Bird Conservation International (2013) 23:463–468. © BirdLife International, 2012
doi:10.1017/S0959270912000482

Short communication

Conservation of Iberian Black Storks *Ciconia nigra* outside breeding areas: distribution, movements and mortality

LUIS SANTIAGO CANO, CLÁUDIA FRANCO, GUILLERMO DOVAL, ALEJANDRO TORÉS, ISIDORO CARBONELL and JOSÉ LUIS TELLERÍA

Summary

Seven out of ten Black Stork chicks fitted with satellite tags successfully made the journey from Iberia to the Sahel. Four died there during their first winter and one additional bird in the second winter. Our results show that 30% of the tagged fledglings died in Iberia and 50% (5/10) in the Sahel. In the Sahel, Black Storks occupy areas of seasonal rivers and small bodies of water in these sub-Saharan savannas, where they track suitable sites according to the progressive drying of the Sahel after the summer monsoon. This behaviour may make them more susceptible to coming into contact with humans and, consequently, current and future action plans for conserving the Iberian Black Stork population should link efforts with AEWA's Strategic Plan and other international initiatives to promote the global use of water resources for humans and wildlife in the Sahel.

Introduction

Migratory animals present a unique challenge for predicting population trends because they are influenced by events at multiple stages of their annual cycle that are separated by large geographic distances (Norris and Marra 2007). This may be a critical issue in endangered birds because, in addition to non-fatal carry-over effects produced by geographical differences in habitat quality, it is important to know the existing rates of mortality throughout the full migratory circuit. However, data on the fate of scarce species are difficult to obtain because of the challenges in monitoring populations over the huge areas they cover during their migratory movements (Webster *et al.* 2002). Fortunately, these shortcomings are being rapidly surmounted by the use of tracking technologies designed to provide direct information on migratory individuals over large areas (Fiedler 2009).

In this note, we explore the movements and mortality of a set of satellite-tagged Iberian Black Storks *Ciconia nigra* moving to Africa. These birds belong to the vulnerable Iberian population (around 400 breeding pairs), which is isolated from the main range of the species in Eurasia (Cano *et al.* 2006). Migratory movements and stopovers of Central European Black Storks have already been studied by satellite telemetry (Bobek *et al.* 2008, Chevallier *et al.* 2011), but we have little knowledge on the movements of the Iberian population and we know nothing about mortality patterns within the migratory circuit (Cano 2004).

After breeding and during the migratory and wintering period, Black Storks move along riverbanks and among pools in search of food (Jiguet and Villarubias 2004). We do not know the extent of these movements in Iberian Black Storks nor whether they differ between the Iberian

Peninsula (just after the breeding period and before moving south) and the wintering area in the Sahel. Differences in these movements are usually related to the availability of suitable sites at which to feed (Schoener 1968). Thus, differences in the way storks move could reflect difficulties in coping with habitat requirements and could explain mortality patterns in Iberia and the Sahel. In addition, Black Storks are strongly affected by direct interference and overexploitation of water resources by humans (Chevallier *et al.* 2010). If we presume that protected areas may reduce conflicts between humans and wildlife, it would be interesting to explore whether post-breeding ranges and mortality of Iberian Black Storks occur inside or outside the reserve network (Jiguet *et al.* 2011). This may allow us to test the effectiveness of protected areas in the conservation of this species, which is listed in Annex 1 of the EU Directive on the Conservation of Wild Birds (EEC/79/409), recorded as SPEC 2 by BirdLife International (2011) and included in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA).

