Differences in birds' adaptation to anthropogenic disturbance in different urban green spaces

——Response of urban birds to man-made noise in Beijing as an example

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Abstract: With the accelerating process of urbanization, noise pollution in urban areas has become a major factor affecting biodiversity. In this study, we took Beijing as an example and conducted experiments on common birds in several urban green spaces. By controlling variables and playing different types and intensities of sounds for common birds in urban green belt, we explored the birds' adaptability to urban noise and their responses and sensitivities to different types of noises, and attempted to provide effective scientific support for the protection of urban birds in terms of noise reduction. The results showed that urban birds were generally more alert to dog barking and clear human voices, and less alert to other types of noise like car hooting, cacophonic human voices, and cat calls. The results of this study can provide scientific ideas for bird protection from the perspective of noise control, such as reducing human voices and dog barking which can easily cause birds to fly in alarm, setting up guard rails around bird habitats, strengthening daily patrols, and prohibiting dogs from entering the range of bird habitats, so as to promote the harmonious symbiosis between human life and ecology and nature in the city.

Keywords: Biodiversity; Urban Green Space; Birds; Noise Pollution; Man-Made Sounds; Beijing

1. Introduction

As a result of rapid urbanization, the issues like the loss of biodiversity, fragmentation of habitats, homogenization of vegetation types have become world-widely severe. The fifteenth Conference of the Parties (COP15) to the Convention on Biological Diversity (CBD) summarized the current state of global ecological conservation as follows: countries around the world have actively taken measures to introduce a series of policies and jointly promoted the signing of a series of international conventions related to biodiversity conservation. However, the international biodiversity conservation situation is still serious, and it is necessary to make transformational changes to the previous conservation measures[1].

Among the various factors contributing to the loss of ecological diversity, noise plays a significant role and according to Lachapelle et al. Artificial noise has a negative impact on the normal habitat of most animal populations, for example, noise pollution interferes with an animal's ability to attract mates, communicate, navigate, search for food, or avoid predators, and therefore may pose an existential threat to vulnerable organisms[2], and the affected species also include birds[3]. As an important part of the ecosystem and an environmental indicator species with high mobility, birds can rapidly reflect the current state and changes of the environment, and play an important role as indicators in the assessment of biodiversity, which is representative of the overall biodiversity situation[4]. Therefore, birds were selected as the research object in this study.

Current research on urban bird diversity shows that human-generated sounds and the sounds of birds' natural predators can have an impact on bird behavior, causing birds to become alert and fly in alarm. In the study of Lai Jiejun et al., the flight distance of birds, i.e., the degree of reaction intensity, was related to species, environment, natural predators, urban construction, and anthropogenic disturbances[5]; and the study of Bao Mingxia et al. showed that the development of urbanization would lead to the shortening of the tolerance distance of birds' flights, i.e., the increase of their tolerance and adaptability to anthropogenic disturbances[6]. This study expands on the above studies by taking the Beijing area as an example to compare the differences in the specific responses and sensitivity of different urban green spaces and different species of

common birds to different types and intensities of sound, including anthropogenically generated sound or noise and the calls of birds' natural enemies.

2. Methods

2.1. Study area and Sampling Design

The study area for this experiment is located in the urban area of Beijing, and different representative urban green spaces in highly urbanized areas were selected. Beijing is located in the northern part of the North China Plain, bordered by the Huanghuaihai Plain in the south, the Shanxi Plateau in the west, and the Inner Mongolia Plateau in the north, with a total area of 16,400,000 m^2. The Beijing area has a warm-temperate monsoon climate, with arid and windy springs, high temperatures and heavy rainfalls in summers, cool and humid autumns, and cold and dry winters, plus the changes of the four seasons are clearly defined. According to the data of China Meteorological Administration, the average annual rainfall in Beijing is 532.1 mm, which is concentrated in summer, and the average annual temperature is 12.6℃, with an average temperature of -3℃ in January and 27.3℃ in July[7]. The three urban green areas selected for this study are Tiantan Park, Fayuan Temple and Hepingmen neighborhood green belt, the specific locations are shown in the figure below.

Figure 1 Schematic representation of the location of the study area

Tiantan Park covers an area of 205,000,000 square meters, and the outer altar, where the experimental site is located, is a vegetation type dominated by deciduous and mixed forests, with nursery land, fruit tree land, and flower land, with a vegetation cover of 85%. Common birds include tree sparrows (Passer montanus), magpies (Pica pica), azure-winged magpies (Cyanopica cyanus), bulbuls (Pycnonotus sinensis), crows (Corvu ssp), spotted doves (Spilopelia chinensis), Gray-headed woodpeckers (Picus canus), great spotted woodpeckers (Dendrocopos major), blackbirds (Turdus merula), and others.

