DIURNAL LOCAL BIRD MOVEMENTS IN THE AREA OF THE NEW LISBON AIRPORT

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Abstract

In order to understand the diurnal bird movements in the area of the new Lisbon airport and to identify potential risks of collision at take off and landing surveys were carried in the area of this new airport from May 2001 to May 2002. Data was analysed and a search for patterns in the local movements was conducted.

The surveys were made using panorama-scan method at 6 different survey sites, being five within the limits of the new airport and one outside these limits. They were selected in order to cover not only the area where the airport is to be built but also the surrounding area within a range of ca. 1000m. The scans were performed fortnightly during one full day at one-hour intervals. At each survey point the observations were separated in eight sectors and three distance belts. The observations were aggregated in taxonomic groups / size classes and transformed in biomass by scanned volume. A ANOVA was used in data analysis in order to evaluate the differences in biomass according to site, season and day period. The relative risk of collision was determined for each season and day period and was expressed as the proportion in relation to the maximum value of the product between the percentage of aircraft movements and the percentage of bird biomass.

The risk of collision with aircraft for the overall bird groups was higher during the migratory period and from 12:00 h to 16:00 h. Gulls were the group of birds that showed the highest collision probability during all year.

This work was carried under contract to NAER, SA., the company that is in charge of the project developing for the New Lisbon Airport.

Key words: New Lisbon airport, panorama-scan, local bird movements, collision risk

1. Introduction

According to most recent estimates Lisbon airport, located within the city limits, will reach its maximum capacity in 10/15 years. As result the Portuguese government has decided to look for alternatives and promoted in 1998 a comparative preliminary impact study of two alternatives, one 42 km South of Lisbon, Rio Frio, and another one at north-east of the city, Ota. The study concluded that the Ota location was better in many respects than the other one. The risk of bird strikes was assessed in a very schematic way but was considered to be smaller in this option. Yet, the study pointed to the need of further studies concerning the bird movements within the area of Ota to assess the collision risk in a more thorough way.

Following this recommendations NAER, SA., the body in charge of the implementation of this new Lisbon Airport, asked for support from ICAO for the definition of the studies to undertake and as a result of that a report was produced by BLOKPOEL (1999) that recommended the elaboration of studies on local and migratory bird movements in order to assess the collision risk involved in the choice to be made. The author was later asked by the new airport authority to elaborate the terms of reference for the studies to be undertaken.

NAER, SA. decided to commission part of the suggested studies to the University of Lisbon, namely those that deal with diurnal local bird movements and the assessment of the risk resulting from those movements. The present paper presents part of the results of this study that was carried out at Ota between May 2001 and May 2002, namely in what concerns the identification of species or groups of species involved in this movements and the patterns for their movements as well as to evaluate the potential risk of collision for the different groups.

2. Study Area

The selected site for the New Lisbon Airport, Ota, is situated 45 km from Lisbon (39º 05’ N; 08º 56’ W) and is presently partially occupied by an air base, which is out of use since 1992 (PESSOA et al 2000). The remaining area is devoted to agriculture, with irrigated crops (25.4%), fallow fields (17.7%) and vineyards (5.4%) accounting for most of the area, and part of the area occupied by forestry, namely cork oak woods (13.9%), pine woods (4.0%) and eucalyptus woods (7.4%).

3. Methods

3.1 Measurements

To determine the density of birds in movement through the study area observations were carried out from six fixed points using a standardised method “Panorama-scan” (LENSINK et al. 2000). In this method a fixed volume is scanned through a pair of binoculars (10x50) fixed to a tripod and moved around its axis. At each point the scan was separated in eight sectors (of 45º) and each sector was observed for two minutes. The information registered during the scanning included number of birds, species or group, distance to the observation point (0-500m, 500-1500m and 1500-2500m) and direction of flight. Observations were performed fortnightly during one full year at hourly intervals during one day. The number of birds relatively to the scanned volume corresponds to the density of birds moving over each place of the area.

