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SHORT COMMUNICATION

A massive spoonbill stopover episode: identifying emergency sites for the conservation of migratory waterbird populations

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ABSTRACT

1. The existence of emergency sites could reduce the mortality rate associated with stochastic adverse weather conditions experienced by migratory waterbirds. However, as they are not regularly used by significant fractions of any population they are not integrated within conservation strategies.

2. A massive stopover of Eurasian spoonbill (*Platalea leucorodia*) occurred simultaneously at three coastal wetlands in northern Spain (Txingudi, Urdaibai and Santoña) during 3 consecutive days in September 2011. By analysing the resightings of PVC-ringed birds it was estimated that it comprised 18% of the population. At least 23% of these birds made short journeys between sites, the majority (77%) overwintering in Africa. A higher percentage of spoonbills that stopped over at Txingudi overwinter in Africa compared with the other areas.

3. During September 2011 there were more periods of consecutive days with adverse wind conditions than any other year. Furthermore, wind conditions during the massive stopover, as well as precipitation, exerted a continuous negative influence on the resumption of migration, lasting 3 consecutive days.

4. The scarcity of consecutive days with favourable winds and adverse weather conditions further encountered once en route probably led to an emergency strategy developed by a significant fraction of a spoonbill population, with several birds choosing then to make a short diversion in a westerly direction from Txingudi. Since this stopover site usually appears to be skipped during migration, it will not fit Ramsar Criterion 6 for spoonbills even after including the massive stopover (*c.* 7%), because average numbers will hardly satisfy the requisite of 'regularly supporting' a population.

5. A criterion is proposed to identify emergency sites for the conservation of migratory waterbird populations thus improving landscape connectivity and accounting better for long-term natural variability associated with stochastic adverse events. Being a flagship and umbrella species, the recognition of emergency sites for spoonbills would help the conservation of other associated waterbirds.

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KEY WORDS: birds; conservation evaluation; estuary; migration; wetland

INTRODUCTION

Migratory movements can be very long, energetically costly and often take place in stochastic dynamic conditions, especially for birds (Liechti, 2006; Gill *et al.*, 2009). As a consequence, birds show behavioural plasticity allowing them to make adaptive decisions once en route in relation to local weather conditions (Saino *et al.*, 2010; Shamoun-Baranes *et al.*, 2010; Morganti *et al.*, 2011). Recent studies suggest that weather conditions can act as obstacles during migration (Shamoun-Baranes *et al.*, 2010; Mellone

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et al., 2011), hence meteorological barriers, as well as ecological (Strandberg *et al*., 2009) or geographical barriers, such as deserts (Delingat *et al*., 2008), seas (Gill *et al*., 2009; Mellone *et al*., 2011) and mountain ranges (Åkesson and Hedenström, 2007), could also shape the behaviour of migrating birds. Therefore, the existence of emergency sites could reduce the mortality rate associated with stochastic adverse weather events (or years) experienced by long-distance migratory birds, especially for long-lived species adapting to a changing climate (Knudsen *et al*., 2010).

The emergency stopover strategy is a facultative response to changing environmental conditions and can be seen as an example of an 'emergency life-history stage' (Shamoun-Baranes *et al*., 2010): rapid behavioural and physiological responses to short-term unpredictable events (Wingfield, 2003). As mortality rate during migration increases with distance (Alerstam and Lindström, 1990, Hedenström, 2008), long-distance migrants are more likely to benefit from the use of emergency sites in response to changing environmental conditions once en route than short-distance migrants (Drent *et al*., 2003). The existence of emergency stopover sites could thus exert a great influence on the life history of long-lived species that overwinter in different latitudinal areas. However, as emergency sites are not regularly used by significant fractions of migratory populations, thus hardly satisfying Criterion 6 of the Ramsar Convention for the classification of Areas of International Importance (Wetlands International, 2006), they are neither consistently designated as migratory hotspots (Shamoun-Baranes *et al*., 2010) nor accurately integrated within conservation strategies (Amat *et al*., 2005; Wilcove and Wikelski, 2008). In addition, even for large and conspicuous species, the chance of distinguishing an emergency stopover episode from a regular increase in numbers during migration is rather low.