Fayuan Temple covers an area of 6,700 square meters, and the vegetation of the open space at the experimental site is dominated by coniferous forests and mixed forests, with lawns for decorative purposes and floral sites, and common birds include tree sparrows, magpies, azure-winged magpies, Spotted doves, ospreys, white-cheeked starlings, and bramblings (Fringilla montifringilla).

The total area of green space in Hepingmen Neighborhood is about 3,000 square meters, and the vegetation of the open space at the Experiment is dominated by deciduous forests, with lawns and floral sites for decorative purposes, and common birds include tree sparrows, magpies, grey magpies, spotted doves, blackbirds, and bulbuls.

2.2 Subjects of the Study

In this study, we selected birds that are more common, more numerous and representative of urban green spaces in Beijing. In the survey of Huang Yue et al, sparrows, azure-winged magpies, magpies, swifts, bead-necked doves and Gray-headed woodpeckers ranked in the top 15 in the number of urban parks in Beijing, and the sum of the number of their species accounted for 94.35% of the total number of birds[8], so we selected these kinds of birds for the experiment.

The experiment involves the characteristics of birds:

(1) Tree sparrow: Tree sparrows are small birds of the genus Sparrow (hereinafter referred to as "sparrows") of the family Sparidae. The body length is 7 to 10 centimeters. The forehead, top of the head to the back of the neck are chestnut brown, the side of the head is white, the ear has a black spot, feet and toes and so on are stained yellow-brown. Often move in groups,

foraging on the ground. When disturbed, they immediately fly away in groups.

(2) Spotted dove: Pearl-necked turtledove is a small bird of the genus Pearl-necked turtledove of the family Hatydidae. Commonly known as partridge eagle, etc., body length 17 to 25 centimeters. The head is pigeon gray, the back of the neck has broad black, which is covered with white tiny spots formed by the collar spot. Often in small groups, foraging on the ground, sometimes also mixed with other turtledoves.

(3) Gray-headed woodpecker: The Gray-headed woodpecker is a bird of the genus Green Woodpecker in the order Woodpecker, family Woodpecidae, with a body length of about 24 to 27 cm. The male's forehead and the front of the head is reddish-vermilion, the eyes and cheek lines are black, the occiput is black, the back of the head and neck is gray, and the back and wing feathers are greenish-yellow. The female has a gray crown, or black stripes or all black without red spots, and the rest of the body color resembles that of the male, often foraging alone in trees or on the ground.

(4) Azure-winged magpie: The azure-winged magpie is a bird of the genus azure-winged magpie of the Crow family of the order Passeriformes, with a body length of 28 to 35 centimeters. It is a small songbird of the Crow family in the middle and large songbirds. Adults have a black forehead, top of the head, occiput, side of the head and back of the neck with a slight bluish metallic luster; grayish blue on the wings; grayish blue tail feathers with a white end spot; blackish brown iris, black margins and feet. Sometimes in flocks, foraging on the ground.

(5) Magpie: The magpie is a species of crow in the family Corvidae, genus Magpie bird of prey that is a member of the family Coryphaenidae, a genus of birds Magpie: Magpies are a kind of bird in the family of crows and the genus Magpie. Body length 40-50 cm, head, neck, back to the tail are black, and from the beginning to the rear respectively show purple, green-blue, green and other luster, wings black and in the wings and shoulders have a large white spot, tail far longer than the wings, cuneate, mouth, legs, feet are pure black, the ventral surface of the chest as the boundary, before the black after the white. They sometimes move in groups and forage on the ground.

(6) Bramblings: The bramblings is a bird of the genus bramblings in the family bramblingsidae of the order Finches. The body length is 13 to 17 centimeters. The breeding plumage of the male bird is grayish-black from head to back, with a yellowish-brown margin on the back; the shoulders, the middle coverts on the wings, the tips of the large coverts, the waist and the tail coverts are white, and the flight feathers have a leathery-yellow outer margin. Females are lighter in color, with black spots on brown upperparts, narrow black margins on top of the head and occiput, gray on the side of the head and neck, and white on the loins. Often found in flocks, foraging on the ground.

2.3 Duration and Scope of the Study

The field survey of this study was conducted from February to May 2023, and two locations with high frequency of birds feeding on the ground were selected for the experiment in each of the set study sites (Tiantan Park, Fayuan Temple, and Hepingmen neighborhood green belt).

