BIRD TOLERANCE TO HUMAN IN RURAL AND URBAN AREAS OF KATHMANDU VALLEY, NEPAL

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special paper Ecology and Environment.

Submitted to

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Tribhuvan University

Kirtipur, Kathmandu

Nepal

May 2023

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award for any degree. All sources of information have been specifically acknowledged by reference to authors or institutions.

Date: May 14, 2023

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On the recommendation of the supervisor, Associate Professor, Dr. Hari Prasad Sharma, this thesis submitted by Mr. Amrit Nepali entitled "**Bird tolerance to human in rural and urban areas of Kathmandu Valley, Nepal**" is approved for the examination in partial fulfilment of requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Mr. Amrit Nepali entitled "**Bird tolerance to human in rural and urban areas of Kathmandu Valley, Nepal**" has been accepted as partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
SD	Starting Distance
FID	Flight Initiation Distance
AD	Alert Distance

ABSTRACT

Growing urbanization has altered behaviors of wildlife including birds. Birds perceive human as a predator and flee away when approached towards them, and a point at which birds decide a risk of predation equals to cost of escape is called flight initiation distance (FID). The escape behavior of animals was mainly due to presence of human and these are varied among bird species according to habitat, body size, sex, flock size as well as behavior. The degree to which a species tolerates human interference is one mechanism that could explain coexistence. This study was conducted to evaluate the tolerance of bird with respect to human presence in rural and urban areas and also to identify the factors affecting their tolerance. The field work was carried in urban and rural areas of Kathmandu Valley in two seasons; winter and summer. During the field visits alert distance (AD) and FID of bird species in response to human was collected. Total 991 FIDs of 45 bird species were collected during the survey, out of which 922 FIDs from 33 species were used for analysis. Generalized Additive Model was adopted to determine the effect of habitat contrast, sex, season, feeding guild, body size, flock size, behavior, and time of day on tolerance of bird. FID was lower in urban birds than their rural conspecifics. FID was varied with feeding guild, habitat contrast and winter season. Body size has positive impact on FID while flock size has negative impact. It was found more on male birds than female, birds involved in foraging than in roosting, and at morning than at late afternoon. The findings of this study recommend using FID of large, carnivore bird species as parameter for species conservation.

1. INTRODUCTION

1.1 Background

Rapid urbanization has resulted habitat loss and fragmentation, which threatens biodiversity (Seto et al. 2012). Due to changes in the habitat, species tend to change their behavior to adapt with changed environment (Bradshaw and Holzapfel 2006). Some species are able to adapt, survive and thrive in urbanized environment, however, majority of species are unable to tolerate such changes in environment, especially increasing urbanization (Bonier et al. 2007) and suffer with population decline (Moller 2008b). Many studies across different areas have supported this scenario and possess serious threats to the bird species and their behavior (Blumstein 2006; Møller et al. 2014). Consequently, many bird species are becoming increasingly dependent on their ability to tolerate human in their environment (Marzluff 2001). Generally, human disturbances negatively affect birds in many aspects of their life history including behavior, such as foraging, reproduction and fitness (Price 2008).

Birds' response to certain stimulus or approaching disturbances such as loud noises, predators or human, and as a response they flee away (Frid and Dill 2002). They are forced to make decisions about their fitness depending on the disturbances as a pertaining threat (Frid and Dill 2002). The decision of birds to flee may have a direct impact on feeding success because early departure reduces foraging efficiency (raising the danger of starvation) and delayed departure increases the probability of predation (Schadegg and Herberholz 2017). Adult birds are affected by exposure to potential predator which can be transferred to their offspring with negative consequences in development and growth (Saino et al. 2005). Based on Optimal Escape theory, "prey flee away from predator when the predator reaches a point at which the risk of predation equals the cost of escape" (Ydenberg and Dill 1986). Flying is one of the most widespread anti-predator responses in birds (Chalfoun et al. 2002).

The distance at which prey flee away from approaching predator or any disturbances is referred as flight initiation distance (FID) (Blumstein 2006). As human is potential predator of birds, their flight initiation distances have been used as indicators of anti-predatory responses and anthropogenic stresses (Blumstein 2006). This can be used to measure the impact of antipredator strategies, monitor habituation to disturbances, to analyze human impact on wildlife (Blumstein 2003) as well as to design core and buffer zone in reserves of target species (Fox and Madsen 1997). FIDs can also be used to standardize the length of buffer zones for species protection from human disturbances (*see* waterbird protection in Florida: Rodgers and Schwikert 2002). This FID is dependent on factors such as habitat, body size, flock size, sex, time of day, behavior, season, and feeding guild (Blumstein 2006; Samia et al. 2015a; Møller et al. 2019b; Tryjanowski et al. 2020).

Generally, the shorter FIDs are noticed in urban birds than their rural counterparts when approached by human (Kitchen et al. 2010; Carrete and Tella 2011; McGiffin et al. 2013; Matsyura et al. 2018; Carvalho and Toledo 2021) which correlates to higher human density. This in turn increases habituation to human in urban than rural areas (Burger and Gochfeld 1991; Fernández-Juricic et al. 2001; Mikula 2014; Carlen et al. 2021). Larger birds flee at slower pace and cover a longer distance than smaller birds (delBarco-Trillo 2018). They are more visible thus much vulnerable to the predators, which encourages the development of skills for detecting possible opponents across long distances. Smaller birds, however, can flee quickly and are thus better equipped to withstand the presence and proximity of approaching disturbances (Díaz et al. 2013). Smaller birds have high tolerance than larger birds (Bjørvik et al. 2014). However, larger birds with high tolerance and higher survival rate in urban areas are also noticed (Brown and Graham 2015). Flock size is also predicted to be an important determinant of FID when approached by a predator or any disturbances (Laursen et al. 2005; Halassi et al. 2021). Birds in larger flock is expected to decrease their FID as individual risk is diluted in larger group or predators are less likely to make a successful hunt on multiple target due to confusion effect (Stankowich and Blumstein 2005; Mikula et al. 2018). This is due to the security that comes with a flock as a result of behaviors like altruism and kinship (Kay et al. 2019). Sex can have a significant effect on bird tolerance, as male are more colorful and detectable, which makes them less tolerant than female birds (McQueen et al. 2017). Also male are more aggressive than female and female are often more camouflaged which reduces their probability of detection making them more tolerant (García-Arroyo and MacGregor-Fors 2020). FID is also observed to change over a day which is generally related to the degree of satiation of the individual; the less the starvation, the higher the alertness (Piratelli et al. 2015; Schadegg and Herberholz 2017). Increase in temperature over the course of day might increases the FID as high temperatures experienced by birds can trigger a different thermal problem like heat stress (Schleucher 2001). Birds involved in foraging are less tolerant than birds that involved in resting or roosting as more energy is spent at the time of foraging and accumulate during the time of resting. So, when a predator attacks, the foraging birds need more time to accumulate energy and the risk of predation is higher during foraging than during resting (Mori et al. 2001). On the other hand, the foraging birds are less aware of their surrounding compared to those involved in other behaviors (Tsurim et al. 2008). Birds are observed to have lower FID during breeding and post breeding season, because of parental investment on offspring as well as their fitness is directly associated with offspring survival (Blumstein 2006; Piratelli et al. 2015; Poddubnaya et al. 2020). Carnivore mostly feed on swiftly moving prey which make their detecting ability better than omnivore, herbivore and granivores and thus can detect approaching predator or human from far distance and therefore has larger FID (Blumstein 2006).

In this regard, this study is based on hypothesis that tolerance of birds to human presence varies between rural and urban areas and their tolerance capacity is affected by factors like sex, body size, flock size, behavior, habitat, season, time of day. As very few studies had been done on effect of urbanization on tolerance of birds from Asia and Nepal, this will provide baseline information on bird tolerance to human as well as fulfill the existing gap.

1.2 Objective

1.2.1 General objective

The general objective of this study was to determine the birds' tolerance to human in rural and urban areas of Kathmandu Valley.

1.2.2 Specific objectives

The specific objectives of this study were as follows:

1. To compare the tolerance of bird in rural and urban areas.
2. To determine the effect of sex, body size, feeding guild, behavior, time of day, flock size and season on tolerance of bird.

