

AVIAN ECOLOGY AND CONSERVATION IN AN URBANIZING WORLD

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Chapter 12

Bird tolerance to human disturbance in urban parks of Madrid (Spain): Management implications

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Abstract: The effects of human disturbance in urban parks of Madrid (Spain) on bird tolerance were studied to derive recommendations for urban park planning. We intended to determine (1) how habitat structure influenced flush distances, (2) whether flush distance increased with body-size, and (3) whether flush distances varied with the amount of people visiting the park. In four city parks in Madrid with different levels of human visitation and habitat structure, we recorded flush distances of four bird species of different sizes (overall body length: *Passer domesticus*, 15 cm; *Turdus merula*, 24-25 cm; *Columba palumbus*, 40-42 cm; *Pica pica*, 44-48 cm). Humans approached individual birds when they were foraging on the ground. Habitat structure (shrub cover, shrub and tree height) influenced flush distances of the four species. After controlling for the effects of different microhabitat use, averaged flush distances varied significantly among species; large species were less tolerant of human disturbance than small ones. Birds were more tolerant of our intrusions in parks with more human visitors. To enhance the suitability of urban parks for bird species, the following recommendations may be considered: (a) flush distances could be a first indicator of appropriate set-back distances (minimal distance that a pedestrian may approach a bird) for pathways, (b) flush distances of large bird species could be used to determine minimum area requirements of resource patches separated by pathways, (c) habitat complexity could increase the availability of escape cover for native bird species, and (d) highly variable visitation rates may be less harmful in popular parks, because bird tolerance to human disturbance appears to increase with the overall amount of visitors per park.

1. INTRODUCTION

Urban parks may serve as reservoirs for native species in densely populated areas (Baker and Graf 1989, Goode 1991). One of the main features of these natural settings within cities is that they are heavily visited by people, who may potentially interact with wildlife in different ways (Dickman 1987, Blair 1996, Fernández-Juricic and Tellería 2000). Studies conducted in protected areas demonstrate that human presence can disturb bird species, with negative effects at the individual, population and community levels (Skagen et al. 1991, Klein 1993, Rodgers and Smith 1995, Gill et al. 1996, Riffell et al. 1996, Gutzwiller et al. 1998). However, little empirical evidence exists as to how bird species in urban parks tolerate human presence and the environmental factors associated with their response. Understanding bird tolerance to humans may ultimately be useful for improving the design of urban parks and reducing the negative impacts of bird-human interactions.

Bird tolerance to human presence may depend on several factors. As habitat structure increases in complexity, birds show more tolerance to people since they have more available cover to hide from visitors (Knight and Temple 1995). Generally, species vary in tolerance levels; large species seem less tolerant of humans than small ones (Cooke 1980, Humphrey et al. 1987, Holmes et al. 1993, but see Gutzwiller et al. 1998). Habituation to human presence may explain some variation in tolerance levels; for instance, migrants are less tolerant than resident species because of less contact with people throughout the year (Burger and Gochfeld 1991).

Bird tolerance can be estimated by flush distance, the distance at which a species escapes from a visitor; the larger the flush distance, the less the tolerance (Cooke 1980, Humphrey et al. 1987, Gutzwiller et al. 1998). Such flush distances may be used to develop appropriate estimates of disturbance buffer zones or set-back distances to reduce the effects of human disturbance on wildlife (Knight and Knight 1984, Rodgers and Smith 1995). The purpose of this paper is to present flush distances of four different-sized bird species inhabiting four urban parks with different habitat structure and visitor loads in the city of Madrid (Spain). We (1) determine the influence of foraging microhabitat use on flush distances; (2) analyze the variation in flush distances within and among species relative to visitor load and species size (considering total body length); and (3) make recommendations to apply bird tolerance levels to urban planning and the conservation of urban bird species. We expected flush distances to decrease with increases in the amount of available habitat and the number of visitors, but decrease with species size.

2. METHODS

2.1 Study Area

The study was conducted from May to July 1998 in four large parks of Madrid (40.25 N; 03.43 W): Moro (18 ha), Dehesa de la Villa (25 ha), Oeste (98 ha), and Retiro (110 ha) (see Fig. 12.1 for an overview of Madrid and Retiro, Moro, and Oeste parks). Created more than 50 years ago, these parks are representative of the urban parks of this city, with many deciduous and coniferous trees and extensive areas of watered grass. All parks include recreational areas (< 1% built, 0 buildings/ha) divided into patches defined by walking paths. Although people are used to walking within paths, they sometimes encroach in patches for picnicking or resting.

