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ORIGINAL PAPER

Disturbances to great bustards (*Otis tarda*) in central Spain: human activities, bird responses and management implications

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Abstract We investigated the effects of human activities on the behaviour of great bustards (*Otis tarda*) in a Special Protection Area in central Spain. We recorded 532 disturbances, at a rate of 0.93 disturbances per hour, a high value compared to other studies. Escape (flight/running) was observed more often than alert. Flight was more frequent than running. Car traffic and walkers were the main sources of disturbance. Motorcyclists, dogs, helicopters and aeroplanes were also harmful in relation to their abundance and time of permanence. Farming and shepherding produced few disturbances and usually did not cause a flight response. These activities are thus considered compatible with the conservation of the great bustards. Hunting caused an increase in the frequency of disturbance on weekends and holidays with respect to working days. We propose access restrictions to car traffic and helicopters/airplanes and hunting limitations in those areas more frequently used by the species.

Keywords Behaviour · Management · Steppe-land bird · Threatened species · Time budget

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Introduction

Several studies focussing on birds have shown that human-induced disturbances may affect the energy budget of individuals (Tucker 1969; Riddington et al. 1996), their foraging efficiency (Burger and Gochfeld 1991; Burger 1994) or breeding success (Parsons and Burger 1982; Safina and Burger 1983; Rodgers and Smith 1995; Fernández-Juricic 2002; Weimerskirch et al. 2002; Brambilla et al. 2004) and may ultimately reduce their survival (e.g. Goss-Custard et al. 2006). This is because birds usually react to disturbances in a similar way as to predation risk (Frid and Dill 2002). Therefore, knowing the effects of human activities on wildlife is essential to design management plans for species or areas of special conservation interest (Ramírez Sanz et al. 2000).

The great bustard (*Otis tarda*) is a globally threatened species, considered as "vulnerable" at international and national levels (BirdLife International 2004a, b; Palacín et al. 2004). Spain holds 27,500–30,000 individuals, ca. 60% of the world population (Palacín and Alonso 2008). Of these, approximately 1,400 are found in Madrid province (Alonso et al. 2003, 2006). The future of this species is endangered in some Spanish regions due to habitat degradation caused by agriculture intensification and urban or infrastructure development and to non-natural mortality due to bird collisions with power lines (Palacín et al. 2004). This process is particularly noticeable near Madrid city, where urban development is increasing at a high speed (Naredo and Frías 1988; Ruíz 1999), reducing the habitat suitable for great bustards and causing an aggregation of birds at the better areas through conspecific attraction (Alonso et al. 2003, 2004; Martín 2008). Urban development also determines other indirect impacts, such as an increase in human recreational activities. Since great bustards typically live in cereal farmland, they are also exposed to disturbances caused by farming activities. Finally, hunting of small game species is allowed, and sheep grazing is common, in most great bustard areas in Iberia. However, human-induced disturbances to these birds have never been quantified, and the extent to which these human activities, hunting in particular, may be compatible with great bustard conservation is unknown.

In this study, we quantified the effects of all human activities causing disturbances to great bustards, based on the bird responses. We also compared the frequency of disturbance between seasons. Finally, we examined the differences between weekends and working days to evaluate negative impacts associated to these day categories. Our aim was to assess the compatibility of all human activities with the conservation of this endangered species. The results of this study may be useful to control human activities in areas designed to preserve great bustard populations.

Materials and methods

Study area

The study was carried out in the Special Protection Area for Birds 139 “Estepas Cerealistas de los Ríos Jarama y Henares”, located in Madrid, central Spain (40°45′ N, 3°30′ E, 33,110 ha). The area has a Mediterranean semi-arid climate and a mean altitude of 698 m a.s.l. It holds 65% of the great bustards breeding in Madrid region (Alonso et al. 2003, 2006). Other threatened species found in the study area and sharing the same habitat are the little bustard (*Tetrax tetrax*), the black-bellied sandgrouse (*Pterocles orientalis*) and the Montagu’s harrier (*Circus pygargus*). The most common potential predators for these species are the red fox (*Vulpes vulpes*) and the golden eagle (*Aquila chrysaetos*). The main land use is dry cereal agriculture (wheat *Triticum aestivum* or barley *Hordeum vulgare*) in a 1-year fallow system. Legumes as vetch (*Vicia sativa*) are cultivated occasionally. The study area is crossed by numerous tracks with free access for vehicles and walkers. Other important land uses are extensive livestock farming, with sheep herds controlled by shepherd with dogs, shooting of wild rabbits (*Oryctolagus cuniculus*) and red-legged partridges (*Alectoris rufa*) and hunting of hares (*Lepus granatensis*) with greyhounds. In this hunting modality, a group of hunters move out over broad areas searching for hares, which are persecuted and captured by the greyhounds. Hunting is allowed between October and January, on Saturdays, Sundays, public holidays and Thursdays, although the latter one is rarely used by hunters.

