Bird Study (2000) **47,** 13–21

Effects of human disturbance on spatial and temporal feeding patterns of Blackbird *Turdus merula* in urban parks in Madrid, Spain

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We studied how human presence in three urban parks in Madrid (Spain) might affect Blackbird densities by changing feeding behaviour patterns. Our specific purposes were: (a) to ascertain the effect of park visitors on Blackbird feeding behaviour; (b) to analyse the influence of human disturbance on foraging success; and (c) to determine how humans affect Blackbird spatial and temporal patterns of habitat use. Pedestrians were the main source of flushing responses in all sampled parks, followed by Magpies Pica pica *and dogs accompanying visitors. Blackbird responses to visitors entailed more time being vigilant and moving away from people and less time searching for food (decreasing food intake), a response that remained constant in the three parks. The number of pedestrians was positively correlated with Blackbird distance to pathways and negatively correlated with distance to protective cover. The number of active birds decreased with increase in the number of pedestrians during the day. Blackbird density was negatively related to the number of visitors per park. Our results confirmed that human disturbance negatively affects Blackbird feeding strategies in urban parks, ultimately modifying spatial and temporal patterns of habitat selection and abundance. Since such responses could also affect densities of other urban species by the same process, we propose some management measures to decrease the levels of disturbance as well as to enhance the recreational use of urban parks.*

There is an increasing interest in the management of urban parks to improve wildlife diversity since many of them may be important reservoirs for native species in densely populated areas.[1–5] Several works on the local and landscape determinants of bird densities in urban parks have yielded the level of human presence as a relevant factor negatively affecting breeding densities and distributional patterns of bird species.[6–9] Lack of food resources, little protective cover, increasing levels of predation and human disturbance are all processes put forward as explanations for the reported decrease;[7–10] however, these factors have yet to be tested to unravel the possible mechanisms involved. This paper deals with one such process capable of producing a negative response on density patterns of breeding species: the presence of humans in urban parks as a factor modifying spatial and temporal feeding patterns. We selected the Blackbird *Turdus merula* as a representative urban model to test this idea because it is a common species in urban areas of the Palaearctic, and is found in gardens and parks over much of its range.[11]

The approach we followed to study variations in feeding behaviour assumes that birds perceive humans as potential predators,[12]

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such that the response to human disturbance can be assessed in a similar way to that of predation.[13] As a result, birds may modify some behavioural traits (such as feeding and moving rate, and distance to cover) to achieve protection.[14–16] Since these behavioural adjustments are also affected by the duration, frequency and proximity of disturbance,[17] it might be supposed that birds living in urban parks under different levels of disturbance (number of visitors) would face different levels of stress. If this is the case, the management of the number and distribution of visitors in urban parks may be an important strategy to improve habitat suitability for native species.[8,18]

The aims of this work are: (a) to evaluate the role of park visitors upon Blackbird feeding behaviour in relation to other potential sources of disturbance; (b) to analyse the influence of human disturbance on Blackbird feeding success; and (c) to ascertain how pedestrians affect Blackbird spatial and temporal patterns of habitat use. We predict that, as the number of people increases, Blackbirds will increase their vigilance and moving rates, decreasing the time spent foraging and searching for food, and thus their feeding success. As a result, they will be located further from the source of disturbance (pathways) and nearer to cover. This process would constrain their daily feeding activities, decreasing the number of active feeding birds (either searching for food or feeding) during periods of high visitor abundance. In the end, such patterns would be reflected in decreasing Blackbird densities according to the number of human visitors.

METHODS

Study area

During the spring/summer of 1997, Blackbirds were studied in three urban parks in Madrid (Spain): Retiro Park (110 ha), Oeste Park (98 ha) and Moro Park (18 ha). All were created more than 80 years ago, and are representative of the urban parks of this city, sharing a similar cover of developed deciduous and coniferous trees, with extensive areas of watered grass. Internally, these parks are divided into patches bordered by a series of pathways which are used by people as recreational grounds, particularly for strolling, jogging and dog walking. Blackbirds are abundant in these parks, where they feed on earthworms and other invertebrates.[11]

We selected certain areas with similar structural characteristics (approximately equal percentages of grass, tree and shrub cover) within each park, and we determined the number of Blackbirds by mapping their territories.[19] Thus, each patch surrounded by pathways was assumed to be a sample unit, since there was little movement of birds across patches because of visitors. Within the selected patches, we assessed the variation in feeding behaviour, spatial and temporal habitat use, and human disturbance.