The present study analyses an unusual massive stopover of Eurasian spoonbill (*Platalea leucorodia*) that occurred simultaneously at three coastal wetlands located within 150 km of each other in northern Spain during 3 consecutive days in September 2011. Approximately 14% of the studied population is currently marked with individual PVC-rings with a similar proportion of individuals having been marked at breeding colonies for more than 20 years (O.O. unpubl.data). Spoonbills are significant flagship species (Jin *et al*., 2008), being an easily spotted species in most wetlands visited by ornithologists and birdwatchers. A great effort is made to monitor spoonbill abundance at several wetlands in the East Atlantic Flyway (Triplet *et al*., 2008), with a huge observation of PVC-ringed individuals in comparison with other migratory populations, with the resighting rate one of the highest available. Accordingly, this dataset has been used as a model in several ecological studies (Bauchau *et al*., 1998; Overdijk and Triplet, 2008; Navedo *et al*., 2010b; Lok *et al*., 2011). The resightings of PVC-ringed birds registered during the massive stopover were analysed to quantify the proportion of the population that made use of the sites. As the overwintering areas of many individuals were known, differences between stopover areas related to the total migratory distance of birds that comprised the massive stopover episode were examined.

Weather conditions during September 2011 were compared with conditions registered for the same month during a previous 4-year period (Navedo *et al*., 2010a) to identify differences that could have driven the massive stopover episode. The overwintering area of the PVC-ringed birds that comprised the massive stopover was compared with data registered during the same 4-year period (Navedo *et al*., 2010b). Since birds within this breeding population overwinter at different latitudes (Navedo *et al*., 2010b; Lok *et al*., 2011), a comparatively high frequency of long-distance migrants at stopover areas used as emergency sites was expected.

Based on these results, the extension of the strategic framework for the interpretation of Criterion 6 of the Ramsar Convention, for the identification of Areas of International Importance for a given migratory waterbird population is proposed through the identification of potential emergency sites for spoonbills. The aim is to contribute to the definition of emergency sites in order to improve landscape connectivity for the conservation of migratory waterbird populations.

MATERIALS AND METHODS

Eurasian spoonbill is a large waterbird that makes long-distance migratory journeys with limited staging sites (Triplet *et al*., 2008), developing a diurnal fly-and-forage pattern (Alerstam, 2009) between stopover areas. Around 30–40% of the North Atlantic breeding population (i.e. the

Netherlands and France) regularly make a strategic stopover at a single wetland, Santoña Marshes Natural Park, during the autumn migration, before crossing the Iberian Peninsula (Navedo, 2006). This continental area represents about 800 km of presumably unsuitable land for migratory spoonbills before they reach the next potential staging sites on the SW Iberian coast. Moreover, spoonbills have to climb to 1500 m a.s.l. to pass over the Cantabrian Mountains that are located close to the coast (see details in Navedo *et al.*, 2010a). Eastwards, but within 150 km of Santoña Marshes, there are two other similar coastal wetlands used as stovover sites during the autumn migration: the Urdaibai rivermouth, which annually supports 3–10% of this breeding population (Del Villar *et al.*, 2007); and Txingudi Marshes, which do not usually hold high numbers of spoonbills, but host 1–2% (Luengo and Arizaga, in prep).

The majority of spoonbills (*c.* 90%) migrate through the area during September (Navedo, 2006; Del Villar *et al.*, 2007; Luengo and Arizaga, in prep). During the 2002–2005 migration period only six spoonbills (2% of all birds; n = 323) were registered both at Urdaibai and Santoña, despite a daily comparable observation effort between areas (Navedo and Garaita, 2012), whereas there was not a single bird located first at Txingudi and then at Santoña (J.G.N. unpubl. data). This low connectivity between nearby areas for spoonbills should not be considered a methodological artefact, since numbers at Txingudi were actually very low throughout the autumn migration (Luengo and Arizaga, in prep).

