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Short communication

Do systematic daily counts reflect the total number of birds using stopover sites during migration? A test with Eurasian Spoonbill

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ABSTRACT

Many migratory waterbird populations are declining and wetland connectivity is a major conservation challenge. The importance of stopover sites has been typically assessed by peak counts of birds, which underestimate the total number of individuals using the site over a migratory season, especially in small wetlands. We analysed the accuracy of different daily count schemes to estimate the total number of Eurasian Spoonbill that stop over at two tidal wetlands during their autumn migration and compared them with the birds observed leaving the area each day. Total number of birds was obtained by combining numbers of each flock of birds leaving during the season. We obtained different accurate predictors for birds departing daily from each stopover area. Daily low-tide counts were the best predictor of the daily number of birds that stopover in a tidal wetland mainly used to refuel (staging site), whereas daily high-tide counts were best at a wetland mainly used to rest (stopover site). Each measure also accurately predicted annual trends for each area, respectively. Daily low-tide counts could be used as an easy census method to estimate the daily number of individuals using a staging site consistently during the entire migratory season, as well as indicating trends, without the necessity of estimating turnover rates. By contrast, daily high-tide counts would be especially suitable for determining the minimum relevance and the population trends of other tidal wetlands (especially the smaller ones), which regularly support moderate numbers of spoonbills during migration where birds use to stop over for less than one day. This method developed for the spoonbill, a flagship and umbrella species, could represent a first step in improving the conservation of other endangered migratory waterbird populations.

Introduction

The most recent reviews of the population status of migratory waterbirds confirm that many of them are in decline (Wetlands International 2006). Although there are many factors that might be impacting negatively on these populations, loss and/or alteration of natural wetlands are probably the main causes (Morrison et al. 2001). Recently, many efforts have been made to clarify the importance of stopover sites in the regulation of populations of migratory waterbirds (reviewed in Newton 2006), since their key role has been demonstrated for some of the most well-known endangered species. For example, an increasing proportion of Red Knot (*Calidris canutus rufa*, Wilson, 1813) failed to reach threshold departure masses during their stopover at Delaware Bay during the period 1997–2002, which had severe fitness consequences for adult survival and recruitment of young in subsequent years (Baker et al. 2004).

To date, the assessment of the importance of stopover sites for waterbirds has typically been based on peak counts of any species, which underestimate the total number of birds using the site over a season because of the turnover of individuals (Frederiksen et al. 2001). This method highlighted the importance of conserving large wetlands that commonly support big flocks of a species during migration, whereas it underestimated the importance of small wetland areas that do not support large numbers of migratory birds. Furthermore, the conservation of many waterbird populations relies on wetland connectivity (Haig et al. 1998), including moderate to small wetland areas where birds can refuel and/or rest before resuming migration. Areas located before an ecological or geographical barrier are particularly important (Åkesson & Hedenström 2007). These stopover sites are essential for long-distance migrants that employ a 'jumping' strategy (i.e. long displacements between breeding and wintering grounds using a few stopover areas), and have been recently renamed staging sites (i.e. sites with abundant, predictable food resources where birds prepare for an energetic challenge; Warnock 2010).

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Therefore, there is an urgent need to identify and evaluate the total number of birds that stopover in single wetlands in order to assess their conservation value for many endangered migratory waterbird populations.

Although the total number of migrating birds is difficult to calculate for any species, an estimation of the rate at which the individuals present are changing (turnover rate) is possible. Special techniques, such as direct observation of migratory flocks (e.g. Alonso et al. 1990; Frederiksen et al. 2001; Navedo et al. 2010a), or indirect observation through studies of marked (ringed) individuals (e.g. Gillings et al. 2009; Meissner 2007), are required to calculate the turnover rate using specific software for analysis of capture–mark–recapture data (reviewed by Lindberg, in press). Thus, to fulfill international, national and regional governmental requirements, site managers have often simply combined non-systematic records of each species in a certain period to estimate the total number of birds using a wetland, which is an erroneous assumption (Brouwer et al. 2003; Frederiksen et al. 2001).

Here we analyse the accuracy of different daily counts to quantify the total number of birds of a waterbird species, the Eurasian Spoonbill (*Platalea leucorodia leucorodia*, L. 1758), using two different stopover sites during fall migration. This species is charismatic and easy to detect, and accordingly has been monitored in many wetlands over several years and throughout its life cycle (Triplet et al. 2008). Most of these monitoring schemes were based on peak counts, thus potentially including a significant bias when estimating the total number of spoonbills using a given stopover. Furthermore, its current position as a functional top predator in estuaries makes it a suitable umbrella as well as a flagship species (Jin et al. 2008; Lorenz et al. 2009) for ecosystem-level conservation of wetland areas (Sergio et al. 2006; Sergio et al. 2008).

Supported by a continuous daily monitoring program allowing direct estimation of the total number of spoonbills at two important stopover sites during their autumn migration (Del Villar et al. 2007; Navedo 2006), the aim of this study was to evaluate whether there was an accurate indirect method that could be used to assess the total number of spoonbills at tidal wetlands during migration as a basis of systematic daily counts of birds. As spoonbills are restricted to foraging at low tide at both areas studied (Navedo 2006, R. Garaita, *pers. obs.*) we expected that the tidal cycle would have a great influence on the daily counts of spoonbills.