Data collection

We selected six observation points to cover the main areas where great bustards are found in the study area. The average estimated surface surveyed from each observatory was around 500 ha, which means we surveyed 3,000 ha in total, more than 9% of the surface of the Special Protection Area. At these vantage points, we could see the movements of great bustards with telescope and binoculars from far enough to prevent affecting their behaviour. To prevent that two observers recorded the same bird movements, observation points were far enough from each other, and the surveyed areas were well defined by easily identifiable limits (roads, rivers). Data were collected during 164 days (575 observation hours), through the winters 2003–2004 and 2004–2005 (107 days, 415 h) and the springs of 2004 and 2005 (57 days, 160 h). Observations were made both on working days (94 days, 324 h) and on weekends/public holidays (70 days, 251 h).

We started observations before sunrise and ended around midday, when bustards lay down to rest (Martínez 2000, personal observation). Observations were interrupted before midday only when bad weather conditions (strong rain or fog) reduced visibility, or when birds occasionally abandoned the area due to high disturbances. Bird locations were plotted on 1:10,000 maps at sunrise, before human activities started, and then every 30 min. Spontaneous movements of birds and changes in the size of the flocks were also recorded. Birds flying across the observation area without landing at sight were not considered. Disturbances were grouped as shown in Table 1. As “hunters”, we included both hunters with greyhounds and hunters with fire guns and dogs; “walkers” included those with and without accompanying dogs; “dogs” were those vagrant not associated to hunters, walkers or other factors of disturbance and “others” included various sporadic factors of disturbance, such as burning of stubbles. The starting and ending times were noted for each activity or factor of disturbance observed. Disturbances caused by wild animals (mainly foxes, crows and golden eagles) were also recorded, but not included in the evaluation of human disturbances. The following variables were recorded for each disturbance event: type of response (no reaction, alert, running or flight), duration of the response and number of individuals reacting. When birds escaping from disturbances abandoned our observation area, we measured the duration of the escape movement during the time individuals were at sight.

Table 1 Types of human activities, frequency distribution of disturbances caused to great bustards (n=532), frequency distribution of activities recorded (n=1320) and other indexes of incidence

Factors of disturbance	Frequency of disturbances (%)	Frequency of activities (%)	Probability of disturbance	Disturbances per disturbing activity	Time of permanence (%)	Disturbances per hour of activity	Birds disturbed (%)	Individual time spent responding (%)
Cars	**25.0**	**33.9**	0.23	1.27	21.6	0.61	24.9	**16.9**
Walkers	**21.1**	14.6	0.39	1.44	12.2	0.92	22.3	**29.7**
Tractors	13.1	14.4	0.23	1.56	**32.1**	0.22	9.7	8.9
Hunters	9.2	5.4	0.34	**1.96**	13.4	0.36	8.2	8.8
Motorcyclists	8.2	4.9	0.40	1.62	0.9	**4.93**	8.4	4.5
Sheep herds	6.8	5.8	0.36	1.30	11.2	0.33	8.3	**15.8**
Helicopters	5.3	3.6	0.42	1.35	0.4	**7.47**	6.2	3.8
Dogs[a]	2.9	1.3	**0.53**	1.67	1.6	0.96	2.9	1.8
Cyclists	2.7	2.9	0.29	1.27	0.8	1.85	2.9	2.9
Aeroplanes	2.5	6.2	0.13	1.18	0.3	**3.96**	3.8	4.1
Trucks	1.6	2.8	0.14	1.60	2.7	0.31	0.4	0.8
Horse riders	1.0	1.9	0.20	1.00	1.4	0.37	1.5	2.0
Others[b]	0.4	0.5	0.33	1.00	1.4	0.15	0.6	0.1