1.3 Rationale of the study

Since 1980, Nepal's urbanization has been rapidly increasing, particularly in Kathmandu Valley, the most populated and unplanned city which has resulted in the loss of forests and an increase in habitat fragmentation and alteration of the land use system (Sharma 2003). It is the global problem and is one of the major factors for biodiversity loss. Species richness and diversity of all birds declined from rural and urban areas showed significant variation along urban-rural gradient in Kathmandu Valley (Katuwal et al. 2018). Bird Conservation Nepal has been carrying out survey on birds along urban-rural gradient every year. But data on the behavioral activities of birds especially on human disturbances is deficient and it can be assumed that it is creating problem for species- and site-specific conservation action and management plan. As there is a lack of information on how birds behave in reaction to humans and their activities, this study will help to fill that gap. Also, many studies on tolerance of bird in response to human disturbance have undertaken in other continents than Asia which shows differing pattern across different study areas (Møller et al. 2014), there is less focus in such topics in Asia as well as Nepal. This study is one of the first of its kind in Nepal.

2. LITERATURE REVIEW

The history of research on bird tolerance to human disturbance has evolved from a focus on the impact of human disturbance on bird populations to a focus on understanding the factors that influence bird tolerance to human disturbance. Early studies focused on the negative impact of human disturbance on bird populations, such as redirection of time and energy expenditure away from other important activities, such as reproduction and feeding (Price 2008). Later studies focused on understanding the factors that influence bird tolerance to human disturbance, such as the type of habitat and level of disturbance (Tryjanowski et al. 2020; Mikula et al. 2023). Most recent studies have identified key predictors of avian tolerance of humans across different bird species and ecosystem (Mikula et al. 2023).

Different methods were used to study the behavioral response of bird to different kinds of disturbances including experimental manipulation such as Liker and Bokony (2009) who tested the ability of House Sparrow experimentally by presenting a new foraging task of opening a familiar feeder in an unfamiliar way to House Sparrow in small and large groups. Vincze et al. (2016) carried out experiment by keeping House Sparrows of both urban and rural areas in captivity and measuring their habituation level. Some studies were also done by using playback sound, such as McQueen et al. (2017) used playback sound of predators to study antipredator behavior of Super Fairy-wren to their predators. Almost all of the study that has been done on response of birds' behavior to human has collected its Flight initiation distance (FID), the distance from a predator when the prey initiates escape, has been linked to a number of characteristics in birds.

The study of response of bird to human disturbance has been growing exponentially since 1989. Before this most of the studies were on response of mammals' behavior to human presence or disturbances. One of the earliest studies in this field was conducted by Cooke (1980) who compared tolerance level of birds in urban and sub urban areas. In 1960s and 1970s, there was a surge of interest in this topic, as researches began to focus on the effects of recreational activities, such as boating on bird behavior. During 1980, the focus shifted to the effects of urbanization on birds' populations, with researchers examining the effects of habitat fragmentation, noise pollution, artificial lighting and increasing human density on bird behavior. Most of these studies (more than 40%) were conducted in Europe.

Several studies have investigated the differences in bird tolerance to human disturbance between urban and rural areas. Many studies recorded urban birds being more tolerant than rural birds along urban-rural gradient (Kitchen et al. 2010; Carrete and Tella 2011; McGiffin et al. 2013; Matsyura et al. 2018; Carvalho and Toledo 2021). Recent study in different cities of different continents found that traits shaping tolerance of urban birds differ around the world, with urban-associated species tending to be smaller, less territorial, have greater dispersal ability, broader dietary and habitat niches, larger clutch sizes and higher reproductive rates (Neate-Clegg et al. 2023). A study investigated the effects of human disturbance in urban parks of Madrid (Spain) on bird tolerance and found that bird tolerance to human disturbance can be influenced by the design of urban parks (Fernández-Juricic et al. 2001). It suggested that urban park planning should take into account bird tolerance to human to minimize the negative impact of human disturbance on bird populations. Urban birds have broader environmental tolerance than rural conspecifics, as estimated by elevational and latitudinal distributions (Bonier et al. 2007). Another study investigated the effect of human presence on bird anti-predatory response in natural areas and found that human presence can have negative effects on bird population by altering bird settlement patterns (Bötsch et al. 2018).

The distance at which birds flee from an approaching threat, known as flight initiation distance (FID), is influenced by various factors (Blumstein 2003; Blumstein 2006). The size of the approaching group, whether it is human or birds, can affect FID, with some birds being more disturbed by larger groups of people and others exhibiting larger FIDs as number of approaching people increased (Piratelli et al. 2015; Mikula et al. 2018). The location of the bird can also influence FID, with birds in a location protected by a fence or other obstacles having longer FIDs than unprotected individuals (Ikuta and Blumstein 2003). The source of disturbance, such as pedestrian or dog walkers, can also affect FID, with people leading dogs eliciting longer FID. Additionally, the type of water body and the orientation of the walker group can also affect FID (Fernández-Juricic et al. 2005). FID is also influenced by life history and morphological traits. It has been suggested that individuals of longer-lived species are flightier because they become more wary with time and experience, but they may also have more chance to learn that humans pose little threat (Blumstein 2006). Body size is also a factor affecting FID, with larger species fleeing at a greater approach distances than smaller species (Fernández-Juricic et al. 2006; Symonds et al. 2014; Samia et al. 2015a). Flight performance (speed, duration) decreases as body size increases because smaller birds have a larger power-to mass ratio that allows them to accelerate rapidly.

Thus, less agile, larger-bodied and heavier species should particularly benefit from early predator detection (Bjørvik et al. 2014). Smaller bird species need to continue foraging and monitoring the predator or human, rather than initiate early escape, as they are less likely to be able to store large energy reserves and have a higher cost of flight (Coetzer and Bouwman 2017). Large species are more adapted at detecting approaching predators because they have larger eyes and better visual activity (Møller et al. 2016). They also flee earlier because they are more conspicuous and predators/humans are therefore more likely to detect larger species birds easily (Samia et al. 2015a).

The tolerance of birds towards humans is likely to vary seasonally as estimated predation risk and available risk also vary seasonally (Jorgensen et al. 2016). Nesting birds were found to have higher FID during breeding and post breeding season due to parental investment on offspring and their direct fitness is associated with offspring survival (Blumstein 2006; Piratelli et al. 2015; Poddubnaya et al. 2020). Similarly, Black Grouse *Tetrao tetrix* took flight at greater distances during winter and spring (Baines and Richardson 2007). Eurasian Oystercatchers *Haematopus ostralegus* exhibited shorter FIDs to humans when food was scarce in winter and they were thus able to remain near essential resources longer (Stillman and Goss-Custard 2002). The color of observer cloth also affect FIDs of bird, as red color is easily detectable from far distance, birds have low tolerance to observer wearing red or bright colored clothes than camouflaged color (Zhou and Liang 2020). Also color of the bird plumage affects FID, camouflaged birds being more tolerant as they are not easily detectable to predators than other colorful plumage (McQueen et al. 2017).

Most of these studies were carried out from Europe and there is less focus in such topics in Asia as well as Nepal. This study is one of the first of its kind in Nepal.

3. METHODS

3.1 Study Area

The study was conducted in Kathmandu Valley (27^o 24' 10" to 27^o 48' 56" N and 85^o 11' 27" to 85^o 34' 15" E), encompassing the administrative districts of Kathmandu, Bhaktapur, and Lalitpur. It is located in the mid-hills of Nepal, ranging from 1200 – 2760 m asl, and is encompassed by hills include Phulchoki, the highest peak in the south, the Shivapuri range in the north, Nagarkot in the east and Chandragiri-Nagarjun in the west, thereby showcasing a diverse and picturesque landscape. Temperature in valley varies from 0°C to 35°C.

Kathmandu Valley was divided into urban and rural areas following Katuwal et al. (2018). The study area includes both rural and urban areas in the Kathmandu Valley. The rural areas are characterized by extensive agricultural fields with scattered buildings especially close to the foothills of the valleys, while urban areas are characterized by a continuous built-up environment with roads and city parks interspersed especially in the ring-road area.

