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Drifting space use of common cranes—Is there a mismatch between daytime behaviour and management?

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ABSTRACT

Many populations of large grazing birds (cranes, geese, swans) have recovered following protection. During migration, these birds often aggregate in large numbers at staging sites and feed on agricultural crops. Because staging sites often coincide with protected wetlands, extensive crop damages may avert both bird and wetland conservation. There is a need to integrate damage mitigation and conservation of large grazing birds staging in agricultural landscapes, based on knowledge of large grazing birds' spacing behavior. Their space use forms the basis for assessment of damage risk and for the scale at which measures should be implemented. We used high-resolution GPS location data to assess space use of common cranes *(Grus grus)* at an important staging site in south-central Sweden. We focus on daytime behaviour because this is the time when foraging cranes may cause crop damage and when preventive measures such as scaring and culling are conducted. We found that the daily activity area (mean 4.4 km^2) did not vary within staging periods. Cranes exhibited high site fidelity during staging, as their activity area over the staging period (mean 15.6 km^2) was considerably smaller than the entire staging site (> 200 km^2). However, on a daily scale cranes gradually shifted activity areas, forming a space use pattern analogous to overlapping rings. This pattern is presumably explained by heterogeneous and unpredictable food availability caused by continuous changes in agricultural practices, weather conditions and competition. Considering the size of crane activity areas over the staging period and the scale of current damage preventive measures (*e.g.,* hunting permissions given for a few fields [mean size 0.049 km^2] at a time), we suggest that current preventive measures might be implemented on a too small scale compared to that of crane space use. Our findings highlight the necessity of adapting crop damage preventive measures to the scale of bird space use to facilitate both bird conservation and agricultural practices at wetlands staging sites along the flyways.

1. Introduction

Damage by wildlife on crops, forest or livestock is on the rise in many areas due to expanding human land use and recovery of protected species (Bruskotter and Shelby, 2010; Chapron et al., 2014; Herfindal et al., 2015; Salvi, 2010). When species of high conservation concern cause damage, multi-objective management is needed to preserve species while minimizing their negative impact on human livelihood and ecological knowledge of the target species is needed to understand both the impact of wildlife on human livelihood and the effects of mitigating measures (Amano et al., 2007). Individual space use of animals is an important determinant of population structure and distribution (Morales et al., 2010; Sutherland, 1996) and consequently, the extent of space use and site fidelity is essential for assessing risk of damage caused by wildlife and to implement damage preventive measures at an appropriate spatial scale (Campbell et al., 2015; Karlsson and Johansson, 2010).

Cranes, geese and swans (hereafter: large grazing birds) commonly cause damage to agricultural crops at staging sites along their migratory route that often stretches over large areas covering multiple international and administrative borders (Leito et al., 2015; Madsen and Williams, 2012). During migration, large grazing birds exhibit site fidelity at several spatial scales: from staging sites along the flyways to specific agricultural fields within staging sites (Fox et al., 2002; Johnson, 1980; Phillips et al., 2003). At staging sites, large grazing birds are gregarious and forage mainly on crop fields during daytime and repeatedly return to wetland roost sites at night (Bautista et al., 1995; McIvor and Conover, 1994). Staging and roost sites often coincide with internationally important and protected wetlands (Kleijn et al., 2014; Vegvari and Tar, 2002). Crop damage and the consequent

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economic losses leads to reluctance among farmers, not only to conservation of large grazing birds, but also for conservation measures taken for wetlands and for vulnerable bird species dependent upon these wetlands (Amano et al., 2007; Dickman, 2010; Frank et al., 2016; Salvi, 2010).

The importance of food resources is accentuated for staging cranes due to their high energy need during the fall and spring migration and subsequent breeding period (Arzel et al., 2006) and knowledge of bird space use at staging sites is thus important to reduce damage on agricultural crops. Resource distribution and predictability are important determinants for animal space use and fidelity (Switzer, 1993; van Beest et al., 2013; van Moorter et al., 2009), and at staging sites these factors may vary considerably over time and space due to agricultural practices (Nilsson et al., 2016), emphasizing the importance of considering multiple spatiotemporal scales.

Common cranes staging in the vicinity of protected wetlands illustrates the challenge of managing the impact on crop production whilst preserving large grazing birds and wetland habitats. Similar to other large grazing birds, common cranes have increased in Europe during the last decade (Harris and Mirande, 2013; Mewes et al., 2010). This increase has been explained by increased food availability in a modernized agricultural landscape, legal protection and wetland restoration (Mewes et al., 2010; Nilsson, 2002). The increase in crane numbers has been accompanied by increasing levels of crop damage and economic compensations to farmers (Frank et al., 2016; Salvi, 2010). For example, in Sweden the costs for damage compensation and preventive measures amounted to 3.5 million € in 2011–2015 (Frank et al., 2016).