Aerial photography (scale 1:10000) was used to quantify the level of urbanization surrounding parks. We measured the number of buildings in 10 ha squares throughout the fringes of each park. We averaged these figures, and expressed final estimates as number of buildings/ha. To determine the number of humans/ha surrounding parks, we quantify the number of people walking in five minutes intervals in 25-m radius circular plots at the edges of each park. These figures were averaged and transformed to humans/ha.

The matrix surrounding parks differed in several ways. The Moro park is located near Casa de Campo (a 1722 ha forest fragment immediately NW of Madrid) and is surrounded by a suburban matrix (0.6 buildings/ha), with large historic buildings and few people (10-200 humans/ha). Dehesa de la Villa is adjacent to a large natural area (Monte del Pardo) and a University campus. The matrix surrounding Dehesa de la Villa can be considered exurban, with a few sparsely distributed buildings (<0.5 buildings /ha), and relatively few people (10-150 humans/ha). The Oeste park is fringed by a more developed suburban matrix (1.5 buildings/ha), with sporting areas, roads, and office buildings and about 400-600 humans/ha. Retiro is the largest urban park, located near the city center. It is surrounded by an urban matrix, with large commercial buildings (5 buildings/ha), and a dense human population (>600 humans/ha).

2.2 Field Methods

House Sparrow (*Passer domesticus*), Blackbird (*Turdus merula*), Woodpigeon (*Columba palumbus*), and Magpie (*Pica pica*) are representative urban models for investigating tolerance levels. These species are common in urban areas of the Palaearctic, and their selection was based mainly on their considerable abundance, similar foraging habits (ground foragers), and size differences to compare specific tolerance levels to human

disturbance. Following Cooke (1980), we used overall body length as an indicator of species size: House Sparrow (15 cm), Blackbird (24-25 cm), Woodpigeon (40-42 cm), and Magpie (44-48 cm) (Tellería et al. 1999).

Samples of vegetation structure were obtained independently from those taken when approaching birds (see below). We were interested only in comparing habitat structure among parks rather than analyzing specific habitat features within each park. Habitat structure was measured in 25-m radius circular plots distributed at 30-m intervals (Tellería and Santos 1997). Variables visually estimated (Prodon and Lebreton 1981) were: grass cover,

