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Research Article

Tolerance to Human Presence, a Comparison between Rural and Urban Birds in Southeastern Brazil

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Abstract

Green urban areas such as parks, squares, gardens, and forest fragments present a large diversity of uses and conservation objectives. These spaces provide resources for many species of birds that are confronted with the necessity of living in proximity to humans. It is assumed that bird species that acquire resources in urban environments live in a constant state of fear to guarantee survival and reproduction. In this context, the objective of this study was to evaluate the tolerance of birds with respect to human presence in two distinct conditions, rural areas (low level of human presence) and urban areas (high level of human presence). The fieldwork was conducted in a city in the Southeast region of Brazil, and the methodology used the alert distance and flight initiation measurements based on the approach of an observer to the individual bird being focused. Our results suggest that individuals observed in urban areas rely on shorter alert and escape distances, especially males, adults, and birds that forage in interspecific flocks. We discuss the challenges and strategies with respect to escape characteristics of urban birds, with special focus on the economic escape theory. In general, our results support those from studies conducted in other urban areas in different biogeographic regions, and they will aid in comprehending the impacts caused by the increase in urban areas around the world.

Introduction

In birds, stressful conditions lead to an increase in energy costs associated with fleeing and can be fatal under two conditions: (1) birds that occupy suboptimal areas or that have access to insufficient resources, and (2) birds that face repeated disturbances. Both cases make the individuals vulnerable to diseases and predators thus shortening lifespan or reducing reproductive performance [1-3]. Research conducted on forage has provided ample evidence that species in vulnerable conditions are frequently exposed to danger, for example when confronting a new predator such as occurs in the presence of humans [4, 5]. According to *Diaz et al. (2013),* some birds incur great risk in order to take care of their offspring when mortality rates are high, which results in low reproductive success. In this situation, the costs associated with an opportunity to obtain food could be compensated by rapidly becoming accustomed to threatening situations, thus making confronting stress a common condition. However, species vary as to the level of tolerance, and this is directly related to the degree of genetic plasticity of a species [7, 8]. In this way, some species can become habituated to constant stress or learn to explore new resources [9, 10]. It is expected that carnivores and omnivores have better detection abilities and are more skilled at manoeuvring in their environment than are herbivores since they hunt live prey and rely on dexterous movement abilities [1]. More species that are social are more vigilant due to the need to monitor members of their own species against predators, and this care makes these species more aware of the presence of humans. For this reason, it is expected that the social system stimulate a rapid response to fear in the presence of humans [4, 11]. According to Blumstein (2006), fear exhibited by birds is also related to the body size of a species, which, in turn, determines characteristics of flight. Larger birds tend to escape more slowly and over a greater distance than smaller ones [12]. In addition, larger birds are more conspicuous and therefore more vulnerable to predators, which stimulates the development of abilities to detect potential enemies over large distances. On the other hand, smaller species can escape rapidly, and for this reason are better able to tolerate the presence and nearness of humans [5, 6, 11]. Despite the quick escape response, smaller species need more time to perceive human presence and incur greater risk when foraging, and this exposure to a longer and more intense period of stress causes an increase of the energetic cost due to the increase in time needed for foraging [13]. Therefore, smaller species, even when subjected to disturbance, can tolerate larger risks before taking flight, which is associated with a high cost in terms of energy expenditure. Furthermore, *Carrete and Tella (2011)* showed that species that demonstrate lower levels of fear in the presence of humans have larger brains than those birds that do not allow humans to approach them. Another important aspect is coexistence with humans, which can create a higher level of tolerance through development of novel anti-predator strategies or even the loss of fear in the presence of predators [15]. In this context, we based this study on the supposition that birds can differ with respect to tolerance of human presence between rural and urban environments. In rural areas, birds are not habituated to human presence and are therefore more cautious. In contrast, birds that inhabit urban environments are oftentimes tolerant to the point of not attempting to escape when in the presence of humans and may therefore be referred to as a tame species [14]. In support of this idea, studies have shown that fleeing distances are greater in rural as opposed to urban areas [3, 16, 17]. The objective of this study was to evaluate the tolerance of birds with respect to human presence in two distinct conditions: (1) a rural area (low level of human presence) and (2) an urban area (high level of human presence) in the city in south-eastern Brazil. As a function of the high rate of urbanization that is currently common around the world, this study will contribute to a growing body of information that sheds light on the magnitude of the relationship between humans and bird species that will aid in conservation efforts since it had been established that urbanization is responsible for causing the extinction of many species of animals around the world.

