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Large birds of prey, policies that alter food availability and air traffic: a risky mix for human safety

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Abstract: Raptors are considered to pose one of the greatest aviation bird strike risks. We investigated raptor bird strikes reported at the largest Spanish airport (Adolfo Suárez Madrid Barajas; AS-MB) from 2009 to 2016 to determine the factors contributing to the increased incidences and develop recommendations to mitigate the risks. We hypothesized that increased raptor bird strikes resulted from changes in foraging and dispersal patterns of Iberian Peninsula vultures (*Aegypius* spp. and *Gyps* spp.) after 2004–2005. We used information on raptor bird strikes obtained from official databases and published studies, reported incidences of raptor bird strikes and their characteristics (i.e., time, location, species involved), data collected about raptor flight heights, and estimates of relative abundance of large raptors and their prey species obtained through standardized surveys conducted in the high priority aviation area around the airport to assess bird strike risks. Our field work was conducted from June 2014 to May 2016. We confirmed a direct relationship between the relative abundance of the raptors studied and their prey species in the priority aviation areas. Raptor bird strike risks increased during spring and summer when food sources were abundant in locations where flight altitudes of aircraft were <1000 m above ground level. Our observations appear to be related to European Union sanitary policies that altered the availability and occurrence of livestock carcasses. These changes may have increased the overall movement of vultures in search of new, scarcer, and more distant food sources, enhancing the likelihood of overlap with air traffic corridors. Although further studies on aviation risk are needed, our results suggest the need to implement immediate remedial management actions to alter vulture habitat quality by reducing food sources in sensitive areas, and providing alternative food resources at distances sufficiently far from commercial airports.

Key words: *Aegypius monachus*, airport management, bird strike, cinereous vulture, food availability, griffon vulture, *Gyps fulvus*, raptors, risk assessment, sanitary policies, Spain

Flying birds are one of the most hazardous elements to commercial, private, and military aviation when air traffic routes are poorly designed with respect to bird population distribution and migration routes (Cleary and Dolbeer 2005, DeVault et al. 2013, Lambertucci et al. 2015). Aircraft collisions with birds (i.e., bird strikes) result in economic losses due to damage to aircraft components and sometimes lead to fatal accidents. At least 286 deaths worldwide have been caused by bird strikes or attempts to avoid birds during flight (Thorpe 2012). The risk varies depending on the traits and size of the bird involved and is more serious when caused by large birds, including soaring raptors (DeVault et al. 2011). Raptors were estimated to cause 47% of bird strikes with private aircraft (Thorpe 2012).

The bird strike problem has been addressed by managers and governing bodies (DeVault et al. 2013). However, in general, there is a lack of specific protocols for large raptors, especially outside of North America, in terms of deterrence activities inside and around airports and in managing food sources. Although risks for aircraft collisions associated with Old World vultures have been reported in Asia and Africa, including the highest ever recorded bird strike collision (>11,000 m above ground; Satheesan and Satheesan 2000), in a European context bird strikes have mainly involved waterfowl and medium- and small-sized flocking birds (Soldatini et al. 2010).

An emerging trend has recently been detected as a result of human safety concerns in Spain (Margalida 2016). In 2016, 10 people died in 3 crashes of private aircraft caused by collisions with Eurasian griffon vultures (*Gyps fulvus*). This level of risk had not been previously recorded and represents a milestone

