Bird movements in the vicinity of Campo de Tiro de Alcochete, Portugal: are bird collisions an important risk at the proposed new Lisbon airport?

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Knowledge about the local bird community is key information when planning the construction of a new airport. Aircraft can cause serious impact on the local avifauna, but the birds can also pose a serious threat to aircraft.

A new international airport is currently being planned for the Lisbon metropolitan area. The location that has been selected is Campo de Tiro de Alcochete, near the internationally important Tejo estuary wetland, and in the vicinity of areas under rice cultivation known to be important for the local bird community.

We use available data on the movements of individually marked Black-tailed Godwits *Limosa limosa*, Eurasian Spoonbills *Platalea leucorodia* and one Lesser Black-backed Gull *Larus fuscus*, to examine whether these bird species are likely to cross the paths of aircraft approaching and departing from the future airport. We also use information on the phenology and abundance of these species to better understand the threat that these birds might pose to aircraft.

All three species cross the planned approach and departure routes of the runways of the new airport. Black-tailed Godwits in particular cross these routes at all planned aircraft flight altitudes and even overfly the airport site itself. The large number of birds potentially involved in these movements increases the threat to air traffic.

There are several limitations to our study, especially a lack of information on bird flight altitudes. We therefore highlight the need for further and more detailed studies on the movements of these and other bird species around the airport site. However, by overlapping known individual movements of the three species with aircraft flight routes, we present sufficient data to demonstrate that bird collisions are a real hazard if the airport is built at Campo de Tiro de Alcochete. These findings call into question the wisdom of the proposed airport location and highlight the necessity for thorough research on the impacts of the birds on aircraft safety as well as the impact of aircraft on the local avifauna.

INTRODUCTION

Knowing and understanding the daily and seasonal routines of local avifauna is crucial for the selection of airport locations. This issue can be seen both from the point of view of air traffic safety, and also from that of aircraft impact on wild bird populations.

Bird collision hazard is a serious problem for modern air traffic. In the UK bird collisions are believed to cause 1–2% of accidents and be responsible for 3.4% of aborted take-offs (Nicholls & Bell 2005). Since 1912, bird collisions with commercial aircraft have caused the loss of over 100 aircraft and almost 300 human lives (Thorpe 2008). Military aircraft are also susceptible. From 1950 to 1999 there were 286 serious bird-related accidents involving military aircraft in 32 different countries. Of these, 63 were fatal and caused 141 human deaths (Richardson & West 2000). The actual number of bird collisions is much higher; for example, in the UK alone, there have been 850 since 1990 and in Iran 183 during the last 10 years. Although not responsible for human or aircraft losses, these lesser collisions have significant economic costs (Nicholls & Bell 2005, Tareh & de Hoon 2005). Overall, the aviation industry suffers a conservatively estimated loss of US$1.2 billion per year as a result of damage and delays following bird collisions (Allen 2002).

Bird collision risk is believed to be increasing due to an increase in total air traffic, and its consequences for air traffic are becoming more serious because modern jet aircraft are more susceptible to serious damage by birds than older turboprop planes (Nicholls & Bell 2005).

Aircraft not only kill many bids during flight collisions, but can also cause significant disturbance. Overflying aircraft can lead to loss of usable habitat, making it energetically unprofitable by increasing energy expenditure through disturbance causing alarm flights, or lowering food intake through interruptions. These factors can lead to a decrease in body condition, with potential negative impacts on survival and breeding success, and ultimately population decline (Kempf & Hüppop 1998, Komenda-Zehnder *et al.* 2003, Sutherland 1998).

The likelihood of bird collisions with an aircraft is mainly dependent on the density of birds and aircraft within a given airspace (van Test 1969), but other aspects such as bird behaviour are also important. Young and migrating birds, for example, are more prone to collision than resident birds due to their inexperience around aircraft (Kelly *et al.* 1999). Some birds are more susceptible to collisions because of their flight behaviour, flocking behaviour, size or habitat choice. Gulls (Laridae) and waders (Charadrii) seem to be the most critical groups, and waterfowl (Anseridae), diurnal raptors (Accipteriformes), and pigeons (Columbidae) are also considered susceptible to collisions, whereas ibises and spoonbills (Threskiornithidae) seem to be less prone (Lensink *et al.* 2000, Shaw & McKee 2008, Thorpe 2008). In Iran, most bird collisions occur in the vicinity of areas with known waterbird concentrations (Tareh & de Hoon 2005), which is consistent with the observation that such wetland areas harbour the largest concentrations of the most risk-prone groups: waders, gulls and waterfowl.