Methodology

Study area

The study sites consisted of rural and urban areas selected in the city of Taubaté - SP. Rural sites were in areas with extensive agricultural fields that were more than 2km from the periphery of the urban zone. Urban areas were in parks and town squares where people commonly exercise, and other green spaces in the urban zone where children play, and people engage in team sports activities. There were six areas, being three rural and three urban sites (Figure 1).

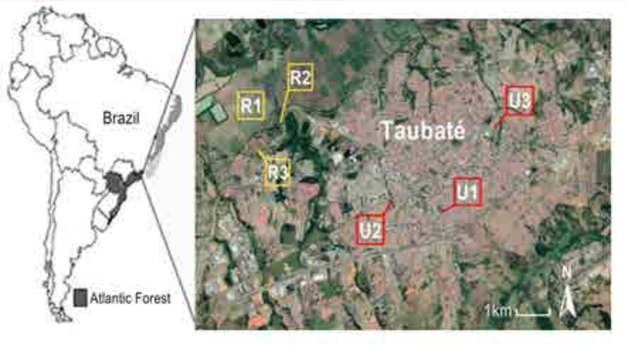

Figure 1: Location of the municipality of Taubaté, state of São Paulo. The yellow rectangles highlight the observation sites in the rural areas (R) and the red ones represent the sites in the urban areas (U).

Data collection

Field observations consisted of recording site location, date, hour, temperature, wind speed, weather conditions, and the presence of people at each collection point. A total of 20 hours of observation were conducted in the rural as well as the urban areas, for a total of 40 hours across both sites from May to June and from October to December 2019. During data collection in the rural area the temperature varied between 16 and 26°C, wind speed was 6 to11km/h and the presence of people in the rural area was <15 people/hour. Temperatures in the urban areas varied between 19 and 27°C, wind speed was consistently 11km/h, and the presence of pedestrians was >30 people/hour. Birds were identified using filed guides (18) and the Brazilian Ornithology Committee - CBO (19). Data registered for each species included relative age (adult or immature juvenile), sex, and if the bird was spotted as an isolated individual, in a pair, or in a group. Observations were done using a pair of binoculars (Swift, model n°820T Audubon HP). The number of birds of the same species within a radius of 1m around the bird(s) being observed was registered an included as a flock [16].

Alert distance - AD and Flight initiation distance - FID

Upon locating and focusing on a bird, the observer walked at a normal pace up to the bird and recorded the number of steps of approximately 1 meter it took to arrive at the final observation point [6]. The FID was measured as the distance between the position of the observer and the point from where the bird began its fleeing action (Figure 2). Only birds spotted on the ground or perched up to 1.5 meters above the ground were registered [11]. To minimize bias associated with a reduction in FID, the observation of a bird was formally initiated at a distance greater than 30 m, and for the reason binoculars were used to locate and observe birds. In the case of escape, was considered of locomotion such as jumping, walking, or flying. The Phi index (φ) to pre-distance (SD to AD) and buffer distance (SD to FID) was calculated to determine the distance travelled until the bird to detect the human presence and tolerance estimate after detecting human presence, respectively [16,20].

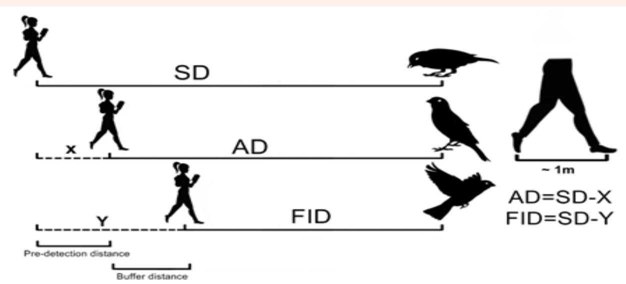

Figure 2: Illustration of the distances used in the present study. Firstly is start distance (SD) when the observer begins the approach a bird; secondly alert distance (AD) when the bird detects the observer presence, and thirdly is FID or Flight initiation distance, when the occur the escape. On the right side, in highlighted, the observer's step width and how each measurement was defined. Below are pre-detection and buffer distances (φ) (Modified from *Samia et al. 2017*)

