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Migration and wintering patterns of a central European population of Common Cranes *Grus grus*

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Capsule German breeding birds wintered mainly in southwest Spain and some in France.
Aims To describe migration routes and phenology, and the interannual fidelity to staging and wintering sites.
Methods A total of 93 cranes were colour-banded, and 67 of them radiotagged, at their breeding territories in northern Germany and later located at their wintering areas in Spain.
Results After a migratory trip lasting 3–28 days, most cranes arrived at Gallocanta in northeastern Spain, where they staged for 1–44 days. Some families stayed there the whole winter, but most continued to southwestern Iberia, where they dispersed over at least 13 wintering areas. Site fidelity was more marked in adult pairs than immatures, half of which used different areas in their second and third winters from those used by their parents.
Conclusions Most German cranes wintered in southwestern Spain, with smaller numbers in France. Some immatures remained in France as second- or third-year birds, after having spent their first winter in Spain with their parents, whereas none of them shifted southwards. This suggests that immatures have probably contributed more than adult pairs to the northward shift in the winter range observed during the last decades.

Although it is known that the Iberian peninsula is the main wintering area for European Common Cranes *Grus grus* (Glutz *et al.* 1973, Cramp & Simmons 1980, Alonso & Alonso 1996), available information on their migration routes is based on counts at staging and wintering areas (Prange 1989, Alonso & Alonso 1990, 1996, Salvi *et al.* 1996), and just a few records of about 100 birds banded with metal rings in Europe (Swanberg 1987). A ringing project based on three colour-ring codes and radiotagging started in Spain in 1988 and resulted in a significant increase in information on the precise location of breeding area, migratory routes and wintering sites of cranes in Europe (Alonso & Alonso 1999, ECWG 2007).

We present the results of a five-year study of aerial location of Common Cranes radiotagged at their breeding locations in Germany. German cranes (about 5000 breeding pairs; total number of birds is 24 000 to 25 000, including one-year-old birds from Scandinavia and Baltic countries) can be considered representative of the crane population migrating through western Europe. Field conditions in Germany allowed us to capture and mark a sufficient number of birds to carry out the study.

Our objectives were to study the migration and wintering patterns of a central European population of this species, identify their migration routes, staging and wintering areas, and assess the degree of interannual winter site fidelity. The short- and long-term changes in numbers of cranes wintering at various sites (Fernández *et al.* 1981, Alonso & Alonso 1990, Avilés *et al.* 2002) suggest that at least part of the population is highly mobile and may shift from year to year between alternative wintering areas. On the other hand, two different migration routes have been described within the Iberian peninsula, one through the northwest and another through the northeast (Alonso & Alonso 1990), but it is not known whether the same birds use each route year after year. We quantify the mobility and use of both routes.

Finally, a shift of the northern limit of the crane

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wintering area from Spain to France has occurred recently (Alonso *et al.* 2003), probably due to abundant food resources at maize stubble fields after harvest in autumn at higher latitudes, i.e. closer to the breeding areas (Génard *et al.* 1992, Salvi *et al.* 1996, Salvi 1999). We test whether these birds are immatures that are not faithful to their parents' traditional wintering areas in the Iberian peninsula.

METHODS

Between 1995 and 1999, 93 Common Cranes were captured as flightless young (89 birds) or moulting adults (four birds) at their breeding territories in Mecklenburg-Vorpommern, northern Germany, in an area covering 690 km^2 centred at 53°36′N, 12°00′E (Fig. 1). All birds were provided with individual combinations of three colour-rings for visual identification; 67 of them (63 young and four adults; five birds in 1995, 18 in 1996, 18 in 1997, 15 in 1998 and 11 in 1999) were additionally provided with backpack (47 birds) or leg-mounted (20 birds) TW-3 radio-transmitters (Biotrack Ltd, UK). The weight of the young captured varied between 1700 and 4050 g; the adults weighed 4650–5700 g. As a rule, only birds weighing less than 3000 g were provided with leg-mounted transmitters, which were attached to the leg by a leather strip or glued to a long PVC band. The leg-mounted transmitters weighed 20–30 g and the backpack ones 65 g; the life of their batteries was two years and three to five years, respectively. For details on capture and marking see Nowald (2003).