2.4 Research Methodology

Experiments were conducted on clear, windless mornings (6-8 a.m.) when there were a certain number of birds feeding on the ground and there were no significant noises, pedestrians, or natural predators of birds in the vicinity exceeding 40 dB. Sounding devices and video recording equipment were placed near the location where the birds were feeding (approximately 1 meter away). Playback of pre-prepared sounds, including clear human voices, noisy human voices, car hooters, dog barks, cat calls, and kestrel calls, began after the birds were more stable and had no tendency to fly up. Each type of sound was played with its volume gradually increasing from small to large, i.e., from the lowest volume (60 dB) of that sound to the highest volume (90 dB) in a uniform and slow manner. At the same time, the minimum volume to the maximum volume of each sound was divided into four intervals that were more evenly spaced, and at the five volume nodes corresponding to these intervals (including the minimum volume and the maximum volume, which were 60, 67.5, 75, 82.5, and 90 dB, respectively), the initial number of birds and the number of birds that flew away were recorded, as a measure of the bird's response to and sensitivity to the noise.

3. Data and Analysis

The results of the study showed that in Tiantan Park, sparrows had a flight rate of 0.209 for all sounds, 0.197 for clear human sounds, 0.333 for dog barking, and no clear data on flight rate for car honking. Similar data were available for birds such as the Spotted dove, Gray-headed woodpecker, Azure-winged magpie, and Magpie. At Fayuan Temple, sparrows had a

startle flight rate of 0.1 for all sounds and 0.1 for human sounds, and there were no definitive data for the other bird species. In the neighborhood, the startle flight rate of the bead-necked dove for all sounds, for human sounds, and for car hooters was 0.325, 0.25, and 0.4, respectively. The specific data are shown in the following table.

Note: Since all subjects had no significant reaction after playing noisy human voices, catcalls and kestrel calls, and the number of startled flights was all zero, these three sounds were omitted from the above table.

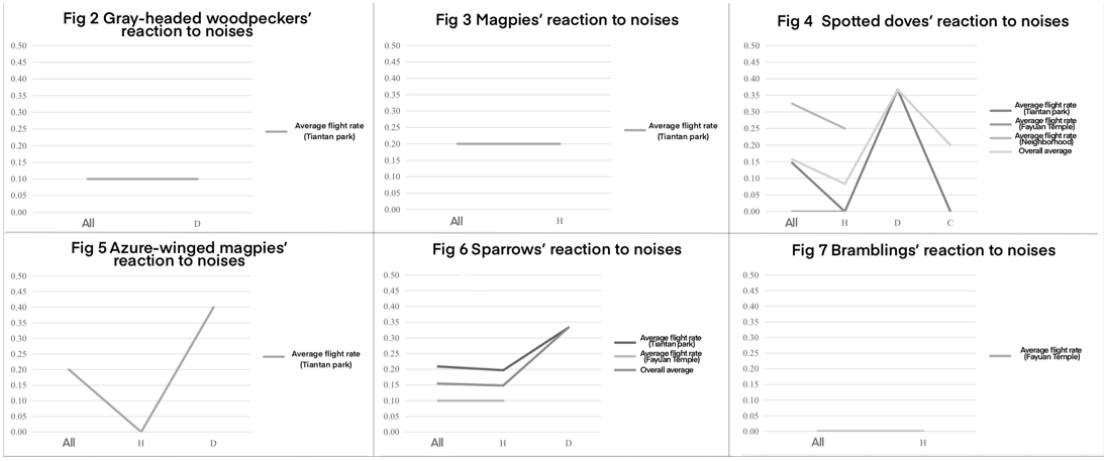
In the table, H=clear human voice, D=dog barking, C=car honking, and "all" denotes the average of all sounds corresponding to the flight rate.

Table 1 Response of different bird species to noise in each green space

Location	Bird species	Type of noise	Flight rate
Tiantan Park	sparrows	All	0.209
Tiantan Park	sparrows	H	0.197
Tiantan Park	sparrows	D	0.333
Tiantan Park	spotted doves	All	0.147
Tiantan Park	spotted doves	H	0.000
Tiantan Park	spotted doves	D	0.367
Tiantan Park	spotted doves	C	0.000
Tiantan Park	gray-headed woodpeckers	All	0.100
Tiantan Park	gray-headed woodpeckers	D	0.100
Tiantan Park	azure-winged magpies	All	0.200
Tiantan Park	azure-winged magpies	H	0.000
Tiantan Park	azure-winged magpies	D	0.400
Tiantan Park	magpies	All	0.200
Tiantan Park	magpies	H	0.200
Fayuan Temple	sparrows	All	0.100
Fayuan Temple	sparrows	H	0.100
Fayuan Temple	bramblings	All	0.000
Fayuan Temple	bramblings	H	0.000
Fayuan Temple	spotted doves	All	0.000
Fayuan Temple	spotted doves	H	0.000
neighborhood	spotted doves	All	0.325
neighborhood	spotted doves	H	0.250
neighborhood	spotted doves	C	0.400