Determination of human disturbance

In order to gauge the amount of human disturbance, the following protocol was set up. Four randomly chosen points were selected in each park to record the number of pedestrians passing by in 3-minute periods (finally expressed as rates per minute) during the morning (09.00 to 11.00 hours) and afternoon (12.00 to 15.00 hours). This procedure was repeated three times at each park with an interval of 17 days, finally yielding six samples per park (three in the morning and three in the afternoon). In determining differences in disturbance levels among and within parks, we performed planned comparisons by means of a two-way ANOVA (balanced design with three cases per cell, with pedestrian rate as the dependent variable, whereas parks and time of day were the predictor factors; see Table 1).

The main sources of Blackbird disturbance (pedestrians, Magpies *Pica pica*, dogs, conspecifics and cars) were determined by counting the number of flushing events in feeding Blackbirds. We took such information when measuring the variations in Blackbird feeding behaviour (see below) from fixed points, and finally included just one flee response per sampled individual. In seeking differences in the frequencies of disturbance events among parks, departures from the proportion of flushing responses were examined through a chi-squared test, encompassing only three sources of disturbance (pedestrians, Magpies and conspecifics) due to sample sizes.

Table 1. Contrasts based on planned comparisons to determine different levels of human disturbance (pedestrians per minute) in the three parks sampled in Madrid (Spain). Results from a two-way ANOVA (balanced design with three cases per cell).

Contrast		$F_{1,12}$	P
1. Did disturbance levels differ between morning and afternoon in the Moro Park?	NO	1.544	0.237 ns
2. Did disturbance levels differ between morning and afternoon in the Retiro and Oeste Parks?	YES	94.549	< 0.001 *
3. Did disturbance levels differ in the Retiro and Oeste Parks in relation to the Moro Park, without considering morning and afternoon?	YES	82.709	< 0.001 *
4. Did disturbance levels differ in the Retiro and Oeste Parks in relation to the Moro Park, taking into account morning and afternoon?	YES	21.1529	< 0.001 *

Dependent variable: pedestrian rate; independent factors: park and time of day (PARK: Moro, Oeste and Retiro; TIME: morning and afternoon).
ns, non-significant; *, significant.

Feeding behaviour

In total, 197 hours of focal observations[20] were recorded, between 07.30 and 19.00 hours. We considered an individual to be disturbed when it reacted to a human presence on a pathway near its patch, by displaying vigilance behaviour. Such responses were usually triggered by at least one pedestrian in the vicinity of the patch. We randomly selected 20 structurally similar patches (replicates), and in each patch samples were taken from undisturbed and disturbed individuals. When more than two such measures were obtained from each replicate, we pooled the responses for each treatment in each patch and used the mean values.

Sampling was done from 15–20 fixed observation points from which the selected patches could be seen by the observer, who was out of sight of the focal individuals. In cases when a Blackbird detected the observer, the point was abandoned for one hour before resuming sampling. Sampling lasted from two to seven minutes, and we gauged the frequency of searches (head down and pecking), feeds (food intake was recorded when Blackbirds pecked, then slightly raised their heads and finally swallowed), movements (walks and hops) and head-up postures (vigilant behaviour). We only included in the analysis those samples where head-ups lasted less than two seconds. All behaviour was expressed as rates per minute. In order to have a single measure of time devoted to being vigilant and to searching for food, we divided head-up rate by search rate (thereafter the V/S rate; values greater than 1 mean more time spent being vigilant, and values less than 1 imply more time searching for food).

Many factors could modify Blackbirds' feeding response to humans. No differences in sensitivity to visitors were detected among the three studied parks.[a] Food availability, another confounding factor, was assumed to be similar in the three studied sites, since grass cover is sustained throughout the year by watering three days per week (four hours per day) in each park. Finally, since Blackbird feeding rates could be modified by the presence of conspecifics,[21] we only analysed those focal samples in which Blackbirds were feeding without conspecifics within 15 metres.

We first tested the possibility that Blackbird response could vary depending upon sex or age with a two-way ANOVA considering only the V/S rate as the dependent variable (independent factors: disturbance with two levels, disturbed and undisturbed, and age/sex; disturbance with three levels: males, females and juveniles; ten replicates of each age/sex class).

