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Responses of birds to observers holding popguns: Hunting history influences escape behavior of urban birds

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Abstract

Human activities affect bird behavior both directly and indirectly. Birds constantly regulate their behavior in response to human disturbance. Gun hunting, a major directional disturbance, puts enormous selection pressure on birds. In China, gun bans have been in place for nearly 30 years, and little hunting using guns occurs in modern cities. However, little attention has been paid to whether a history of hunting still affects the behavioral adaptations of urban birds. In this study, we compared the flight initiation distance (FID) of the Eurasian tree sparrow *Passer montanus*, Azure-winged magpie *Cyanopica cyanus*, Common hoopoe *Upupa epops* and Eurasian magpie *Pica pica* in the presence of observers with or without popguns. The Eurasian tree sparrow, Azure-winged magpie, and Eurasian magpie effectively recognized the difference between the observers, and perceived the armed observer as a greater threat, exhibiting earlier escape behavior, but this phenomenon was not found in the Common hoopoe. The different expressions in FID of experimental bird species in China cities may be affected by the different levels of recognition of hunting pressure due to different hunting histories.

Key words: anthropogenic disturbance, bird, human hunting history, flight initiation distance, predation risk.

Human disturbance is the disruption to normal physiological or behavioral states when a potential threat or stimulus (such as a person, vehicle, or aircraft) is approaching (Weston 2019). The effect of human disturbance on animals is an important topic in wildlife conservation research. Many animals perceive human disturbance as a predation risk (Walther 1969; Mikula et al. 2023). Accumulating research has shown that human disturbance can alter the behavioral strategies of individual animals and thus affect populations and communities (Frid and Dill 2002), disrupt ecological functions and reduce the resilience of ecosystems (Matuoka et al. 2020). For example, human disturbance negatively affects the feeding strategy of the blackbird *Turdus merula* in urban parks, thereby altering the spatial and temporal patterns of habitat selection and population abundance (Fernández-Juricic and Tellería 2000). In relation to birds, human disturbance includes those caused by humans and domestic animals (Fernández-Juricic and Tellería 2000; Fernández-Juricic 2002; Díaz et al. 2022), vehicles and noise (Delaney et al. 1999; Arévalo and Kimberly 2011), construction (Barrios and Rodriguez 2004), and human activities such as fireworks displays (Shamoun-Baranes et al. 2011). The bird tolerance of human disturbance was even found in regions with only recent history of human-induced disturbance (Tryjanowski et al. 2020). In the context of the recent coronavirus outbreak, adaptations to masked humans may result in weaker fear responses (Jiang et al. 2020; but see Mikula et al. 2021). It is noteworthy that birds are capable of discriminating between approaching humans based on the human's behavior and equipment being carried, such as binoculars and cameras (Radkovic et al. 2019; Slater et al. 2019).

Hunting, a major anthropogenic disturbance poses a lethal risk to birds, leads to biodiversity loss and exerts significant selection pressure on wildlife. Compared with not hunted areas, hunted areas exhibited a 58% (25–76%) and 83% (72–90%) decrease in bird and mammal abundance, respectively, in tropical areas (Benitez-Lopez et al. 2017). Initially, bird hunting was not only a recreational pastime, but also a livelihood. With the invention of gunpowder, firearms gradually became the dominant hunting weapon. The use of firearms increased the risk of predation and led to the extinction of some birds, directly or indirectly, such as the passenger pigeon *Ectopistes migratorius* (Halliday 1980). Human hunting activity directly influences animal threat assessments and subsequent anti-predatory behavior. Studies of the effects of gun hunting are key to understanding adaptations to human disturbance. In particular, birds in areas with hunting activity show less tolerance to human disturbance than those in areas without hunting activity (Magige et al. 2009).

China promulgated the Law of the People's Republic of China on the Control of Firearms in 1996. Effective after October 1, 1996, this law was adopted at the 20th meeting of the Standing Committee of the 8th National People's Congress on July 5, 1996. Any unit or individual is prohibited from possessing or manufacturing firearms in violation

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of the provisions of the law. This legislation has helped to regulate hunting activity while also promoting the conservation of wildlife, including birds. In urban environments where humans rarely harm or hunt birds, birds have become better adapted to human activity and the urban environment (Møller and Ibáñez-Álamo 2012).