Bird control measures and risk assessment are often focused on the birds living in or close to the airport location (de Hoon & Buurma 2003). However, the greatest risk comes from overflying birds, which may not necessarily be local. Moreover birds in a large area around an airport can suffer both direct damage and indirect damage from air traffic, either being directly killed, or suffering a reduction in the profitability of their foraging sites (Komenda-Zehnder *et al.* 2003).

Currently, the Portuguese government is planning the construction of a new international airport for the Lisboa metropolitan area, and the announced location is Campo de Tiro de Alcochete (CTA), which is close to the most important Portuguese wetland, the Tejo Estuary Nature Reserve. This wetland harbours 75,000–100,000 waterbirds each winter (Costa & Rufino 1994, 1996a, 1996b, 1997, Leitão *et al.* 1998, Rufino & Costa 1993). Moreover, nearby there are also several important agricultural areas, especially rice plantations, that attract large numbers of Black-tailed Godwits *Limosa limosa*, White Storks *Ciconia ciconia*, herons (Ardeidae) and gulls (Laridae) (Lourenço & Piersma 2009).

The aim of this study is to analyse seasonal and daily movement patterns of the bird community in the vicinity of the new Lisbon airport location. We focus on individually marked Black-tailed Godwits, Eurasian Spoonbills *Platalea leucorodia* and one Lesser Black-backed Gull *Larus fuscus* to illustrate the potential risk for bird collisions if the plan to build an airport at this location goes ahead.

METHODS

The new international Lisbon airport at CTA is east of the Tejo estuary. The approach and departure vectors for aircraft using the airport's planned runways will be aligned NNW–SSE (LNEC 2008). Each map in Fig. 2 shows the areas in which aircraft will fly at <500 ft (152 m), <1000 ft (305 m), <2000 ft (610 m) and <3000 ft (914 m) within those vectors (LNEC 2008). In order to evaluate whether birds are likely to fly through this airspace, we use data on birds movements between the Tejo and Sado estuaries and between the estuarine areas and the rice fields located to the north, north-east and east of the Tejo estuary.

We used different methods to assess the movements of each of our focal species. For Black-tailed Godwit and Eurasian Spoonbill we used re-sightings of birds with individual colour ring combinations (e.g. van den Brink *et al.* 2008, Gunnarsson *et al.* 2005). We recorded 38 (2005/06), 168 (2006/07), 195 (2007/08) and 300 (2008/09) different individual Black-tailed Godwits each winter respectively. Since 1998, 191 different individual colour-ringed spoonbills have been sighted within the study area. We considered a movement record to be valid when the same individual was recorded at different locations within the same winter. The movements of one Lesser Black-backed Gull, fitted with a GPS satellite transmitter in the Netherlands (SOVON 2009), are shown by precise GPS locations obtained once every 2 h. Of 14 Lesser Black-backed Gulls fitted with such transmitters, this was the only bird which wintered within our study area.

To determine the period when there would be potential bird collision risk, we analysed the phenology of the three focal species in the area, using a different approach in each case.

For Black-tailed Godwit, all the terrestrial areas of occurrence around the airport site, mainly rice fields, were surveyed weekly from Nov to Mar, the period when the population is present (Kuijper *et al.* 2006), in the winters 2005/06, 2006/07, 2007/08 and 2008/09. During the same period, the rice fields around the Sado estuary were also surveyed and since movements occur between the two estuaries, the total counts include the rice fields of both estuaries. The estuarine sites of the Tejo were surveyed every fortnight from Sep to Mar during the winters 2006/07 and 2007/08, covering the entire wintering season, both when rice fields are and are not used, and thus including movements between the estuary and the rice-fields.

Two populations of Eurasian Spoonbills occur in the area: those that breed in Portugal and are present all year; and the wintering population that breeds further north in W Europe. Only individuals of the wintering population have been colour-ringed, so our analysis is restricted to these birds. The GPS data for the one Lesser Black-backed Gull include the precise dates of arrival and departure from the Tejo estuary and a detailed record of all its local movements.

An important aspect to take into account in assessing bird collision risk is the abundance of each population. Only for Black-tailed Godwit do we have precise count data from surveys in the rice fields and estuarine sites. For the two other species we use published information to estimate their abundance around the CTA.