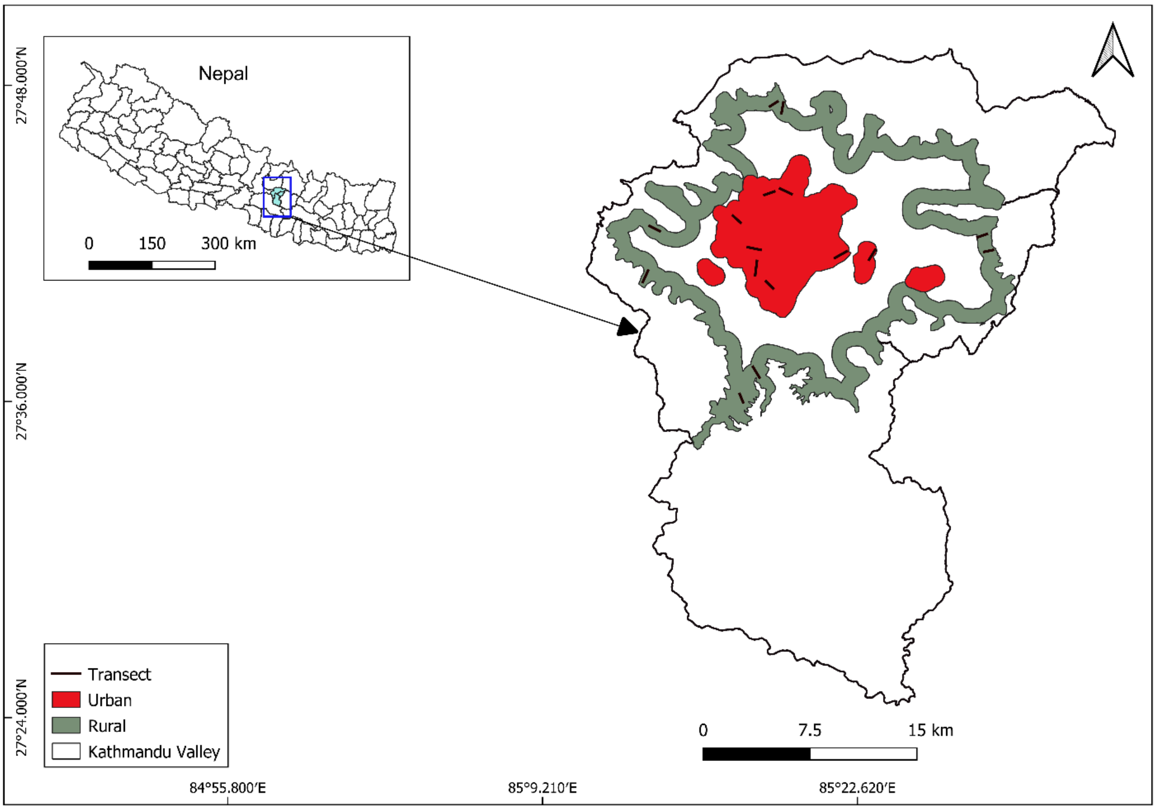

Figure 1 Map of study area showing transect location in rural and urban habitats in Kathmandu Valley

3.2 Data Collection

Birds' tolerance towards human-induced disruptions was assessed using the commonly employed method of flight initiation distance (FID), which is indicative of the distance at which an organism initiates escape from an approaching predator (Samia et al. 2015a). The method followed for this analysis adhered to the protocol outlined by Blumstein (2006). A total of 32 days observation was conducted across two seasons (winter-January and February and summer-April and May, 2022), especially, during favorable weather conditions (characterized by sunny skies, no rain, and strong wind) in morning 7:00 to 11:00 am and late afternoon 2:00 to 5:00 pm. Transects established by Katuwal et al. (2018) along an urban-rural gradient within the Kathmandu Valley was visited. However, for this study only 16 transects (urban = 8 and rural = 8) were chosen of length 1 km of walking distance (aerial distance = 786 ± 119m) (mean ± SD). Each transect was visited twice a day, one in the morning and another at late afternoon, for two days, alternating between the time periods in each season. Birds that were engaged for foraging or in relaxed behavior, such as, preening or roosting were focused, while juvenile birds were avoided to minimize the potential disturbances given their shorter FID (Møller 2008). In order to estimate the FID, birds were approached at a consistent pace of approximately 0.5 m/s. The starting distance (SD), which is the initial distance from which the observer begins to approach the bird, was noted during each observation. Previous studies (Blumstein 2003; Moller 2008a), have reported a significant relation between FID and SD. Therefore, birds were approached ensuring that minimum starting distance of 15 m is maintained. Once the bird noticed the observer, alert distance (AD) was recorded, which is the distance between the bird and the observer at the point when the bird became aware of the observer's presence. The FID was then recorded as the distance at which the bird either fled on foot or took flight in response to the approach. These distances were measured using rangefinder. However, the laser range finder used could not take distance measurements of less than 5 m. Therefore, for such cases, a meter-length stick was used to measure the distance. In addition, other relevant information, including sex, flock size and behavior (foraging or roosting) was also recorded for each bird species. Body size and feeding guilds of bird species were classified based on Grimmett et al. (2016) and Katuwal et al. (2016). The feeding guilds include insectivores (mainly eating insects, and sometimes small vertebrates), carnivores (primarily eating vertebrates including carrion), granivores (mainly eating seeds with few fruits and insects), and omnivores (diverse and varied diets) (Katuwal et al. 2022).

To avoid resampling the same individual birds, data was collected from various geographical locations to ensure that the data represented in this study was with a wide range of individual birds. In cases where flocks of birds were present, the nearest bird was focused and approached it to record its FID. Birds in flocks often behave differently when approached by humans compared to solitary birds due to the effects of 'dilution' or 'many eyes' effects (Pullim 1973) Thus, to account for these effects, size of flocks was also noted in which the target bird occurred when estimating FID. In cases where a group of interspecific bird species was present, nearest species was approached and noted the co-occurring species within a 5 m radius, as well as their respective flock sizes.

To minimize any confounding effects due to habituation, birds inside the compound of houses or temples were not approached where they are already accustomed to human presence. For instances where there was another form of disturbance, such as a predator or approaching vehicle, the FID of the bird was not recorded. In order to avoid any unintended influence on the bird's behavior, clothes that were neither too bright nor too camouflaged was worn, as birds can detect bright colors from a long distance. Additionally, to avoid any disturbance to nesting or breeding behavior, birds that were in possession of nesting material, sitting on a nest, or caring for fledglings were not approached.

3.3 Data Analysis

Statistical analysis was conducted for the data collected to compare mean FID of common bird species in rural and urban areas using hedges' g, which is a widely used method for comparing effect sizes. Hedges' g is a widely used measure of standardized mean difference that corrects for bias, and it is particularly useful when sample size is small (Hedges 1981). It is defined as the difference between two means, divided by a pooled estimate of the standard deviation. Unlike Cohen's d, which can overestimate the effect size when sample size is small, Hedges' g incorporates a correction factor that adjusts for the bias in the estimation of the pooled variance (Hedges 1981). This makes it a suitable measure for comparing means between groups with small sample sizes. An effect size measured by Hedges' g that falls below 0.2 is considered to be small, while a value between 0.2 and 0.5 indicates a medium size effect. A value exceeding 0.5 is considered to represent a large effect size. The 'effectsize' package (Ben-Shachar et al. 2020) was used to carry out this analysis. In addition, same method was to make comparisons between different factors, such as, sex (male and female), behavior (foraging and roosting), time of day (morning and late afternoon), season (summer and winter), body size (<15 m; small), 15-30 m (medium), >30 m (large), feeding guild (carnivore, omnivore, insectivore and granivore) between rural and urban areas. For each comparison of rural and urban areas, mean FID of common species in rural areas with those of urban areas was compared. Generalized additive model (GAM) using 'gam' package (Hastie 2011) was used to identify factors affecting FID. Factors, such as, habitat contrast, body size, behavior, time of day, season, flock size and feeding guild were included. Model selection approach was used to determine the most important variables influencing FID in birds. Top models based on Corrected Akaike's Information Criterion (AICc) were selected. 'Top models' within 4 ΔAICc of the highest ranked model was selected using the 'dredge' function in the package MuMIn (Barton 2009). Model averaging was done using all models to estimate 95% confidence intervals for each variable and accepted statistical significance at $\alpha < 0.05$. As only seven species have shown sexual dimorphism, sex as factor was excluded in generalized additive model analysis and only hedges' g was compared between them. All statistical analyses were done using R Program (R Core Team 2022).