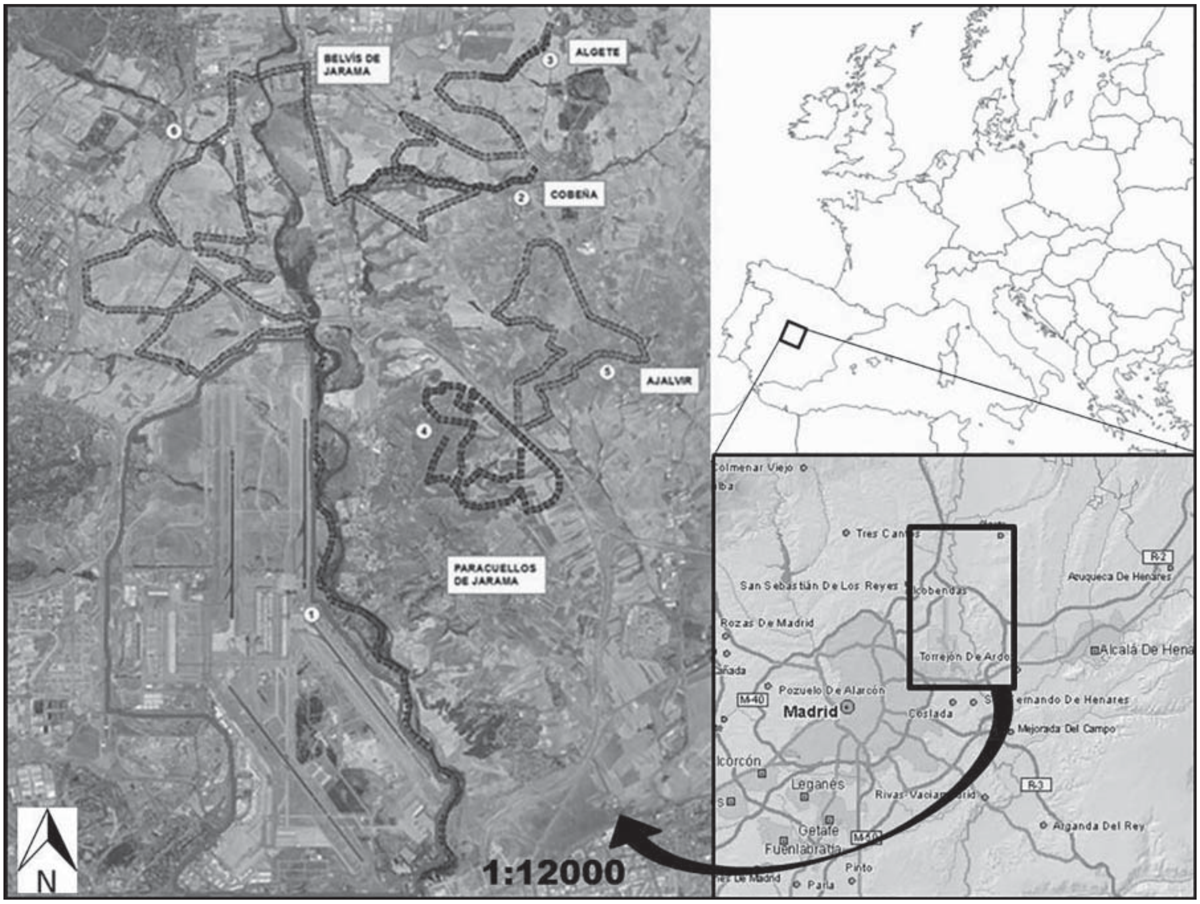

Figure 1. Survey transects for obtaining relative abundances of birds of prey (numbers 5 and 6), and wild rabbit (*Oryctolagus cuniculus*), wood pigeon (*Columba palumbus*), and red partridge (*Alectoris rufa*; numbers 1 to 4), in the high-priority area (HPA) around the Adolfo Suárez-Madrid Barajas Airport, Madrid, Spain, between 2014 and 2016. The names of the towns in the study area are also shown (scale 1:10000).

in comparison to global historic bird strike data. For example, from 1912 to 2012 for aircraft <5,700 kg, 69 casualties from 32 accidents were recorded worldwide (mean 0.69 deaths/year; Thorpe 2012). In addition, there have been at least 26 collisions with raptors between 2006 and 2015 around the largest Spanish hub (Adolfo Suárez-Madrid Barajas, AS-MB), with no human injuries reported (Tragsatec 2016), and yet no incidents had been reported before 2006. As a result, a change in the likelihood of collisions with raptors has occurred in recent years, which necessitates a scientific assessment and the adoption of appropriate management measures.

The causes of raptor bird strike hazards are not well understood for either the AS-MB airport or for aviation across Spain, in terms of seasons, height from the ground, regions, species, time, and circumstances. At a European level, the available information on aircraft collision hazards is similarly scarce (Soldatini et al. 2010). Despite being a priority issue for aviation safety and the fact that Spain is home to the most important western European populations of raptors (Deinet et al. 2013), global patterns of the impact, times, and places where the risk may be highest have not been properly studied. This analysis is urgent given the growing concern for the affected stakeholders (Margalida 2016).

Our study constitutes the first detailed analysis of the interaction between large raptors (LBPs) and commercial aviation in Europe, specifically in Spain. We were interested in determining the relative abundance of LBPs, the species involved, places, time, season, and correlations with prey species and their causes in areas of greatest risk for aviation, using the largest airport in Spain as a case study. We hypothesized that the incidents reported by the airport management authority, both in numbers and in relation to height from the ground, were correlated with the relative abundance of LBPs, and that their presence was associated with prey species numbers inhabiting priority avian areas. We assessed the effects that different environmental management policies have had on LBP bird strikes locally and across Spain. Finally, we reviewed and proposed mitigation measures that could be implemented at the national level to reduce the LBP bird strike hazard.

Study area

We completed our fieldwork to assess the status of LBPs and prey availability in areas outside the AS-MB airport (Madrid, Spain, UTM 30N 451310/4482476; Figure 1) in collaboration with other monitoring programs developed by the company managing air navigation and operation of the Madrid airport "Aeropuertos Españoles y Navegación Aérea [AENA]". In addition, we collected information on LBP bird strikes and sightings from airplanes for the full territorial scope of the Madrid airport.

The landscape of the study area is dominated by agricultural lands consisting of cereal crops and a forest mosaic formed by sclerophyllous forests (*Quercus rotundifolia*) with patches of high density of trees and other more open areas with pastures subject to livestock use. The climate is Mediterranean, characterized by winters and summers with extreme temperatures and soft autumns and springs when the highest rainfall is recorded, with an annual average of approximately 504 mm. The LBPs common to the area of the Madrid airport that were included in the study included the cinereous vulture (*Aegypius monachus*), Eurasian griffon vulture, Spanish imperial eagle (*Aquila adalberti*), golden eagle (*Aquila chrysaetos*), and eagle owl (*Bubo bubo*).