RESULTS

Black-tailed Godwit

The occurrence of Black-tailed Godwits was rather similar between years, with 3,000–4,000 using the Tejo estuary throughout the winter from Oct to early Mar and with usage of the rice fields around the Tejo and Sado estuaries being restricted to late Nov to Mar (Fig. 1). Each winter, peak numbers in the rice fields occurred in the second half of February and averaged 44,200±2,770 (n = 4, range: 40,240–46,700).

This is the species for which we have the most movement information and we can therefore examine different types of movements. First there are the movements that occur at dawn and dusk between the roosting sites in the saltmarshes near the estuary and the rice fields (Fig. 2a). These involve all the birds using the rice fields on a particular day and occur over a short period of sometimes less than an hour. Some flocks consist of many thousands of birds. These movements are likely to cross the northern flight vector of the airport where aircraft will fly at 2,000–3,000 ft.

On average, the re-sighting probability of each colour-marked individual was 30% per week across the study period. The observation of colour-ringed individuals allowed us to detect 25 movements between different rice field areas near the Tejo estuary (Fig. 2b), 32 movements between the Tejo estuarine areas and the rice fields (Fig. 2c), and 23 movements between the rice fields of the Tejo and the Sado (Fig. 2d). In the first two cases, the birds may cross the northern flight vector where aircraft fly at 2,000–3,000 ft. In the latter case the godwits are likely to overfly the future airport site and cross both the northern and the southern flight vectors at all aircraft flight altitudes from 0 to 3,000 ft. We also recorded a further 50 movements within the rice field areas of the Sado, and while these do not cross the flight vectors, they show how frequently Black-tailed Godwits move between different foraging locations.

Eurasian Spoonbill

The frequency of re-sightings of marked birds showed that wintering spoonbills occur in the Tejo estuary region from Oct to Feb, with some birds remaining as late as May (Fig. 3). However, the species is relatively scarce in the region. Between 2005 and 2007, January counts averaged 445±73 (n = 3, range: 300–531, V. Encarnação unpubl. data).

Individually marked spoonbills were sighted on average 2.7 times per winter (range: 1–9). Although much less information is available for this species, we were able to determine 37 movements. Movements between the Samouco saltpans on the Tejo estuary and the rice fields to the north-east cross the northern flight vector where aircraft will fly at 2,000–3,000 ft (Fig. 2e).

Lesser Black-backed Gull

This species is very abundant on the Tejo estuary with a winter population estimated at 20,000 (Leitão *et al.* 1998). The numbers that use agricultural fields north of the estuary are unknown, but observations near the estuarine roosts suggest that several thousand leave those areas early in the morning flying in a north-easterly direction. This suggests that the birds are moving to the rice fields or other foraging locations inland. The one GPS-tagged bird was present on the Tejo between 26 Nov and 31 Mar, a typical period for a wintering individual. During this period it made 108 movements between the estuary area and sites north-east of the estuary. The total range of the flights made by this bird covered a wide area north and north-east of the estuary and in several movements it crossed the northern flight vector where aircraft will fly at 2,000–3,000 ft and, to a lesser extent, where aircraft will fly at 1,000–2,000 ft (Fig. 2f). In each of these movements the bird spent less than 2 hours (the minimum time interval for which we have data) in the aircraft flight paths, and likely spent just the few minutes necessary to traverse them.

DISCUSSION

The proposed site for the new Lisbon airport is located in the vicinity of several important foraging and roosting sites for birds. The left bank of the Tejo estuary is merely 20 km to the west. This important wetland is both a RAMSAR site and a nature reserve and its vast mudflat areas and saltpans attract 75,000–100,000 waterbirds each winter (Costa & Rufino 1994, 1996a, 1996b, 1997, Leitão *et al.* 1998, Rufino & Costa 1993). To the north and north-west there are several areas of rice cultivation, which have been shown to be important for waterbirds (Lourenço & Piersma 2009) and raptors (Lourenço, in press) and over 40,000 Black-tailed Godwits stopover there during spring migration.