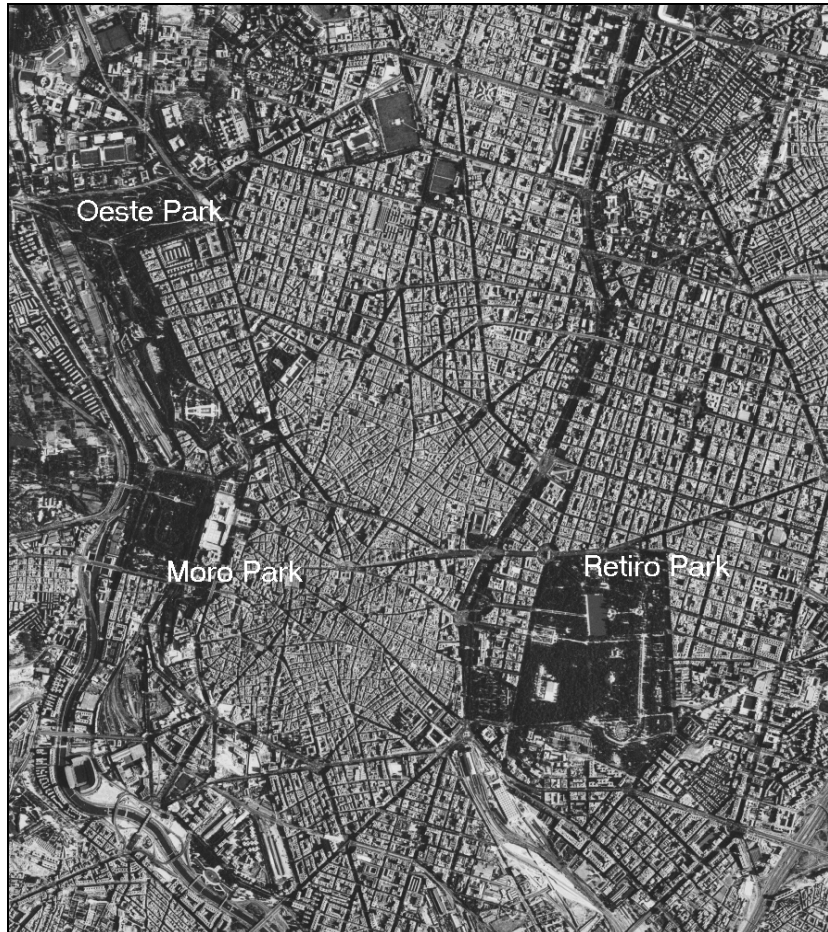


Figure 12.1. Spin-2 satellite image of downtown Madrid and three urban parks: Retiro Park, Moro Park, and Oeste Park. The image encompasses approximately 8 mi² and was taken in 1987.

paved ground cover, shrub cover, number of shrub species, shrub height, coniferous cover, deciduous cover, number of tree species, and tree height.

In determining human visitation in each park, a team of observers recorded simultaneously the number of pedestrians observed at five minute intervals in 10 different 25-m radius circular plots in those sectors of the parks in which birds were experimentally approached. We made 10 counts at morning (7:30-11:00) and 10 at midday (12:00-14:30). Preliminary sampling yielded significant differences in visitor load between, but not within, weekend and workdays. Hence, each park was sampled two days during workdays and one day during the weekend to compare visitor loads among parks. Final figures were averaged in each park as pedestrians/minute. Although visitation samples were not taken at the same time as an experimental approach to birds, our estimates could be considered reliable because visitation showed little variation within days. Following a similar sampling procedure, we also recorded dogs in each park, since they also could modify tolerance levels of urban birds.

Two observers (authors M.D.J. and E.L.) made all observations. They were previously trained in approaching birds in a 20-ha park different from those used in the analyses to avoid conditioning birds. Preliminary analysis showed that ambient temperature did not affect flush distances of any species (Fernández-Juricic et al. unpubl. data). All samples were taken during sunny or partially cloudy conditions, but never when raining. Samples were gathered between 7:30 and 18:00, totaling 347 observation hours. An individual bird was approached by a single observer at a steady speed (1 step/sec) to record its flush distance, which was defined as the distance from the observer to the bird at the moment it started to flush (either walking, running, or flying towards escape cover) (Rodgers and Smith 1997). All birds approached were on the ground. The approach was linear with unobstructed visual contact between the observer and the bird. The bird to be approached was selected following these criteria: the focal bird was not within 21 ± 1.7 m of any person, it was not feeding although it could be searching for food, and it did not show any alert behaviors (Fernández-Juricic and Tellería 2000). We excluded samples that involved birds looking for nest material. Most birds we approached were alone or with only one or two conspecifics. In the latter case, the observer focused their measurements on a single individual in the group chosen before the approach. When birds were disturbed by any kind of sound during our observations, we stopped our approach. Once the focal bird flew away, the observer continued the approach up to the point from which the bird left. At this point they recorded the following microhabitat variables from a 25-m circular plot: grass cover, paved ground cover, shrub cover, shrub height, coniferous cover, deciduous

cover, and tree height. These data were used to analyze whether microhabitat complexity influenced flush distances.

Observers conducted flush distance samples at the same time but in different parks. They visited parks at random with at least one-day interval between visits to the same park. We collected 20-23 samples per species per park. For each species and park, samples were gathered from different locations to reduce pseudoreplication by disturbing the same individual. Before sampling we mapped species territories by means of thorough searches in the areas that were later used for approaches. The observers never collected two samples from the same species in a row nor from contiguous territories to circumvent any dependence between the first and subsequent approaches.

2.3 Statistical Analyses

We employed a discriminant function analysis (DFA) to identify the main habitat characteristics that differentiate the four parks. Significant variables were selected by forward stepwise procedures (StatSoft 1996). The results of the DFA were interpreted considering the significance of the discriminant function, and the accuracy of the classification of cases into groups. With the variables identified in the DFA we calculated a structural diversity index (Shannon-Wiener index) for each park. Visitor and dog rates were compared among parks by means of ANOVA tests. To determine the relationship between microhabitat use and flush distances in each park, we used Pearson correlations. We used ANCOVA to analyze inter and intra-specific differences in flush distances in the four studied parks. Those microhabitat structure measures that influenced flush distances were included as covariates to control for the effects of habitat use on tolerance levels. We checked for normality and homocedasticity of variables and of residuals before and after the analyses, respectively.