The highest values or those mentioned in the text are indicated in bold

[a] Vagrant dogs not accompanying hunters, walkers or other activities

[b] Low frequency activities, such as burning of stubbles or rubbish blown by the wind

Data analyses

To compare the relative frequencies of bird responses, we considered each disturbance event as a data point and used χ^2 tests. One-factor analysis of variance (ANOVA) and Student's t tests were used to compare the duration of the responses in the whole sample and amongst types of human activities, after discarding those producing very few disturbances (n<4). The number of individuals reacting to each disturbance event was analysed in the same way as the duration of the response, and we tested whether these two variables—number of individuals reacting and duration of the response—were correlated. In comparisons between seasons (winter vs. spring) and between days of the week (working days vs. weekends/public holidays), we considered each observation day (n=164) as a data point and used Student's t tests. The interaction between these two factors (season and day of week) was analysed with multi-factor ANOVA. We considered observation days as data points also when calculating correlation coefficients between the different variables used (frequency of occurrence of activities, frequency of disturbance, frequency of escape response etc.).

The impact of each human activity on the behaviour of the birds was estimated through various indexes measuring the intensity of the bird response (percentage of the total number of disturbances caused by each activity, percentage of the total number of birds disturbed and fraction of the individual's time budget spent responding) and the probability of causing disturbance (number of activities causing disturbances/number of activities observed, mean number of disturbances per disturbing activity—one activity may cause disturbances to different flocks—and mean number of disturbances per hour of activity; see Table 1).

Results

We recorded 532 disturbance events, at a rate of 0.93 disturbances per hour. Most of them were caused by human activities (96.1%), whereas only 3.9% were due to wild animals. An accumulated total of 7,250 individual birds were involved in the disturbances recorded during the study (12.6 birds disturbed/h). The mean number of birds controlled from an observation point (disturbed and undisturbed) was 58.2; therefore, each great bustard in the population suffered on average 0.22 disturbances/h (one every 4 h and 35 min) and spent responding approximately 0.58% of its time budget (21 s/h, or 1 min out of 3 h).

The escape response (running or flying) was more frequent than the alert response (76% vs. 24%; χ^2=143.19, df=1, p<0.0001), and amongst escape responses, flight was more frequent than running (267 flight vs. 137 running responses; χ^2=41.83, df=1, p<0.0001). There were significant differences in the duration of the response amongst the three response types considered (F=15.878, df=2, p< 0.0001). The average time spent flying (44 s) was shorter than both, running time (85 s, t=−5.343, df=399, p<

0.0001) and alert time (92 s, $t=-4.998$, $df=389$, $p<0.0001$). The difference between running and alert times was not statistically significant. The number of individuals reacting did not differ amongst types of response. The correlation between number of individuals reacting and duration of the response was not significant, neither in the whole sample nor by type of response.

Human activities and disturbance frequency

Car traffic and walkers were the main sources of disturbance, followed by tractors and hunters, as judged by the frequency distribution of disturbances by activity (Table 1). Amongst a total of 1,320 activities gathered (2.3 activities/h), car traffic was the most common, followed by walkers and tractors, whilst vagrant dogs were the least frequent (Table 1). However, when considering the probability of causing disturbance, dogs were the most harmful, followed by helicopters, motorcyclists, walkers and hunters. Once an activity had caused disturbance, it might determine several disturbance events to the same or different flocks of birds. This was the case of hunters, whose mean number of disturbance events per disturbing activity showed the highest value.

Tractors showed the longest time of permanence in the area (308 h; Table 1). The average activity duration was the highest for hunters (109 min/activity), tractors (97 min/activity) and sheep herds (85 min/activity), whereas aeroplanes, helicopters and motorcyclists were much shorter (<10 min/activity). When considering the frequency of disturbance as a function of the activity duration (number of disturbance events per hour of activity), helicopters produced the highest value, followed by motorcyclists and aeroplanes. Tractors, trucks, sheep herds, hunters or horse riders provoked <0.5 disturbances/h of activity. Amongst walkers, those accompanied by dogs caused more impact than those without dogs, both in number of disturbances per disturbing activity (1.79 vs. 1.23) and in number of disturbances per hour of activity (1.55 vs. 0.68).