Table 2 Response of different bird species to noise

Bird species (regardless of location)	Type of noise	Average flight rate	Overall average
sparrows	H	0.197	0.265
sparrows	D	0.333	
spotted doves	H	0.083	0.217
spotted doves	D	0.367	
spotted doves	C	0.2	
gray-headed woodpeckers	D	0.1	0.1
azure-winged magpies	H	0	0.2
azure-winged magpies	D	0.4	
magpies	H	0.2	0.2
bramblings	H	0	0



According to the results of the experiment, at the three selected experimental sites (locations), the degree of response of the bird species involved to the noise was, in descending order, sparrows, spotted doves, magpies, azure-winged magpies, gray-headed green woodpeckers, and bramblings; and the variable of location within the experimental range did not have a significant effect on the degree of vigilance of the birds, and there was not much difference in the response of birds in different regions.

4. Discussion

4.1 Different Responses of Birds to Different Noises

The results of the experiment showed that the birds involved in the experiment were generally more sensitive to clear human voices and dog barking, presumably because in urban parks, dogs and pedestrians are a greater threat to birds, and additionally, dogs are natural enemies of birds; however, the cries of cats and kestrels which are also the natural enemies of birds, did not cause birds to fly, probably because cats and kestrels do not chirp during the predation process, and therefore the birds did not establish a direct connection between their calls with danger.

The experimental results also showed that most of the birds in the city park reacted more when they heard clear, individual human voices than when they heard cacophonic human voices, (the birds hardly reacted when cacophonic human voices were played) and the time to regroup after they flew away was longer than when they heard noisy human voices. The reason for this might be that humans who are closer to the birds are a greater threat to the safety of the birds, and thus the birds in the city park were more alert to the visitors who approached them. And most of the experimental subjects had almost no reaction to the sound of car hooters. It is speculated that the reason may be that there is a large amount of traffic in the city, and the birds have been in the environment of car noise for a long time, so their vigilance to the sound of car hooters is reduced, which reflects a certain degree of adaptation to the noise.

4.2 Different Responses to Noise in Different Species of Birds

The experimental results showed that the flight rate of sparrows and turtle doves was generally higher when the noise was played. It was hypothesized that sparrows and turtle doves foraged in flocks and had a strong sense of group consciousness, so that when one bird was frightened and flew away, it would also lead most of the birds in the group to raise their alertness at the same time. On the other hand, magpies and gray-headed green woodpeckers, which forage more frequently independently, have a lower instinct for group cooperation, and a large number of birds in the vicinity will not lead to an increase in their vigilance.

4.3 Responses of Birds to Noise at Different Locations

According to the results of the experiments, the change of location within the experimental range hardly led to the change of the birds' response level to the noise. It is hypothesized that the reason may be that the study sites chosen for this study were all located in the urban area of Beijing, where the environmental noise and all aspects of the conditions were similar, and the level of vigilance of the birds was also roughly similar.

5. Prospects

This study can provide ideas for bird conservation at the level of noise control and promote the harmonious coexistence of human life and ecological nature in the city. The details are as follows:

Studies have shown that birds are highly wary of visitors and dogs, so if a bird needs to be protected at a noise level, the focus could be on controlling the number of visitors and dogs around its habitat. Neighborhoods or parks can consider adopting a series of management measures, such as setting up guardrails around bird habitats and strengthening daily patrols, prohibiting visitors and dogs from entering bird habitats, and setting up signboards to reduce noise in bird activity areas. In the future, we still need to conduct more in-depth studies to fully understand the response of birds to various human activities, and to more accurately locate the adverse impacts on the survival of urban birds, so that we can adopt more effective strategies in a timely manner to better coexist with birds and other animals, and to build an ecologically friendly and animal-friendly city.

The sites chosen for this study were all located in the urban area of Beijing, where the degree of urbanization and environmental noise were similar, so the results did not show a relationship between the variable of location and the degree of bird response to noise. For future studies, research locations with greater differences in all aspects can be selected for experiments. Meanwhile. Although the dependent variable recorded in this study did not include the time for the birds to regroup after a startled flight, it was observed during the experiment that when the same sound was played several times, the time between the birds' flight away and regrouping saliently became shorter, and it was hypothesized that it might be due to the multiple playbacks of the same sound, which made the individual birds believe that this sound was not associated with actual danger, and reduced the alertness of the flock to this sound. This variable could be added in future studies to further quantitatively explore bird adaptation to noise.

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