The breeding area of the cranes in Mecklenburg is flat to slightly undulating, cultivated mostly with cereal and rape, and with small to medium-sized wooded areas where most pairs nest, usually in flooded alder wetlands. Radiotagged cranes were located with variable periodicity during the post-nesting period throughout the summer both at their territories, where they remain until late July, and at their main summer concentration area, the Langenhägener Seewiesen, where they roost until migratory departure usually in late October or early November.

During the winter seasons (October to March) of 1995/96 to 1999/2000 we made monthly surveys both with telescopes and radiotracking receivers at Laguna de Gallocanta in northeastern Spain (40°58′N, 1°30′W), one of the main staging and wintering areas on this migratory route. In 1996/97 and 1997/98 we additionally installed an automatic location system (ALS; Radiolocation AB, Sweden) at 2 km from the main roost. This system allowed us to calculate the exact date of arrival of marked cranes in these two winter seasons. The ALS recorded on computer diskettes the presence of all radiomarked birds every five minutes continuously from mid-October to mid-March. To test that the system worked properly, we installed two beacon transmitters close to the roost which were also recorded by the ALS. The main purpose of these surveys and radio-frequency searches at Gallocanta was to determine the proportion of cranes that either staged or spent the whole winter there, and to determine whether this is related to the choice of migration route in Iberia.

Figure 1. Location of the Spanish wintering sites of 24 radiotagged cranes mentioned in Table 1. 1, Gallocanta; 2, Navalcán; 3, Rosarito; 4, Valdecañas; 5, Gabriel y Galán; 6, Borbollón; 7, Talaván; 8, Aldea del Cano; 9, Cornalvo; 10, Pela; 11, Siruela; 12, Peraleda del Zaucejo; 13, Castuera. The inset map shows where cranes were radiotagged in Germany, and the areas where we searched for marked cranes: Arjuzanx in SW France, Gallocanta in NE Spain, and Extremadura, the main wintering area in SW Spain.

We considered the month of January as the main wintering period, as very few cranes move between different areas during that month. In January from 1996 to 2000 we made one or two aerial searches of all radio-frequencies over all potential wintering areas in Extremadura and nearby regions in southwest Spain, which together with Gallocanta contains about 85% of the estimated 70 000 to 80 000 cranes wintering in the Iberian peninsula (Alonso & Alonso 1990, 1996, Sánchez *et al.* 1998). Our aerial locations represent a non-biased sample of the wintering area of the cranes, as compared with previous sightings of banded birds at certain staging or wintering areas with particularly high numbers of birds. Aerial searches did not include

France, Morocco and five or six small wintering areas in other Spanish regions and Portugal, which may have held a total of 20 000 to 39 000 birds in the three winters studied (P. Petit, pers. comm., own unpubl. data). At the main staging area in southwest France a search for radiotagged cranes was performed with a radio-receiver during the winters of 1998/99 and 1999/2000, and additional searches were carried out every winter using telescopes (P. Petit, S. Avignon and C. Riols, pers. comm.).

Aerial location in southwest Spain was performed with a Bonanza E-24 aircraft of the Spanish Air Force, to which we had attached two antennae, a three-element Yagi directional antenna and an omni-directional antenna; this combination of antennae allowed the survey of large areas. The equipment used for both aerial and ground tracking was a TS1-TR2 scanner-receiver (Telonics Inc., USA). After hearing a signal, the exact position of the bird was determined with a GPS receiver. Detection distance depended mainly on the bird's position and activity, reaching up to 40 km. The average distance between aerial co-ordinates and subsequent ground locations was only about 500 m (more details on aerial tracking techniques are given in Cochran 1972, 1980, Drewien & Bizeau 1981, Gilmer *et al.* 1981).