3.2 Data Analysis

The observed volume was measured taking into account greater obstacles, the relief and the altitude of each observation point using ArcView Gis, Arc Info and AutoCAD (ICIST 2002). Corrections were made for days with fog. The mean biomass for each group of species was calculated using published values (SNOW & PERRINS 1998) and the density of bird movements is expressed in g/m^3. The observed volume in the scannings was limited not only by the binoculars aperture (6,5º) but also by obstacles existing in the field.

Data analysis was performed for groups of species that present a higher risk for aircraft based on their biomass density in the area, available data on collision rates and species statistics (Canadian Aircraft, United States Federal Aviation Administration), bibliographic references (*LENSINK* et al. 2000b), size, flock formation and the probability that their presence will be reduced as a result of airport construction. Hence the analysed groups were: gulls, storks, domestic pigeons, large and medium sized raptors, waders, hirundines and swifts, crows and starlings.

A ANOVA was used to evaluate the differences in bird movements (expressed in biomass) for each observation point, season (winter, breeding and migration) and period of the day (morning, mid-day, afternoon). Whenever the null hypothesis was rejected, *a posteriori* multiple comparisons Tukey tests were performed.

Spatial distribution of bird movements within the study area is presented in a map based on the biomass density in each sector and distance obtained by interpolation with IDW (Inverse Distance Weighted) method in Arc View Gis 3.2.

The potencial risk of collision was analysed for all observed groups of species and determined for each season and day period and was expressed as the proportion in relation to the maximum value of the product between the percentage of aircraft movements and the percentage of bird numbers. The number of aircraft movements per hour and per month was obtained from ANA – Aeroportos de Portugal, S.A. (www.ana-aeroportos.pt).

4. Results and Discussion

4.1 All groups together

From May 2001 to May 2002, 54 sessions of Panorama-scan observations were performed in the area of the Ota future airport. A total of 200883 movements of birds were recorded. The groups of birds that contributed more to the biomass densities observed in the study area were gulls (with 53.6% of the total density of movements), storks (14.0%) and feral pigeons (9.7%).

The ANOVA of the data relative to bird movements density according to observation points (OP), seasons and periods of day showed significant differences for all the factors considered [*Table 1*].

Table 1. *Results of ANOVA analysis for all the analysed groups. For each considered factor is presented the corresponding F value and the significance level (*- p<0.05; ***- p<0.005; ****- p<0.001).*

Group	***Observation point***	***Season of the year***	***Period of the day***
All groups	3.732****	129.979****	13.474****
Storks	4.701****	3.188*	0.579
Gulls	2.142*	120.736****	13.488****
Feral pigeons	42.96****	21.46****	9.640****
Raptors	8.907****	7.862****	10.446****
Starlings	1.805	18.966****	17.670****
Martins and Swifts	8.338****	120.355****	0.078
Carrion crows	11.290****	43.074****	6.406***

The spatial distribution of birds throughout the study area [*Figure 1*] is not homogeneous and the sites that presented the highest values, and thus presenting a higher potential risk of collision for aircraft, were:

- Around Ota's rubbish tip, located North of the airport, mainly due to the presence of gulls and storks;
- The whole eastern part of the study area, , where all groups of birds present proportionally higher densities. This area is dominated by farmland, cork oak woods and crop fields that are usually flooded during winter and the human pressure is lower.

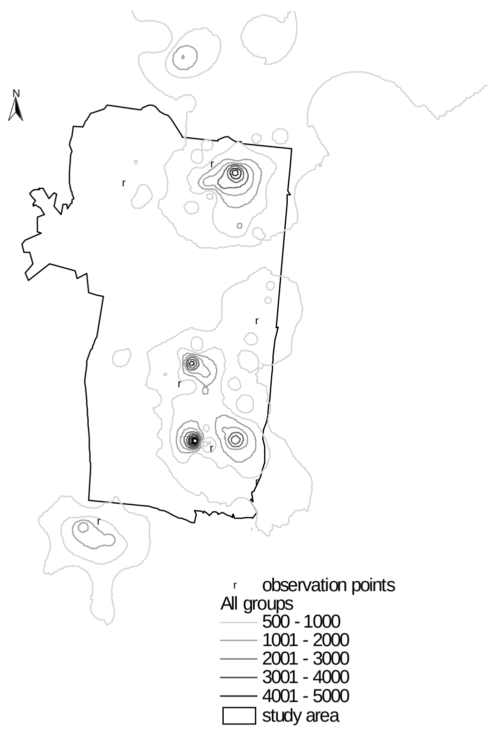


Figure 1. *Spatial distribution of all groups according to biomass density (*10^{-6} g/m^3) in the study area.*