Bird responses

Considering each type of activity separately, escape was the most frequent response, except in the case of aeroplanes (Fig. 1a). Helicopters produced similar numbers of alert and escape responses. Amongst escape responses, tractors were the only activity that provoked more running than flight (Fig. 1b). Sheep herds produced similar numbers of flight and running responses.

Mean alert time showed significant differences amongst activities ($F=2.174$, $df=8$, $p<0.0348$), being longer for walkers and hunters than for other activities ($t=3.451$, $df=117$, $p<0.0008$). In the case of aeroplanes, two disturbance events produced by the same small plane that stayed flying over the area at low altitude during 20 min provoked unusually long alert times that contributed to increase the standard deviation. Mean running time also differed between activities ($F=4.181$, $df=5$, $p<0.0016$), because it

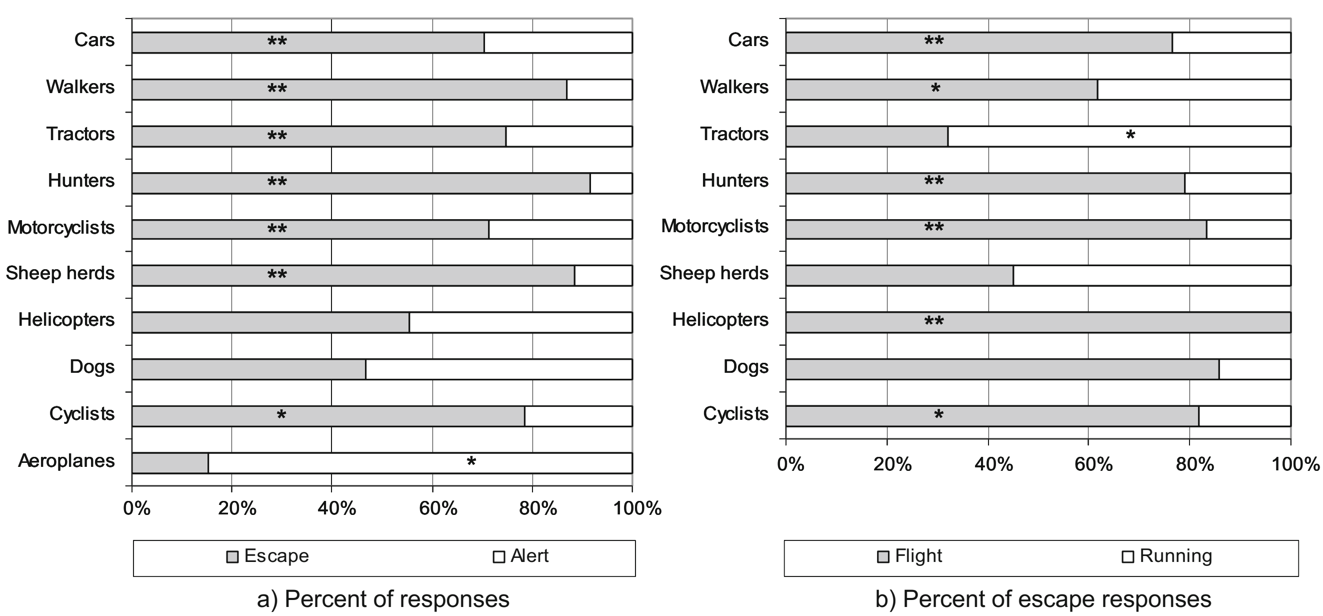

Fig. 1 **a** Proportions of escape and alert responses of great bustards caused by different factors of disturbance. **b** Proportions of flight and running responses to these factors. Significant differences are shown (χ^2: *$p<0.05$; **$p<0.01$). Activities producing a small number of disturbances ($n<8$) are not included. Aeroplanes are not included in **b** because they produced very few escape responses ($n=2$). No test has been done for the dogs due to the low sample size

was much longer in the case of sheep herds than in other activities ($t=-4.525$, $df=120$, $p<0.0001$). We found no significant difference in flight duration amongst activities ($F=1.422$, $df=8$, $p=1.8990$).