During 16–18 September 2011, more than 400 resightings of PVC-ringed spoonbills were received from several coastal wetlands located in northern Spain; 98% of them from Txingudi, Urdaibai and Santoña. These resightings were made by several observers (see Aknowledgements), and some birds were even reported more than once in the same area on the same date. In those cases it was assumed that the individual bird had made a short journey that day between both areas in a westerly direction. A total of 1236 PVC-ringed spoonbills were reported being alive in 2011, 185 of them were never located outside of Africa (O.O. unpubl. data). By relating the total number of different PVC-ringed individuals accurately identified in the database during the 3 days to total PVC-ringed birds reported alive in the European part of the flyway (i.e. 1051 birds), the scale of the massive stopover episode could be indirectly quantified. Nevertheless, during the 3 days, resightings did not show a systematic pattern within areas, but rather between areas. Therefore, it was conservatively considered that resightings of individuals represented a good proxy for quantifying the massive stopover episode, but represented an underestimation of individual movements between areas.

Spoonbills breeding in the Netherlands and France overwinter in north-western African wetlands of Mauritania and Senegal (total distance 4000–4500 km) (Bauchau *et al.*, 1998), with *c.* 20% currently overwintering in the Iberian Peninsula (Lorenzo and De le Court, 2007), thus considerably reducing their total migration distance by *c.* 2000–2500 km. Recent studies of this population suggest that spoonbills show a strong fidelity to overwintering area from their second winter onwards (Lok *et al.*, 2011). Therefore, the overwintering areas of PVC-ringed birds that comprised the massive stopover were used in the analyses even if the overwintering area was not known for the 2011/12 period, but only for birds within their year-calendar or more, because first and second year calendar spoonbills could have changed overwintering area (Lok *et al.*, 2011). Under these premises, information about overwintering area was analysed for a total of 85 birds (38 first located at Txingudi, 23 at Urdaibai and 24 at Santoña; data obtained from the Dutch Spoonbill Working Group database). Following Navedo *et al.* (2010b), resightings of PVC-ringed spoonbills during November and December were grouped into the Iberian-wintering class (41% of total) or into the African-wintering class (59% of total).

Weather conditions

Daily data of wind direction and speed at sea level at Santoña during September 2011 was obtained and the daily direction and speed were calculated as the mean value of records at 13:00 and 18:00. Daily wind conditions were further characterized by the tailwind component (TWC: Åkesson and Hedenström, 2000) for the two main routes: 200º and 275º, the SW and W routes, respectively (see Navedo *et al.*, 2010a for more details). Positive TWC indicates wind conditions favouring flights and negative values indicate winds opposing migration in the preferred direction. A TWC equal to zero indicates still air or a wind exactly perpendicular to the migratory direction. After

manually checking the conditions for small TWC values (Tsvey *et al.*, 2007), it was concluded that small TWC values corresponded to strong side winds for both routes during 2011, and extreme TWC values corresponded to rather strong tail- or headwinds. Daily rain conditions were registered as accumulated daily precipitation (mm).

For periods of consecutive days with adverse weather conditions throughout the month, both TWC and rain were further explored, trying to account for general differences in its distribution between years. A day with adverse wind conditions to resume migration to the principal SW route was considered to be when TWC was below $0.5\,m{\cdot}s^{-1}$, thus eliminating the potential noise of low positive values that, in this case, represented strong side winds rather than weak tailwinds (see above). Similarly a day with adverse rain conditions was considered to be when accumulated precipitation exceeded 5 mm, thus reducing the potential noise of slight showers in the results.