Data analysis

Results were presented as absolute values, proportions (%), average ± standard deviation. A non-parametric t-test was used to compare the Phi index (φ), alert distance (AD) and flight initiation distance (FID) between rural and urban areas. This test was also used to make comparisons between sex, age, size of flocks, behavior (foraging or others such as preening and perching). We used Pearson linear correlation (r) to correlate the number of individuals in a flock with AD and FI distances. All statistical analyses were done using IBM SPSS Statistics 20.0, which is freely available on the internet.

Results

One hundred and eight individuals from 24 species and 16 families were registered (Table 1). There were 16 and 12 species in rural and urban areas respectively, with the most abundant species being *Crotophaga ani* and *Bulbucus ibis* in rural areas, and *Columbina talpacoti* and *Passer domesticus* in urban ones.

Forty-five individuals were approached in the rural area and 63 individuals in the urban areas. Considering all species, the results show significant differences between rural and urban areas for alert distance (t=5.08; p=0.0001), as well as for FID (t=5.25; p=0.0001), with higher values for both distances in rural areas (Figure 3a). Analysis using only species that occurred in both areas, such as *Columbina talpacoti* (Figure 3b) and *Pitangus sulphuratus* (Figure 3c) revealed significant differences for AD (t=2.37; p=0.02) and FID (t=2.29; p=0.03), with distances being longer in rural areas. The test for pre-distance and buffer detection of human presence (φ) was significantly different between rural and urban areas (t= 3.75; p= 0.000), with lower values in urban as opposed to rural areas (Figure 3d) of the species exhibiting sexual dimorphism, 16 males were registered (three in rural and 13 in urban areas), and 17 females (four in rural and 13 in urban areas). There was a difference between genders with respect to human presence, with males (AD average= 22±6 steps; FID average= 9±5 steps) and females (AD average= 18±6 steps; FID average= 8±4 steps), and a significant difference between males and females for escape distance (t=2.32; p=0.03), and no difference between rural and urban FID (t=1.14; p=0.26). There was also a significant difference for AD between males and females in the urban area (t=2.77; p=0.01), but the values of FID were not different between males and females in the urban area (t=1.33; p=0.19). Considering only rural areas with respect to differences between males and females, there were no significant differences for alert distance (t=0.36; p=0.72) or FID (t=0.23; p=0.82) (Figure 3e). With respect to age class in rural and urban areas respectively, 90.48% (n=57) and 91.11% (n=41) were adults, and 8.89% (n=4) and 9.52% (n=6) were juveniles. For adults, the AD in rural areas was an average 7±3 steps, and in urban areas this average was 20±1 steps, which was a highly significant difference (t=5.43; p=0.000). The values for FID for adults in rural areas was an average of 20±2 steps, while in urban areas this average was 8±1 steps, and these values were significantly different and much lower in urban areas (t=5.75; p=0.000) (Figure 3f). There were no significant differences for the comparison of alert distance in juveniles (rural average= 14±4 steps, urban average= 19±2 steps) there was no (t=1.08; p=0.30), or for FID for juveniles (rural average= 2±1 steps, urban average= 4±2 steps) (t=0.9; p=0.39) (Figures 3g and 3h).