Methods

To prioritize monitoring activities and management proposals, we completed an initial delimitation of priority aviation areas around the Madrid airport, following previous approaches developed in the United States (Blackwell et al. 2009, Martin et al. 2011). We established a high priority area (HPA) delimited by a radius of 13 km around the 2 northernmost runways of the airport (International Civil Aviation Organization 2012). This area included air space in which aircraft perform take-off/landing operations up to a height of approximately 1,000 m from the ground, where >90% of all bird strikes are registered (Dolbeer 2006). Aviation at the airport was mainly dedicated to passenger transport (>50 million movements/year, the fifth highest in Europe) with a mean daily frequency of 1,036 flight operations on their 4 runways (<http://www.aena.es/csee/Satellite?pagename=Estadisticas/Home>).

Data collection

Our data were collected at 2 levels. First, data regarding interactions between LBPs and aircraft from 2009 to 2016 (already reported in Tragsatec 2016) were compiled from databases managed by AENA. Incidents were defined as: 1) sightings of LBPs from aircraft by pilots (within a short enough distance to allow their identification and subsequent reporting, which is mandatory), and 2) actual bird strikes. Bird strikes must also be registered by the airlines and communicated through notification reports. We also compiled information on flight heights of several LBPs, including from other parts of world, that could inform about aerial distribution patterns of large soaring raptors. This information was used to determine the relationship between LBP heights and incidents. To obtain this information, we completed a search of scientific journals and technical reports (Table 1).

Secondly, to evaluate the relative abundance of LBPs and their patterns of use in the HPA, we conducted direct counts from a car with weekly frequency during all the weeks of the 2 years of study, focused on individual LBPs that were on the ground or foraging (i.e., flying up to 200 m from the ground, approximately). We selected the northern and eastern territory outside the airport, as these are the only non-urbanized surrounding areas with open natural and agricultural habitats selected for foraging (Donázar et al. 2016). We calculated a kilometer abundance index (KAI, expressed as the number of individuals per kilometer; Bibby et al. 2000) along 2 predetermined non-paved census roads (Figure 1). The distance of the 2 itineraries of census was 30 km and 50 km, respectively. We discarded monitoring during rainy and windy (>20 km/hr) days, as these unfavorable weather conditions reduce the foraging activity of the LBPs (Hiraldo and Donázar 1990). This continuous monitoring allowed us to determine trends in time and

Table 1. Percentage distribution of flight height locations, in meters from the ground, of different species of large soaring birds of prey.

Height from the ground (m)	*Aegypius monachus*[1]	*Gyps fulvus*[2]	*Coragyps atratus* and *Cathartes aura*[3]	*Aquila nipalensis*[4]	*Gyps coprotheres*[5]	*Gypaetus barbatus*[5]	Mean ± SD
0–400	16.2	49.9	96.0	48.8	87.5	90.3	64.7 ± 31.5
401–800	55.7	38.1	4.0	37.4	12.5*	9.7*	26.2 ± 20.4
801–1,200	26.2	11.6	0.0	8.1	0.0*	0.0*	7.6 ± 10.3
>1,200	1.9	0.4	0.0	5.7	0.0*	0.0*	1.3 ± 2.6

[1]Jiménez and González 2012
[2]Boscaje 2012
[3]DeVault et al. 2005
[4]Spaar and Bruderer 1996
[5]Rushworth and Krüger 2014
*estimated from the published article

selection patterns of high priority areas around the AS-MB airport. The monitoring period lasted from June 2014 to May 2016 (2 years).

In addition, we completed prey species surveys to evaluate the food abundance for LBPs in the HPA and to understand its relationship with the relative abundance of LBPs. The surveys were conducted biweekly by driving a car along 4 predetermined transects on non-paved roads (Figure 1). We recorded all live wild rabbits (*Oryctolagus cuniculus*), wood pigeons (*Columba palumbus*), and red partridges (*Alectoris rufa*), which are the selected prey of large raptors in Spain (Fernández de Simón et al. 2011), including vultures and facultative scavengers that consume them as carcasses (Delibes-Mateos et al. 2007, Blanco-Aguiar et al. 2012, Moreno-Opo et al. 2012, Moreno-Opo et al. 2016, Margalida et al. 2017).

Prey surveys were conducted during the first hour after dawn or the hour prior to dusk, at a continuous speed of no more than 20 km/hr. We also considered the distance traveled by vehicle to calculate a kilometer abundance index (KAI), expressed as the number of individuals divided by the distance driven in km. For rabbits, we also applied stratified counts in assigned bands (up to 25 m from the vehicle and more than 25 m to the vehicle; Fernández de Simón et al. 2011) to obtain a relative density index expressed as the number of rabbits per hectare. The distance of the 4 itineraries of census was 12.8, 4, 4.5, and 5.2 km (Figure 1). We discarded monitoring during rainy and windy (>20 km/hr). The work was conducted from June 2014 to May 2016 (2 annual periods).