Statistical analyses

Pearson χ^2 tests were used to examine for differences between observed frequencies of birds that stopped over first at each study area in relation to total distance to overwintering area. This test was also used to explore for differences in frequency of days with adverse weather conditions between years. Kruskal–Wallis tests were used to investigate potential differences in annual wind conditions and tendency to follow the SW or the W route, as well as rainfall among 2002, 2003, 2004, 2005 (Navedo *et al.*, 2010a) and 2011 autumn migrations. Meteorological data were obtained from the official database of the Spanish Meteorological Agency of the former Spanish Ministry of the Environment. Despite minor differences it was assumed that conditions registered at Santoña resembled overall wind patterns, precipitation, and temperature experienced at all three nearby areas.

Statistical analyses were performed using STATISTICA v6.1 (StatSoft Inc. 2002). In all cases a 0.05 level of significance was used. Values are presented as means ± SE.

RESULTS

A total of 224 different PVC-ringed individuals were registered during 16–18 September 2011, at these three wetlands (92 birds were registered first at Txingudi, 69 at Urdaibai and 63 at Santoña) and were accurately identified in the database. This massive stopover thus included 18% of all PVC-ringed individuals reported alive within the population. At least 37 birds (23% of total) made short journeys in a westerly direction, 36 from Txingudi to either Urdaibai (9 birds) or Santoña (27 birds) during the 3-day period, but only one bird moved from Urdaibai to Santoña. Interestingly, this individual had been fitted with a satellite-device during the 2010 breeding season (BB31: O.O. unpubl. data), which allowed a direct comparison with its migratory behaviour during the previous season. One spoonbill stopped over at all three areas.

A higher percentage of spoonbills that stop over at Txingudi overwinter in Africa in comparison with percentages registered both at Urdaibai and Santoña (Figure 1), although these differences are not significant ($\chi^2 = 4.80$; $P = 0.09$). From this subset, the majority of birds (77%) that moved from Txingudi to either Urdaibai or Santoña during the 3-day period (n = 17) overwinter in Africa.

Mean TWC SW ($1.29 \pm 0.35\,m\ s^{-1}$; n = 30) and mean daily precipitation (1.18 ± 0.55 mm; n = 30) registered in September 2011 showed the lowest values in the 5-year comparison (Figure 2). On the other hand, mean TWC W showed a mean positive value during September 2011 ($0.14 \pm 0.46\,m\ s^{-1}$; n = 30), whereas it showed a mean negative value during the 2002–2005 period (Figure 2). However, overall weather conditions for the resumption of migration during September 2011 were not significantly different from those recorded annually during 2002–2005 at Santoña for any of the SW ($H_{4,147} = 4.87$; $P = 0.30$) or W routes ($H_{4,147} = 1.30$; $P = 0.86$), and mean daily

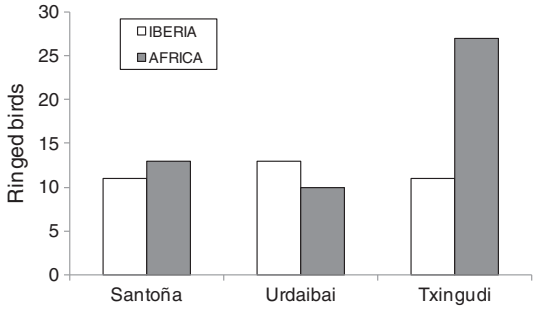

Figure 1. Number of Eurasian spoonbills (*Platalea leucorodia*) that stopped over during the massive stopover of 16–18 September 2011 at Santoña (n = 24), Urdaibai (n = 23) and Txingudi (n = 38) as a function of their known core overwintering area (Iberia and Africa).