In urban areas, with respect to behaviour in the observation moment, in urban areas 90% (n=57) of the individuals were foraging, and 12% (n=8) were engaged in other activities such as walking, vocalizing, bathing in the sand or idly perched. The average values for AD and FID were significantly different between these activities (t=3.15; p=0.002). The number of individuals foraging was large in urban as well as rural areas. In this way, when comparing only individuals that were foraging, the differences were significant between AD (t=6.17; p=0.000) and FID (t=4.49; p=0.000), and in each case the distances were lower in urban areas (Figure 3i). Among species that live in flocks or groups, there were similarities between rural and urban areas, with the number of species observed in large flocks (>6 individuals) were 20% (n=9) in the two areas, and in small bands (<6 individuals) were less common, in rural 73.33% (n=33) and urban areas 63.49% (n=40). The results of the Pearson linear correlation for the number of individuals in a group and for the alert distances não were not significant for each of the evaluated conditions. Only the FID showed a correlation between the size of the band in the rural areas, which was negative and significant (r= - 0.33; p= 0.02), which means that as groups get smaller the FID gets larger. In relation to the method of fleeing used by the birds, flight was predominant in rural (97.78%, n=44) as well as urban areas (73.02%, n=46). On the other hand, few birds evaded human presence by running or jumping, with only one individual that escaped using this method in the rural areas, and 26.98% (n=17) in urban areas. Considering only those birds that escaped by flying, there were differences between urban and rural areas for AD (t=5.06; p=0.000) as well as for FID (t=4.39; p=0.000).

Table 1: List of species that were approached in the rural and urban areas.

Family	Specie	Rural area	Urban area	Common name
Anatidae	*Amazonetta brasiliensis* (Gmelin,1789)	x		Brazilian Teal
	Bubulcus ibis (Linnaeus, 1758)	x		Cattle Egret
Ardeidae	*Ardea alba Linnaeus*, 1758			Great Egret
Charadriidae	*Vanellus chilensis* (Molina, 1782)	x	x	Southern Lapwing
Jacanidae	*Jacana jacana* (Linnaeus, 1766)	x		Wattled Jacana
	Columbina talpacoti (Temminck, 1810)	x	x	Ruddy Ground-dove
	Columba livia Gmelin, 1789		x	Rock Pigeon
Columbidae	*Patagioenas picazuro* (Temminck, 1813)		x	Picazuro Pigeon
Cuculidae	*Crotophaga ani Linnaeus*, 1758	x		Smooth-billed Ani
Strigidae	*Athene cunicularia* (Molina, 1782)	x		Burrowing Owl
Falconidae	*Caracara plancus* (Miller, 1777)	x		Southern Caracara
Furnariidae	*Furnarius rufus* (Gmelin, 1788)		x	Rufous Hornero
	Pitangus sulphuratus (Linnaeus, 1766)	x	x	Great Kiskadee
	Machetornis rixosa (Vieillot, 1819)		x	Cattle Tyrant
	Tyrannus savana Daudin, 1802	x		Fork-tailed Flycatcher
Tyrannidae	*Fluvicola nengeta* (Linnaeus, 1766)		x	Masked Water-tyrant
	Pygochelidon cyanoleuca (Vieillot, 1817)	x		Blue-and-white Swallow
Hirundinidae	*Riparia riparia* (Linnaeus, 1758)	x		Bank Swallow
Turdidae	*Turdus leucomelas Vieillot*, 1818		x	Pale-breasted Thrush
Passereliidae	*Ammodramus humeralis* (Bosc, 1792)	x		Grassland Sparrow
	Molothrus bonariensis (Gmelin, 1789)		x	Shiny Cowbird
Icteridae	*Sturnella superciliaris* (Bonaparte, 1850)	x		White-browed Meadowlark
Thraupidae	*Sicalis luteola* (Sparrman, 1789)	x		Grassland Yellow-finch
Passeridae	*Passer domesticus* (Linnaeus, 1758)	x	x	House Sparrow

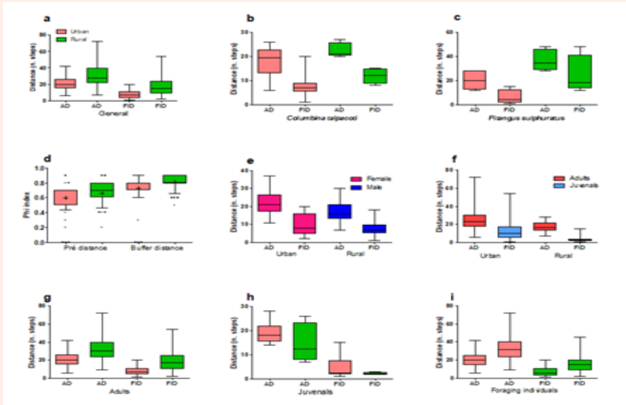

Figure 3: Boxplot with with maximum and minimum maximum and minimum values to alert (AD) and flight initiation (FID) distances (number of steps) according to (a) general numbers of individuals approached, (b) *Columbina talpacoti*, (c) *Pitangus sulphuratus*, (d) Phi index or pré-distance, (e) female and male, (f) adult and juveniles, (g) adult individuals, (h) young individuals, and (i) foraging individuals in the urban and rural areas.