Using random factors to examine the generality of a fixed factor (in this case disturbance), the statistical inferences can be applied to the entire range to which the statistical population belongs.[22,23] We then employed a mixed ANOVA model to generalize the response of Blackbirds in urban parks: V/S, feeding and moving rates were the dependent

factors, and parks (random factor, with three levels: Moro, Oeste and Retiro) and disturbance (fixed factor, with two levels: disturbed and undisturbed) the independent factors; 20 replicates were made of each combination of treatments. Our sampling design met the assumptions of ANOVA analysis.[23,24,b] To circumvent the effect of increasing the probability of Type I error due to the high number of probability estimations, a Bonferroni sequential correction was performed.[25]

Spatial and temporal distribution of feeding activities

We tested the predictions of increasing distance to pathways and decreasing distance to cover elicited by an increase in pedestrians in the Retiro and Oeste Parks only, since the Moro Park had a rather low visitor rate, which prevented any comparison. Regression analysis was employed to build up linear models of distance to pathways and to cover with visitor rates. We included 40 samples per park, corresponding to two samples from each of the 20 selected patches, which were taken at different times of day (morning and afternoon) during different days.

We recorded the number of active (searching for food and feeding) and perching birds during morning and afternoon with respect to pedestrian rates. Perching birds were identified acoustically (after being disturbed, individuals usually perched and began vocalizing) and visually (many individuals were easy to locate after a careful examination). A chi-squared test was performed to examine the difference in the proportion of individuals active and perching between morning and afternoon, in each park.

Density estimates

Parks were censused four times in the morning (07:30 to 11:00 hours) in order to estimate Blackbird density in the three studied parks. We recorded the number of individuals seen and displaying vocal behaviours in 100 × 50 m fixed line transects. Each transect was regarded as a sample unit. Densities were first pooled for each visit and then pooled across all visits undertaken. Final figures were expressed as number of birds per 0.5 ha, and analysed by means of a one-way ANOVA.

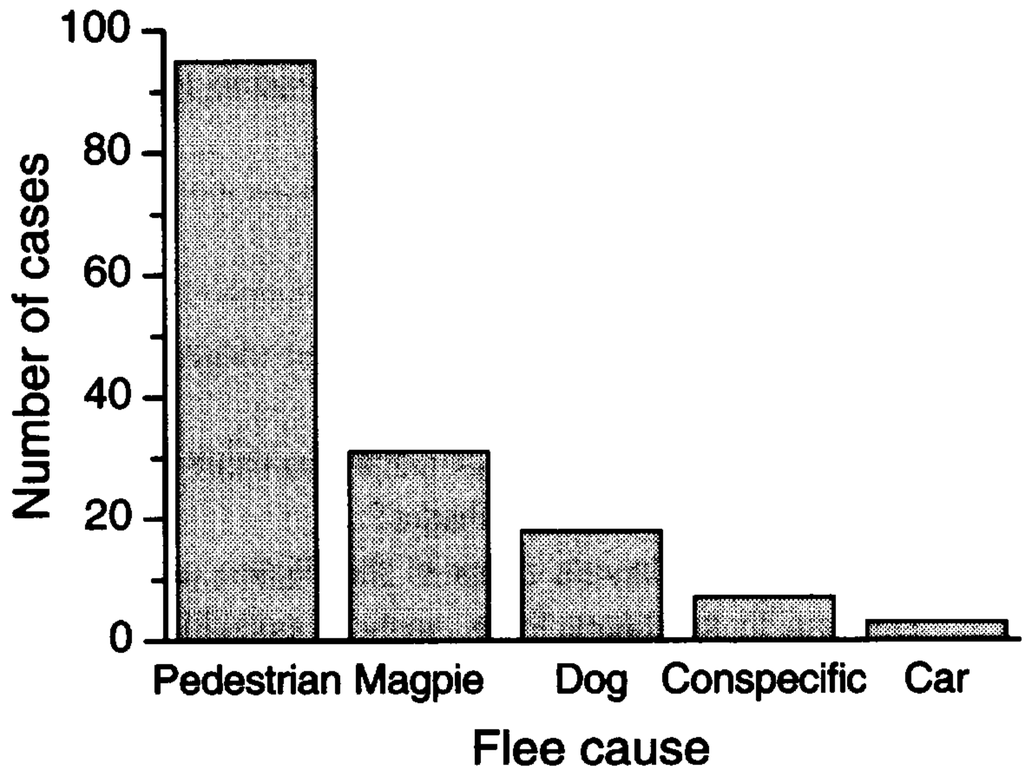

Figure 1. Sources of disturbance that caused flushing responses of Blackbirds in three urban parks in Madrid.

RESULTS

Pedestrians were the main source of disturbance for Blackbirds, followed by Magpies and dogs (usually accompanying visitors) (Fig. 1). The relative importance of these sources did not differ among sampled parks ($\chi^2 = 5.17$, df = 4, $P = 0.269$).

There were no differences in V/S rates between age classes (ANOVA, $F_{1,54} = 0.0009$, ns) or sexes (ANOVA, $F_{1,54} = 0.0009$, ns).