The results also show that during winter bird density in the airport area is higher [*Table 2*], as a result of the presence of gregarious wintering species such as gulls (*Larus* sp.), lapwing

(*Vanellus vanellus*) and golden plover (*Pluvialis apricaria*), and the gregarious behaviour of some resident species, namely finches, sparrows and starlings (*Sturnus* sp.).

Table 2. *Density of each group by season of the year. All values are expressed in *10^{-7} g/m^3.*

Group	***Breeding***	***Migration***	***Winter***
All groups	13.85 ± 21.80 (922)	24.48 ± 70.00 (454)	79.86 ± 148.56 (984)
Storks	3.80 ± 12.90 (922)	9.03 ± 45.62 (454)	6.89 ± 44.73 (984)
Gulls	0.55 ± 7.41 (922)	5.64 ± 39.66 (454)	52.73 ± 130.82 (984)
Feral pigeons	3.03 ± 11.15 (984)	1.91 ± 7.76 (922)	6.34 ± 22.95 (454)
Raptors	1.41 ± 2.54 (922)	0.92 ± 2.22 (454)	1.05 ± 2.90 (984)
Starlings	0.44 ± 1.68 (984)	1.58 ± 4.442 (922)	1.52 ± 4.85 (454)
Martins and swifts	0.77 ± 1.56 (922)	1.00 ± 2.45 (454)	0.06 ± 0.53 (984)
Carrion crows	0.78 ± 1.48 (984)	2.06 ± 4.18 (922)	2.31 ± 5.03 (454)

The analyses of movements pattern according to the period of the day demonstrates that the density is higher during the morning and afternoon than at mid-day [*table 3*].

Table 3. *Density of each group by period of the day. All values are expressed in *10^{-7} g/m^3.*

Group	**Morning**	**Mid-day**	**Afternoon**
All groups	62.97 ± 150.72 (744)	28.16 ± 70.52 (837)	41.14 ± 81.03 (779)
Gulls	40.86 ± 134.84 (744)	10.75 ± 47.87 (837)	19.97 ± 64.75 (779)
Feral pigeons	5.65 ± 18.19 (744)	2.59 ± 11.01 (837)	4.51 ± 20.17 (779)
Raptors	0.78 ± 2.01 (744)	1.46 ± 2.86 (837)	1.22 ± 2.89 (779)
Starlings	1.02 ± 3.30 (744)	0.66 ± 3.02 (837)	1.69 ± 4.96 (779)
Carrion crows	2.03 ± 5.27 (744)	1.81 ± 2.88 (837)	1.71 ± 3.26 (779)

4.2 Storks (*Ciconia ciconia*)

The ANOVA showed that there are significant differences in stork densities between observation points and seasons [*Table 1*].

Stork's distribution on the airport area is irregular, being higher in the Northeast corner, in the area of the Ota's rubbish tip [*Figure 2*]. Storks used the tip as feeding grounds and the majority of their nests are placed in electrical poles located in this area. High densities were also observed in the southern part of the study area, where crop fields are flooded during winter.