Data analysis

Data were analyzed to determine the relationship between the number and patterns of LBP bird strikes and sightings with the relative abundances of foraging LBPs and prey by season. The relationship between the presence of LBPs in the HPA and the relative abundance of prey species was also analyzed.

Parametric techniques were used when the data met the principles of normality and homoscedasticity, including their logarithmic transformation. We performed linear regressions when the dependent and independent variables were quantitative. This was the case of the analyses of the relationship between the number of incidents, the relative abundance of LBPs, and the relative abundance of prey, as well as those checking the link between flight heights of the LBPs and of the incidents. Simple linear regression was also used to compare the trend of the number of incidents around the AS-MB airport and the trend of the number of aviation flights in Madrid and all of Spain. For comparing the distribution of percentages of the flight at which incidents occurred, we carried out a frequency analysis (Chi-square). We considered statistical significance at $P < 0.05$. The statistical analyses were conducted with Statistica 6.1 (StatSoft, Tulsa, Oklahoma, USA).

Results

We found a direct relationship between food availability, LBPs, and the number of aircraft incidents (mean 197.00 ± 181.59 incidents/year). Regarding the hypothesis of a direct significant relationship between the number of incidents

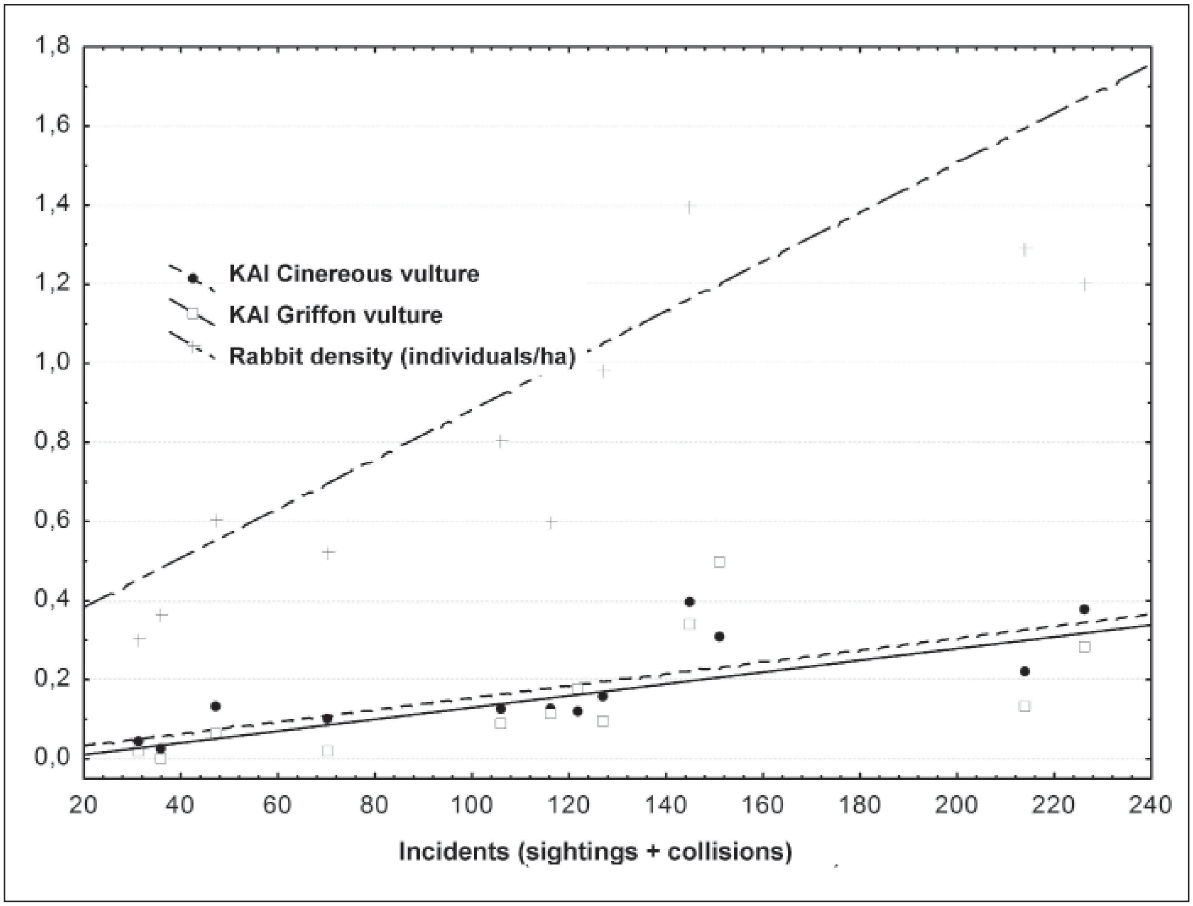

Figure 2. Relationship between Kilometer Abundance Index (KAI) expressed as individuals (n)/km of cinereous vulture (*Aegypius monachus*; r^2 = 0.62; P = 0.002) and griffon vulture (*Gyps fulvus*; r^2 = 0.39; P = 0.028), as well as the relative density (individuals (n)/ha) of wild rabbit (*Oryctolagus cuniculus*; r^2 = 0.62; P = 0.002) in relation to the number of incidents (sightings from aircraft + collisions) with aircraft around Adolfo Suárez-Madrid Barajas Airport, Madrid, Spain, between June 2014 and May 2016.