4. RESULTS

A total 991 FIDs of 45 bird species were collected during the survey. However, FIDs of only those species with more than four FIDs were included, which resulted 922 FIDs of 33 species (505 FIDs of 32 species from rural areas and 417 FIDs of 18 species from urban areas). Birds were approached at distances ranging from 15 to 45 m (18.862 ± 4.711). Focal individuals were found to exhibit an alert behavior at distance of 4 to 37m (10.77 ± 4.11) while FID ranged from 1 to 30m (8.39 ± 4.62). For comparision of bird tolerance in rural and urban areas, only 18 common species were considered (Appendix 1). In case of feeding guild, four carnivores, five granivores, four insectivores, and four omnivores' species were common in both rural and urban areas (Appendix 1). Regarding body size, four small sized, nine medium sized and five large sized were observed in both rural and urban areas (Appendix 1). Only five bird species were distinctly identified as male and female and were common in both rural and urban areas. For behavior, seven species were common in both areas which are involved in both roosting and foraging. In case of season, 10 species were common in both habitat contrasts across both seasons. Nine species were common in rural and urban areas in case of time of day. But to determine the effect of different factors to FID, all 33 species were considered.

4.1 Bird tolerance in rural and urban areas

Urban birds tolerate more than its rural conspecifics with large difference in FID and with large effect size (hedges' g = 1.14; Figure 2). In case of body size, large difference was found in all category with large effect size (large = 1.25, medium = 1.37, small = 1.56; Figure 2) between rural and urban populations' FID. Similarly in case of behavior also, large difference in foraging and roosting was detected with large effect size (foraging = 2.24, roosting = 1.67; Figure 2) between urban and rural populations. Also, a large difference was found in time of day (morning as well as in late afternoon) (morning = 1.66, late afternoon = 1.11; Figure 2) between rural and urban populations. In comparing FIDs of different feeding guilds between rural and urban population, large difference was observed for omnivore (hedges' g = 3.41; Figure 2) followed by insectivore (hedges' g = 2.81), and carnivore (hedges' g = 1.10) while least was observed for granivore with medium effect size (hedges' g = 0.59). When comparing FIDs of summer and winter between rural and urban populations, large difference was found across both seasons (summer = 1.04, winter = 1.32; Figure 2). Similarly in case of sex, male showed large difference than female (male = 4.48, female = 0.78; Figure 2) between rural and urban populations.

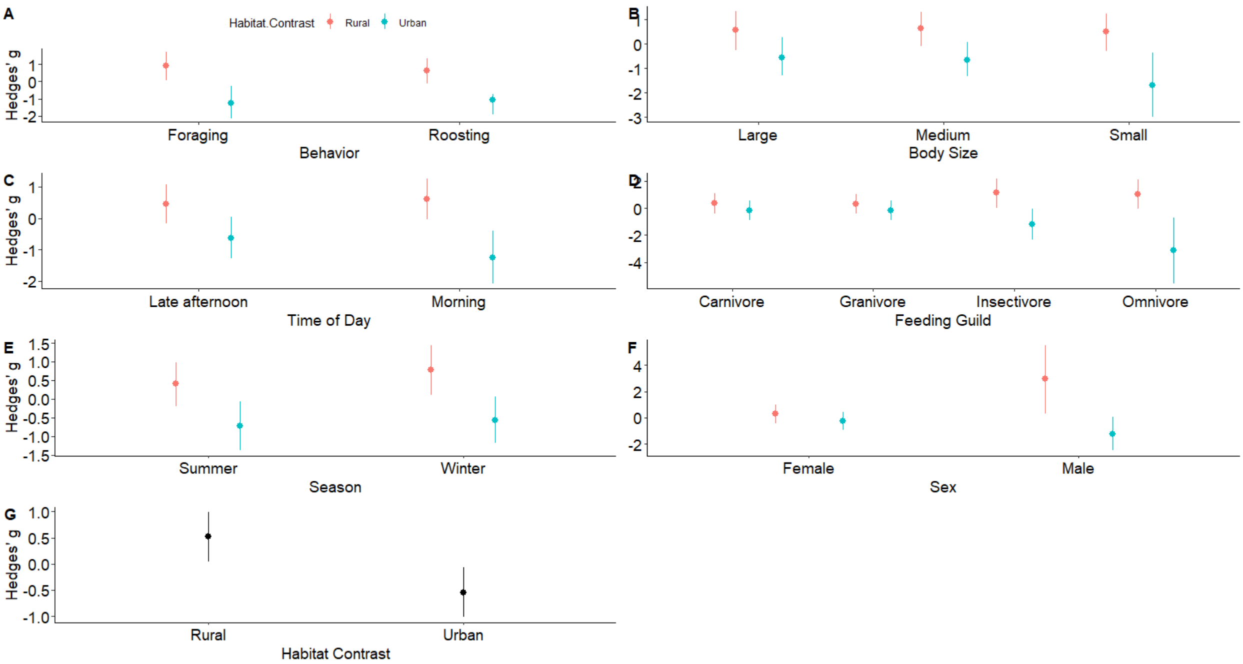

Figure 2 Comparison of effect of six predictors of effect size (Hedges' g) of bird tolerance to human disturbance from populations of urban and rural areas.

4.2 Factors affecting bird tolerance

The best supported model was found with variables including body size, feeding guild, habitat contrast and season (ΔAICc = 0.000, AICc weight = 0.152), followed up by model containing feeding guild, habitat contrast and season (ΔAICc = 0.587, AICc weight = 0.113) (Appendix 2). Behavior, body size, feeding guild, habitat contrast and season (ΔAICc = 1.643, AICc weight = 0.067) is the third best model while feeding guild and habitat contrast were included in fourth best model (ΔAICc = 1.870, AICc weight = 0.0060) (Appendix 2).

Table 1 Model-averaged parameters and their lower (LCI) and upper (UCI) (95%) confidence limits describing factors affecting bird tolerance. Flight initiation distance was used as response variable while body size (cm), feeding guilds, habitat contrasts, sex, flock size, season behavior, and time of the day were used as predictive variables.

Parameters	Estimate	SE	LCI	UCI	Z value	p
Intercept	12.954	2.086	8.688	17.253	6.185	<0.001
Body Size (Medium)	-0.793	0.634	-2.038	0.465	1.243	0.214
Body Size (Small)	0.603	0.894	-1.193	2.346	0.67	0.503
Feeding Guild (Granivore)	-5.107	1.132	-7.278	-2.847	4.491	**<0.001**
Feeding Guild (Insectivore)	-2.717	0.741	-4.149	-1.247	3.649	**<0.001**
Feeding Guild (Omnivore)	-3.335	0.651	-4.605	-2.016	5.096	**<0.001**
Habitat Contrast (Urban)	-3.106	0.53	-4.15	-2.057	5.824	**<0.001**
Season (Winter)	-0.917	0.464	-1.823	0.01	1.967	**0.049**
Behavior (Roosting)	-2.311	3.148	-8.541	3.9	0.73	0.466
Flock Size (Small)	0.331	0.59	-0.813	1.52	0.557	0.577
Time of day (Morning)	-0.14	0.465	-1.061	0.777	0.3	0.764

The best predictors for bird tolerance to human disturbance were habitat contrast, feeding guild and season. Urban birds showed significantly greater tolerance to approaching human than its rural conspecifics (P<0.001) (Table 1; Figure 3). Carnivore species were less tolerant than other feeding guild (granivore, insectivore and omnivore) birds (P<0.001) (Table 1; Figure 3). Similarly, bird tolerance level was found significantly higher in winter than in summer (P=0.049) (Table 1; Figure 3). Smaller birds are more tolerant to human disturbance than larger birds (Table 1; Figure 3). In case of flock size, bird tolerance level decreases with increase in flock size (Table 1; Figure 3). Also, bird tolerates more when they are involved in roosting behavior than in foraging (Table 1; Figure 3). Birds were found to tolerate more in morning than in late afternoon (Table 1; Figure 3). In case of sex, female birds were significantly more tolerant than male birds (hedges' g = 1.44) (Figure 3).