Flight initiation distance (FID) is an important indicator of anti-predatory behavior and can be used to indicate bird tolerance and adaptation to human disturbance (Møller 2008a). FID is the distance between a target animal and a predator or human when the target animal adopts avoidance behavior (Hediger 1934; Gotanda et al. 2009; Møller et al. 2015). FID is considered to be the behavioral basis for determining life history. There are trade-offs associated with staying in place and with fleeing prematurely. The former may increase the risk of predation and reduce future reproductive success, whereas the latter increases the metabolic cost and reduces food intake. The FID reflects the degree of risk that an animal is willing to take in a given situation (Møller 2014). For example, tropical birds have longer FIDs than their temperate sister populations, indicating that tropical birds have a smaller capacity for taking risks (Møller and Liang 2013). An individual animal makes constant trade-offs to optimize its fitness and any factors that affect the assessment of predation risk and costs and benefits of escape may affect the FID (Ydenberg and Dill 1986; Cooper and Frederick 2007). FID is affected by many factors, such as the habitat (Fernández-Juricic et al. 2004; Samia et al. 2015), morphological characteristics (Blumstein 2006; Fernández-Juricic et al. 2006; Møller and Erritzøe 2010; Glover et al. 2011) and predation risk (Geist et al. 2005; Bateman and Fleming 2011; Møller et al. 2017) Recent studies have shown that the body size effect on FID may be driven by human hunting, with species with larger body size having longer FID (Glover et al. 2011; Gnanapragasam et al. 2021). FID is also considered a behavioral indicator of hunting pressure in birds. In a study of the sooty-headed bulbul *Pycnonotus aurigaster*, it was noted that FID increased with hunting pressure (Sreekar et al. 2015). In addition, there is an underlying adjustments of avian FID with time since urbanization, which could also be explained by a reduction in hunting, among other things (Symonds et al. 2016), with the advances in FID research, deeper time associations between humans (hunters) and birds are also evident at the continental scale (Weston et al. 2021).

Almost 30 years have passed since the gun ban was enacted in China. As almost there is no hunting with guns in modern cities, little attention has been paid to whether hunting history still affects the adaptation of urban birds to human disturbances. Therefore, in this study, common bird species in different cities were selected, namely the Eurasian tree sparrow *Passer montanus*, azure-winged magpie *Cyanopica cyanus*, common hoopoe *Upupa epops* and Eurasian magpie *Pica pica*, and the influence of hunting history on anti-predatory behavior was investigated by measuring the FID in the presence of observers with and without popguns. FID, which is influenced by body size, was predicted to be positively correlated with body size regardless of whether the observer was armed. Birds were predicted to escape earlier when confronted with an armed observer. The tendency to escape earlier was hypothesized to be more pronounced in birds that had historically been hunted.

Materials and Methods

Study area

The study sites included Haikou City, Hainan, south China; Yinchuan City, Ningxia, north China; and Qingyang City, Gansu, northwest China.

Haikou (110°10′–110°41′ E, 19°31′–20°04′ N) is located in the northern part of Hainan Island, which has a marine monsoon climate characterized by concentrated periods of precipitation, with an average temperature was 26 ° C–33 ° C. Surveys were conducted in June 2022 and mainly in parks in Haikou City (Wanlv Garden, Meishe River Park, and Baishamen Park) (Zhou and Liang 2020).

Yinchuan (105°50′–106°41′ E, 38°17′–38°39′ N) is located in the middle of the Ningxia Plain in northwest China. It is the capital of the Ningxia Hui Autonomous Region, bordered by the Yellow River to the east and the Helan Mountains to the west, with an annual average temperature of about 8 ° C. Surveys were mainly conducted in June 2022 in Rixin Park of the city.