There were no significant differences between activity types in the number of individuals reacting. Cars and walkers were also the main sources of disturbance when considering the numbers of birds reacting (Table 1). Walkers caused the highest time loss, reaching 29.7% of the cumulative time spent responding by individual great bustards, followed by cars (16.9%) and sheep herds (15.8%).

Daily and seasonal variation in disturbances and responses

Although human activities were more frequent in winter than in spring ($t=2.07$, $df=162$, $p<0.040$), disturbance frequency did not differ between seasons ($t=1.5$, $df=162$, $p<0.136$). Certain activities like hunters and horse riders were observed only in winter, and others were more frequent in that season, like sheep herds ($t=3.792$, $df=162$, $p<0.000$) or motorcyclists ($t=2.070$, $df=162$, $p<0.040$). No significant differences were found between seasons, neither in the proportion of each response type nor in response duration. The aggregation patterns of great bustards (size and number of flocks) were different in spring and winter. In spring, we observed a daily maximum of 12.6±6.4 standard deviation flocks, with 5.4±6.0 individuals reacting to each disturbance event (a value close to the mean size of the flocks). In winter, the daily maximum was 4.7±2.3 flocks, with 15.5±17.3 individuals reacting.

The disturbance frequency was higher on weekends/public holidays than on working days ($t=-2.78$, $df=162$, $p<0.006$), although the frequency of occurrence of activities did not differ ($t=-1.26$, $df=162$, $p<0.208$). The frequency of alert responses was higher on weekends/public holidays ($t=-3.02$, $df=162$, $p<0.003$), whereas the frequency of escape responses did not change, and thus, the proportion of escape responses was lower on weekends/public holidays (72.9%) than on working days (78.1%). The response duration was significantly longer on working days than in weekends/public holidays in the case of running ($t=2.26$, $df=104$, $p<0.026$), with no significant difference in the case of flight and alert. Certain activities were more frequent during working days (e.g. aeroplanes, helicopters and tractors, $df=162$, $p<0.05$ in all cases), whilst other types were more frequent during weekends/public holidays (hunters, motorcyclists, cyclists, horses and walkers with dogs, $df=162$, $p<0.01$ in all cases). The frequency of other activities (cars, walkers, sheep herds, vagrant dogs) did not differ between working days and weekends/public holidays. Considering each type of activity separately, no significant difference was found neither in the frequency of each response type nor in response duration.

The interaction between season and day of week was not statistically significant, neither in activity frequency ($F=1.325$, $df=1$, $p=0.25$) nor in disturbance frequency ($F=1.127$, $df=1$, $p=0.29$). However, some differences were found only in one season, e.g. the difference in disturbance frequency between working days and weekends/public holidays was significant in winter ($t=-2.777$, $df=105$, $p<0.006$) but not in spring ($t=0.504$, $df=55$, $p<0.616$). In certain types of activities, the difference in frequency between days of the week was similar in winter and spring, as was the case of cyclists, which were always more frequent on weekends/public holidays (in spring, $t=-2.153$, $df=55$, $p<0.036$; in winter, $t=-2.146$, $df=105$, $p<0.034$). Such differences were sometimes found only in one season, as was the case of hunters, which were more frequent on weekends/public holidays only during winter ($t=-4.712$, $df=105$, $p<0.0001$).

The results of the correlation analyses showed that (a) the disturbance frequency was higher on days with higher frequency of activities ($r=0.402$, $n=164$, $p<0.001$), (b) the proportion of escape responses was lower on days with higher disturbance frequency ($r=-0.339$, $n=164$, $p<0.003$) and (c) the proportion of flight responses was higher on days with higher disturbance frequency ($r=0.500$, $n=164$, $p<0.0001$).