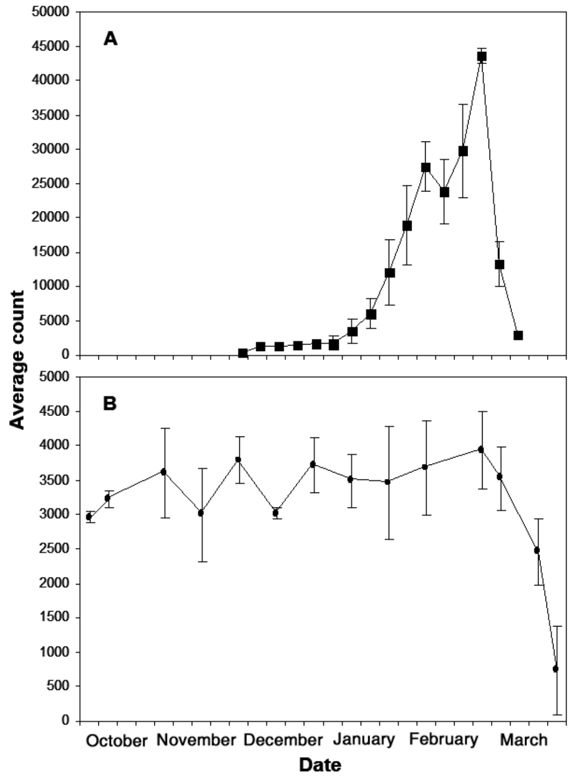


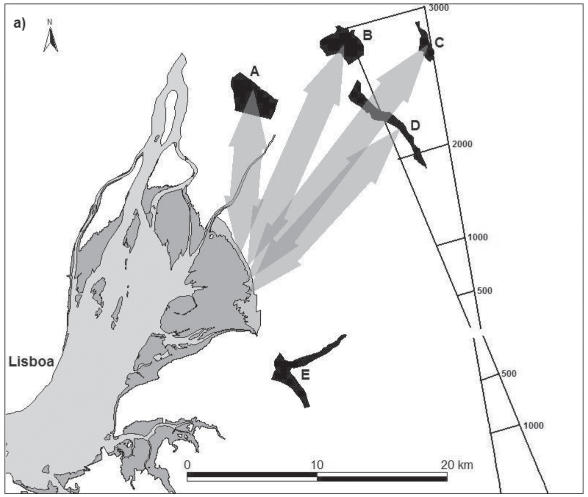
Fig. 1. Counts of Black-tailed Godwits *Limosa limosa* (A) in the rice fields around the Tejo and Sado estuaries from 2005/06 to 2008/09, and (B) in the estuarine areas of the Tejo estuary in 2006/07 and 2007/08 (average ±1SE).

The wetlands and rice fields within about 30 km of the proposed airport support up to 20% of the entire population of the *limosa* subspecies of the Black-tailed Godwit. However, only the western part of the *limosa* population occurs in Portugal and of that as much as 40–50% passes through the Tejo and Sado rice fields (Lourenço *et al.* in press). Furthermore, over 10% of the population of the *islandica* subspecies winters in the same area (Gunnarson *et al.* 2005). The count data we cite suggest that 2% of the Lesser Black-backed Gull population and 0.3–0.6% of the Eurasian Spoonbill population winters in the vicinity of the proposed airport (BirdLife International 2009a, 2009b).

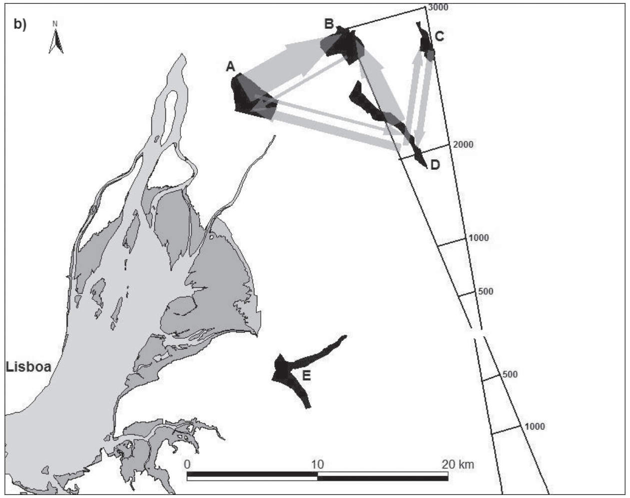
All three of the bird species we have studied are likely to cross the flight vectors of the proposed airport. In most cases this will occur at an altitude of about 2,000 ft (610 m) or more. However, Black-tailed Godwits moving between the Tejo estuary rice fields and the Sado estuary are likely to cross the vectors at all aircraft flight altitudes and overfly the airport itself. To evaluate how this translates into risk to air traffic, we need to take account of the seasonality of the occurrence of each species in the area, the number of birds involved in these movements, the flight altitudes of these birds, and how frequent these movements take place. Also, each bird species poses potentially different threats due to differences in body size (Dolbeer *et al.* 2000) and in flight and flocking behaviour.