3. RESULTS

3.1 Park Structure, Visitor And Dog Rates

Parks differed in the degree of habitat complexity (Fig. 12.2). The discriminant function analysis identified five variables that significantly discriminated among parks: grass and shrub cover, coniferous and deciduous cover, and tree height (Fig. 12.2, Wilks' Lambda: 0.19, $F_{15,237} = 13.06$, $P < 0.001$). Seventy one percent of cases were correctly assigned to their proper parks. The squared Mahalanobis distances among parks were significant

(SMD ranged from 3.28 to 21.22, $F_{7,84}$ ranged from 5.62 to 35.87, $P < 0.001$), which indicates that all parks differed in the aforementioned variables. Because cover variables provided the greatest discrimination among parks, we calculated diversity indices relative to vegetation cover (grass, shrub, coniferous and deciduous). The Moro park was the most diverse ($H' = 1.76$) followed by the Oeste ($H' = 1.71$), Retiro ($H' = 1.6$), and Dehesa de la Villa ($H' = 1.47$) parks.

We found significantly different human visitation among parks; Moro was the least and Retiro the most visited parks, and Oeste and Dehesa de la Villa having similar visitor rates (Fig. 12.3; ANOVA, $F_{3,316} = 17.8$, $P < 0.001$). Dog visitation also differed among parks (ANOVA test, $F_{3,316} = 18.2$, $P < 0.001$). Dogs were more common in Retiro park (0.73 ± 1.15 dogs/m), followed by the Oeste (0.21 ± 0.81 dogs/m) and Dehesa de la Villa parks (0.03 ± 0.16 dogs/m). We did not observe any dogs in Moro park.

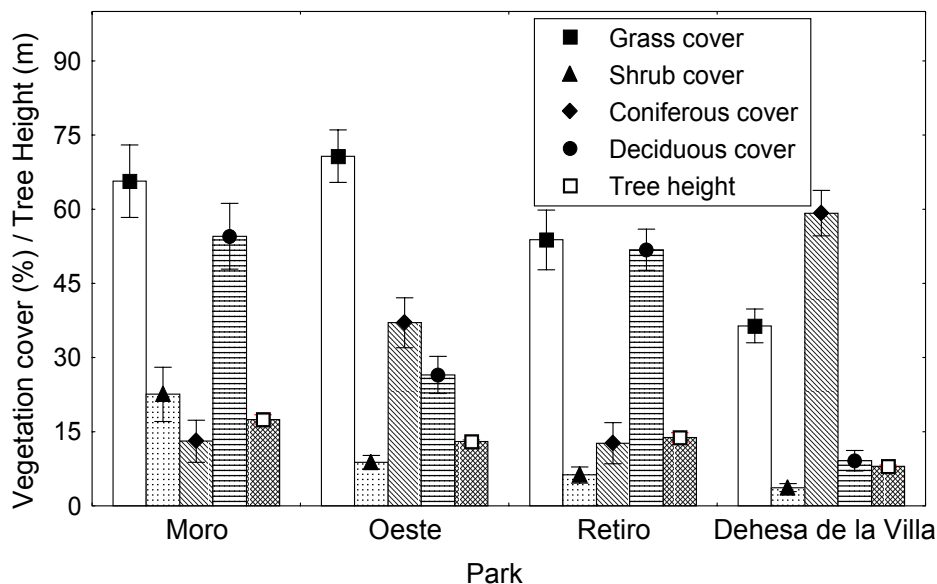


Figure 12.2. Habitat structure differences between four parks in the city of Madrid (Spain). Variables were selected from a discriminant function analysis, and differed significantly among parks.