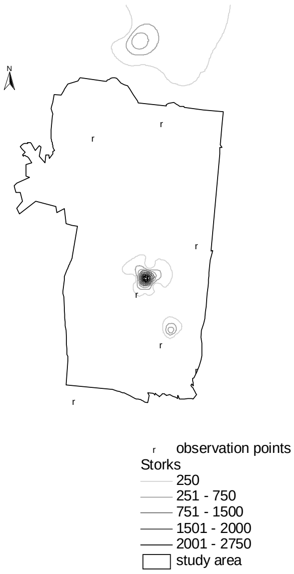


Figure 2. *Spatial distribution of storks according to biomass density (*10^{-6} g/m^3) in the study area.*

Stork density also varied between seasons, with higher figures during migration and lower during breeding season [*Table 2*]. Higher densities observed in the migration season are probably related to the presence of juvenile birds that left their nests at that time and also to the presence of some migrating birds that are only passing by, on their way South and use the study area as a stopover to eat and rest. During the breeding season storks spend much time in their nests and are less likely to be detected in panorama scans.

4.3 Gulls (*Larus sp.*)

For this group, all the factors considered in the ANOVA showed significant differences [*Table 1*].

Gulls showed higher densities in the vicinity of Ota's rubbish tip, which seems to be an important feeding ground and was used on a daily basis. In the south-eastern corner of the area numbers of gulls were also high as this area is used by birds while coming from the Tagus river and moving northwards to the rubbish tip. Higher densities registered in this area are also due to the presence other gull species, namely *Larus ridibundus*, that feed in the flooded crop fields.

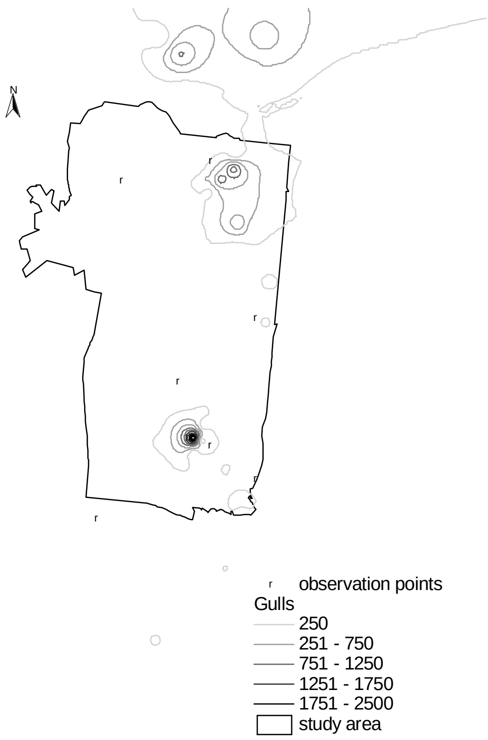


Figure 3 *Spatial distribution of gulls according to biomass density (*10^{-6} *g/*m^3*) in the study area.*

As expected gull density in the wintering period was significantly higher than in the other seasons [*Table 2*]. The two more numerous species of this group, *Larus fuscus* and *Larus ridibundus*, are essentially winter visitors or migrants in Portugal.

The post-hoc comparisons showed significant differences between all the three periods of day. Higher densities of gulls in flight were registered during the morning [*Table 3*], when these birds were recorded crossing the airport area and moving northwards, on their way to the Ota rubbish tip. In the afternoon smaller numbers of gulls were recorded crossing the area on their way south to the Tagus river. At mid-day movements were significantly lower compared to the other two periods.

4.4 Feral Pigeons (*Columba livia*)

The ANOVA showed significant differences for all factors considered [*Table 1*].

Densities of feral pigeons were higher in the southern parts of the study area, with significantly higher figures in the south of the study area, in agreement with the location of the larger urban areas.

Density of domestic pigeons in flight was also significantly higher in winter compared to other seasons [*Table 2*] and the highest densities were recorded during the morning and the afternoon [*Table 3*].

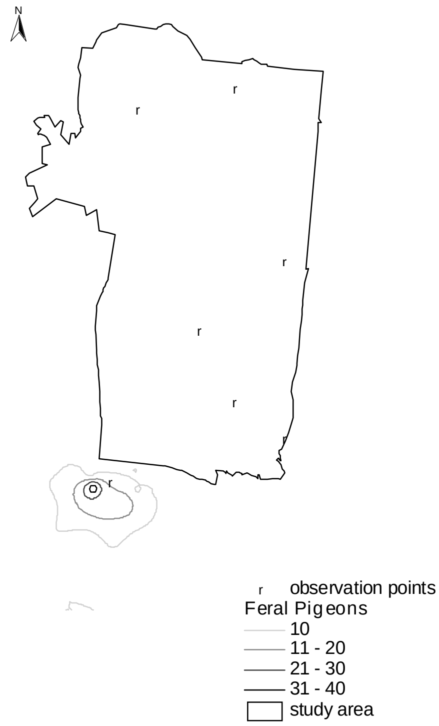


Figure 4. *Spatial distribution of feral pigeons according to biomass density (*10^{-6} g/m^3) in the study area.*