Methods

We studied the movements and survival of 10 satellite-tagged Black Storks. Eight nestlings were equipped with Solar-GPS/Argos PTTs-100 70 g tags from Microwave Telemetry (USA) at different sites in Eastern Portugal (two birds in 2003, two in 2004 and one in 2006) and central Spain (two in 2007 and one in 2008). The Solar-GPS PTTs were programmed to collect data every hour of daylight for two Black Storks in Portugal and every two and three hours of daylight in Portugal and Spain for the other six birds. In 2005, one breeding adult and one immature bird were captured in western Spain and equipped with conventional Argos PTT 60 g tags from Northstar Science (USA). Signals from these transmitters were intercepted by NOAA satellites and sent to Argos headquarters. Only the most accurate locations provided by Argos (categories 3, 2, 1) were used to study the distribution of storks. Georeferenced locations of tagged birds were analysed with ArcView® GIS 3.2 and ArcGIS® 9.2. We used the density of locations to explore the ranges used by individual Black Storks in Iberia and Africa. We estimated 50% and 90% adaptive kernels to define the size and structure of individual ranges, particularly to show the existence of large, contiguous ranges or disconnected multi-nuclear ranges. All individual ranges were calculated by using Home Range Extension (Rodgers and Carr 1998) for ArcView3.2®GIS. We explored the way individuals moved within their ranges in Iberia and the Sahel by assessing the number of kilometres moved per day. We used available geographic information to map the protected area networks in the western Sahel (IUCN and UNEP 2010), Portugal and Spain (EEA 2010). Surface area of global ranges inside protected areas was calculated for each individual in Iberia and Africa. We used Mann-Whitney U-tests and factorial ANOVA to compare between-period differences in the size ranges and the mean daily distances covered by birds in their summer and winter ranges. All computations were performed using STATISTICA version 7.0 for Windows.

Results

Of the 10 tagged individuals, three died in Iberia before moving to Africa. One young bird died just after leaving the nest and was discarded from further analyses; another was lost during the post-fledging period in Iberia and another during autumn movements across the Peninsula before crossing the Strait of Gibraltar. Of the seven individuals arriving in the Sahel, four abruptly ceased to move during the first winter and one other during the following winter. The last locations received from two transmitters were from villages, two others were from fixed localities in the wild and the carcass of the last bird was recovered in Senegal. If we assume that the most plausible explanation for these abrupt halts in transmission is the death of the birds, our results show that 30% (3/10) of tagged birds died in Iberia post fledgling, and 50% (5/10) in the Sahel (70% over the course of two winters).