and the relative abundance of the studied birds, we checked this relationship for the species causing >90% of the registered incidents such as the cinereous and griffon vultures ($F_{1,10}$ = 16.41, P = 0.002 and $F_{1,10}$ = 6.52, P = 0.028 respectively; Figure 2). Thus, the number of sightings and LBP bird strikes were directly related to their relative abundance ($F_{1,2}$ = 18.22, P = 0.050; Figure 3).

With respect to flight heights, information on the distribution of aerial locations of LBPs showed an increased relative abundance between 0 to 400 m above ground, except for cinereous vultures (Table 1). Higher than 800 m, the proportion of flight locations declined by 13.8%, while only 5.7% of the records corresponded to flights higher than 1,200 m. On the other hand, the height at which incidents occurred was heterogeneous (χ^2_3 = 62.24; P < 0.001; Table 2), with these events observed to a greater extent between 0 and 400 m (69.4%). Higher than 800 m, only 10.4% of incidents with soaring birds were recorded (Table 2). As a consequence, there was a marginally positive relationship between the proportion of locations of the LBPs and the proportion of incidents for height classes ($F_{1,2}$ = 12.59; P = 0.071).

Our hypothesis on the association between LBPs and prey numbers was confirmed: cinereous vultures and prey abundances were associated ($F_{1,133}$ = 6.78, P = 0.010 for rabbit, and $F_{3,150}$ = 4.24, P = 0.041 for all prey species jointly; Figure 4). Moreover, prey numbers were also positively correlated to the number of incidents with aviation for all LBP species, both for rabbits ($F_{1,10}$ = 7.17, P = 0.023; Figure 2) and for all prey species considered ($F_{1,10}$ = 10.36, P = 0.009). Finally, we observed that flights decreased between 2004 and 2015 (8.7% from 401,503 to 366,608 in Madrid, $F_{1,10}$ = 6.41, P = 0.029; and 7.5% from 2,056,959 to 1,902,967 in Spain, $F_{1,10}$ = 9.29, P = 0.012), unrelated to an increase in LSR bird