All three of the study populations are not residents in the area. Lesser Black-backed Gulls and Eurasian Spoonbills are mostly present from Oct/Nov to Feb/Mar, using the area as a wintering site. Some Black-tailed Godwits are also present over the same period, but the large concentrations of godwits that use the rice fields and move across the aircraft

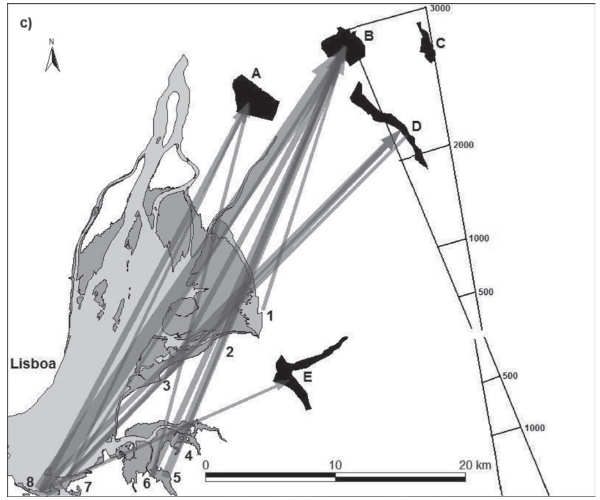
Fig. 2. Maps illustrating the movements made by individually marked birds. The estuarine tidal area is represented in grey, the rice fields in black. The approach/departure vectors of aircraft at the proposed airport are shown with the different flight altitude areas: up to 500 ft (152 m), 1,000 ft (305 m), 2,000 ft (610 m) and 3,000 ft (914 m). In map (a) the width of the arrows is not representative of the number of movements, but in maps (b), (c), (d) and (e) the width of each arrow is proportional to the number of movements between each location and the thinnest arrow represents only one movement.
Key to locations: A – Giganta, B – Samora Correia, C – Paúl do Trejoito, D – Santo Estevão, E – Barroca d'Alva, F – Zambujal, G – Marateca, H – Palma, I – Alcácer do Sal, J – Montevil, K – Monte Novo, L – Comporta, 1 – Vale de Frades, 2 – Hortas, 3 – Samouco, 4 – Sarilhos, 5 – Moita, 6 – Alhos-Vedros, 7 – Barreiro, 8 – Seixal.



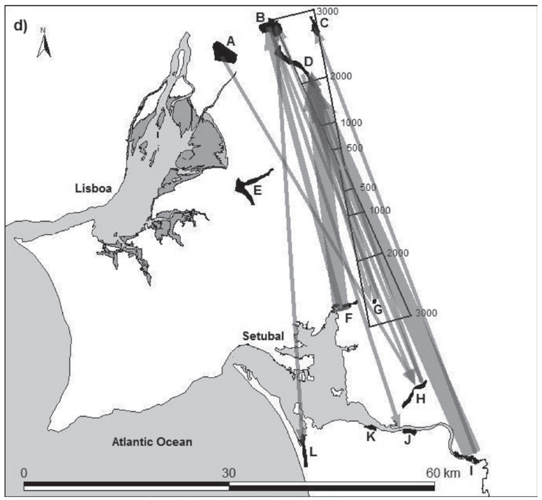
(a) Black-tailed Godwit movements at dawn or dusk between roosting sites near the Tejo estuary and foraging sites in rice fields.



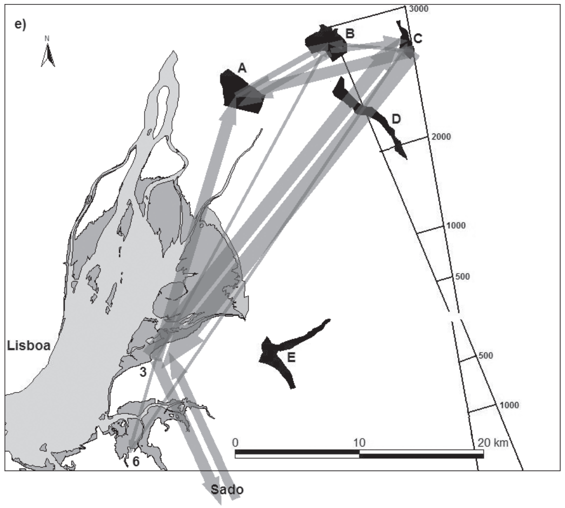
(b) Twenty-five Black-tailed Godwit movements between different rice field areas near the Tejo estuary.