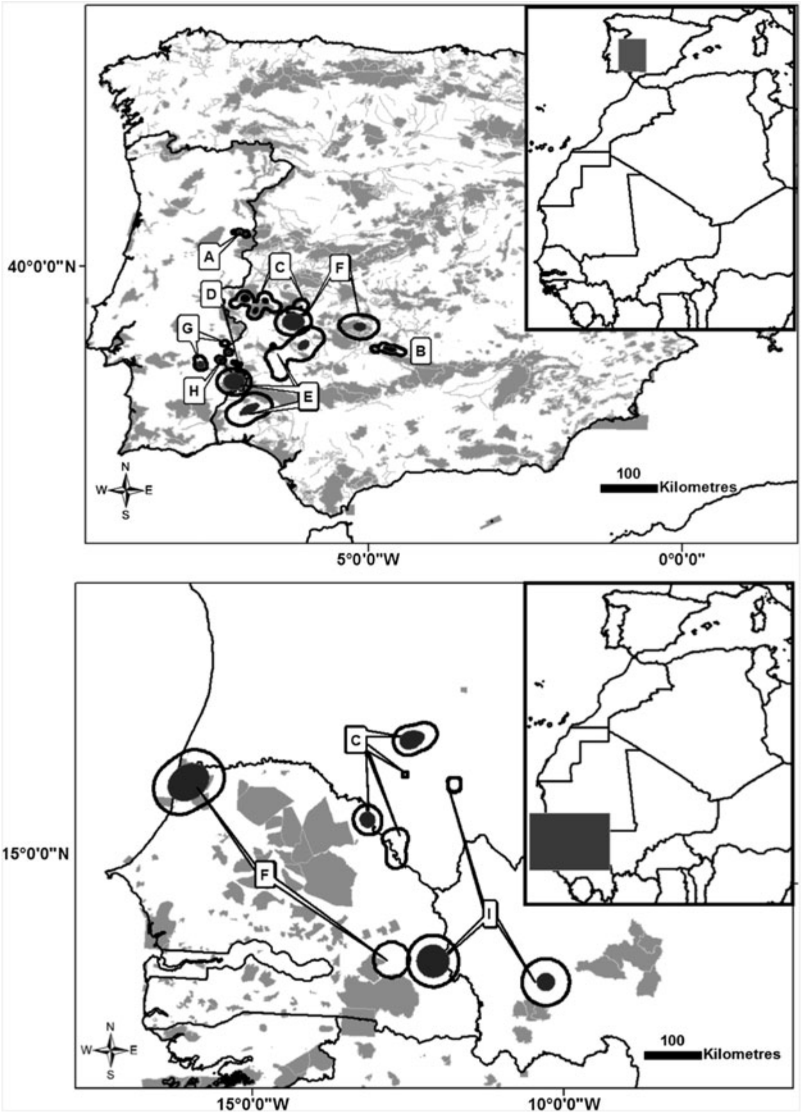

Figure 1. Adaptive Kernel core ranges by 50% and 90% of locations of Iberian Black Storks during the post-breeding (above) and wintering (below) seasons. Grey areas represent the protected areas in Iberia and Africa. A: Espartero; B: Caridad; C: Lavandula; D; Negrita; E: Lua Nova; F: Fe; G: Venâncio; H: Nerium, I: Esperanza.

Home ranges post fledgling (1,955.6 ± 963.63 km^2, n = 8) in Iberia were smaller than in Africa (11,473 ± 1,764.4 km^2, n = 3; Mann-Whitney U test, $U < 0.01$; $P < 0.05$). Some Iberian birds (n = 4) showed continuous large ranges and the rest multi-nuclear ranges. The African ranges split into at least two different nuclei located more than 150 km from each other (Figure 1). Differences in the size of ranges were related to differences in daily movements, with storks moving longer distances in Africa than in Iberia (factorial ANOVA; Iberia vs. Africa effect: $F_{1,1024} = 16.99$, $P < 0.001$; individual bird effect: $F_{5,1024} = 8.35$, $P < 0.001$; interaction $F_{5,1024} = 0.37$, $P = 0.866$; Figure 2).

https://doi.org/10.1017/S0959270912000482 Published online by Cambridge University Press

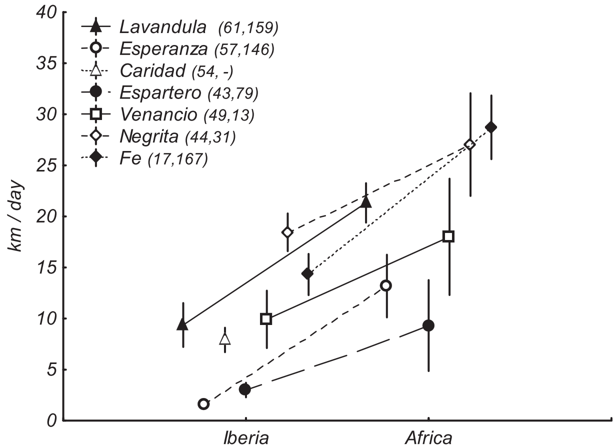

Figure 2. Mean (± SE) daily distances covered by Iberian Black Storks in Iberia and Africa. In parentheses are the number of days considered in Iberia and Africa. The daily distance covered by Caridad is missing in Africa because this bird died upon arrival.

More than one third (37.2%, n = 8) of the Iberian ranges and less than 10% (8.6%, n = 3) of the African ranges of individual Black Storks were within protected areas. One of the three storks lost in Iberia and one of the five Black Storks lost in the Sahel disappeared within a protected area (Sierra de San Pedro, Spain, and Diawling, Mauritania).