Methods

Santoña Marshes Natural Park (43°25′N, 3°30′W) and Urdaibai Biosphere Reserve (43°22′N, 2°40′W), designated as Ramsar sites and Special Protection Areas (SW Europe, 65 km distance between both sites; Fig. 1), are similar estuarine wetlands covering nearly 1250 ha and 250 ha of effective intertidal areas (estimated following Stillman et al. 2001), respectively. Both are strategically located between breeding (mainly the Netherlands and France) and wintering areas (SW Iberia and NW Africa) for the 'Atlantic' population of the species (Triplet et al. 2008). Since 30–40% of this breeding population stop over at Santoña to refuel during the autumn migration (Navedo 2006), it has been identified as a key stopover site for the species (Navedo 2006; Triplet et al. 2008). On the other hand, Urdaibai has been identified as another important stopover site during the autumn migration (Triplet et al. 2008), as it supports hundreds of birds throughout this period, thus accounting for ca. 3–10% of the population (Del Villar et al. 2007).

A census of the number of spoonbills using both tidal areas was undertaken by experienced ornithologists (JGN at Santoña and RG at Urdaibai) on a continuous basis from 09:00 to 20:00 h during (at least) 28 consecutive days in September in four consecutive years (2002–2005) (for more details see Del Villar et al. 2007; Navedo et al. 2010a). Spoonbills were surveyed from hills overlooking the entire estuaries. At both study areas we were able to directly observe each flock of birds leaving the estuary (see Navedo et al. 2010a, R. Garaita, *pers. obs.*). Therefore, we had an accurate measure of the daily number of birds leaving both estuaries (*n*OUT) and, following Navedo (2006) the total number of birds was then obtained by combining numbers for each flock of birds leaving during the study period. Despite a comparable daily observation effort, only six PVC-ringed spoonbills registered at Santoña during this 4-year period (2% of all birds; $n = 323$; data from Navedo et al. 2010b) were previously registered at Urdaibai. Therefore, there is a generally low connectivity between areas.

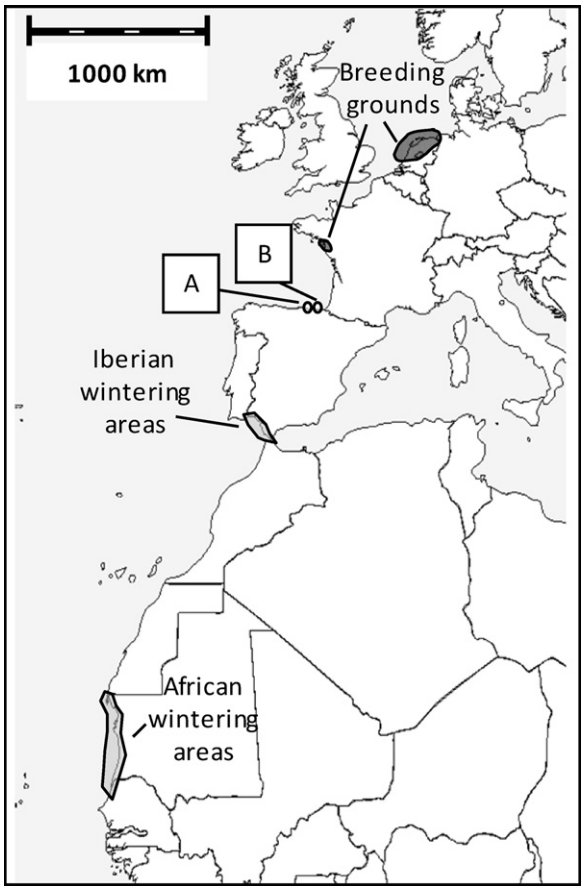

Fig. 1. Location of Santoña Marshes (A) and Urdaibai rivermouth (B) within the autumn migration route of the Atlantic population of Eurasian Spoonbill.

We systematically registered the hourly presence of spoonbills from 09:00 (n0) to 20:00 (*n*END) at both areas. Tidal stage has a strong influence on spoonbill departure decisions at Santoña, since the majority leave the stopover area after foraging during the low tide (Navedo et al. 2010a). Thus, we further estimated the number of spoonbills in relation to tidal cycle, at the low- (*n*LOW) and high-tide peaks (*n*HIGH) at both areas. We finally selected four daily periods (*n0*, *n*END, *n*LOW and *n*HIGH) instead of any other period, because numbers of spoonbills at any period during daylight strongly depended on how many individuals were there at sunrise, and the tidal stage governed foraging and resting activities, as well as departure decisions at Santoña (Navedo et al. 2010a), during their stopover at both areas (Navedo 2006; Del Villar et al. 2007). All censuses were log transformed before analysis to meet normality and homocedasticity in data.

As expected (see above), the four potential predictors were highly correlated between them at both study areas (Santoña: Spearman $r > 0.41$; $p < 0.00001$ in all cases; Urdaibai: Spearman