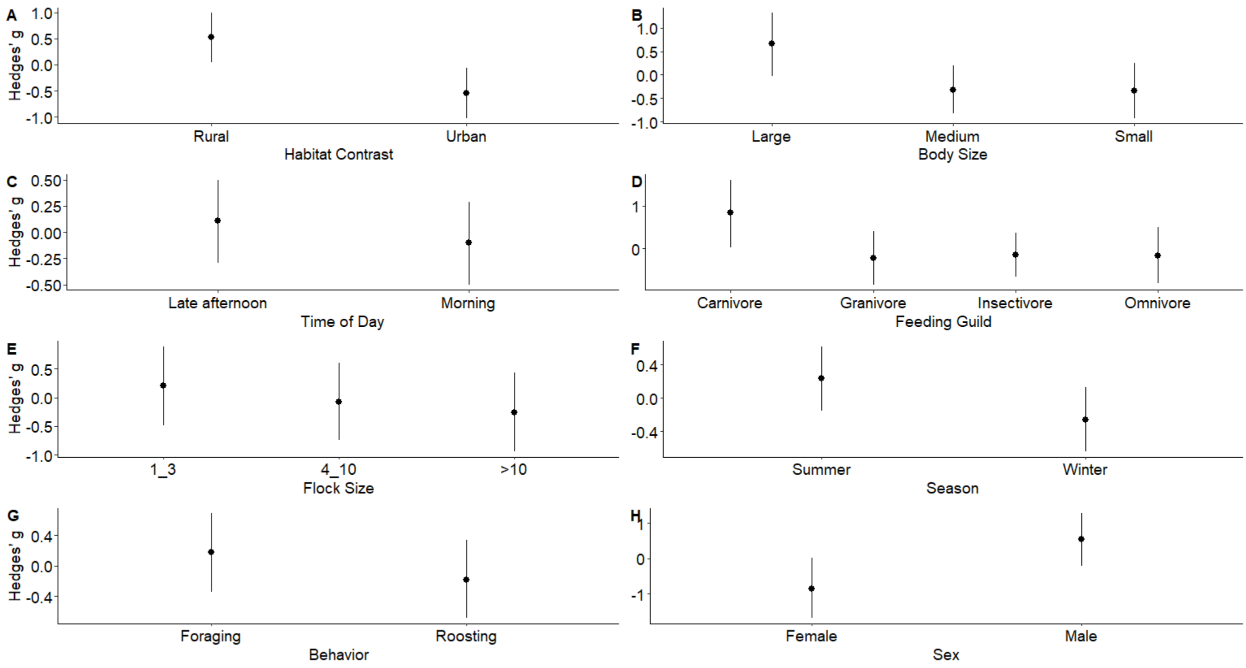

Figure 3 Effects of eight predictors on the effect sizes (Hedges' g) of bird's tolerance of human disturbance using the full data set

5. DISCUSSION

In this study, a variation was recorded in FID between rural and urban bird species across various categories such as body size, behavior, feeding guilds, seasons, time of day and sex. The effect size (hedges' g) found for each comparison is large for all, indicating a substantial difference between the two populations. This study suggests that urban birds are less sensitive to disturbance than their rural conspecifics, which could have important implications for their survival and reproductive success (Moller 2009). This might be due to the bird behavior influenced by human presence and birds may habituate to humans when their behavior is non-threatening (Cooper and Blumstein 2015). In areas where humans are frequently present and pose no direct danger to the birds, the birds may learn that humans do not pose a threat and may adjust their behavior accordingly this can include a reduction in bird's fear response, resulting in shorter FID (Stankowich and Blumstein 2005; Rollinson and Jones 2006; Samia et al. 2017).

Carnivorous birds were detected to be less tolerant to humans compared to other feeding guild birds (insectivores, granivores and omnivores). This might be due to their increased sensitivity to movement, which helps them to detect swiftly moving prey but also make them more responsive to human presence (Blumstein 2006). These results are consistent with previous studies (Blumstein 2006; Samia et al. 2017) which suggests dietary habit as an important factors in determining sensitivity of birds to humans. This indicated that carnivorous birds are more vulnerable to human disturbance, which may have implication for their conservation. Male birds were found to be bolder than their female counterparts in terms of FID as male birds are more aggressive and more colorful than female which are easily detectable and noticeable from far distance. This decreases in time of escape and increases their FID and females being more camouflaged decreases the detection probability from far distance provides them more time for saving energy to escape from predators (Møller et al. 2019a; García-Arroyo and MacGregor-Fors 2020). Nevertheless, this findings contrast with Carvalho and Toledo (2021) from Southeastern Brazil that reported females to be more bolder than male and with MacGregor-Fors et al. (2019) from and Hall et al. (2020) that reported no difference in FID between male and female.

Birds in summer season were found to have lower tolerance than in winter season. It might be due to predation risk on birds during the summer season where increased visibility or presence of more predators, and consequently they have more cautious during this time (Tay et al. 2021). Summer is also the breeding season for many birds (Inskipp et al. 2016) and birds respond differently during breeding season to approaching predator because of parental investment on offspring and their direct fitness is associated with offspring survival (Frid and Dill 2002). Alternatively, it could be that birds have less access to food resources in winter season (Newton 1980) and hence, they are obliged to take risks in winter season. Larger animals have lower tolerance levels than smaller animals (Blumstein 2006; Fernández-Juricic et al. 2006; Gotanda et al. 2009). Similar to this fact larger birds were found to exhibit greater FID than smaller birds, which could be attributed to the fact that larger birds are more easily detectable and less agile than smaller birds, making them more vulnerable and hence, more likely to take flight (Burger and Gochfeld 1991; Fernández-Juricic et al. 2002; Blumstein et al. 2016). Additionally, larger birds with relatively larger brains may possess superior cognitive abilities, allowing them to better evaluate risks (Samia et al. 2015b). In contrast, smaller birds tend to allocate more time for foraging due to their relatively higher energy requirements (Bennett and Harvey 1987), which could explain why they are more tolerant of risk before taking flight. Interestingly, medium-sized birds exhibited similar tolerance levels as small-sized birds. This could be because the medium-sized birds recorded had greater exposure to humans and were thus more accustomed to their presence.

In addition, negative relation was found between FID and flock size indicating that birds perceive high level of threats with human with decrease in flock size because individual risk is diluted in larger group and predators are less likely to make a successful hunt on multiple targets due to dilution effect (Pulliam 1973; Roberts 1996). This finding therefore agrees with the study of (Mikula et al. 2018) in Europe that individuals in a group may benefit through risk dilution and so perceive a lower risk when in larger groups. However, positive relation have been reported between FID and flock size in water birds of Danish Wadden Sea (Laursen et al. 2005) and Mekhada marsh (Halassi et al. 2021) and gregarious birds of Europe (Morelli et al. 2019) which can be due to "many eyes effect" hypothesis (Caraco 1980). Therefore, the effect of flock size seems to vary and appears to depend on the species- and site-specific context.

Our study suggests FID of foraging bird species to be slightly longer than those of roosting species. This might be because the more time an individual spends on foraging, the less time it has to be vigilant for predators and vice versa. As a result, foraging species have evolved different strategies to balance this trade-off and reduce their predation risk (Mori et al. 2001). This finding suggests that the foraging species are under greater predation risk and are more sensitive to approaching predators than are roosting species. Interestingly, some birds were slightly more sensitive to approaching predator over the course of a day. This effect might be influenced by the degree of satiation of the individual (Piratelli et al. 2015). Hunger can impair cognitive function, leading to decreased attention, memory and decision-making abilities. Conversely, being well-fed and satiated can improve cognitive performance, increasing alertness and focus (Schadegg and Herberholz 2017).

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study has provided insightful findings regarding the adaptability of birds to human. Birds of both rural and urban areas exhibit varying degrees of tolerance to human. This study showed that FID differ among bird species due to different type of habitat, behavior, sex, body size, time of day, flock size, season and feeding guild. Overall, understanding tolerance of different bird species to human in different habitat types is crucial for effective conservation strategies and for promoting coexistence between human and birds.

6.2 Recommendations

Based on the results of the entire study following recommendations are made:

(a) FID could be the first indicator of setback distance to pedestrian in urban and rural park.

(b) FID of male large bird species involved in foraging alone in winter season should be used to determine minimum area requirements of resource patches separated by pathways.

7. REFERENCES

Baines, D. and Richardson, M. 2007. An experimental assessment of the potential effects of human disturbance on Black Grouse *Tetrao tetrix* in the North Pennines, England. Ibis **149**: 56–64. https://doi.org/10.1111/j.1474-919X.2007.00638.x

Barton, K. 2009. MuMIn: Multi-model inference (R package version 0.12.2).