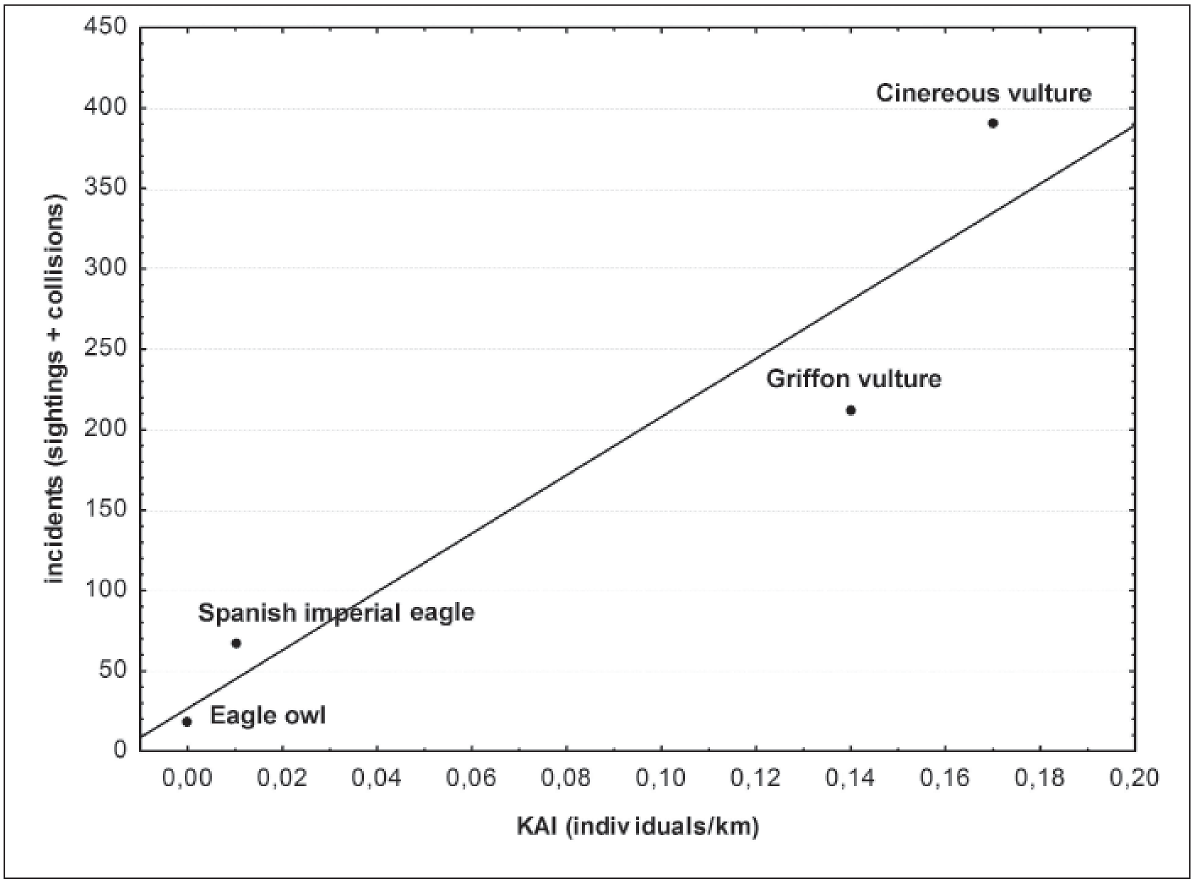

Figure 3. Linear regression of the number of incidents with aircraft (sightings from aircraft + collisions) in which a large bird of prey species was involved for the 2009–2016 period, in relation to their mean abundance (individuals (n)/km; r^2 = 0.90; P = 0.050) around the Adolfo Suárez-Madrid Barajas Airport, Madrid, Spain, between June 2014 and May 2016.

strike hazards ($F_{1,10}$ = 0.33; P = 0.58; <http://www.aena.es/csee/Satellite?pagename=Estadisticas/Home>).

Discussion

Potential causes of an increase in bird strikes in Spain

The increase in LBP bird strikes and sightings from aircraft reported by pilots since 2006 may be a result of several factors. First, there has been no increase in the number of air transits, either at the AS-MB or in Spain as a whole.

On the other hand, the modification of the spatial planning of flight corridors has a direct impact on bird strikes (Blackwell et al. 2009). The runways at the AS-MB were expanded in 2005 toward the north, both in number and distance, bringing aircraft closer to griffon and cinereous vulture feeding areas (game farms with abundant rabbit and ungulate carcasses and landfills). The enlarged area of the airport hosts very high densities of wild rabbit, estimated at >4 individuals/ha (González et al. 2008). Moreover, one of the largest landfills of organic waste in central Spain, where hundreds of raptors and storks continuously feed, is only 19 km to the north of the airport (Vergara et al. 2007).

Urban landfills are not subject to national or European regulations regarding minimum distances to airports. Finally, whereas >90% of the Western Palearctic vultures live in Spain, and these are among the most hazardous species to aviation among birds (Dolbeer et al. 2000), vulture population growth has slowed in the last 10 years from a rate of 207.3% between 1975 and 2005 to a rate of 111.1% between 2005 and 2015. Thus, the more LBP bird strikes do not seem to be due to a growth in vulture numbers.

In addition, changes in space use by vultures after 2006 could play a key role in these trends. Behavioral shifts (Zuberogoitia et al. 2010, Margalida et al. 2011), changes in prey selection patterns (Donázar et al. 2010), and decreases

Table 2. Number and percentage distribution of commercial aviation incidents around Adolfo Suárez-Madrid Barajas Airport between January 2009 and May 2016 relative to the registered height from the ground (Tragsatec 2016).

Height from the ground (m)	Bird sightings from aircraft		Bird strikes		Total incidents	
	n	%	*n*	%	*n*	%
0–400	82	73.9	4	30.8	86	69.4
401–800	23	20.7	2	15.4	25	20.2
801–1,200	4	3.6	6	46.1	10	8.0
>1,200	2	1.8	1	7.7	3	2.4