4.5 Raptors (large sized - including Buteo buteo, Milvus migrans and Hieraaetus pennatus)

Significant differences were registered for all factors considered in the ANOVA [*Table 1*].

As shown in *Figure 5* large raptors were more abundant in the central and north-eastern parts of the study area, with significantly higher densities at OP 3, where are located the main areas of woodland.

The density of raptors in flight during breeding season was significantly higher when compared with the two other seasons [*Table 2*]. The number of species present in the area increased during this season with the arrival of migratory species such as *Milvus migrans* and *Hieraaetus pennatus*.

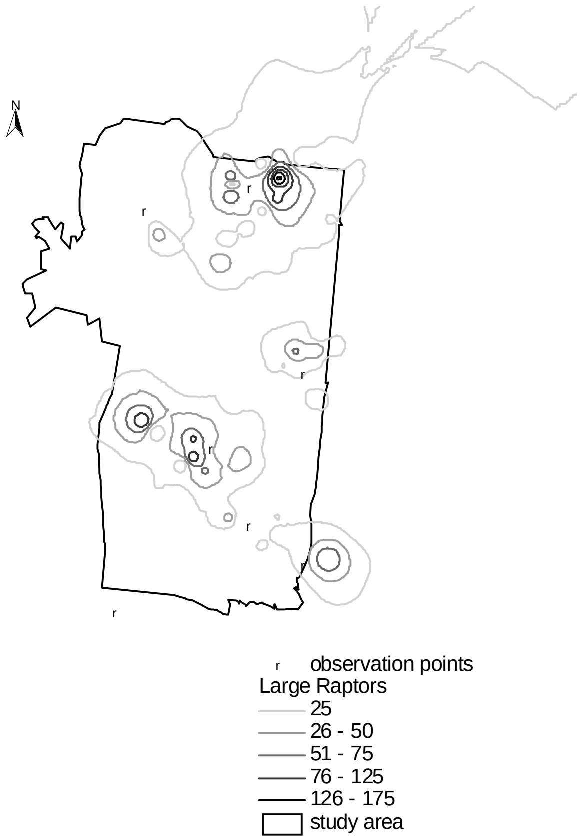


Figure 5. *Spatial distribution of large raptors according to biomass density (*10^{-6} g/m^3) in the study area.*

Densities were significantly lower during the morning than those registered at mid-day and at the afternoon [*Table 3*], in accordance to their needs of warm air currents to fly and reach higher altitudes, which do not occur during the early hours of the day.

4.6 Starlings (*Sturnus* sp.)

The ANOVA showed significant differences only between seasons and day period [*Table 1*].

The absence of significant differences between observation points suggests that the distribution of starlings in the airport is relatively uniform. In fact, *Figure 6* shows that the birds are well distributed in the study area.

Starling densities are significantly higher during the wintering season and the migratory period [*Table 2*]. During these two seasons the birds tend to form flocks, and a second species of this group, *Sturnus vulgaris*, is present in the area, whereas in spring only the resident *Sturnus unicolor* occurs.