Bennett, P. M. and Harvey, P. H. 1987. Active and resting metabolism in birds: Allometry, phylogeny and ecology. Journal of Zoology, **213**(2): 327–344. https://doi.org/10.1111/j.1469-7998.1987.tb03708.x

Bjørvik, L., Dale, S., Hermansen, G., Munishi, P. and Moe, S. 2014. Bird flight initiation distances in relation to distance from human settlements in a Tanzanian floodplain habitat. Journal of Ornithology, **156**: 239–246. https://doi.org/10.1007/s10336-014-1121-1

Blumstein, D. T. 2003. Flight-Initiation Distance in Birds Is Dependent on Intruder Starting Distance. The Journal of Wildlife Management, **67**(4): 852. https://doi.org/10.2307/3802692

Blumstein, D. T. 2006. Developing an evolutionary ecology of fear: How life history and natural history traits affect disturbance tolerance in birds. Animal Behaviour, **71**(2): 389–399. https://doi.org/10.1016/j.anbehav.2005.05.010

Blumstein, D. T., Samia, D. S. and Cooper, W. E. 2016. Escape behavior: Dynamic decisions and a growing consensus. Current Opinion in Behavioral Sciences, **12**: 24–29. https://doi.org/10.1016/j.cobeha.2016.08.006

Bonier, F., Martin, P. R. and Wingfield, J. C. 2007. Urban birds have broader environmental tolerance. Biology Letters, **3**(6): 670–673. https://doi.org/10.1098/rsbl.2007.0349

Bötsch, Y., Gugelmann, S., Tablado, Z. and Jenni, L. 2018. Effect of human recreation on bird anti-predatory response. PeerJ, **6**: e5093. https://doi.org/10.7717/peerj.5093

Bradshaw, W. E. and Holzapfel, C. M. 2006. Evolutionary Response to Rapid Climate Change. Science, **312**(5779): 1477–1478. https://doi.org/10.1126/science.1127000

Brown, L. M. and Graham, C. H. 2015. Demography, traits and vulnerability to urbanization: Can we make generalizations? Journal of Applied Ecology, **52**(6): 1455–1464. https://doi.org/10.1111/1365-2664.12521

Burger, J. and Gochfeld, M. 1991. Human Distance and Birds: Tolerance and Response Distances of Resident and Migrant Species in India. Environmental Conservation, **18**(2): 158–165. https://doi.org/10.1017/S0376892900021743

Carlen, E. J., Li, R. and Winchell, K. M. 2021. Urbanization predicts flight initiation distance in feral pigeons (*Columba livia*) across New York City. Animal Behaviour, **178**: 229–245. https://doi.org/10.1016/j.anbehav.2021.06.021

Caraco, T., Martindale, S. and Pulliam, H. R. 1980. Avian time budgets and distance to cover. The Auk, **97**(4): 872-875.

Carrete, M. and Tella, J. L. 2011. Inter-Individual Variability in Fear of Humans and Relative Brain Size of the Species Are Related to Contemporary Urban Invasion in Birds. PLoS One, **6**(4): e18859. https://doi.org/10.1371/journal.pone.0018859

Carvalho, T. F. and Toledo, M. C. B. 2021. Tolerance to Human Presence, a Comparison between Rural and Urban Birds in Southeastern Brazil. Environ Sci Ecol: Curr Res, **2**(3): e1023.

Chalfoun, A. D., Thompson, F. R. and Ratnaswamy, M. J. 2002. Nest Predators and Fragmentation: A Review and Meta-Analysis. Conservation Biology, **16**(2): 306–318. https://doi.org/10.1046/j.1523-1739.2002.00308.x

Coetzer, C. and Bouwman, H. 2017. Waterbird flight initiation distances at Barberspan Bird Sanctuary, South Africa. Koedoe, **59**(1): a1419. https://doi.org/10.4102/koedoe.v59i1.1419

Cooke, A. S. 1980. Observations on how close certain passerine species will tolerate an approaching human in rural and suburban areas. Biological Conservation, **18**(2): 85–88. https://doi.org/10.1016/0006-3207(80)90072-5

Cooper, W. E. and Blumstein, D. T. 2015. Escaping from predators: An integrative view of escape decisions. Cambridge university press. http://opus.ipfw.edu/math_facpubs/154

delBarco-Trillo, J. 2018. Shyer and larger bird species show more reduced fear of humans when living in urban environments. Biology Letters, **14**(4): 20170730. https://doi.org/10.1098/rsbl.2017.0730

Díaz, M. Møller, A. P., Flensted-Jensen, E., Grim, T., Ibáñez-Álamo, J. D., Jokimäki, J., et al. 2013. The Geography of Fear: A Latitudinal Gradient in Anti-Predator Escape Distances of Birds across Europe. PLoS One, **8**(5): e64634. https://doi.org/10.1371/journal.pone.0064634

Fernández-Juricic, E., Blumstein, D., Abrica, G., Manriquez, L., Adams, L., Adams, R., et al. 2006. Relationships of anti-predator escape and post-escape responses with body mass and morphology: A comparative avian study. Evolutionary Ecology Research, **8**(4): 731–752.

Fernández-Juricic, E., Jimenez, M. D. and Lucas, E. 2001. Bird tolerance to human disturbance in urban parks of Madrid (Spain): Management implications. In J. M. Marzluff, R. Bowman, and R. Donnelly (Eds.), Avian Ecology and Conservation in an Urbanizing World (pp. 259–273). Springer US. https://doi.org/10.1007/978-1-4615-1531-9_12

Fernández-Juricic, E., Jimenez, M. D. and Lucas, E. 2002. Factors affecting intra- and inter-specific variations in the difference between alert distances and flight distances for birds in forested habitats. Canadian Journal of Zoology, **80**(7): 1212–1220.

Fernández-Juricic, E., Venier, M. P., Renison, D. and Blumstein, D. T. 2005. Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical assessment of minimum approaching distances and buffer areas for grassland birds. Biological Conservation, **125**(2): 225–235. https://doi.org/10.1016/j.biocon.2005.03.020

Fox, A. D. and Madsen, J. 1997. Behavioural and Distributional Effects of Hunting Disturbance on Waterbirds in Europe: Implications for Refuge Design. The Journal of Applied Ecology, **34**(1): 1–13. https://doi.org/10.2307/2404842

Frid, A. and Dill, L. M. 2002. Human-caused Disturbance Stimuli as a Form of Predation Risk. Conservation Ecology, **6**(1): 11. https://doi.org/10.5751/ES-00404-060111

García-Arroyo, M. and MacGregor-Fors, I. 2020. Tolerant to humans? Assessment of alert and flight initiation distances of two bird species in relation to sex, flock size, and environmental characteristics. Ethology Ecology and Evolution, **32**(5): 445–456. https://doi.org/10.1080/03949370.2020.1753115

Gotanda, K. M., Turgeon, K. and Kramer, D. L. 2009. Body size and reserve protection affect flight initiation distance in parrotfishes. Behavioral Ecology and Sociobiology, **63**(11): 1563–1572. https://doi.org/10.1007/s00265-009-0750-5

Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H. S. 2016. Birds of Nepal.Helm Field Guides (Second). Prakash Books. New Delhi

Halassi, I., Ali, E., Telailia, S. and Boutabia, L. 2021. Monitoring human disturbance: Factors affecting escape behaviour of waterbirds in North African wetlands. African Journal of Ecology, **60**(3): 523–532. https://doi.org/10.1111/aje.12949

Hall, M. J., Burns, A. L., Martin, J. M. and Hochuli, D. F. 2020. Flight initiation distance changes across landscapes and habitats in a successful urban coloniser. Urban Ecosystems, **23**(4): 785–791. https://doi.org/10.1007/s11252-020-00969-5

Hastie, T. 2011. Gam: Generalized Additive Models (R package version 1.06.2).

Hedges, L. V. 1981. Distribution Theory for Glass's Estimator of Effect Size and Related Estimators. Journal of Educational Statistics, **6**(2): 107–128. https://doi.org/10.2307/1164588

Hingee, M. and Magrath, R. D. 2009. Flights of fear: A mechanical wing whistle sounds the alarm in a flocking bird. Proceedings of the Royal Society B: Biological Sciences, **276**(1676): 4173–4179. https://doi.org/10.1098/rspb.2009.1110

Ikuta, L. A. and Blumstein, D. T. 2003. Do fences protect birds from human disturbance? Biological Conservation, **112**(3): 447–452. https://doi.org/10.1016/S0006-3207(02)00324-5

Inskipp, C., Baral, H. S., Phuyal, S., Bhatt, T. R., Khatiwada, M., Inskipp, T., et al. 2016. The status of Nepal's bird: The national red list series. United Kingdom: Zoological Society of London.