V/S, feeding and moving rates were found to differ significantly when Blackbirds were disturbed by pedestrians from when they were undisturbed (Table 2, Fig. 2). Nevertheless, no significant difference was detected in any of the three parks (random factor), so that the observed response could be regarded as a general pattern for these urban parks. Blackbirds reacted to visitors by spending less time searching for food (diminishing food intake), more time being vigilant and intensifying their movements.

As predicted, the number of visitors was positively correlated with distance of Blackbirds to pathways (Fig. 3) and negatively with distance to protective cover (Fig. 4), although the relationship in the Oeste Park was rather weak. Therefore, it is likely that Blackbirds restricted the area used for food searching to the core of each patch as the number of visitors increased in a given park.

Considering the spatial distribution of Blackbirds, we first tested how the amount of human disturbance varied between parks and time of day. No difference was found between

Table 2. Partial results of mixed ANOVA tests.

Dependent variable	Effect	df	*F* ratio	*P*-level
V/S rate	Disturbance	2	417.111	0.002*
	Park	114	0.208	0.813
	Interaction	114	0.652	0.523
Feeding rate	Disturbance	2	6252.567	0.0001 *
	Park	114	1.075	0.345
	Interaction	114	0.018	0.982
Moving rate	Disturbance	2	59.532	0.016 *
	Park	114	0.213	0.808
	Interaction	114	3.056	0.052

Fixed factor: disturbance (two levels: disturbed and undisturbed); random factor: parks (three levels: Moro, Oeste, Retiro); number of replicates in each level of the random factor: 20. Dependent variables: V/S rate (vigilance/search), feeding rate, and moving rate (walking and hopping). Data were log transformed (log $x + 1$).
df, degrees of freedom; *, significant.

morning and afternoon disturbance levels in Moro Park (Table 1) but there were differences between morning and afternoon disturbance levels in Retiro and Oeste Parks (Table 1). These distinctions allowed us to classify the Retiro and Oeste as the more disturbed parks, and Moro Park as a control owing to the lower levels of disturbance. The daily activity of Blackbirds was probably associated with such visitor levels, since the number of active birds decreased (and the number perching increased) in relation to the increased number of pedestrians during the afternoon in Retiro ($\chi^2 = 33.62$, df =1, $P < 0.001$) and Oeste ($\chi^2 = 20.48$, df = 1, $P < 0.001$) Parks as against the control park (Moro, $\chi^2 = 0.08$, df =1, ns) (Table 3). Finally, Blackbird densities varied significantly among parks (Fig. 5), and that variation was negatively related to the number of visitors per park (Table 3).

DISCUSSION

As many bird species inhabiting wildlife reserves are affected by human visitors,[16, 26–28] it is not surprising that Blackbirds are affected in urban parks, where human disturbance reaches higher levels because these areas have recreational purposes. In fact, human visitors seem to be the main cause of Blackbird flushing responses during the breeding season, despite their frequent aggressive interactions with Magpies.[29,30] Our results suggest that Blackbirds react to human visitors as if they were potential predators,[13] changing the spatial and temporal use of their habitat. For example, Blackbirds increased the scanning rate with increasing number of pedestrians in the proximity of their feeding patches, a common reaction of birds foraging in exposed parts of their habitats.[31–33] The more frequent movement of Blackbirds with increasing number of pedestrians could be regarded as a way of escaping risky situations in search of cover. This is a frequent behaviour pattern of conspicuous prey;[13] it differs from that of cryptic species, which usually restrict moving rates so as to decrease the probability of being detected.[34,35]

Blackbirds moved away from pathways, occupying areas close to cover, probably to increase protection, since tolerance to disturbance diminishes as the stimulus (in this case pedestrians) gets closer. Similar results have been found in other studies with wildlife species in protected areas.[36,37] Such shifts may correspond closely to changes in the foraging sites, as has been reported for other species, which under increasing risk of predation make similar modifications in habitat utilization.[38,39] Therefore, human disturbance in urban parks arises as another relevant factor that could temporarily modify Blackbird foraging activity levels, lessening feeding bouts and increasing the time before the resumption of feeding.