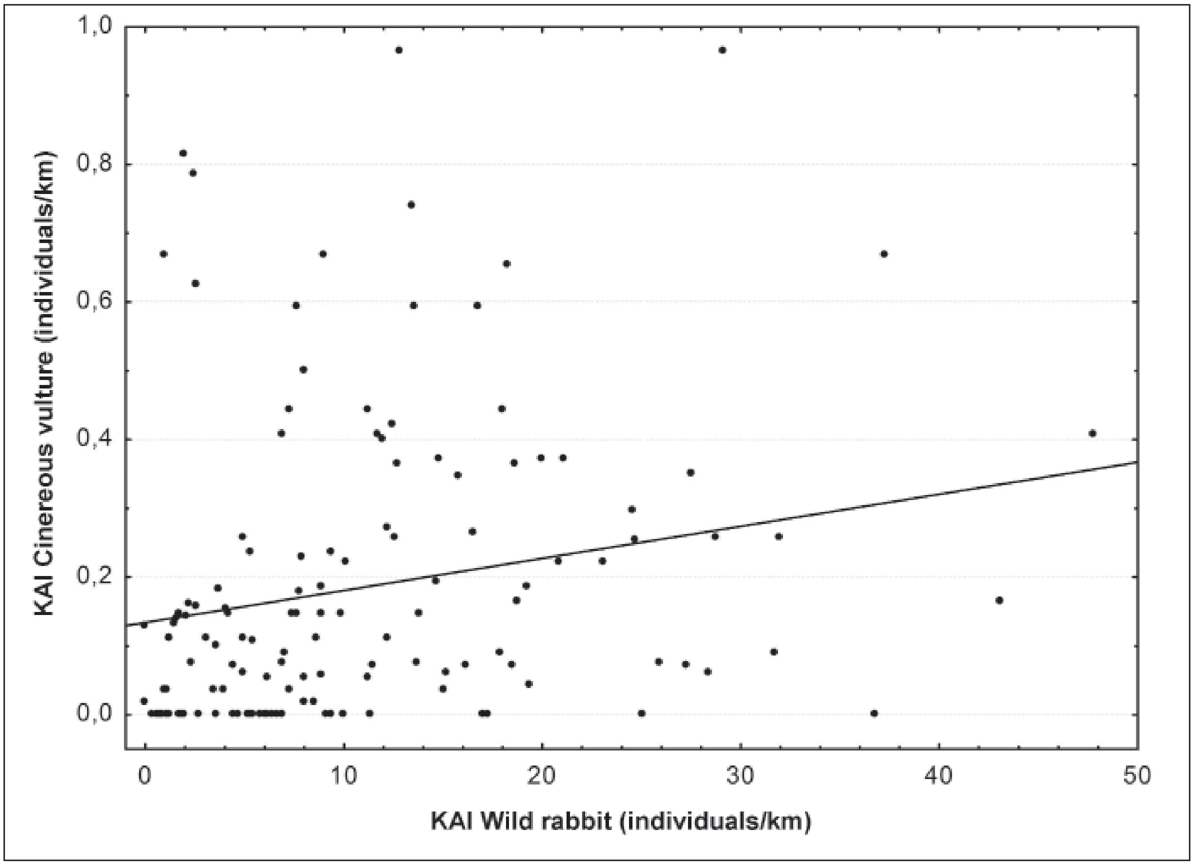

Figure 4. Relationship between Kilometer Abundance Index (KAI) expressed as individuals (n)/km of cinereous vulture (*Aegypius monachus*) and wild rabbit (*Oryctolagus cuniculus*; $r^2 = 0.05$; $P = 0.010$), around Adolfo Suárez-Madrid Barajas Airport, Madrid, Spain, between June 2014 and May 2016.

in demographic parameter values (Margalida et al. 2014) as a result of the sanitary policy for the management of animal byproducts implemented in the mid-2000s have been described (Donázar et al. 2009). This policy (Council of Europe 2002) resulted in the closure of many widely distributed small feeding sites for scavengers associated with slaughterhouses, farms, or village dumping sites as well as the compulsory removal of livestock carcasses from the field for their subsequent incineration.

Changes in food occurrence and availability

The enforcement of Regulation EC 1774/2002 entailed the removal from the field and destruction of >85% of livestock carcasses since 2004 in Spain (Moreno-Opo and Margalida 2014). This changed the occurrence, abundance, and characteristics of food for scavenger species and in turn led to shifts in the demographic, ecological, and behavioral patterns of vultures (Donázar et al. 2009, Margalida et al. 2014).

This regulation for carcass management did not sufficiently consider the negative effects at an ecological level, applying the precautionary principle only for sanitary reasons (Margalida et al. 2010). Unfortunately, no accurate data on variables related to LBP bird strike risk before and after the application of the aforementioned regulation are available for the AS-MB airport. However, there is evidence, at a national scale, of changes in space use by vultures that could be related to a higher probability of aircraft incidents.

Vulture feeding sites were reconfigured in Spain after 2004–2005, with the general closure of indeterminate but abundant and widely distributed sites (Margalida et al. 2010). This decline triggered previously infrequent behaviors in vultures, especially for griffon vultures, such as predation on dying animals, the use of other types of prey, a greater tolerance for human activity, and presence in areas far from the breeding range (Donázar et al. 2009, Zuberogoitia et al. 2010).

From the mid-2000s, food acquisition by vultures in landfills increased substantially (Donázar et al. 2010). Although this had previously been observed in the griffon vulture, it was much less geographically and numerically widespread. For the cinereous vulture, attendance at landfills had been very rare, but now is common in practically all landfills in their range. Furthermore, this attracts vultures to more urbanized zones, including airports, thus serving as a lure toward areas sensitive for aviation.

Food availability for avian scavengers is not uniform throughout the year. In general, the highest mortality rate in livestock coincides with both adverse weather and calving. In wild ungulates, in addition to coinciding with calving, the highest mortality occurs in autumn and winter, overlapping with the main hunting season. These 2 food sources, with which feeding sites are supplied, provide the highest biomass to the vulture diet (Costillo et al. 2007, Donázar et al. 2010). During spring and summer, a higher energetic demand is needed due to chick-rearing, which is partially alleviated by the continuous presence of food in landfills and by an increase in rabbit mortality as a consequence of viral diseases (Delibes-Mateos et al. 2007). In this sense, the diet of the most abundant griffon vulture shifted after the regulatory changes of the mid-2000s (Donázar et al. 2010), moving toward more ingestion of smaller carcasses (e.g., rabbit). For this reason, in the summer vultures perform larger foraging movements to areas with food, which increases the risk of collision with aircraft (DeVault and Washburn 2013), as has been observed at the AS-MB.