Jorgensen, J. G., Dinan, L. R. and Bomberger Brown, M. 2016. Flight initiation distances of nesting Piping Plovers (*Charadrius melodus*) in response to human disturbance. Avian Conservation and Ecology, **11**(1). https://doi.org/10.5751/ACE-00826-110105

Katuwal, H. B., Basnet, K., Khanal, B., Devkota, S., Rai, S. K., Gajurel, J. P., et al. 2016. Seasonal Changes in Bird Species and Feeding Guilds along Elevational Gradients of the Central Himalayas, Nepal. PLoS One, **11**(7): e0158362. https://doi.org/10.1371/journal.pone.0158362

Katuwal, H. B., Pradhan, N. M. B., Thakuri, J. J., Bhusal, K. P., Aryal, P. C. and Thapa, I. 2018. Effect of Urbanization and Seasonality in Bird Communities of Kathmandu Valley, Nepal. Proceedings of the Zoological Society, **71**(2): 103–113. https://doi.org/10.1007/s12595-018-0265-z

Katuwal, H. B., Rai, J., Tomlinson, K., Rimal, B., Sharma, H. P., Baral, H. S., et al. 2022. Seasonal variation and crop diversity shape the composition of bird communities in agricultural landscapes in Nepal. Agriculture, Ecosystems and Environment, **333**: 107973. https://doi.org/10.1016/j.agee.2022.107973

Kay, T., Lehmann, L. and Keller, L. 2019. Kin selection and altruism. Current Biology, **29**(11): 438–442. https://doi.org/10.1016/j.cub.2019.01.067

Kitchen, K., Lill, A. and Price, M. 2010. Tolerance of Human Disturbance by Urban Magpie-larks. Australian Field Ornithology, **27**(1): 1–9.

Laursen, K., Kahlert, J. and Frikke, J. 2005. Factors affecting escape distances of staging waterbirds. Wildlife Biology, **11**(1): 13–19. https://doi.org/10.2981/0909-6396(2005)11[13:FAEDOS]2.0.CO;2

Liker, A. and Bokony, V. 2009. Larger groups are more successful in innovative problem-solving in house sparrows. Proceedings of the National Academy of Sciences, **106**(19): 7893–7898. https://doi.org/10.1073/pnas.0900042106

MacGregor-Fors, I., Quesada, J., Lee, J. G.-H. and Yeh, P. J. 2019. On the lookout for danger: House Sparrow alert distance in three cities. Urban Ecosystems, **22**(5): 955–960. https://doi.org/10.1007/s11252-019-00874-6

Marzluff, J. M. 2001. Worldwide urbanization and its effects on birds. In J. M. Marzluff, R. Bowman and R. Donnelly (Eds.), Avian Ecology and Conservation in an Urbanizing World (pp. 19–47). Springer US. https://doi.org/10.1007/978-1-4615-1531-9_2

Matsyura, A., Jankowski, K. and Zimaroyeva, A. 2018. Corvidae tolerance to human disturbance in settlement landscapes of Zhytomir (Ukraine). Romanian Journal of Biology-Zoology, **60**(1): 39–47.

McGiffin, A., Lill, A., Beckman, J. and Johnstone, C. 2013. Tolerance of human approaches by Common Mynas along an urban-rural gradient. Emu-Austral Ornithology, **113**(2): 154–160. https://doi.org/10.1071/MU12107

McQueen, A., Naimo, A. C., Teunissen, N., Magrath, R. D., Delhey, K. and Peters, A. 2017. Bright birds are cautious: Seasonally conspicuous plumage prompts risk avoidance by male superb fairy-wrens. Proceedings of the Royal Society B: Biological Sciences, **284**(1857): 20170446. https://doi.org/10.1098/rspb.2017.0446

Mikula, P. 2014. Pedestrian Density Influences Flight Distances of Urban Birds. Ardea, **102**(1): 53–60. https://doi.org/10.5253/078.102.0105

Mikula, P., Díaz, M., Albrecht, T., Jokimäki, J., Kaisanlahti-Jokimäki, M.-L., Kroitero, G., et al. 2018. Adjusting risk-taking to the annual cycle of long-distance migratory birds. Scientific Reports, **8**(1): 1–9. https://doi.org/10.1038/s41598-018-32252-1

Mikula, P., Tomášek, O., Romportl, D., Aikins, T. K., Avendaño, J. E., Braimoh-Azaki, B. D. A., et al. 2023. Bird tolerance to humans in open tropical ecosystems. Nature Communications, **14**(1): 2146. https://doi.org/10.1038/s41467-023-37936-5

Moller, A. 2008a. Flight Distance of Urban Birds, Predation, and Selection for Urban Life. Behavioral Ecology and Sociobiology, **63**: 63–75. https://doi.org/10.1007/s00265-008-0636-y

Møller, A. P. 2008b. Flight distance and population trends in European breeding birds. Behavioral Ecology, **19**(6): 1095–1102. https://doi.org/10.1093/beheco/arn103

Moller, A. P. 2009. Successful city dwellers: A comparative study of the ecological characteristics of urban birds in the Western Palearctic. Oecologia, **159**(4): 849–858. https://doi.org/10.1007/s00442008-1259-8

Møller, A. P., Samia, D. S. M., Weston, M. A., Guay, P.J., and Blumstein, D. T. 2014. American Exceptionalism: Population Trends and Flight Initiation Distances in Birds from Three Continents. PLoS One, **9**(9): e107883. https://doi.org/10.1371/journal.pone.0107883

Møller, A. P., Samia, D. S. M., Weston, M. A., Guay, P.J., and Blumstein, D. T. 2016. Flight initiation distances in relation to sexual dichromatism and body size in birds from three continents. Biological Journal of the Linnean Society, **117**(4): 823–831. https://doi.org/10.1111/bij.12706

Møller, A. P., Liang, W., and Samia, D. S. M. 2019a. Flight initiation distance, color and camouflage. Current Zoology, **65**(5): 535–540. https://doi.org/10.1093/cz/zoz005

Morelli, F., Benedetti, Y., Díaz, M., Grim, T., Ibáñez-Álamo, J. D., Jokimäki, J., Kaisanlahti-Jokimäki, M.-L., et al. 2019b. Contagious fear: Escape behavior increases with flock size in European gregarious birds. Ecology and Evolution, **9**(10): 6096–6104. https://doi.org/10.1002/ece3.5193

Mori, Y., Sodhi, N. S., Kawanishi, S., and Yamagishi, S. 2001. The effect of human disturbance and flock composition on the flight distances of waterfowl species. Journal of Ethology, **19**(2): 115–119. https://doi.org/10.1007/s101640170007

Neate-Clegg, M. H. C., Tonelli, B. A., Youngflesh, C., Wu, J. X., Montgomery, G. A., Şekercioğlu, Ç. H., et al. 2023. Traits shaping urban tolerance in birds differ around the world. Current Biology, **33**: 1677–1688. https://doi.org/10.1016/j.cub.2023.03.024

Newton, I. 1980. The Role of Food in Limiting Bird Numbers. Ardea, **55**(1–2): 11–30. https://doi.org/10.5253/arde.v68.p11

Piratelli, A. J., Favoretto, G. R., and Maximiano, M. F. de A. 2015. Factors affecting escape distance in birds. Zoologia (Curitiba), **32**(6): 438–444. https://doi.org/10.1590/s1984-46702015000600002

Poddubnaya, N., Korotkova, T., and Vanicheva, P. 2020. Increasing corvid tolerance to humans in urban ecosystems with increasing latitude. Biological Communications, **64**(4): 252–259. https://doi.org/10.21638/spbu03.2019.404

Price, M. 2008. The impact of human disturbance on birds: A selective review. In Australian Zoologist (Vol. 34, pp. 810–821). https://doi.org/10.7882/FS.2008.023

Pulliam, H. 1973. On the advantages of flocking. J. Theor. Biol. **38**: 419–422.

R Core Team. 2022. R: A Language and Environment for Statistical Computing [Vienna, Austria]. https://www.R-project.org/

Roberts, G. 1996. Why individual vigilance declines as group size increases. Anim. Behav. **51**: 1077–1086 .

Rodgers, J. A., and Schwikert, S. T. 2002. Buffer-Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-Powered Boats. Conservation Biology, **16**(1): 216–224. https://doi.org/10.1046/j.1523-1739.2002.00316.x

Rollinson, D. J., and Jones, D. N. 2006. Tolerance of Australian Magpies *Gymnorhina tibicen* Towards Humans: A Comparison Along an Urban Gradient. Australian Field Ornithology, **23**(1): 29–35.