Human disturbance effects also appear to explain the daily rhythms of Blackbirds. Although the decrease in the number of active individuals towards midday can be related to other factors (e.g. thermoregulation[40,41]), Blackbird inactivity appears to be coupled with human presence as suggested by the fact that in the least disturbed park (Moro), activity levels

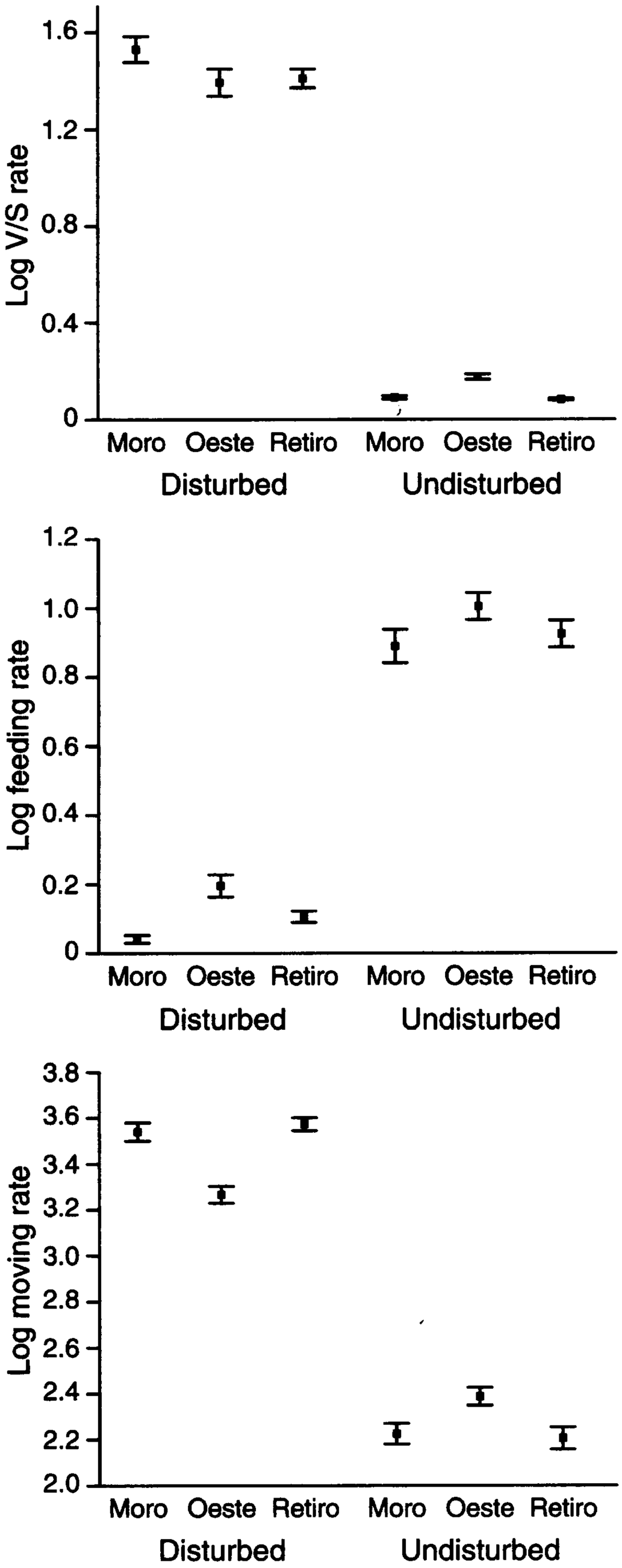

Figure 2. Mixed ANOVA results of the variation in Blackbird V/S, feeding and moving rates (log-transformed) considering two situations (disturbed and undisturbed) in three parks in Madrid (Spain): Moro, Oeste and Retiro. Mean values and se are shown.