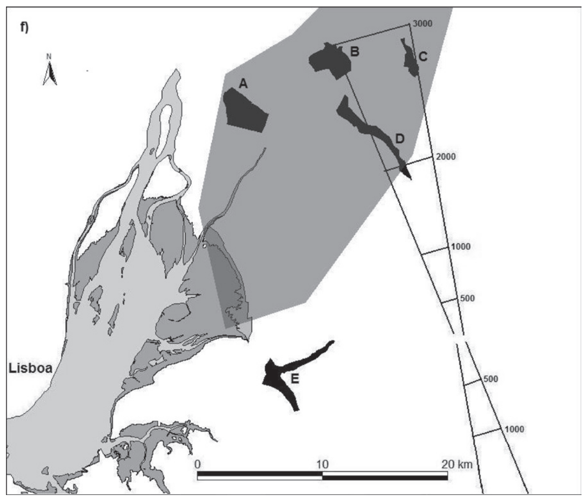
(c) Thirty-two Black-tailed Godwit movements between the Tejo estuary and the rice fields.



(d) Twenty-three Black-tailed Godwit movements between the rice fields of the Tejo estuary and the rice fields of the Sado estuary.



(e) Movements of Eurasian Spoonbills between estuarine areas and rice field areas in the Tejo and Sado.



(f) The total area covered by the 108 recorded movements of a GPS-tagged Lesser Black-backed Gull.

flight vectors occur mostly in Jan and Feb during the stopover of the *limosa* subspecies (Lourenço & Piersma 2008a). Therefore in respect of the three study populations the risk of collisions with aircraft using the proposed airport is limited to autumn and winter; however this risk may be relatively high as migratory birds may be less experienced around aircraft (Kelly *et al.* 1999).

The three species have different local abundance. Spoonbills are relatively scarce, and are most likely to be found in small groups, but gulls and godwits occur in the tens of thousands around the airport site. It is not clear how many gulls use the areas north and north-east of the estuary, and thus cross the aircraft flight paths, but the largest concentrations of Black-tailed Godwits occur in the rice fields, and show strong flocking behaviour (Lourenço & Piersma 2008b); hence flocks of several thousand can be expected to cross the aircraft flight paths.

The movements we have recorded suggest that gulls and spoonbills will only cross flight vectors in the area where aircraft will fly at 2,000–3,000 ft (610–914 m), whereas godwits will cross the vectors at any aircraft flight altitude. Unfortunately, most research on bird flight altitudes has focused only on migratory flights and not in everyday movements, but one study tracked Lesser Black-backed Gulls by Doppler radar during local movements and found an average altitude of 378m (n = 97, range: 174–738 m, Shamoun-Baranes *et al.* 2006). During our field work we frequently estimated Black-tailed Godwit flocks as flying at altitudes in the range 300–500 m based on comparison with landscape features like antennas, power lines and buildings; however these estimates lack the precision of radar. We have been unable to find information on the flight altitudes of spoonbills, but since they often soar on thermals they are likely to fly at high altitudes. Another species that frequently soars on thermals, Common Buzzard *Buteo buteo*, flies at an average of 665 m (n = 447, range: 208–1,592 m, Shamoun-Baranes *et al.* 2006) during local movements. Therefore it is very likely that all three of our study species regularly fly at altitudes that risk collision with arriving and departing aircraft.

During migration, bird flight altitudes will be much higher than in local movements. Black-tailed Godwits use the rice fields during a migratory stopover, which means that during Jan and Feb flocks will be arriving from Africa and others departing towards N Europe. Two closely-related species, Bar-tailed Godwit *Limosa lapponica* and Marbled Godwit *L. fedoa*, have been recorded migrating at altitudes well over 2,000 m (Battley & Horn 2006, Dove & Goodroe 2008, Green 2004). This is consistent with the optimal predicted flying altitude of 3,000 m for Bar-tailed Godwits flying from Africa to Europe based on water balance arguments (Landys *et al.* 2000). There is no reason to believe that Black-tailed Godwits will fly at a different altitude during migration. Therefore, it is likely that during Jan and Feb flocks of godwits will be arriving at and departing from the area around the new airport undertaking ascending and descending flights to and from these high altitudes.