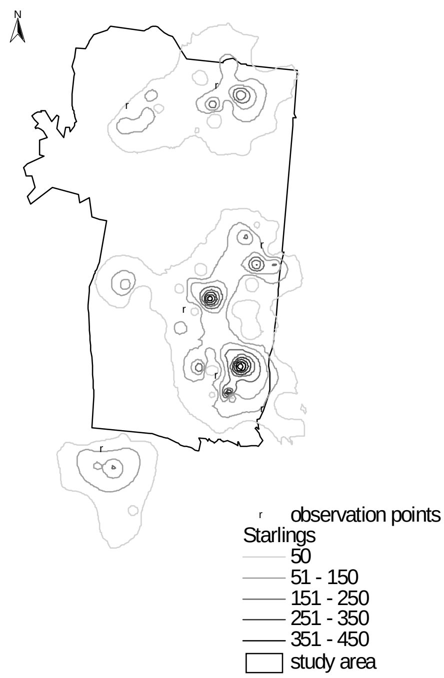


Figure 6 *- Spatial distribution of starlings according to biomass density (*10^{-6} g/m^3) in the study area.*

Higher densities were registered during the afternoon [*Table 3*] probably because this is the time of day that birds gather in larger flocks to go to their roosting sites.

4.7 Martins (*Delichon urbica*), Swallows (*Hirundo rustica*) and Swifts (*Apus sp.*)

The ANOVA showed significant differences in densities between observation points and seasons [*Table 1*].

Significantly higher densities of this birds were registered in the south-east part of the study area [*Figure 7*], where land use is dominated by irrigated crops, a habitat rich in small insects that are the main prey for this species. Relatively high densities were also registered throughout the whole of the eastern and in the north-western part of the study area, where is located a colony of house martins (*Delichon urbica*) in the buildings of the Ota air-base. Most of the house martin colonies are located in the urban areas that border the western part of the study area [*Figure 7*].

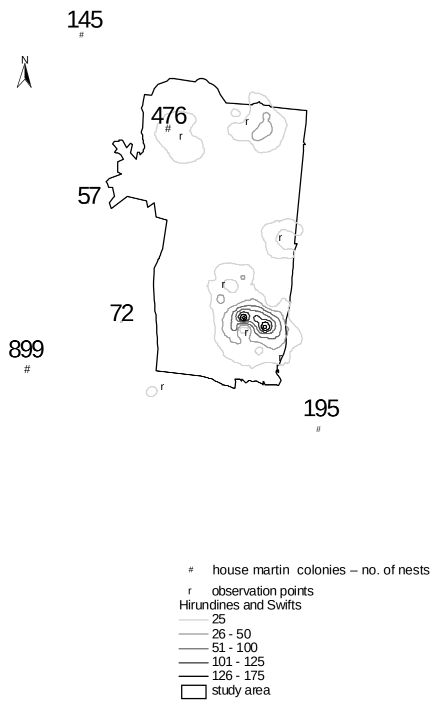


Figure 7. *Spatial distribution of martins and swifts according to biomass density ($*10^{-6}$ g/m^3) in the study area and location of house martin colonies.*

Post-hoc comparisons showed significant differences in the densities of hirundines and swifts for all the seasons, with higher values during the migratory period [*Table 2*], probably because most of the first year birds had left their nests at that time. During winter, these birds were almost absent from the airport area as all the species leave Portugal in this period.

4.8 Carrion crow (*Corvus corone*)

Significant differences were obtained for all the factors considered [*Table 1*].

The higher densities of carrion crows were registered in the north-east part of the study area [*Figure 8*]. These birds were frequently observed between the crop fields and the forested area around the Ota's air-base. They even use the air-base and the runways.

Densities were significantly higher during the migratory period and the wintering season [*Table 2*], when the carrion crows have a gregarious behaviour. It is also possible that there is an increase in birds density due to the presence of some migrating individuals, wintering in the study area.

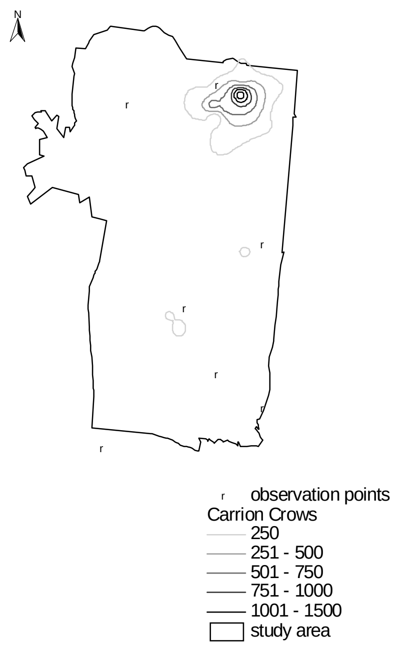


Figure 8. *Spatial distribution of carrion crows according to biomass density (*10^{-6} g/m^3) in the study area.*

During the morning the density of carrion crows was significantly higher compared to the other periods of the day [*Table 3*].