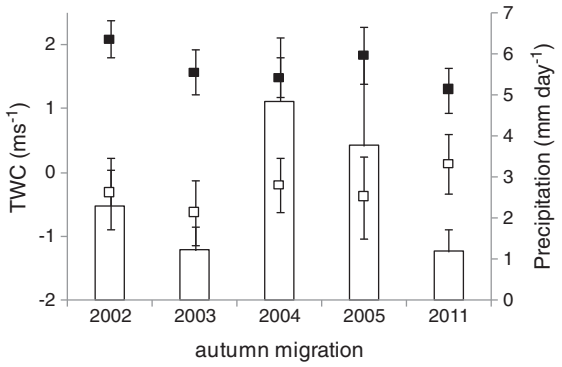

Figure 2. Mean values (± SE) of the tailwind component (TWC: left axis) for the SW (black dots) and W (white dots) routes, as well as rainfall (white bars: right axis), registered during September at Santoña.

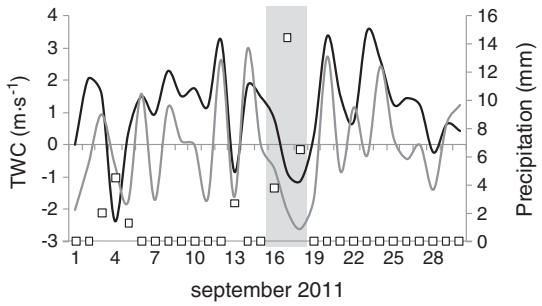

Figure 3. Mean tailwind component (TWC) for the SW (black line) and W (grey line) routes, as well as accumulated rainfall (white dots), registered daily during September 2011 at Santoña. Grey shading highlights weather conditions observed during 16–18 September 2011, coinciding with the massive stopover episode in the area.

precipitation was also similar ($H_{4,142} = 5.74$; $P = 0.22$).

There were more days with adverse TWC conditions in September 2011 than during the compared 4-year period (Table 1), although frequencies were not significantly different between years ($\chi^2 = 5.86$; $P = 0.21$). However, in 2011 there were more periods of 2 consecutive days of adverse TWC conditions, and there was one exceptional episode of 3 consecutive days with adverse TWC during the compared 4-year period (Table 1), which went on to last for 4 consecutive days. By contrast, the number of rainy days during 2011 was low (Table 1), with similar frequencies between years ($\chi^2 = 7.50$; $P = 0.11$), and there was only one period of consecutive rainy days (Table 1).

Besides these general patterns, during the 3 days of massive stopover of spoonbills that occurred in 2011, wind conditions as well as precipitation (8.3 ± 3.2 mm; n = 3) exerted a strong and continuous negative influence on the resumption of migration (Figure 3), particularly via the direct route (TWC SW: -0.8 ± 0.7 m s^{-1}; n = 3) and, despite being more variable (TWC W: -0.9 ± 1.8 m s^{-1}; n = 3), for the coastal route too.

Table 1. Number of consecutive days with bad weather conditions (TWC < 0.5 m s^{-1} and rain > 5 mm) to resume migration towards the principal SW route for spoonbills during September at each of the compared years

	2002	2003	2004	2005	2011
TWC SW < 0.5 m·s^{-1}					
n days	5	6	5	9	11
2 consecutive days	2	0	1	1	3
3 consecutive days	1	0	0	0	1
4 consecutive days	0	0	0	0	1
Rain > 5 mm					
n days	5	2	8	3	2
2 consecutive days	1	0	2	0	1

DISCUSSION

During a 3 day period in September 2011, three adjacent coastal wetlands held 18% of the individuals of a migratory waterbird population (21% if we omit those immature birds only reported alive in 2011 in Africa). These areas were already identified as important stopover sites holding in total *c*. 32–52% of this population, with huge differences between them (see Methods). However, PVC-ringed birds registered in Txingudi, Urdaibai, and Santoña during the massive stopover accounted for similar percentages of the population; 7.4%, 6.4% and 7.4%, respectively. This represents an unusual and massive stopover episode, supporting half of the birds that usually stop over throughout the whole migration period in only 3 days.