The lack of detailed information on flight altitudes is one of the shortcomings of our study. Another is that we only have precise data on the movements of one bird, the GPS-tagged Lesser Blacked Gull. For the other two species movements are based on sequential sightings of colour-marked birds, which are frequently separated by days or even weeks. Therefore the flight paths may have been quite different from a straight line between each sighting. However, observations of flocks in flight confirm that the various movements we describe really do occur, both between different foraging areas and between foraging areas and roosting areas. Moreover the birds almost invariably flew in straight lines. The fact that birds were observed flying between foraging sites proves that they often take the direct route without passing through the roosting areas.

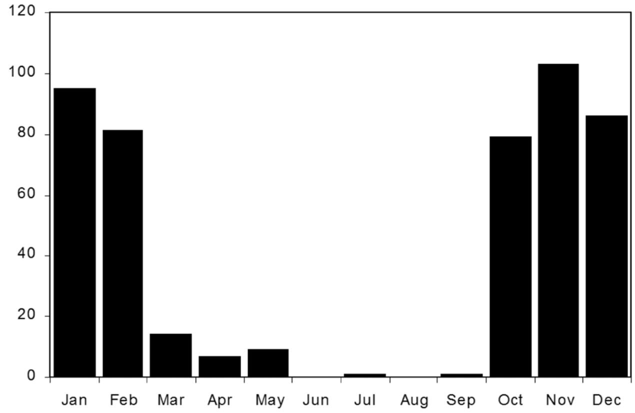


Fig. 3. Total monthly re-sightings of Eurasian Spoonbills individually colour-marked in N Europe and recorded in the study area during 1998–2008. It is assumed that this graph represents the pattern of occurrence in the study area of spoonbills that breed in N Europe.

It is not possible to verify direct flights between the two estuaries, as they are too far apart. However, on three occasions individual birds were detected first in one estuary and later in the other on consecutive days, which gives some support to the idea that they might fly direct.

Can we expect a conflict between birds and aircrafts if the new Lisbon airport is built at CTA? Several very important foraging and roosting areas for birds will suffer from disturbance by low flying aircraft, as they are located near the airport site. The consequences for the local bird community are not clear, but in similar scenarios birds have been found to suffer decreased foraging rates and increased energy expenditure due to escape reactions from aircraft disturbance, and even completely abandon foraging sites (Kempf & Hüppop 1998, Komenda-Zehnder *et al.* 2003).

The risk of bird-aircraft collisions is the key aspect of the potential conflict as it may not only cause death to birds, but also damage to aircraft and loss of human life (Nicholls & Bell 2005, Richardson & West 2000, Thorpe 2008). We have established that the movements of three bird species that occur in the area of the proposed airport for part of the year cross the approach and departure vectors, and although information on bird flight altitude is sparse, it is likely that they fly at altitudes that risk collision with aircraft. Of the three species, the most likely to be involved in collisions is Black-tailed Godwit, as it occurs in the largest numbers, forms large flocks, and can intercept with aircraft flight paths near the airport at any altitude. However, the other two species have larger bodies, and thus even a few or a single individual could cause damage to aircraft on the less frequent occasions when they cross aircraft flight paths. Also, many other bird species large enough to damage aircraft occur in the area for which no information on movements is currently available. These include Common Buzzard and White Stork, which are both common in the rice fields (Lourenço *in press*, Lourenço & Piersma 2009) and are likely to fly at high altitudes, thus also posing a threat to aircraft (Dolbeer & Eschenfelder 2003, Lensink *et al.* 2000).

Our study relates to the limited data available on just three species. Further research is necessary to determine the movements of these species more precisely in time and space, as well as the altitude at which they take place. Also, it is important to cover a wider range of bird species to truly understand the conflicts that may arise between birds and the new airport. Nevertheless we believe that the present analysis gives rise to enough *reasonable doubt* that the option of building the new airport at CTA should be seriously questioned. The analysis also illustrates the importance of data on bird movements in evaluating airport projects in bird rich areas. The CTA infrastructure is likely to cause disturbance to the local bird community and the movements of these birds are very likely to pose a threat to air traffic with potentially dire costs in terms of damage to aircraft and, more seriously, loss of human life.

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