4.9 Risk analysis

The potential risk of collision with aircraft for the overall bird groups was higher during mid-day of the migratory period [*Figure 9*].

The distinct groups of birds have a different potential risk to aviation safety, based on their contribution in movement numbers in the study area. This potential risk was different according to season of the year and period of the day. The main trends that can be outlined are:

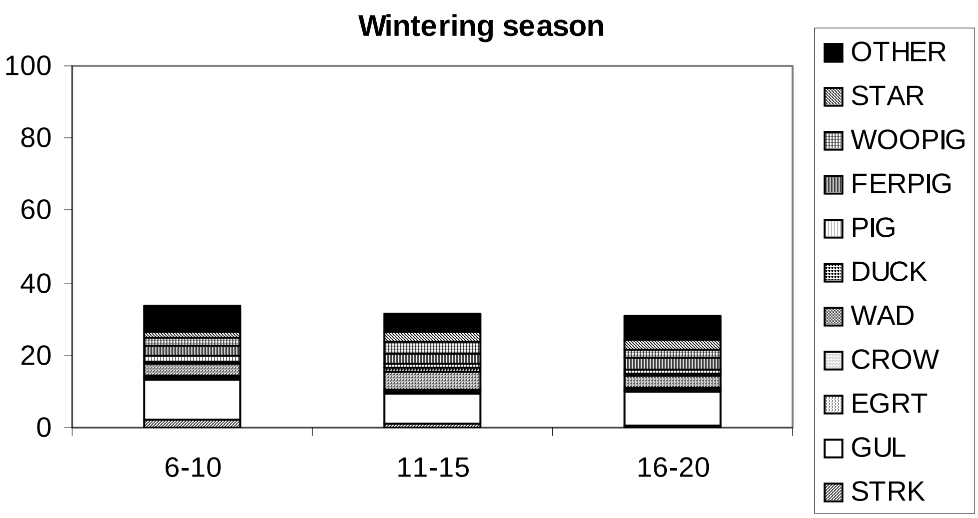
- Gulls was the group of birds that showed a higher collision probability, and this was especially high for the migratory period;

- Starlings showed a high collision probability during the migration period, particularly in the afternoon, but the potential risk of collision during winter is also worth to take in consideration.
- Storks and ducks presented a higher collision risk during the migratory period. Ducks presented a higher potential risk during the morning and for storks the risk increased at mid-day and in the afternoon.
- Feral pigeons showed higher values during the migratory period and a moderate risk during the other seasons.
- Waders, which are only present in the study area during winter, were the second more important group in terms of collision risk during this season.
- Wood pigeons presented higher values during winter and at mid-day during migration but these correspond to a moderate risk.