Qingyang (106º20´–108º45´ E, 35º15´–37º10´ N) belongs to the gully area of the Loess Plateau in the middle reaches of the Yellow River. This region, which has higher elevations in the east, north, and west, and lower elevations in the middle and south, is known as the “Longdong Basin.” The average annual temperature is 10.1 °C, with 2221 h of annual sunshine. Surveys were conducted in February 2022 covering most streets across this city.

The three cities are all famous historic cities, compared with the fast-emerging cities (such as Shenzhen), these ancient cities have similar histories of human disturbance. Therefore, the impact of differences among cities in the history of human disturbance can be ignored in this study.

Data collection

The clothing color of experimenters affects FID (Gould et al. 2004; Zhou and Liang 2020). Therefore, in this study, experimenters wore the same clothing: a black hat, a black top, and long pants. Two experimental groups of observers were established, one of which held popguns (Figure 1). Both groups were given the same observation route, but in a randomized order. In order to avoid pseudo-replication, the observers walked continuously in only one direction without turning around, to prevent sampling from the same position twice; however, one site could be used a second time with the respective other presence of observers with and without popgun. The field survey was conducted from June 2022 to July 2022 (the breeding season).

To avoid the influence of factors such as vertical height on bird FID (Møller 2010), FID data in this study were only collected for birds foraging or moving on the ground and measured using standardized procedures (Blumstein 2006). All observers were given at least two months in advance to familiarize themselves with the standardized procedures for conducting FID measurements. When an observer spotted a bird, using binoculars, the species of bird was identified, and the observer moved horizontally toward the bird at a normal walking speed (~0.5 m/s). The straight-line distance from the observer when the bird began to take off was measured and recorded as the FID. The following criteria were used: (1) the bird had to be on the ground and in an open space (at least 10 m from the thicket) to ensure that the FID was not influenced by nearby shrubs. (2) To ensure that the

Figure 1. An example of observers with (right) and without (left) popguns.

FID was not influenced by the responses of other bird species, multi-species mixing was not tested. (3) In the case of homogeneous bird groups, only the individual closest to the observer was selected for FID estimation. (4) No other human influences were observed within 20–30 m of the bird.

The body size information of species in this study is referenced to the book "A Field Guide to the Birds of China" (Mackinnon et al. 2000). It may be difficult to sample the four species in all cities and to meet the sample size requirement, because not all cities have the same bird species, that is, no magpies in Haikou. Therefore, the FID data of the Azure-winged magpie and common hoopoe were collected in Haikou, the FID data of the Eurasian tree sparrow was collected in Qingyang and the FID data of Eurasian magpie was collected in Yinchuan.

Data analyses

To verify interspecific variability in FID and to compare differences in FID in response to the different groups of observers, a generalized linear mixed model (GLMM) was used to analyze differences in the FID of the Eurasian tree sparrow, azure-winged magpie, common hoopoe, and Eurasian magpie in the presence of observers with or without popguns. The dependent variables were the FID of different bird species; the fixed variables were the bird species, the group size, popgun in hand or not and species × popgun in hand or not; and the random variables were the ID of the birds. Data were expressed as the mean ± standard deviation (SD). Statistical results were considered significant at the threshold $P < 0.05$. All tests were two-tailed. Data analyses were performed using IBM SPSS 22.0 for Windows (IBM Inc., USA).

Results

There was a significant difference in the FID among the four species ($F = 49.368$, $P < 0.001$, GLMM; Table 1). Further pairwise contrasts of the four species revealed that $FID_{\text{Eurasian tree sparrow}} < FID_{\text{Azure-winged magpie}} < FID_{\text{Common hoopoe}} < FID_{\text{Eurasian magpie}}$, with significant differences observed among these four species ($P_{all} < 0.05$, Table 1; Figure 2).

It is noteworthy that the birds had a greater FID when confronted with an armed observer (With popgun: FID

Table 1. Generalized linear mixed model (GLMM) analysis on the effects of bird species (Eurasian tree sparrow, Common hoopoe, Azure-winged magpie, Eurasian magpie), the presence of observers with or without popguns, and group size on the FID of modern urban bird species.

