals. Noticing that the UV signals used for deterrence to birds should emit or reflect light across the 300 -400 nm wavelength spectrum [9].

3.2 Bird-friendly Designs for New Buildings

The simplest design to reduce bird-building collisions is to avoid the anthropogenic factors listed above. For instance, the use of reflective and transparent glass was minimized in the design of Fiserv Forum basketball arena in Milwaukee, Wisconsin to reduce bird collisions. One-way external films are also effective examples which have been applied on both residential and commercial buildings. For some new buildings, windows are suggested to be installed at an angle to reflect the ground instead of the surrounding environment. Nighttime light emission and vegetation close to the glass surfaces should be reduced as well [1].

There have also been several proposed long-term solutions aimed at eradicating bird-building collision issues. To improve the artificial lighting at night, continuous light is to be replaced by blinking light and red light should be applied in the scenario that continuous light is required [5]. An audible sound field is to be introduced to slow down the birds from a surface that they are unable to detect [10].

4 Current Status of Bird-Building Collisions in China

China is situated at the core section of the East Asian-Australasian Flyway. A vast number of migratory birds are threatened by the rapid urbanization [3]. The proliferation of high-rise buildings, extensive use of glass curtain walls, and prevalent nighttime lighting collectively contribute to the increased incidence of bird-window collisions. However, the majority of current bird collision research in China pertains to bird strikes on aircraft. There is a paucity of research on bird-building collisions [3].

In China, bird-friendly buildings are the most prevalent measure for bird collision prevention. Futian Mangrove Ecological Park stickies dot shaped stickers on the concave side of Science Education Center to mitigate bird collisions. While this initiative has not completely prevented bird collisions, it has effectively reduced the frequency and mortality rate of bird collisions [11]. This bird collision prevention measure features relatively low implementation costs and minimal technical barriers. Moreover, the dotted stickers adopted by the Futian Mangrove Ecological Park are aesthetically pleasing and fully preserve the architectural visual integrity. However, these measures have been implemented only on a single building within the park, indicating an urgent need to expand their application scope.

Some researchers have investigated the effects of both urban vegetation and artificial light at night on bird collisions in China [12] . This pioneering research on bird collisions in China provides valuable insights for the national bird collision prevention program. By building on existing bird collision prevention strategies from North America, this research enables China to identify and adopt measures that are more suitable for its unique environmental and ecological circumstances. Therefore, more extensive research with broader geographical coverage is essential to formulate tailored mitigation measures appropriate for China's specific contexts.

5 Outlook and Strategic Integration of North American Insights

Overall, China currently faces core challenges including lack of data, insufficient research, fragmented mitigation

measures, and absence of standardization. North American research provides a clear pathway forward: its well-established citizen science monitoring networks enable large-scale data collection, bird-friendly building standards have been put into practice, and it has developed precise predictive models by integrating weather radar and urban landscape data.

To address these critical gaps, China should strategically integrate approaches pioneered in North American research. The establishment of a standardized, national monitoring network—modeled on successful citizen science programs—is essential for generating systematic, large-scale collision data. The predictive power of this database would be significantly enhanced by incorporating real-time meteorological conditions and nocturnal migration intensity data from weather surveillance radar [13].

Therefore, China's future efforts should prioritize the development of a unified national monitoring system. This system would leverage citizen science and AI-assisted reporting to build a comprehensive database that links collision events with meteorological conditions, radar-derived bird migration traffic, and high-resolution urban landscape features. This robust evidence base will fuel predictive models to create dynamic risk maps, enabling targeted mitigation measures such as lights-out directives and bird-friendly building design in high-risk zones.

6. Conclusion

Research on bird-building collisions in North America has a relatively long history of development. Systematic experiments conducted by North American researchers have led to iterative advancements in the understanding of prevention measures for bird-building collisions. The applications of visual markers and UV signals have successfully mitigated bird mortalities from colliding with windows. Other research findings that have not yet been implemented also offer valuable guidance for future architectural design. Sound field and blinking artificial lights satisfy the needs of both human and bird populations. Urgent bird collision prevention measures in China demand a tailored strategy. While North American research provides a crucial framework and effective examples, China must adapt solutions to its unique flyway, rapid urbanization, and specific avian species. The immediate priority is to close the data gap by creating a national monitoring network. With the assistance of citizen science, AI reporting, and radar data will generate the essential foundations to build accurate risk models and identify mortality hotspots. Ultimately, integrating conservation into urban planning is key to transforming Chinese cities into safer habitats for birds, so as turning a pivotal predicament into an opportunity for sustainable leadership.

Authors' Contribution

All the authors contributed equally and their names are listed in alphabetical order.

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