Despite its long-term recovery (Overdijk and Triplet, 2008), the current spoonbill population size was *c*. 1.5 times larger than during the 2002–2005 period, and the 2011 breeding season (2500 pairs) (O.O. unpubl. data) was not markedly different from previous years, with a reproductive success below average due to floods that killed chicks and eggs (O.O. pers. obs). Therefore, there was not a significant change in population figures to have driven this massive stopover episode of spoonbills. On the other hand, general weather patterns throughout September 2011 were similar to those registered during a previous 4-year study (Navedo *et al.*, 2010a), although the number of consecutive days with bad TWC conditions were noticeably higher. During September 2011, birds had thus experienced few periods of consecutive days with favourable winds to migrate through this area, which could exert a great influence on migratory decisions (Weber and Hedenström, 2000). Moreover, there was an exceptional episode of

4 consecutive days with adverse TWC, coinciding with the massive stopover of spoonbills in the area.

Weather conditions encountered once en route could lead to an emergency stopover strategy, especially with headwinds that increase energy expenditure during flight (Shamoun-Baranes *et al.*, 2010). Spoonbills experienced continuous headwinds ($-0.8\,m\,s^{-1}$) and high rainfall in this area (including a daily accumulated precipitation of 14.5 mm on 17 September) throughout the 3-day period, which prevented birds resuming migration via the principal SW route (Navedo *et al.*, 2010a). The absence of thermal currents during rainy days (Newton, 2008) had a further negative effect on spoonbills departing via that route. By contrast, favourable wind conditions to depart to the coastal (secondary) W route are not usually selected by spoonbills (Navedo *et al.*, 2010a). In this sense, at least 23% of all birds made short displacements in a westerly direction after stopping over at Txingudi, thus deviating from the principal SW route. Although results are not conclusive because the effects being tested are unreplicated, we suggest that bad weather conditions encountered once en route by spoonbills led to an emergency strategy. This massive stopover could probably be influenced by a reduction in frequency of consecutive days with favourable winds during the migratory season, thus driving a concentration of the migratory flux during those days. After the emergency stopover, several spoonbills then made a short displacement in a westerly direction before crossing an ecological barrier (i.e. the Iberian Peninsula), probably during periods without precipitation and/or calm wind. In support of this, the adult bird fitted with a satellite-device stopped over for up to 6 days in this area, even making a short displacement between Urdaibai and Santoña, before resuming its migration via the SW route (total migration duration 24 days), whereas it had skipped the area during the previous autumn migration (total migration duration 14 days), passing through this area a week before (O.O. unpubl.data).

Migration is a costly process with energy demands and associated travel costs varying among migratory strategies (Alerstam *et al.*, 2003; Drent *et al.*, 2003; Hedenström, 2008). Displacements between nearby areas not located within the main direction will slow down the migration of any individual, unless they make a detour (Alerstam, 2001; Purcell and Brodin, 2007). Spoonbills that overwinter in Iberia could follow either the principal SW or the secondary W route by making short stopovers (Navedo *et al.*, 2010b), thus slowing down their migration, or follow a detour once en route, as they significantly reduced total migration distance (Alerstam and Hedenström, 1998). By contrast, African-wintering spoonbills follow the principal SW route and make longer stopovers (Navedo *et al.*, 2010b), skipping several areas within the migration route, thus reducing total migration time (Alerstam and Hedenström, 1998). Since carrying larger fuel-loads increases travelling costs (Pennycuick, 2008), African-wintering spoonbills incur a higher penalty than Iberian-wintering birds both from slowing down migration and by not making best use of transported energy loads (Drent *et al.*, 2003). A higher percentage of spoonbills stopped over first at Txingudi and overwintered in Africa (71%) than those registered at Urdaibai (43%) and Santoña (54%), although differences were not statistically significant. Furthermore, a large majority of birds that stopped over first at Txingudi and then hopped to those nearby wetlands during the 3-day period overwintered in Africa. Hence, it seems that the restricted sample size from the massive stopover episode led to the lack of significant differences observed. In support of this, a preliminary study estimated that more than 1800 spoonbills were observed flying over Txingudi in a SW direction during both 2009 and 2010 migrations, but only 180–280 birds (10–15%) stopped over at the area (Luengo and Arizaga, in prep). Therefore, it appears spoonbills usually skip Txingudi, but the area can be used as an emergency site to overcome stochastic adverse weather conditions encountered once en route, especially for long-distance migrants (i.e. African wintering birds).