	F	*df*1	*df*2	*P*
Intercept	15.718	20	518	<0.001
Species	49.368	3	518	<0.001
Popgun in hand or not	18,776	1	518	<0.001
Group size	0.769	13	518	0.694
Species × popgun in hand or not	3.613	3	518	0.013
		t	*df*	*P*
Azure-winged magpie—Eurasian tree sparrow		3.942	518	<0.001
Eurasian magpie—Eurasian tree sparrow		10.290	518	<0.001
Eurasian magpie—Azure-winged magpie		9.670	518	<0.001
Eurasian magpie—Common hoopoe		7.129	518	<0.001
Common hoopoe—Eurasian tree sparrow		5.298	518	<0.001
Common hoopoe—Azure-winged magpie		2.382	518	<0.05
Popgun-not		4.333	518	<0.001
Azure-winged magpie	Popgun-not	1.729	518	0.084
Eurasian magpie	Popgun-not	4.87	518	<0.001
Eurasian tree sparrow	Popgun-not	2.190	518	<0.05
Common hoopoe	Popgun-not	0.099	518	0.921

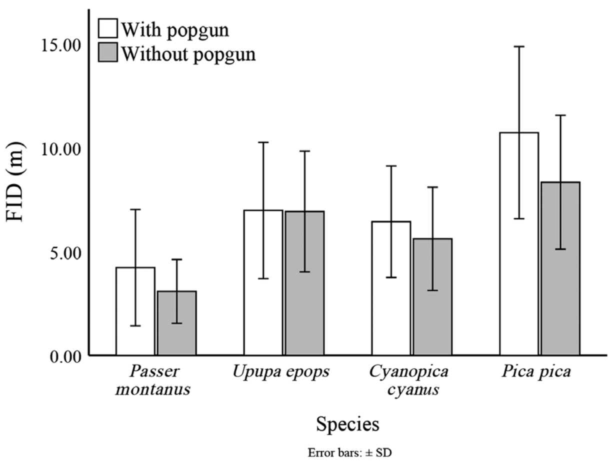

Figure 2. Comparisons of flight initiation distance among the four study bird species. Error bars indicate the standard deviation (SD), and all summary statistics are presented as the mean ± *SD*.

$FID_{\text{Eurasian tree sparrow}}$ =4.22 ± 2.80m, $N = 83$; $FID_{\text{Azure-winged magpie}}$ = 6.43 ± 2.68m, $N = 66$; $FID_{\text{Common hoopoe}}$ = 6.98 ± 3.28 m, $N = 60$; $FID_{\text{Eurasian magpie}}$ = 10.72 ± 4.14m, $N = 63$), compared to that observed in the presence of an unarmed observer (Without popgun: $FID_{\text{Eurasian tree sparrow}}$ =3.08 ± 1.54 m, $N = 60$; $FID_{\text{Azure-winged magpie}}$ = 5.61 ± 2.49 m, $N = 63$; $FID_{\text{Common hoopoe}}$ = 6.92 ± 2.91 m, $N = 61$; $FID_{\text{Eurasian magpie}}$ = 8.33 ± 3.22m, $N = 83$; $F = 18.776$, $P < 0.001$, GLMM; Table 1; Figure 2). However, this difference was more significant in the Eurasian tree sparrow and Eurasian magpie (pairwise contrasts, popgun-not, Eurasian tree sparrow: $t = 2.190$, $P < 0.05$; Eurasian magpie: $t = 4.871$, $P < 0.001$) than in the Azure-winged magpies ($t = 1.729$, $P = 0.084$), but no significant difference was detected in the Common hoopoe ($t = 0.099$, $P = 0.921$). Group size did not have a significant effect on FID ($F = 0.769$, $P = 0.694$, GLMM; Table 1).

Discussion

This study explored behavioral adaptations to hunting history in urban birds by analyzing differences in the FID of the Eurasian tree sparrow, Eurasian magpie, Common hoopoe, and Azure-winged magpie in the presence of armed and unarmed observers. Our study showed significant interspecific variability in the FID of the Eurasian tree sparrow, Azure-winged magpie, Common hoopoe, and Eurasian magpie, in order of increasing FID, regardless of whether the observer was armed, this provides further evidence that FID is species specific. Notably, Eurasian tree sparrows, Azure-winged magpies, and Eurasian magpies were able to effectively identify differences between the two types of observers. They perceived the armed observer as a greater threat and exhibited earlier escape behavior, but the Common hoopoe does not.