Saino, N., Romano, M., Ferrari, R. P., Martinelli, R., and Møller, A. P. 2005. Stressed mothers lay eggs with high corticosterone levels which produce low-quality offspring. Journal of Experimental Zoology Part A: Comparative Experimental Biology, **303**(11): 998–1006. https://doi.org/10.1002/jez.a.224

Samia, D. S. M., Nakagawa, S., Nomura, F., Rangel, T. F., and Blumstein, D. T. 2015a. Increased tolerance to humans among disturbed wildlife. Nature Communications, **6**(1): 8877. https://doi.org/10.1038/ncomms9877

Samia, D. S. M., Pape Møller, A., and Blumstein, D. T. 2015b. Brain size as a driver of avian escape strategy. Scientific Reports, **5**(1): 11913. https://doi.org/10.1038/srep11913

Schadegg, A. C., and Herberholz, J. 2017. Satiation level affects anti-predatory decisions in foraging juvenile crayfish. Journal of Comparative Physiology A, **203**(3): 223–232. https://doi.org/10.1007/s00359-017-1158-8

Schleucher, E. 2001. Heterothermia in pigeons and doves reduces energetic costs. Journal of Thermal Biolgy, **26**(4–5): 287–293.

Seto, K. C., Güneralp, B., and Hutyra, L. R. 2012. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the

National Academy of Sciences, **109**(40): 16083–16088. https://doi.org/10.1073/pnas.1211658109

Sharma, D. P. 2003. Urbanization and development. Population Monograph of Nepal, **1**: 375–412.

Stankowich, T., and Blumstein, D. T. 2005. Fear in animals: A meta-analysis and review of risk assessment. Proceedings of the Royal Society B: Biological Sciences, **272**(1581), 2627–2634. https://doi.org/10.1098/rspb.2005.3251

Stillman, R. A., and Goss-Custard, J. D. 2002. Seasonal changes in the response of oystercatchers *Haematopus ostralegus* to human disturbance. Journal of Avian Biology, **33**(4): 358–365. https://doi.org/10.1034/j.1600-048X.2002.02925.x

Symonds, M. R. E., Weston, M. A., Robinson, R. W., and Guay, P.J. 2014. Comparative Analysis of Classic Brain Component Sizes in Relation to Flightiness in Birds. PLoS One, **9**(3): e91960. https://doi.org/10.1371/journal.pone.0091960

Tay, N. E., Fleming, P. A., Warburton, N. M., and Moseby, K. E. 2021. Predator exposure enhances the escape behaviour of a small marsupial, the burrowing bettong. Animal Behaviour, **175**: 45–56. https://doi.org/10.1016/j.anbehav.2021.02.013

Tryjanowski, P., Kosicki, J. Z., Hromada, M., and Mikula, P. 2020. The emergence of tolerance of human disturbance in Neotropical birds. Journal of Tropical Ecology, **36**(1): 1–5. https://doi.org/10.1017/S0266467419000282

Tsurim, I., Abramsky, Z., and Kotler, B. P. 2008. Foraging Behavior of Urban Birds: Are Human Commensals Less Sensitive to Predation Risk than their Nonurban Counterparts. The Condor, **110**(4): 772–776. https://doi.org/10.1525/cond.2008.8572

Vincze, E., Papp, S., Preiszner, B., Seress, G., Bókony, V., and Liker, A. 2016. Habituation to human disturbance is faster in urban than rural House Sparrows. Behavioral Ecology, **27**(5): 1304–1313. https://doi.org/10.1093/beheco/arw047

Ydenberg, R., and Dill, L. M. 1986. The economics of fleeing from predators. Adv Stud Behav, **16**: 29-249.

Zhou, B., and Liang, W. 2020. Avian escape responses to observers wearing clothing of different colors: A comparison of urban and rural populations. Global Ecology and Conservation, **22**: e00921. https://doi.org/10.1016/j.gecco.2020.e00921

8. APPENDICES

Appendix 1: List of bird species that were approached in urban and rural areas

S.N.	Common Name	Scientific Name	Rural Area	Urban Area	Body Size	Feeding Guild
1	Black Drongo	*Dicrurus macrocercus*	X		M	Insectivore
2	Blue Whistling-thrush	*Myophonus caeruleus*	X		L	Omnivore
3	Blue-fronted Redstart	*Phoenicurus frontalis*	x		S	Insectivore
4	Brown Shrike	*Lanius cristatus*	x		M	Insectivore
5	Cattle Egret	*Bubulcus ibis*	x	x	L	Carnivore
6	Common Myna	*Acridotheres tristis*	x	x	M	Omnivore
7	Common Sandpiper	*Actitis hypoleucos*		x	M	Insectivore
8	Common Stonechat	*Saxicola torquatus*	x	x	S	Insectivore
9	Eurasian Collared-dove	*Streptopelia decaocto*	x	x	L	Granivore
10	Eurasian Tree Sparrow	*Passer montanus*	x	x	S	Granivore
11	Grey Wagtail	*Motacilla cinerea*	x		M	Insectivore
12	Grey-backed Shrike	*Lanius tephronotus*	x	x	M	Carnivore
13	Himalayan Bulbul	*Pycnonotus leucogenys*	x		M	Omnivore
14	Hodgson's	*Phoenicurus*	x		S	Insectivore

	Redstart	*hodgsoni*				
15	House Crow	*Corvus splendens*	x	x	L	Omnivore
16	House Sparrow	*Passer domesticus*	x	x	S	Granivore
17	Indian Pond-heron	*Ardeola grayii*	x	x	L	Carnivore
18	Jungle Myna	*Acridotheres fuscus*	x	x	M	Omnivore
19	Long-tailed Shrike	*Lanius schwhite ach*	x	x	M	Carnivore
20	Olive-backed Pipit	*Anthus hodgsoni*	x	x	S	Insectivore
21	Oriental Magpie Robin	*Copsychus saularis*	x		M	Insectivore
22	Oriental Turtle-dove	*Streptopelia orientalis*	x		L	Granivore
23	Paddyfield Pipit	*Anthus rufulus*	x		S	Insectivore
24	Pied Bushchat	*Saxicola caprata*	x	x	S	Insectivore
25	Red-vented Bulbul	*Pycnonotus cafer*	x	x	M	Omnivore
26	Red-wattled Lapwing	*Vanellus indicus*	x		L	Carnivore
27	Rock Dove	*Columba livia*	x	x	L	Granivore
28	Slaty-blue Flycatcher	*Ficedula tricolor*	x		S	Insectivore
29	Spotted Dove	*Spilopelia suratensis*	x	x	M	Granivore
30	White	*Motacilla*	x	x	M	Insectivore

	Wagtail	*alba*				
31	White-breasted Kingfisher	*Halcyon smyrnensis*	x		M	Carnivore
32	White-breasted Waterhen	*Amaurornis phoenicurus*	x		L	Omnivore
33	White-rumped Munia	*Lonchura striata*	x		S	Granivore

(L = Large, M=Medium, S=Small)

Appendix 2: Generalized Additive Model to identify factors affecting bird tolerance. FIDs (m) were used as response variable while body size (cm), feeding guilds, habitat contrasts, sex, flock size, season, behavior, and time of the day were used as predictive variables.

S.N.	Covariate	df	**AICc**	**ΔAICc**	**Wi**
1	Body Size + Feeding Guild + Habitat Contrast + Season	9	1080.866	0.000	0.152
2	Feeding Guild + Habitat Contrast + Season	7	1081.453	0.587	0.113
3	Behavior +Body Size + Feeding Guild + Habitat Contrast + Season	10	1082.509	1.643	0.067
4	Feeding Guild + Habitat Contrast	6	1082.736	1.870	0.060
5	Body Size + Feeding Guild + Flock Size + Habitat Contrast + Season	10	1082.843	1.977	0.057
6	Body Size + Time of day + Feeding Guild + Habitat Contrast + Season	10	1082.986	2.120	0.053
7	Behavior + Feeding Guild + Habitat Contrast + Season	8	1083.088	2.223	0.050
8	Feeding Guild +Flock Size +Habitat Contrast + Season	8	1083.324	2.458	0.045
9	Time of day + Feeding Guild + Habitat Contrast + Season	8	1083.539	2.673	0.040
10	Body Size + Feeding Guild + Habitat Contrast	8	1083.871	3.005	0.034
11	Feeding Guild + Flock Size + Habitat Contrast	7	1083.984	3.119	0.032
12	Behavior + Feeding Guild + Habitat Contrast	7	1084.186	3.321	0.029
13	Behavior + Body Size + Feeding Guild + Flock Size + Habitat Contrast + Season	11	1084.560	3.694	0.024
14	Time of day + Feeding Guild + Habitat Contrast	7	1084.651	3.785	0.023
15	Behavior + Body Size + Time of day + Feeding Guild + Habitat Contrast + Season	11	1084.682	3.816	0.023
16	Null	2	1158.175	77.310	0.000