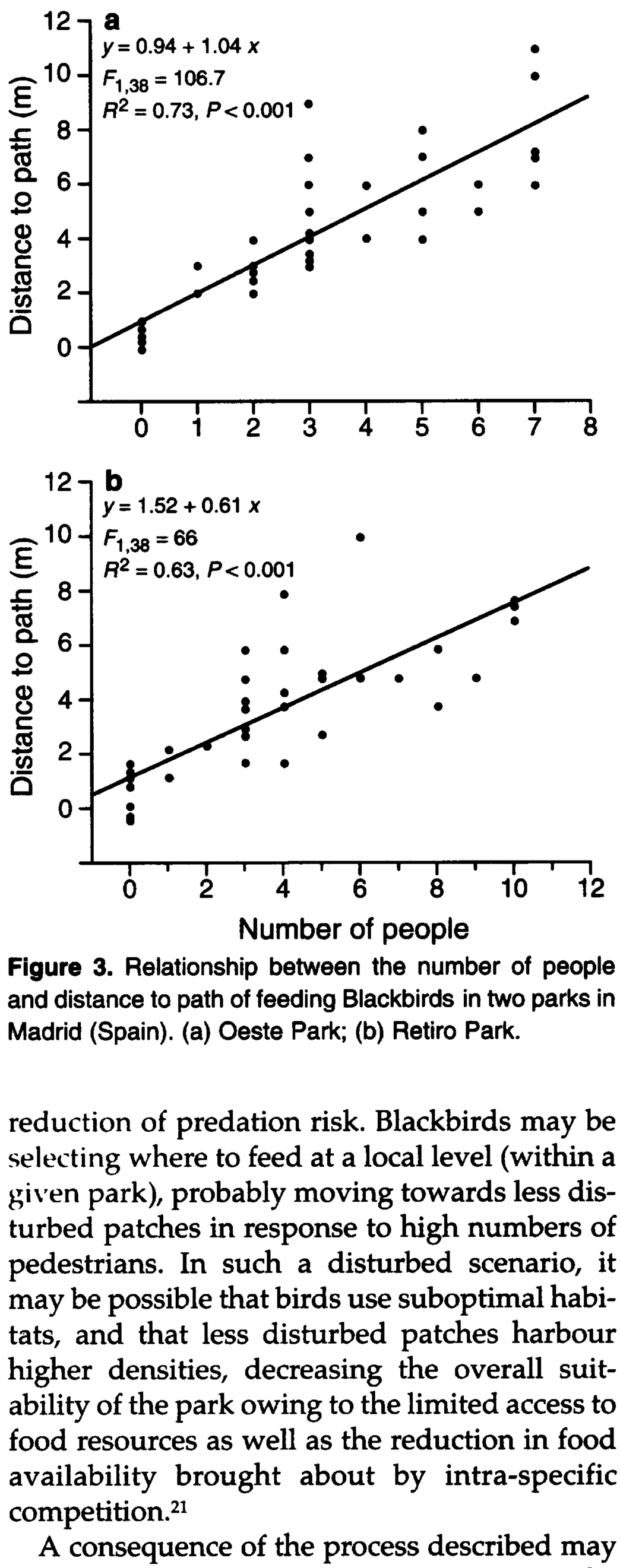

Figure 3. Relationship between the number of people and distance to path of feeding Blackbirds in two parks in Madrid (Spain). (a) Oeste Park; (b) Retiro Park.

remained the same throughout the day. This response to people could be interpreted as being due to energy intake optimization and reduction of predation risk. Blackbirds may be selecting where to feed at a local level (within a given park), probably moving towards less disturbed patches in response to high numbers of pedestrians. In such a disturbed scenario, it may be possible that birds use suboptimal habitats, and that less disturbed patches harbour higher densities, decreasing the overall suitability of the park owing to the limited access to food resources as well as the reduction in food availability brought about by intra-specific competition.[21]

A consequence of the process described may be a reduction in breeding densities as the amount of disturbance increases,[8,42,43] as has been shown for these urban Blackbirds. Reductions of population density are of considerable conservation concern.[8,12,44] Such declines could be caused by, for example, predator avoidance strategies, reduced access to food or nest sites, predation pressure and increasing competition due to low food availability.