Of the 67 radiotagged young cranes, 19 died during their first summer/autumn (between July and the beginning of October) before leaving Germany on migration, therefore the final sample that could be tracked in Spain was 48 birds (see Table 1). Among these were seven pairs of siblings that hatched in the same year and survived until winter, three groups of siblings hatched in different years by the same parents, and three groups of parents with their offspring. Therefore, when analysing the diversity of migration and wintering patterns of these birds in Spain, the sample size was 34 families (identified with different letters in Table 1), as siblings and parents with their offspring could not be considered as independent data points during their first winter, when they migrated and wintered together as a single family unit. For some of the birds belonging to these 34 families, we had data from a variable number of winter seasons, depending on both the year when the birds were radiotagged and the lifetime of the transmitter, but these interannual changes in wintering site selection are analysed separately.

To study the repeated use of the same wintering sites by adult cranes we used the sample of four radiotagged adults and the locations of radiotagged young of

Table 1. Wintering areas of cranes radiotagged in Germany between 1995 and 1999.

Individual	1st winter	2nd winter	3rd winter	4th winter
A-95 ad	PEL	PEL	[a]	
B1-95	NAV	NAV	[b]	
C1-95	GG		[b]	
C2-95	GG	[b]	AC	TAL
D1-96	PER	AC	VAL	PEL
E1-96	PEL	PEL	PEL	PEL
E2-96	PEL	PEL	[b]	
F-96 ad	PEL	PEL	PEL	
G1-96			France	France
H-96 ad	SIR		SIR	
I1-96	ROS	ROS	ROS	ROS
J1-96	PEL	GAL	[b]	
K1-96	AC	AC	TAL	[b]
L1-96	TAL		[b]	
M1-96				France
C3-97	GG	GG	GG	
D2-97	[a]			
D3-97				
F1-97			France	
G-97ad	ROS	ROS	ROS	
H1-97	COR			
N1-97	GG	GG	PEL	
N2-97	GG	GG		
O1-97	France	France	France	
O2-97	France	GAL	France	
P1-97	BOR		France	
Q1-97				
R1-97	TAL	TAL	France	
S1-97	PEL	NAV	NAV	
T1-98				
U1-98	[a]			
C4-98				
C5-98				
V1-98	PEL	PEL		
X1-98	France	France		
Z1-98		ROS		
AA1-98	GG	ROS		
AB2-98	France	France		
AC1-99	VAL			
M2-99	GAL			
AD1-99	GAL			
AE1-99				
AE2-99	GAL			
AF1-99	CAS			
AG1-99	ROS			
W1-99				
AH1-99				
AI1-99				

Birds are identified by alphanumeric codes; those with the same letter and different number are siblings; the number after the hyphen is the year of marking. All birds were marked as young except four, which were captured as moulting adults (indicated by 'ad'). Areas: AC, Aldea del Cano; BOR, Borbollón; CAS, Castuera; COR, Cornalvo; GAL, Gallocanta; GG, Gabriel y Galán; NAV, Navalcán; PEL, Pela; PER, Peraleda; ROS, Rosarito; SIR, Siruela; TAL, Talaván; VAL, Valdecañas (see Fig. 1). [a]Birds found dead in autumn 1997. [b]Transmitter battery exhausted; these birds may still be identified through their colour bands

families where adults were not marked but their young were marked in consecutive years. We assumed that parents of the latter bred every year in the same nest (confirmed through personal observation at various nests with banded adults). The location of the offspring of these adults on subsequent winters enabled us to know the parents' wintering site, as the family remains together until at least the initiation of spring migration (Alonso *et al.* 1984).

RESULTS

Phenology and duration of the migration

Departure dates of radiotagged cranes from Langenhägener Seewiesen, the main summer staging area in northern Germany, were 22–27 October in 1995 (mean 24 October) , 22 October to 12 November in 1996 (mean 5 November), and 2–22 October in 1997 (mean 12 October). Cranes arrived in Gallocanta between 15 November and 7 December in 1996 (mean 23 November), and between 23 October and 19 November in 1997 (mean 27 October). The time spent migrating between both areas was 3–28 days (mean 17.2 ± 8.2 sd; n= 16 birds, 8 in 1996 and 8 in 1997).