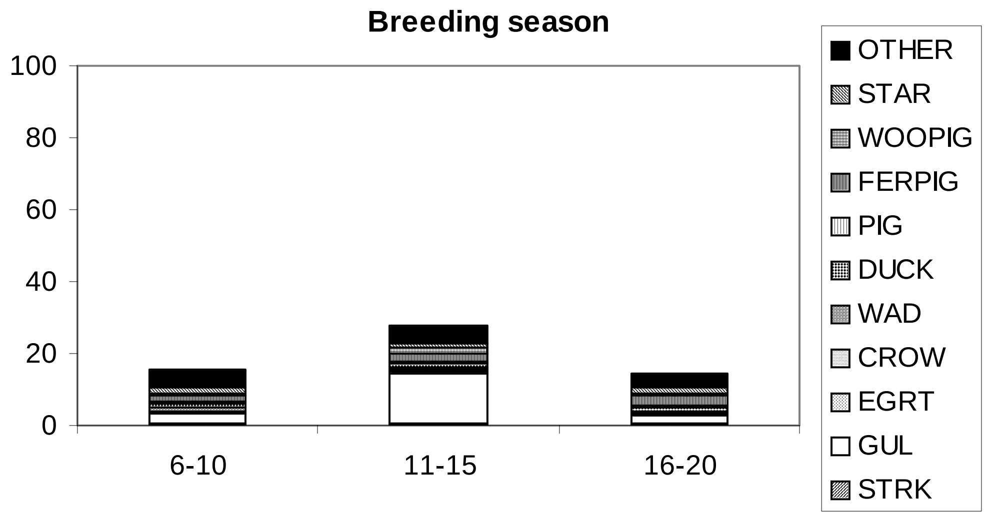
Figure 9. *Potential risk of collision*

OTHER – other species, STAR - starlings, WOOPIG – wood pigeons
FERPIG – feral pigeons, PIG – unidentified pigeons, DUCK – ducks
WAD – waders, CROW – carrion crows, EGRT – Egrets, GUL – gulls
STRK – storks

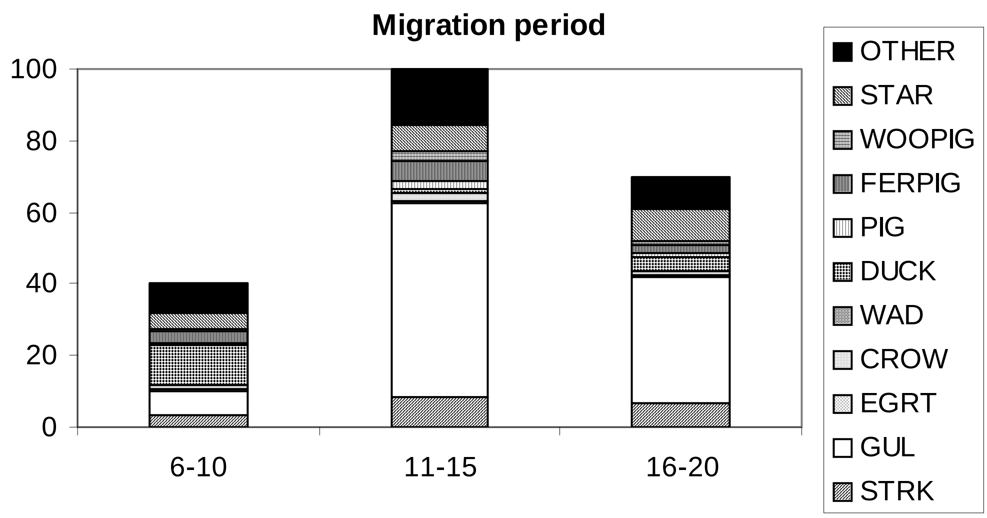
a) wintering season



b) breeding season



c) migration period



The assessment of the potential risk of collision performed in the present paper attributed a equable importance to all groups. However, studies conducted in some European airports have outlined that the risk probability is extremely variable according to bird group because it is particularly related to bird behaviour (e.g. LENSINK et al. 2000). These authors compared the number of bird strikes with the bird density, for each bird group, for some airports in the Netherlands and the United Kingdom and expressed these ratios as the proneness index (PI). With this index they were able to concluded that the highest values were relative to gulls (PI=4.0), waders (PI=3.6), feral pigeons (PI=2.5) and raptors (PI=2.6) and others (namely crows, jackdaw, pipits, finches, fieldfares and magpies) presented low values for the proneness index (PI<1.0).
Considering this information the relative risk determined for the dominant bird groups at the area of Ota future airport may have been underestimated for those groups that typically

present PI values higher than 1 (namely gulls, waders and pigeons), while for those groups with low values of IP (especially large raptors and starlings) may have been overestimated. In order to reduce bias and to obtain more accurate estimates of collision risk it will be particularly important to have records of bird hits for an area with similar habitat characteristics of those found in Ota and within the same biogeographical region.

5. References

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