Discussion

Although our study area is inside a Special Protected Area for Birds, we recorded 0.93 disturbances/h, double that obtained by Hellmich (1991) with the same species in western Spain. This difference was surely due to the much higher human population density in our study area (771 vs. 21 inhabitants/km^2; INE 2003), which is associated to the presence of several small towns over our study area, and the proximity of the capital city of Madrid. The frequency of disturbances recorded by us was also higher than those found in similar studies with other species, e.g. in brent geese (*Branta bernicla*) in Great Britain (0.74–0.83; Owens 1977; Riddington et al. 1996), or in pink-footed geese (*Anser brachyrhynchus*; 0.44; Gill et al. 1996), although lower than that observed in snow geese (*Anser caerulescens*) in North America (1.26; Belanger and Bedard 1989). In our study, car traffic was the most common source of disturbance, followed by walkers. Motorcyclists and helicopters were also frequent. In contrast, Hellmich (1991) found hunting to be the main source of disturbance, followed by agricultural activities, whereas cars, motorcyclists and helicopters were rare. Riddington et al. (1996) recorded a much higher proportion of disturbances produced by wild animals (21%), confirming the predominant role of human activities as sources of disturbance in our study area.

Although we estimated that an individual great bustard spent on average only a 0.58% of its time budget responding to disturbances, the frequency of disturbances suffered by individual great bustards (0.22/h) was close to the critical thresholds for poor feeding conditions established in individual-based models for oystercatchers (*Haematopus ostralegus*) in France (Goss-Custard et al. 2006). In addition to this negative impact on time budget, disturbances causing flight responses increase the probability of collisions with powerlines, the main cause of non-natural mortality in great bustards (Alonso et al. 1994; Palacín et al. 2004).

Several studies have shown that birds respond in different ways to different types of human activities, depending on certain characteristics of the approaching disturbance sources, like speed or noise, or on the potential danger they imply (Riddington et al. 1996). In great bustards, alert was the preferred response only to aeroplanes, all other activities provoking an escape response, except helicopters and dogs for which no response difference was observed. Aeroplanes usually passed by at a high altitude and speed and were not perceived as a risk. Helicopters, in contrast, frequently flew at a lower altitude and slower speed, which probably increased the risk sensitivity of the birds. As for dogs, although bustards perceive them as a threat, their movements are usually erratic (non directional), and thus, the birds probably prefer to stay alert if the dog is far away and escape only if the dog approaches.

When birds decided to escape, the flight response was preferred in most cases (cars, walkers, hunters, motorcyclists, helicopters and cyclists), probably because they identified these disturbances as high-risk threatening factors. In contrast, birds reacted to tractors usually by running, or showed no preference in the case of sheep herds, most likely because these two sources of disturbance are recognised as low-risk factors.

No differences were observed between types of activities in flight duration, which we interpret as being due to the fact that it took the same time to fly to a safe place whatever the source of disturbance was. Differences in the duration of running and alert responses may also be explained by the characteristics of the activities provoking these responses. Alert time was longer in the case of walkers and hunters because these remained longer periods in the area than other sources of disturbance. Although there are no significant differences for sheep herds, the alert time was also raised, but unlike walkers and hunters, birds probably identified them as a low-risk activity and soon felt safe again. Nevertheless, when sheep approached, the birds started escaping, but the low speed of the sheep herds allowed them to do it by walking or running.

Seasonal and weekday-related variations in the frequency of disturbance and bustards responses

The higher frequency of activities in winter was mainly due to hunting (hunters, horse riders, greyhounds and motorcycles), which is allowed only during that season, and sheep herds, because of the seasonal changes in their grazing places. We can think of two reasons for the absence of seasonal difference in the disturbance frequency, in spite of a higher frequency of human activities in winter than in spring. The first was probably the higher natural sensitivity of the birds during the breeding period. The second could have been the more dispersed distribution of the birds in spring (Magaña 2007). A higher number of smaller flocks during this season increased the probability that one of them was affected by a disturbance source passing by.

Disturbance events were more frequent on weekends and holidays, when hunting and recreational activities were performed, than on working days, when only professional activities were carried out. The effect of hunting activities explains why the difference in the frequency of disturbances between days of the week was statistically significant in winter but not in spring, as has been observed in other studies (Evans and Day 2002).

Several authors have found that the predation risk perceived by birds and the consequent effects of disturbance varied with the amount of humans present (Burger and Gochfeld 1991; Beale and Monaghan 2004) and that the effects of human disturbance depended on the frequency of the sources of disturbance (Safina and Burger 1983). However, the seasonal and daily differences found in our study suggest that there is not always a direct relationship between frequency of human activities and frequency of disturbances. Other factors such as the spatial distribution of the birds, the visibility and the frequency of the types of activities that birds may perceive differently can be important too (together with habituation and other factors mentioned further down).