Discussion

According to these results, the mortality of Iberian Black Storks was strongly related to their fate in Africa, where most deaths occurred. It has been shown that Black Storks occupy areas of seasonal rivers and small bodies of water in these sub-Saharan savannas, where they track suitable sites according to the progressive drying of the Sahel after the summer monsoon (Hourlay 2003, Bobek *et al.* 2008, Chevallier *et al.* 2010). In Iberia, storks also track fish in drying creeks and along riverbanks, but benefit from the increasing number of cattle-watering ponds interspersed within the Portuguese and Spanish *dehesas* (Moreno-Opo *et al.* 2011). These environmental differences could explain the huge ranges covered by Black Storks in Africa and their long daily movements (Figures 1 and 2). It may be postulated that reduced water availability in the Sahel (Zwarts *et al.* 2009), and the increasing use of water pools by humans and cattle as drought advances after the summer monsoon, force individuals to move greater distances in search of suitable habitat, a situation that has also been reported in other water-dependent species (Legagneux *et al.* 2009). These constraints will probably lead to an increase in mortality in young individuals (most of the Iberian birds involved in this study) due to a lack of knowledge of suitable wintering areas compared to adults (Bobek *et al.* 2008).

Our results also support the remarkable differences between the protected area network affecting this species in Africa and Europe (Chevallier *et al.* 2011). Today, less than 5% of the West African range of wintering Black Storks is protected by reserves (Jiguet *et al.* 2011), a result that agrees with the pattern depicted for Iberian birds (8.6%). This may explain why most of the Iberian storks lost in the Sahel were outside the reserve network. It may be postulated that, in a context of increasing human pressure on water resources in the Sahel, effective management could be easier in protected areas where additional measures could be established to set aside some sectors for conserving water-dependent wildlife (Tellería *et al.* 2008). However, the potential enforcement of effective management guidelines in reserves will be outside a significant percentage of the wintering range of this species in Africa. Consequently, current and future action plans for conserving

https://doi.org/10.1017/S0959270912000482 Published online by Cambridge University Press

the Iberian Black Stork population should link efforts with AEWA's Strategic Plan and other international initiatives to promote the global use of water resources for humans and wildlife in the Sahel.

Acknowledgements

We thank Victor García, Borja Heredia, Roberto Carbonell, Rocío de Quadros, Belén Vázquez-Quevedo, Javier Marchamalo de Blas and Geoffroy De Schutter for their support and contribution to different aspects of the work. ICNB, Acuavir and Flying Over Natura 2000 project (07040200.00/2004/393583/SUB/B2) provided data for this research. This paper is a contribution to the project CGL2011-22953 "*Conservation of migratory birds in Iberia and the Maghreb: present patterns and future changes*" supported by the Spanish Ministry of Science and Innovation and to the International Campus of Excellence (CEI Campus Moncloa) launched by Complutense University of Madrid (UCM) and Polytechnic University of Madrid (UPM).

References

BirdLife International (2011) http://www.birdlife.org/datazone/userfiles/file/Species/BirdsInEuropeII/BiE2004Sp3830.pdf (accessed on 10 August 2011).

Bobek, M., Hampl, R., Peske, L., Pojer, F., Somek, J. and Bures, S. (2008) African Odyssey project–satellite tracking of Black Storks *Ciconia nigra* breeding at a migratory divide. *J. Avian Biol.* 39: 500–506.

Cano, L. S. (2004) Cigüeña Negra *Ciconia nigra*. In: L. M. Carrascal and A. Salvador, eds. *Enciclopedia virtual de los vertebrados españoles*. Madrid: Museo Nacional de Ciencias Naturales. http://www.vertebradosibericos.org/ (accessed on 09 May 2012).

Cano, L. S., Franco, C., Pacheco, C., Reis, S., Rosa, G. and Fernández, M. (2006) The breeding population of Black Stork *Ciconia nigra* in the Iberian Peninsula. *Biota* 7: 15–23.

Chevallier, D., Maho, Y. L., Baillon, F., Dupponois, R., Dieulin, C., Brossault, P., Lorge, P., Aurouet, A. and Massemin, S. (2010) Human activity and the drying up of rivers determine abundance and spatial distribution of Black Storks *Ciconia nigra* on their wintering grounds. *Bird Study* 57: 369–380.

Chevallier, D., Maho, Y. L., Brossault, P., Baillon, F. and Massemin, S. (2011) The use of stopover sites by Black Storks (*Ciconia nigra*) migrating between West Europe and West Africa as revealed by satellite telemetry. *J. Ornithol.* 152: 1–13.