Discussion

Considering the entire set of independent variables, including adults and juveniles, males and females, group size, and type of behavior, these results support the hypothesis that birds that live in urban areas have greater tolerance of human presence compared to birds in areas where human presence is sporadic. Consequently, bird species that inhabit environments with little human presence are more skittish, detect human presence earlier, and are quicker to flee. Even considering the same species when in a rural area, where human presence is much less common, these species are less tolerant and consequently the predator-prey distance was greater. Several factors have been discussed to explain the decrease in AD and FID in response to a potential predator in urban areas. These factors can be divided into two main groups, the first one based on phenotype, such as body size [21], brain size, [22,23,24], behavior in flocks [25,26], and habituation to human presence [27]. The second group is based on genotype and is related to genetic plasticity, which enables individual characteristics, through the influence of natural selection, to be expressed and favor individuals that are able to have greater well-being and survival in urban areas [2,8]. Our results support several of these forcing factors; for example, adult male individuals that live in flocks tend to better tolerate human presence in urban areas. The alert distance, which can be described as the minimum distance that maintains security, is that distance where a bird monitors an approaching predator [28,30]. According to the economic escape theory [28], birds tend to increase their early-detection distance, resulting in an increase in the alert distance, which in turn lead to a quicker escape [16]. Our results agree with those from *Samia (2017)*, since most birds in rural areas had higher values of AD and FID than those in urban areas. However, in contrast to *Samia et al (2017)* the birds in urban areas in the current study had a larger early-detection distance, with Phi index values near1. This leads to the conclusion that even though urban birds detect human presence more rapidly, they are more greatly exposed to situations of risk and stress. This observation can be explained by the availability of resources, wherein resources are scarcer in urban areas, which makes an individual bird forage for as long as possible in order to compensate for the energy demanded by the constant need to escape [30]. Similarly, the larger distances observed among birds in rural areas can be explained by greater ease in searching for food because interruptions caused by human presence are less frequent. The comparison between individuals that were approached as they were foraging in rural areas showed that there is a delay in detecting human presence (φ), but as soon as that presence was detected, the birds entered into alert and soon after flew off. *Blumstein (2006)* demonstrated that birds in urban environments have two alternatives, forage in places that have a lower supply of resources, or confront stress caused by imminent risk. In this way, the strategy would be to replace energy expenditure in the search by local of safety foraging by coping with the stress caused by human presence [20].

Considering the economic escape theory [28], it is expected that females would be more skittish than males [15]. Our results support this hypothesis since females more readily became alert and escaped in rural as well as urban areas. Therefore, males are more tolerant to human presence, which could affect selection processes for males that are better habituated to human presence, as suggested by *Carrete and Tella (2013) and Carrete (2016).* As for the number of individuals of the same species foraging near each other, Stankowich and Blumstein (2005) commented that there is an influence of the number of individuals in a flock on the variation in AD and FID. Our results showed that this influence was limited to rural areas and was inversely related to the number of individuals in the flock, meaning that the small flocks present greater escape distance. However, this result should be evaluated with caution since some species, despite foraging in groups, such as *Colombina talpacoti and Passer domesticus*, do not make up a social system, as in *Crotophaga ani*. This species was the most frequently registered in rural areas and lives in groups and uses an alarm system that involves sentinels that emit sounds alerting the foraging group to the presence of possible threats [31]. Our dataset did not allow for comparisons between species that forage in groups with those that, besides foraging in groups, employ a vocalization alert system which should be considered by an observer with respect to alert and escape distance measurements. In general, our results reinforce the theory that urban birds have more tolerance to human presence. However, this opens new perspectives for research on selection processes that favor males with better fitness in coping with human presence in urban areas versus birds that, despite detecting human presence over longer distances, also present longer escape distances.

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