The aforementioned changes have led griffon vultures to expand dispersal or foraging movements to areas far from their nesting colonies (Margalida et al. 2010). An augmentation of travel distance, maximal displacement, and flight elevation has been shown to be a consequence of the reduction in food availability (Spiegel et al. 2013), which would lead to an increase in collision risk with aircraft because of a higher total number of prospective flights by vultures searching for food (DeVault and Washburn 2013).

Hazard management

Reducing the LBP bird strike hazard is possible if effective preventive measures are implemented (DeVault et al. 2013). These may include: 1) land use planning prior to the establishment of airport infrastructure, such that risk and environmental assessments adequately consider the presence of soaring birds (Blackwell et al. 2009, Soldatini et al. 2010), and 2) risk detection in air traffic corridors up to the maximum flight height of birds (<1200 m; Table 1).

Avian radars have shown interesting results at different commercial and military aerodromes (Beason et al. 2013). These radars may allow large birds to be detected at a far enough distance from airports for effective mitigation, although available models do not always track single soaring birds accurately (Gerringer et al. 2016). In the case that soaring raptors could be detected by the radars entering air traffic corridors, it should be possible to modulate aircraft routes and flight frequencies accordingly (Beason et al. 2013).

The first proposed line of mitigation is the management of food sources (Cook et al. 2008, DeVault et al. 2013). The reduction in populations of prey species, especially rabbits, is essential given the key role played by this species as prey (Delibes-Mateos et al. 2007). However, rabbit control is not easy and requires sufficiently intense and frequent measures such as ferreting (trapping rabbits with the help of domestic ferrets [*Mustela furo*]), the artificialization of the airport habitat (e.g., asphalting or enmeshing soils and slopes to hinder warren construction), gassing of burrows, or removal of surface-living individuals by shooting, which is the most effective in reducing densities (Thompson and Armour 1951). As for the management of sites with abundant and predictable carrion, their disposal and closure is the most widely recommended measure in areas interfering with commercial aviation (Cook et al. 2008, DeVault et al. 2013). It is essential to suspend any biomass provision that could be exploited by scavenging raptors in landfills or feeding sites near airports.

In relation to the management of LBP populations, the main approach is to shift foraging movements from the most sensitive areas to others with less potential risk. Changes in habitat quality and diversion of birds to other areas with a greater ecological attractiveness and free from aviation hazards have been implemented for several species (Martin et al. 2011, DeVault et al. 2013). The most efficient measure is to reduce food availability in higher risk areas along with a concurrent increase in food availability in remote areas by means of the provision of carcasses (Margalida et al. 2010).

A wide range of bird deterrence measures have been used in airport management (Belant and Martin 2011, DeVault et al. 2013). All the Spanish airports and several from other parts of the world have control services that dissuade medium- and small-sized birds from runways through falconry (Erickson et al. 1990). However, falconry has not been applied to date for large soaring birds in airports due to the time investment in teaching falcons to attack non-prey species like raptors. This requires a significant economic cost and live raptors used as decoys. Moreover, this has not been previously tested to address this issue. However, pyrotechnics (Cleary and Dolbeer 2005), noise, light, and firearms have been used to drive away raptors (Blackwell et al. 2002, Cook et al. 2008), even within the AS-MB. To reduce the likelihood of collisions with vultures, it is advisable to evaluate the effect of specific falconry or drone training designed to deter soaring raptors outside of and within airports (Lambertucci et al. 2015).

Management implications

It is advisable to further explore changes in food availability for scavengers. The number and distribution of feeding sites before 2003–2005 increased the carrying capacity and vulture numbers, and, along with other factors, shaped the spatial distribution of LBP breeding nuclei. However, once the availability of livestock resources was modified, LBP shifted spatio-temporal patterns of foraging and food selection, increasing their presence at new patchy and more predictable food resources. These new patterns may have led LBPs to move throughout the Iberian Peninsula in a different way than before 2003–2005, which increased the potential for LSR bird strikes.

The situation in Spain is novel and unique, requiring urgent commitment from all sectors involved, with sufficient economic investment to ensure human safety. The priority actions to be further studied and developed are the following: 1) test the usefulness of radar systems aimed at detecting the bird strike risk in sensitive air traffic corridors to modify aircraft routes or flight frequencies if appropriate, and 2) implement active management of food resources for LBPs in 2 complementary ways: population reduction of prey species at the HPA around the airports, and the promotion and establishment of feeding sites for LBPs, especially for vultures, outside sensitive areas for aviation with the purpose of modifying the foraging movements toward more safety zones.

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