Previous studies have shown that the FID of birds is influenced by several factors. One important factor is body mass. Larger species usually have a greater FID compared with smaller ones (Blumstein 2006; Møller 2008b; Samia et al. 2015), which is similar to the results of the present study. This phenomenon may occur because larger species move with less agility than smaller ones and thus require more time and space to escape (Fernández-Juricic et al. 2002). In addition, larger birds require longer take-off distances, and the climb rate decreases with increasing body weight (Hedenström and Alerstam 1992; Møller 2008a; Mikula et al. 2023). Larger species are also more likely to be detected by predators and thus are at greater risk of predation; therefore, they escape earlier (Holmes et al. 1993). In addition, some indicators closely linked to body mass, such as the weight of sensory organs and the brain, also influence the FID of birds and are positively correlated with FID (Weston et al. 2012; Møller and Erritzøe 2014). However, in this study, the Common hoopoe has longer FID than the Azure-winged magpie, which is not consistent with expectations. The main possible reason is related to the feeding habits of Common hoopoes; they are usually foraging on the ground surface, which is more susceptible to human disturbance, and thus, the Common hoopoe is inclined to adopt avoidance behavior earlier than the species foraging on the tree.

Some birds recognize the direction of gaze or facial expression and exhibit escape behavior accordingly (Eason et al. 2006; Bateman and Fleming 2011; Clucas et al. 2013). In a study of waterfowl, it was noted that certain waterfowl distinguish between fishermen's clothing and casual clothing, and the ability of birds to recognize threat levels is evidently enhanced by prolonged contact with local fishermen (Feng and Liang 2020). The ability of birds in urban environments to recognize the nuances of human appearance and adjust their anti-predatory behavior accordingly may be attributed to habituation to human presence, which may facilitate adaptations to urban environments (Bateman and Fleming 2011). In this study, were was no significant differences in the FID of Common hoopoes when confronting two different observers. The probable cause may be due to its special uropygial secretions causing pungent smell exuded from the creature's body (Martín Vivaldi et al. 2009), making this species hardly be regarded as the objects by hunters. From hunting history perspective, the Common hoopoe suffered less threats comparing with the other prey species under the same hunting pressure, which may gradually weaken the ability to recognize hunting threats and affect the appropriate expression of escape behavior. Laursen *et al.* (2005) pointed out in their research on waterfowl that hunted species have longer FID than the non-quarry species (Laursen et al. 2005).

Our findings demonstrated that the urban birds in this study may have different levels of recognition of hunting pressure due to different hunting histories, which further affects the recognition ability and the expression of anti-predatory behavior. In addition, the birds in this study all lived in urban environments, and prolonged exposure to human disturbance also increased the bird tolerance to human proximity (Samia et al. 2015). Urbanization also had a similar effect promoting birds to exhibit shorter FID (Møller 2008a), with further weakening the birds' ability to recognize human individuals. Therefore, we speculate that the multiple effects of different hunting histories and urbanization may lead to different behavioral responses of urban birds confronting the same hunting pressure.

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Conflict of Interest

The authors declare that they have no competing interests.

Ethical Standards

The experiments comply with the current laws of China, where they were performed. Fieldwork was carried out without special permit for this study. Experimental procedures were in agreement with the Animal Research Ethics Committee of Hainan Provincial Education Centre for Ecology and Environment, Hainan Normal University (Nos. HNECEE-2014-005 and HNECEE-2016-004).

Data Accessibility

Data in this manuscript were submitted as supplementary materials (Data Table S1).

Authors' Contributions

WL designed the study, KY and SY collected field data, SY and JL conducted the analyses, KY and SY wrote the draft manuscript, JL and WL edited and improved the manuscript. All authors approved the final submission.

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