The reaction of great bustards to disturbances was similar in spring and winter, in spite of the seasonal differences in aggregation patterns. Escape was the most frequent response, although alert was also important, and had been considered only in a few studies (e.g. Fernández-Juricic et al. 2001). The higher frequency of alert response on weekends and holidays was not related to differences in the frequency of specific activities. It could be attributed to the negative correlation between the frequency of disturbance and the proportion of escape to alert responses, since the first was higher on weekends/public holidays. The effect of the frequency of disturbance on the proportion of escape responses may be explained by the birds getting accustomed to human activity (e.g. Rees et al. 2005), or by other processes such as the re-location of birds in safe places after being disturbed once, the lack of alternative places to stay safe when human presence is high or the energetic cost accumulated on days with many disturbances. The same explanation is proposed for the longer duration of running on working days compared to weekends/public holidays.

Management implications

The combination of frequency of occurrence, disturbances per unit time and, especially, type of response may be used to rank different human activities and help establishing which of them can be considered compatible with the conservation of great bustards and which should be carefully regulated. In our study, farming and livestock activities, such as driving tractors and shepherding, may be considered the least harmful and most compatible with great bustard conservation. These activities were moderately common and long-lasting, but were the only ones producing more running than flying responses and therefore affected the energy budget of birds less than other activities. In contrast, cars, walkers, hunters, motorcyclists and helicopters usually provoked flight, thus having a higher impact on the birds' energy budget.

Although car traffic showed moderate values of both probability of disturbance and disturbances per unit time, it was the main source of disturbance to great bustards in our study area and the second most important factor affecting the birds' time budget. Therefore, access restrictions and alternative routes that do not cross the main great bustard areas should be established. Regulation of walkers' transit is also necessary, since this was by far the factor determining the highest investment on vigilance. As for hunters, they produced many disturbance events, with ca. 90% escape response. The frequency of disturbances caused by walkers and hunters was high because, even if their occurrence frequency was not as high as that of cars, their mean time of permanence was long, and in the case of hunters, they sweep broad areas. Hunting is restricted in time, but it is also necessary to regulate this activity in space, limiting it exclusively to zones that are not frequently used by great bustards and other endangered steppe-land birds like little bustards, harriers or sandgrouses. These kind of restrictions have been implemented successfully at some areas (Madsen 1998a, b; Duriez et al. 2005; Stafford et al. 2007; Casas 2008) and would certainly improve the conservation of the steppe-land birds in our study area. Motorcyclists, helicopters and aeroplanes are moderately common and show the highest rates of disturbances per hour of activity; thus, they should be considered harmful and their traffic restricted or prohibited in important bird areas. The probability of vagrant dogs causing disturbance was the highest, which makes them potentially very dangerous (Lafferty 2001), even if their occurrence frequency was low. Since dogs are also important nest predators, their presence should be eliminated from any great bustard area. Walkers produced more disturbances when they were accompanied by dogs (see also Taylor et al. 2007), and thus, we insist on the recommendation of keeping dogs leashed when walking near important areas for steppe-land birds (Lafferty 2001). Alternative open spaces that might attract walkers with dogs are also needed, since it is frequently argued that dogs should be allowed to run off the lead (Underhill-Day and Liley 2007).

Specific management measures should be taken on weekends to reduce the effects of harmful activities such as cars, walkers, hunters, motorcyclists and cyclists. Also, special care should be taken in spring, when disturbances may have very negative effects on the breeding success. Previous works on great bustards have recommended similar regulations, including restrictions for hunting and car access in the most important areas for the species (Hellmich 1991; Faragó et al. 2001). This is particularly important in our study area, considering the foreseeable rapid increase in human population in Madrid region.

Finally, a conflict may arise between the use of the countryside for recreational purposes and the protection of species of high conservation value (Ibis 2007). Regulations and prohibitions on harmful activities should be conveniently integrated with information and environmental education campaigns to promote public awareness and justify the restrictions imposed.

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