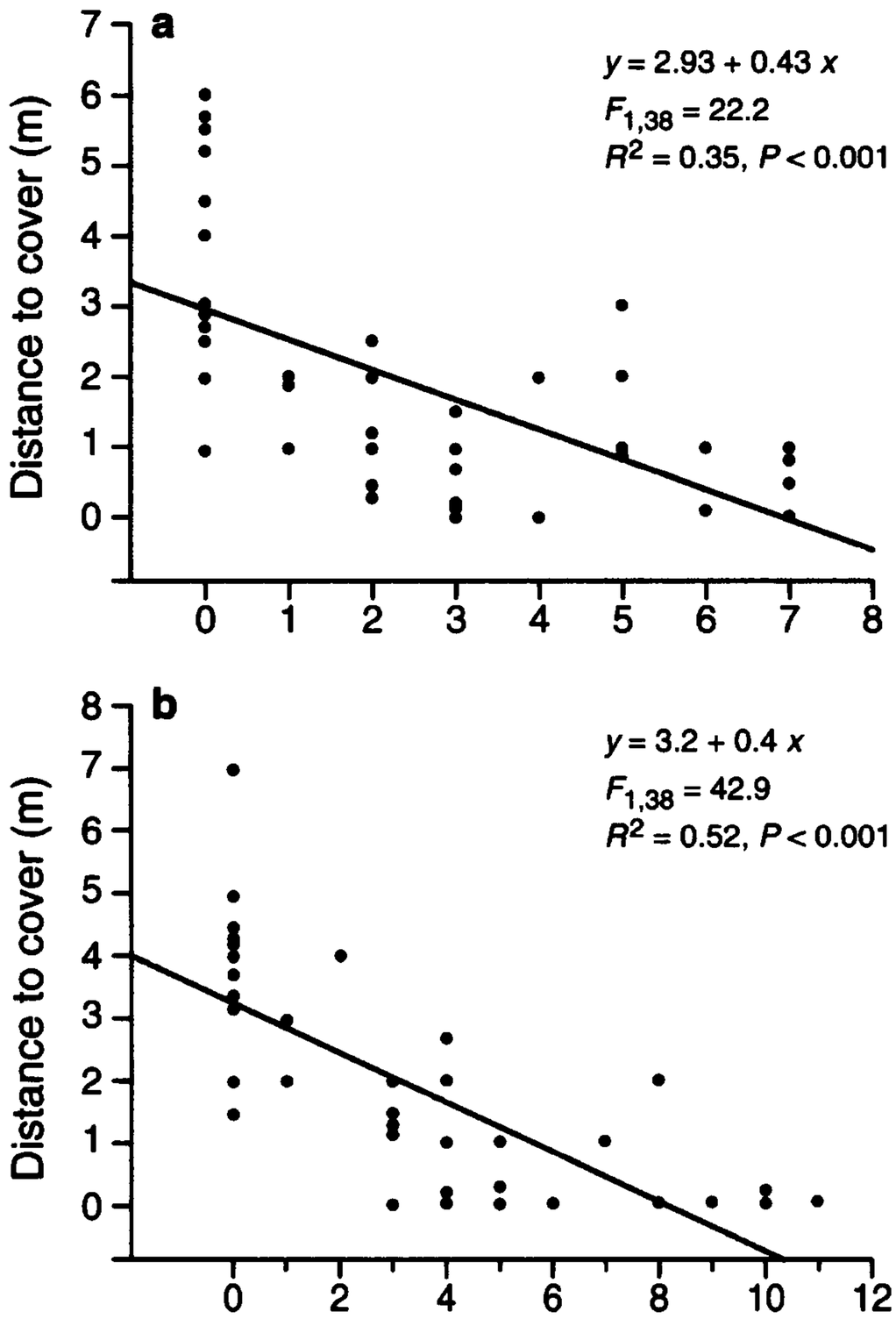

Figure 4. Relationship between the number of people and distance to cover of feeding Blackbirds in two parks in Madrid (Spain). (a) Oeste Park; (b) Retiro Park.

Table 3. Temporal habitat use in relation to pedestrian disturbance, comparing two parks with similar rate of visitors (Retiro and Oeste) to a control area (Moro). Also shown is the proportion of active birds (searching for food or feeding).

Park	Time	Rate of visitors (pedestrians/ minute) ± se	No. of active/total birds
Retiro	Morning	0.537 ± 0.081	0.71
	Afternoon	1.497 ± 0.053	0.29
Oeste	Morning	0.213 ± 0.079	0.66
	Afternoon	0.729 ± 0.136	0.34
Moro	Morning	0.080 ± 0.015	0.48
	Afternoon	0.113 ± .013	0.52

In Retiro and Oeste, disturbance in the morning is far less than in the afternoon. Six samples of human disturbance were recorded at each park (three in the morning and three in the afternoon).
se, standard error.