Whether or not the existence of emergency sites can reduce the mortality rate associated with stochastic adverse weather events (or years) would depend primarily on the probability of encountering such conditions once en route. Changes in wind patterns during recent decades due to climate change have been demonstrated to have a direct effect on breeding output (Weimerskirch *et al.*, 2012) or arrival at breeding grounds (Sinelschikova *et al.*, 2007) of different migratory bird species. There are also some documented episodes of mass mortality because of adverse weather conditions encountered en route (Jehl, 1996). If the probability of encountering stochastic adverse weather events (or

years) during migration, such as the one described here, is likely to increase due to climate change (Knudsen *et al*., 2010), then the existence of emergency sites could be crucial for the conservation of several waterbird populations, especially affecting long-distance migrants (Alerstam and Lindström, 1990). Under this scenario, long-lived migratory waterbirds would suffer from the loss of any wetland that can be used as an emergency site, particularly those sites located before a geographical or ecological barrier. Here, it is difficult to detect and register emergency events within a population because of generally restricted sample sizes, difficulty in observing animal movements or identifying ecological barriers. We have not demonstrated that the use of emergency sites will have direct effects on survival of spoonbills, but if we are to protect migratory species and the migration phenomenon proactive conservation measures are needed while they are still abundant (Wilcove and Wikelski, 2008). Therefore, using spoonbills as a flagship (Jin *et al*., 2008) and umbrella species (Sergio *et al*., 2008), an accurate definition (i.e. which criteria) and further identification of emergency sites would represent a first step in improving the conservation of other associated migratory waterbird populations.

Conservation implications

If a stopover site is occasionally used by a significant fraction of a migratory population during a given season (emergency strategy), its importance will be masked when estimating average numbers of birds during consecutive years, thus not satisfying the requisite of Criterion 6: 'supporting regularly 1% of a population' (Wetlands International, 2006). An accurate identification of these sites will suppose an advance in the interpretation of the long-term use of a site by waterbird populations, since migrating birds could occasionally develop an emergency strategy stopover due to stochastic adverse weather events encountered en route (Shamoun-Baranes *et al*., 2010). The probability of a stopover being an 'emergency site' would be higher within the main migratory route (for each population) and before confronting barriers (ecological or geographical), as well as for long-lived waterbird species and long-distance migrants because mortality rates during migration increase with distance (Alerstam and Lindström, 1990; Hedenström, 2008).

Therefore, when updating the importance of wetland areas during migration for spoonbills by means of Criterion 6 of the Ramsar Convention, we recommend the inclusion of an additional category to identify Areas of International Importance: 'a wetland regularly supports a population of a given size if the maximum number of birds that stopover during migration exceeds X % in a given year, during the last Y years'. Five percent is proposed as an initial percentage based on the actual required amount (regularly support 1%) by means of 5 years at a given area (Musgrove *et al*., 2001; Rehfisch *et al*., 2003); thus, 5% should be similar for an area during a single season ('emergency' stopover). A 10-year period of evaluation is proposed trying to take into account natural variability during the long-term, especially for long-lived species like spoonbills (i.e. more than 20 years), with a higher probability of encountering a stochastic adverse weather event along their life. Regulation of emergency sites will improve landscape connectivity for waterbirds (Amat *et al*., 2005), thus accounting for natural variability as well as uncertainty (i.e. stochastic meteorological events, unforeseen pollution events, diseases, human conflicts) (Prato, 2005) for their long-term conservation.

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