To reduce negative impacts on agricultural crops and simultaneously enhance bird and wetland conservation along the flyways, there is a need for more effective management measures (Fox et al., 2016). One way to accomplish this may be to better adapt preventive measures to large grazing birds' space use and foraging pattern at staging sites. Today, preventive measures at staging sites, such as scaring, restricted culling and diversionary fields, are generally performed on a farm or even field level (J. M. Wikland, Örebro county administrative board, pers. comm.). Prior research on large grazing birds have focused on large scale habitat use (Bos et al., 2005; Lovvorn and Kirkpatrick, 1982; Vegvari and Tar, 2002), foraging strategies (Bautista et al., 1995; Black et al., 1992; Kurvers et al., 2010) and responses to disturbance (Madsen, 2001; Rees et al., 2005; Vegvari et al., 2011) based on flock surveys of populations or individual banding and radio-tracking data. Thus, we acknowledge a need for more detailed individual-based studies of the space use of large grazing birds (Klaassen et al., 2008; Madsen and Williams, 2012; Sutherland et al., 2004).

In this study, we assessed the daytime space use and site fidelity, on a daily basis, of foraging common cranes staging on agricultural land in the vicinity of a protected wetland. We focus on daytime behaviour because this is the time when cranes are foraging and thus cause damage on agricultural fields and when preventive measures are conducted. To assess temporal patterns of individual space use and site fidelity, we examined: 1) daily space use; 2) how space use changes within the staging period; 3) individual fidelity to daily total and core activity areas; and 4) how this fidelity changes with time since the first visit of an individual to an area. We assessed site fidelity on two different spatial scales (*i.e.,* total and core) to investigate whether there is a difference between the scales. This knowledge is essential for implementation of preventive measures at an appropriate spatiotemporal scale to effectively mitigate crop damage while preserving large grazing birds at important staging sites.

2. Methods

2.1. Study area

The study was conducted in Kvismaren (59°10′N/15°22′E), in the boreo-nemoral zone of south-central Sweden (Fig. 1). The study area (minimum convex polygon of all included crane GPS locations) covered 237 km^2 (Fig. 1). The landscape is flat and dominated by productive farmland (~66%) where cereals, ley and potatoes are dominant crops. Crops are generally harvested between August and early October, but harvest is influenced by crop type and weather. The mean ± S.D field size within the study area (Fig. 1) was 0.05 ± 0.08 km^2 and was defined from field borders derived from the administrative database of cultivated crops in Sweden (The Swedish Board of Agriculture, 2017). The mean precipitation (± S.D) in Kvismaren during the month of September (1994–2014) was 57.8 ± 38.1 mm (Asker D: SMHI, 2017). The area is listed under the Ramsar convention of wetlands and as an EU Natura 2000 site (EEA, 2016). The core of the area is a birdlife reserve consisting of two shallow eutrophic lakes, 2.5 km apart, surrounded by narrow strips of grazed wetlands. The shallow lakes and the surrounding agricultural landscape provide both suitable roosting sites and favorable foraging conditions for several large grazing birds (*i.e.,* cranes, bean geese *Anser fabilis fabilis* and greylag geese *Anser anser*). Kvismaren has been a key staging site for large grazing birds during the last 30 years. The site hosted the most cranes during autumn in Sweden with maximum numbers of 15 500–19 500 cranes, 2009–2014 (Nilsson, 2016).

Increasing aggregations of foraging birds in the area has led to an increase in crop damage. Costs for preventive measures and damage compensation in this area have ranged from 48 000 € (in 2010) to 150 000 € (in 2012) (J. M. Wikland, Örebro county administrative board, pers. comm.). In Sweden, measures used to prevent damage from large grazing birds on agricultural fields include scarecrows, propane cannons, diversionary fields (*i.e.,* supplying food at undisturbed locations), and occasional local culling (Hake et al., 2010). The level of scaring activity in our study area was intensive, but difficult to monitor because deployment and operation of devices was uncoordinated. Collectively, the damage control manager for the study area used in total approximately 35 propane cannons, 100 wooden human silhouettes, 3500 pennants and fireworks to repel cranes and geese from fields with unharvested crops during the study period (P. Nilsson, Örebro county administrative board, pers. comm.).

2.2. Capturing and tagging

Nineteen juvenile cranes were captured and equipped with backpack-GPS-transmitters in 2012–2014 ($n_{2012} = 7$, $n_{2013} = 5$, $n_{2014} = 7$) with 14 cranes receiving Vectronic GPS-plus bird backpacks and five cranes receiving Cellular Tracking Technologies (CTT) where the latter was recharged by a solar panel (for details about capture see Månsson et al., 2013). Capture and tagging fulfilled ethical requirements for research on wild animals after approval from the Animal Ethics Committee of central Sweden (C104/10 and C53/13). The captures were conducted within a 30 km radius of Grimsö Wildlife Research Station (59°43′N/15°28′E, 85 km north of Kvismaren) during the breeding season (July and early August) and the fledged cranes migrated with their parents (*i.e.,* a family group) to Kvismaren in late August or early September, before continuing their migration south in late September or early October. Vectronic transmitters were programmed for intensive positioning (1 location/30 min from dawn to dusk) during 8 days evenly distributed during the staging period (*i.e.,* from arrival until late September). CTT solar panel transmitters allowed for continuous intensive positioning (1 location/30 min) during the full staging period. Each individual was monitored during their first staging period in Kvismaren. As juvenile cranes usually stay with their parents for several months after leaving the breeding grounds (Alonso and Alonso, 1993) the GPS locations mirrors the movement of the family group (*i.e.,* parents and occasionally one sibling). During migration the family groups congregate with conspecifics in larger flocks (Aviles, 2003).

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