3.2 Flush Distances

Microhabitat at the observation point influenced flush distance of all species. Individuals fled at shorter distances from the observer as the amount of shrub cover increased. This pattern was true for each species in at least one park: House Sparrows (Dehesa de la Villa), Blackbirds (Oeste and Retiro), Woodpigeons (Oeste), and Magpies (Retiro) (Table 12.1). Magpie flush distances in Dehesa de la Villa and Oeste parks were significantly shorter as shrub height increased (Table 12.1). In Retiro park, Magpies also reduced their flush distance with higher tree heights (Table 12.1) and in Moro park, Magpies reduced flush distance with increased grass cover (Table 12.1). In Dehesa de la Villa and Moro parks, Woodpigeons and Magpies, respectively, reduced flush distances with high coniferous tree cover (Table 12.1). In Oeste park, Blackbirds increased flush distances with increased paved ground (Table 12.1).

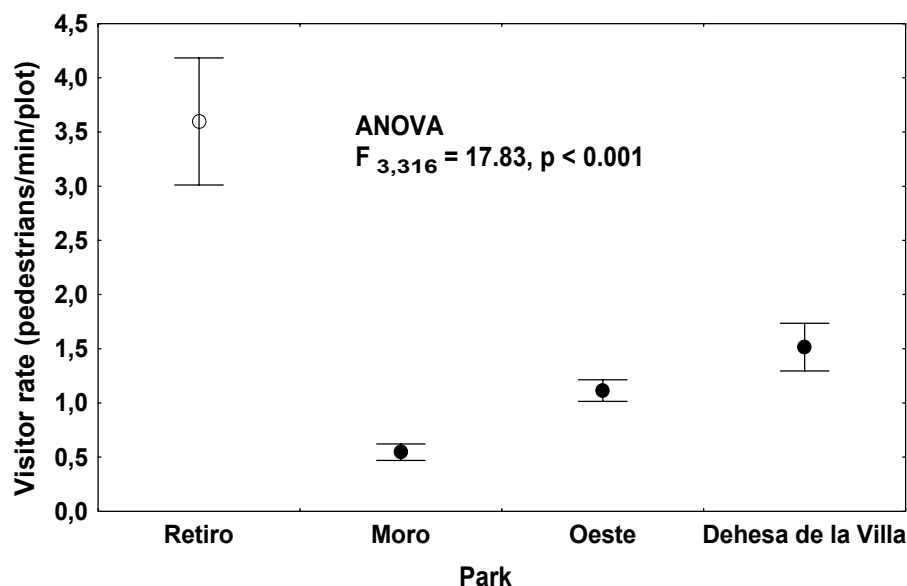


Figure 12.3. Rate of human visitors to four urban parks in the city of Madrid (Spain).

Controlling for microhabitat use, flush distances differed significantly among species and parks, and no interaction was detected (Species, $F_{3,327} = 11.59$, $P < 0.001$; Park, $F_{3,327} = 10.77$, $P < 0.001$; Interaction, $F_{9,327} = 0.71$, $P = 0.703$) (Fig. 12.4). For all parks combined, the smaller species fled at shorter distances than the larger species: House Sparrows (7.27 m) < Blackbird (8.62 m) < Woodpigeon (9.91 m) < Magpie (10.63 m). We also found a park effect, whereby flush distances differed significantly among parks (considering all species): Retiro (7.43 m) < Oeste (7.96 m) < Dehesa de la Villa (10.08 m) < Moro (10.96 m).

4. DISCUSSION

4.1 Flushing Behavior

All species flushed from observers, but varied their flush distances. Individual birds may modify flush distances to optimize escape probabilities based on a balance between the costs and benefits of fleeing (Ydenberg and Dill 1986, Henson and Grant 1991, Skagen et al. 1991). Such balance could be affected by habitat structure, with different variables affecting different species based on their escape tactics (Lima 1993). House Sparrows and

Table 12.1. Microhabitat variables that significantly correlated with flush distances of four bird species in urban parks of Madrid. Abbreviations: SHC, shrub cover; PGC, paved ground cover; CNC, coniferous cover; SHH, shrub height, TRH, tree height; GRC, grass cover.