EEA (2010) *Natura 2000 data - the European network of protected sites*. http://www.eea.europa.eu/data-and-maps/data/natura-1 (accessed on 6 May 2011).

Fiedler, W. (2009) New technologies for monitoring bird migration and behaviour. *Ring. Migr.* 24: 175–179.

Hourlay, F. (2003) Wintering of Western-European Black Storks in West Africa: results of satellite monitoring campaigns and carried out between 1995 and 2000 by the "Cigognes sans frontiers", program and University of Liege. *Aves* 40: 172–174.

IUCN and UNEP (2010) The World Database on Protected Areas (WDPA). Cambridge, UK: UNEP-WCMC. www.protectedplanet.net (accessed on 6 May 2011).

Jiguet, F. and Villarubias, S. (2004) Satellite tracking of breeding Black Stork (*Ciconia nigra*): new incomes for spatial conservation issues. *Biol. Conserv.* 120: 153–160.

Jiguet, F., Massemin, S. and Chevallier, D. (2011) Predictive distribution models applied to satellite tracks: modelling the western African winter range of European migrant Black Storks *Ciconia nigra*. *J. Ornithol.* 152: 111–118.

Legagneux, P., Blaize, C., Latraube, F., Gautier, J. and Bretagnolle, V. (2009) Variation in home-range size and movements of wintering dabbling ducks. *J. Ornithol.* 150: 183–193.

Moreno-Opo, R., Fernández-Olalla, M., Guil, F., Arredondo, A., Higuero, R., Martín, M., Soria, C. and Guzmán, J. (2011) The role of ponds as feeding habitat for an umbrella species: best management practices for the

Black Stork *Ciconia nigra* in Spain. *Oryx* 45: 446–455.

Norris, D. R. and Marra, P. P. (2007) Seasonal interactions, habitat quality, and population dynamics in migratory birds. *Condor* 109: 535–547.

Rodgers, A. R. and Carr, A. P. (1998) *HRE: The home range extension for ArcView*. Thunder Bay, Ontario, Canada: Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research.

Schoener, T. W. (1968) Sizes of feeding territories among birds. *Ecology* 49: 123–141.

Tellería, J. L., El Mamy, H., Fernández, J. M., Bartolomé, J. and Montiano, E. (2008) Crocodiles as focal species for conserving water resources in Mauritanian Sahara. *Oryx* 42: 292–295.

Webster, M. S., Marra, P. P., Haig, S. M., Bensch, S. and Holmes, R. T. (2002) Links between worlds: unraveling migratory connectivity. *Trends Ecol. Evol.* 17: 76–83.

Zwarts, L., Bjilsma, R. G., van der Kamp, J. and Wymenga, E. (2009) *Living on the edge: Wetlands and Birds in a changing Sahel*. Zeist, The Netherlands: KNNV Publishing.

LUIS SANTIAGO CANO*
Departamento de Zoología y Antropología Física, Facultad de Ciencias Biológicas, Universidad Complutense-CEI Moncloa, 28040 Madrid, Spain.

CLÁUDIA FRANCO
Instituto da Conservação da Natureza e da Biodiversidade, Rua de Santa Marta 55, 1169-230 Lisboa, Portugal.

GUILLERMO DOVAL
C/ Nuestra señora de la Soledad 7, 28720 Bustarviejo, Madrid, Spain.

ALEJANDRO TORÉS
P.O. Box 3131, 47080 Valladolid, Spain.

ISIDORO CARBONELL
C/ Pozo 5, 37449 Galindo y Perahuy, Salamanca, Spain.

JOSÉ LUIS TELLERÍA
Departamento de Zoología y Antropología Física, Facultad de Ciencias Biológicas, Universidad Complutense-CEI Moncloa, 28040 Madrid, Spain.

**Author for correspondence; email: catuche.gallego@gmail.com*

Received 18 August 2011; revision accepted 4 March 2012;
Published online 3 April 2013