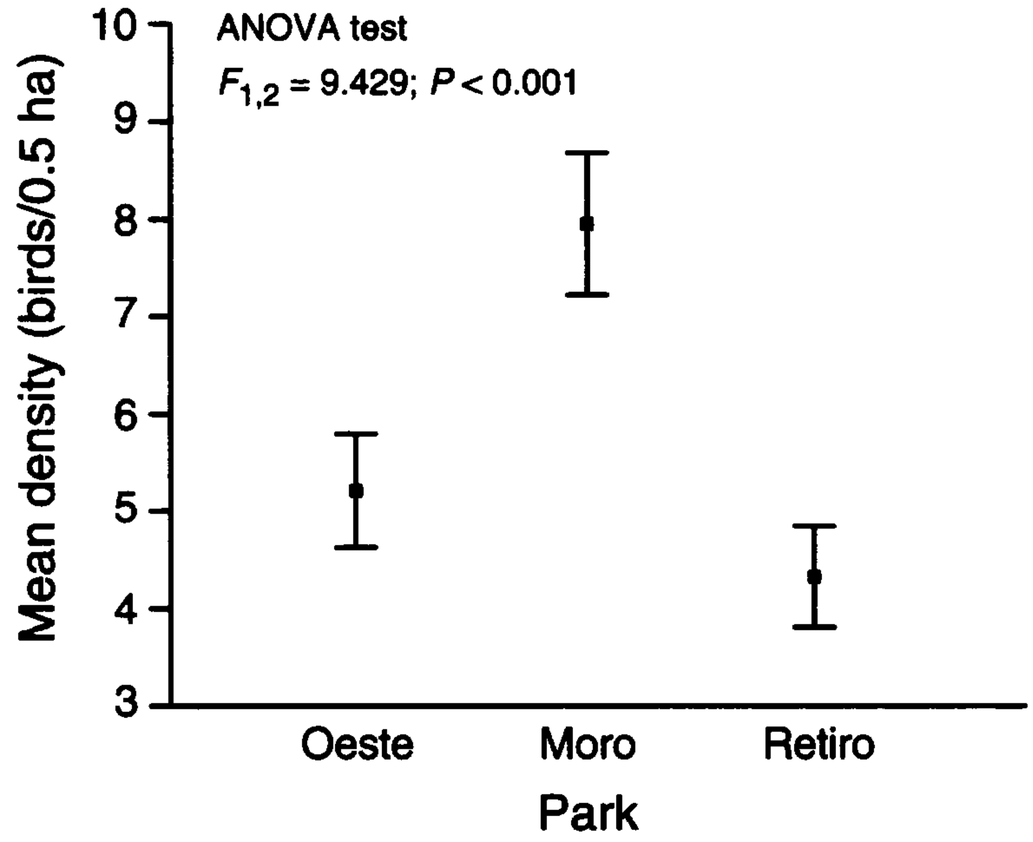

Figure 5. Density of Blackbirds in three urban parks in Madrid (Spain). Values were calculated as the mean number of birds per 0.5 ha.

However, conclusions supported solely by density estimations may be misleading, since the number of individuals at any given site indicates nothing about its reproductive suitability (e.g. whether the site is a source or a sink).[45]

By using the Blackbird as a model species, our work was intended to emphasize that the process of predation avoidance could lead to density reductions, and that human disturbance needs to be taken into account for bird conservation in urban, and indeed other, environments. Considering the effects of human disturbance upon other species, it is likely that sensitivity might differ among species: in general, the larger the species, the more sensitive it is.[17,27,46] Likewise, ground feeders would be more sensitive than foliage feeders. More research in this area is required in order to predict accurately human disturbance impacts in different urban scenarios.

Management measures might help to bridge the gulf between recreational activities and wildlife conservation in urban environments. Urban park planners and managers are faced with a compromise between conserving urban wildlife and promoting activities for people. Because of possible human disturbance impacts, it becomes important that management measures consider seasonal limiting factors; for example, human disturbance may have more influence during winter, when food is barely found and reserves are more quickly exhausted.[43] On the other hand, during breeding seasons birds need to be able to move

freely towards large areas with sufficient protective cover (bushes, trees) in order to nest and care for young. Methods for limiting visitor effects within urban parks may include restricting certain public activities with high levels of pedestrians and noise (particularly during the breeding season), designing special areas for specific purposes (recreative, sports, etc.), setting buffer zones for visitors, determining the appropriate level of visitor presence in sensitive areas (e.g. where birds are nesting), curtailing the use (e.g. for dog walking or strolling) of certain patches with high numbers of sensitive species, and promoting the value of urban wildlife and public awareness by means of environmental education programmes. The information presented here might be useful in suggesting guidelines for the planning, development and improvement of urban green areas aimed at protecting bird species' diversity.

ACKNOWLEDGEMENTS

We would like to thank Mario Díaz, José Díaz, Tomás Santos and Roberto Carbonell for their critical and useful comments on the manuscript. E.F.J. received a grant from the Agencia Española de Cooperación Internacional (AECI, MUTIS Fellowship), which made this study possible.

ENDNOTES

a. Bird sensitivity to human visitors can be assessed by way of flee distances.[46] We found no significant differences in Blackbird flee distances among the three parks (ANOVA, $F_{2,123} = 2.279$, $p < 0.001$), being the mean response, 9.793 m ($n = 126$, sd = 5.338) (Fernández-Juricic, unpublished data).

b. Our sampling design could have been biased (the samples not being independent) because we took two samples (disturbed and undisturbed) from each of 20 different patches. To make sure that the ANOVA assumption of independence of data was accomplished, the described design was compared to the following alternative: 40 patches were selected and a single sample (either disturbed or undisturbed) was randomly taken from each one, so that a higher degree of independence could be ensured. The comparison was done in Oeste Park using a one-way ANOVA test (dependent variable: V/S rate; independent variable: degree of independence). No significant difference was detected between the two procedural schemes (ANOVA, $F_{1,58} = 0.0279$, ns); hence, we adopted the former arrangement primarily for logistical reasons. In addition, data were log-transformed ($\log x + 1$) so as to meet the other two assumptions of ANOVA: normality and homogeneity of variances.

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(MS received 19 June 1998; revised MS accepted 9 March 1999)