Park	House Sparrow	Blackbird	Woodpigeon	Magpie
Dehesa de la Villa	SHC ($r = -0.53$, $P < 0.05$)	-----	CNC ($r = -0.43$, $P < 0.044$)	SHH ($r = -0.50$, $P < 0.02$)
Oeste	-----	PGC ($r = 0.65$, $P < 0.01$); SHC ($r = -0.45$, $P < 0.04$)	SHC ($r = -0.54$, $P < 0.01$)	SHH ($r = -0.44$, $P < 0.05$)
Retiro	-----	SHC ($r = -0.65$, $P < 0.01$)	-----	SHC ($r = -0.46$, $P < 0.04$); TRH ($r = 0.47$, $P < 0.03$)
Moro	-----	-----	-----	GRSC ($r = -0.49$, $P < 0.02$); CNC ($r = -0.55$, $P < 0.01$)

Blackbirds use shrubby vegetation as escape cover; Woodpigeons and Magpies use trees as escape cover.

The amount of shrub cover appeared to be the principal microhabitat characteristic that increased birds tolerance to people in urban parks. This may relate to a greater availability of escape cover and consequently a lower perceived risk of predation (Ydenberg and Dill 1986, Martín and López 1995, Kramer and Bonenfant 1997). This is particularly true for House Sparrows and Blackbirds, although Woodpigeons and Magpies sometimes use shrubs as escape cover. In much the same way, shrub height and coniferous cover may allow some birds to reduce the costs of not fleeing when people approach. Shrub height also increases the availability of cover, probably reducing the perception of risk for Magpies. Coniferous cover may act similarly for Woodpigeon and Magpies, since coniferous trees were their preferred escape cover. Increased tree height, on the other hand, increased Magpie flush distances. Magpies may perceive an increased risk of predation with tall trees (Ydenberg and Dill 1986), since individuals must fly longer distances to reach the tree canopy, their preferred escape cover. Although we did not measure food availability, it may vary with microhabitats and may

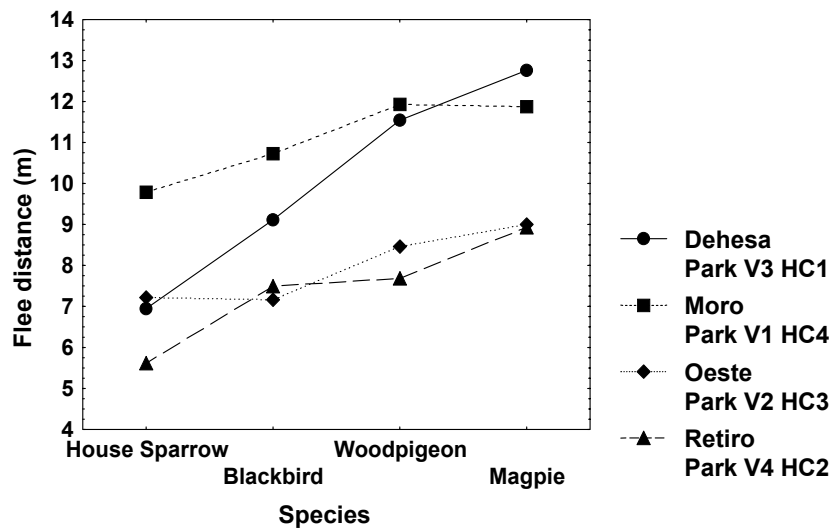


Figure 12.4. Mean flush distances of four bird species in four parks in the city of Madrid (Spain). Also indicated is the visitor load (V) and the degree of habitat complexity (HC) of each park in a scale 1-4 (1 denoting low, and 4, high).

increase the probability of individual birds finding food (Fernández-Juricic and Tellería 1999) and, as a result, delay the flushing response of individuals. Increased foraging success may mean some birds tolerate an increased risk of capture (Ydenberg and Dill 1986). This trade-off may account for the negative relationship between grass cover and Magpie flush distances. Magpies usually feed on worms and small insects on the grass, and increased foraging success could increase their tolerance to people. The positive relationship between paved ground and Blackbird flush distances may have to do with increased risk of detection by predators or with the lack of food resources.

Even though flush distances varied within and among species, they could not be directly attributed to any specific cause due to our sampling design. We can suggest that variation in park visitation, park habitat structure, and species size affects flush distance. Within species, we found a park effect; individuals in less visited parks generally showed longer flush distances (Fig. 12.3 and 12.4). Habituation to people might influence such a pattern. Visitors to urban parks are a relatively benign source of disturbance in that generally the birds are not killed or pursued (Cooke 1980). Therefore, it is likely that individuals have learned to tolerate human intrusions (Rodgers and Smith 1995, Riffell et al. 1996). For instance, House Sparrows seem to be more tolerant to people in parks with high human visitation (Retiro Park) and less tolerant in parks with low visitation (Moro). The same may hold for dogs in urban parks; birds became habituated to dogs in highly used parks.

Another relevant factor that may influence flush distances in more subtle ways is habitat structure. Parks with complex habitat structure may have a greater availability of escape covers, increasing tolerance levels to visitors (Knight and Temple 1995). For instance, Magpie flush distances were high in Dehesa de la Villa park, where tolerance may be low because few potential refuges are available (shrubs, trees, etc., Fig. 12.2). However, flush distances were also high in Moro park where habitat complexity was greater. Even though no interaction effects were detected, the influence of visitation and habitat structure in urban parks may be interacting with each other or with other factors (e.g. food availability, territoriality, etc.) to give rise to more complicated patterns of tolerance (for example, the Woodpigeon, Fig. 12.4).

We found larger species to be less tolerant of human presence (Fig. 12.4), a conclusion supported by other studies (Cooke 1980, Humphrey et al. 1987, Skagen et al. 1991, Holmes et al. 1993). Little empirical consideration has been devoted to this relationship. Perhaps small species have higher energy needs (greater area/body mass ratios) than large ones, such that the former would be more tolerant of human presence to reduce energy costs associated with fleeing (Holmes et al. 1993). Alternatively, larger species may have

higher perceptual ranges (ability to perceive landscape elements, Lima and Zollner 1996) than smaller ones, so they would detect and react to human presence at greater distances.

4.2 Policy And Management Implications

Previous studies in Madrid suggest that pedestrians can reduce feeding rates and breeding densities and change selection of feeding areas of urban birds (Fernández-Juricic and Tellería 2000, Fernández-Juricic 2000). Although the four species studied here are abundant in Madrid and forage mainly on the ground, they could be used as models upon which management can be planned to improve the conservation of urban wildlife. Of interest is the design of urban parks with a network of pathways that minimize the conflicts between visitors and wildlife. In Madrid, the arrangement of pathways in parks has rarely followed biological considerations nor have specific policies regulated the use of city parks by pedestrians. The flush distances of different species could be a reliable indicator of tolerance that may serve to establish set-back distances that guide the spatial arrangement of pathways to minimize disturbance to birds. A similar approach has been applied to colonial waterbirds (Rodgers and Smith 1995, 1997).

Because pathways within parks separate patches that may be used by different bird species for foraging and breeding, set back distances refer to the minimal distance that a pedestrian may approach a bird before it is disturbed. For instance, if patches within parks were circular-shaped, it would be advisable that the radius of these patches were greater than flush distances. Indeed, some authors argue that alert distances would be more useful thresholds for set-back distances (Rodgers and Smith 1995, Fernández-Juricic et al., unpubl. data). Bird diversity in urban parks may be increased if set-back distances were greater than the tolerance levels of the most sensitive species.

To obtain good estimates of set-back distances for different birds, one alternative is to use tolerance levels of the largest species. The implementation of set-back distances based on large species automatically allows smaller ones to use parks for feeding or breeding without being disturbed.

Habitat complexity could increase tolerance levels of many urban birds by increasing the availability of cover used for escape. Management plans aimed at increasing vegetation structure, especially shrub cover, could be a relatively easy means to reduce human disturbance in urban parks and to potentially increase bird tolerance levels.

Tolerance among urban species appears to be related to their degree of habituation to people. Therefore, if visitor loads are to be increased temporarily in certain urban parks (e.g., a public act, a concert, etc.), it is deemed advisable that such increases be implemented in those parks with high pedestrian rates to minimize the harmful effects towards urban birds.

4.3 Research Needs

Future research on the effects of human disturbance on urban birds should encompass the following topics: (1) analyses of the relationships between human disturbance and tolerance levels for less tolerant and less abundant species, which are mainly the target of conservation efforts; (2) evidence on the effect of different spatial arrangements of pathways within parks on the tolerance levels and densities of urban birds; (3) assessment of the relationship between visitation and demography (breeding success and survivorship), particularly for the least tolerant species; (4) determination of visitation thresholds that may maintain breeding density levels of urban birds; and (5) investigation on how the temporal dynamics of visitors to urban parks (daily and seasonally) may influence tolerance levels of bird species.

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