The duration of the migratory trip was not correlated with the departure date from Germany (r = 0.03, P = 0.93, n= 17; both study years were pooled as they were similar regarding weather conditions). Most cranes arrived in Gallocanta during the daytime (14 out of 16 birds), with only two birds arriving by night (at 03:57 and 04:30 hours); these two cranes did the whole migratory trip in only four and three days, respectively.

Staging at Laguna de Gallocanta

Staging at Gallocanta was monitored for 16 families between 1995/96 and 1997/98. Not all cranes used this area as a stopover during migration: nine families (56%) did, while seven (44%) flew directly to their winter localities. Only ten birds from five different families (31%) used Gallocanta during both migrations, while nine birds from four families (25%) staged there only in autumn, and one (6%) stopped there only in spring. However, both adults and young can behave in different ways in consecutive years (see Table 1). Autumn staging at Gallocanta was longer and more frequent than spring staging (t = 3.31, df = 26, P = 0.003; autumn, mean 12.7 days ± 13.2 sd, range 1–44 days, n= 18 birds; spring, mean 3.9 days ± 3.8 sd, range 1–13 days, n = 10 birds). Mean departing date from Gallocanta towards midwinter localities further south was 21 November (range 10 November to 30 December).

Only two second-year cranes spent the whole winter in Gallocanta, although the preceding season these families wintered at other areas. Sixteen out of 17 birds passing through Gallocanta were later located at their wintering areas in Extremadura. Finally, two birds were recorded in Gallocanta just for one day during autumn migration and were not found in midwinter.

Patterns of migration and wintering in Spain

Twenty-six of 34 families (76%) were located wintering in Spain. Another four birds from three families (9% of all families) wintered in France. The remaining 13 birds from five families (15%) were not found during winter, and we have no further information of them. Data in Table 1 show four main patterns of migration and wintering of the marked cranes: (a) cranes that wintered in Extremadura and staged regularly during migration at Gallocanta (18 birds of 16 families); (b) cranes that wintered in Extremadura and did not stage at Gallocanta (ten birds of six families; all but three of these birds wintered in areas located in northwestern Extremadura (El Borbollón, Gabriel y Galán, Talaván)); (c) cranes that wintered in Gallocanta (three birds of three families); (d) cranes that wintered in areas other than Extremadura or Gallocanta, including France and Morocco, and did not usually pass through Gallocanta (13 birds of ten families), although the parents of three of these families had wintered in previous years according to pattern (a). In addition, four birds (C1, C2, H1 and L1) that had migrated following pattern (a), when they were dependent on the parents in their first winter, migrated in their second winter following pattern (d); and two birds (P1 and R1) that had migrated following pattern (b) later migrated as immatures following pattern (d).

In summary, most of our radiotagged cranes spent midwinter in Extremadura, southwest Spain (22 of 34 families). Most of them staged at Gallocanta during one or both migrations (11 families out of 16 (69%) with data of migration through Gallocanta), while five (31%) used a migration route not passing through Gallocanta. Finally, only one adult (H-96), on its second winter as a marked bird, changed to a new wintering site outside the area surveyed during this study after passing through Gallocanta, but none of the other three adults with young or the families with marked first-year birds did this. Twenty-two of 24 birds

migrating through Gallocanta were later located at wintering sites included in the area surveyed during this study. Some first-year birds were seen during autumn migration in Arjuzanx, southwest France, since their first winter (families O, X and AB), and probably spent the rest of the winter there. Some families (D, F and G) showed interannual changes in their migration pattern, one year following pattern (a) and another pattern (d).

The 34 families located during midwinter were found in a total of 13 different wintering areas in southwest Spain: nine in Extremadura (18 families), three in Castilla-La Mancha (localities 2, 3 and 4 in Fig. 1) (three families), and one in northeast Spain (Laguna de Gallocanta, Aragón, selected as wintering site by bird J1 in its second year, having spent its first winter in Pela, Extremadura; Fig. 1 & Table 1).

The midwinter sites selected by most cranes were the typical Spanish 'dehesas', open wooded areas of Holm Oak *Quercus rotundifolia* with cereal fields on the ground (eight sites). In another two wintering areas (Pela and Peraleda), cultivated fields of cereal, maize and rice predominated, with few Holm Oak patches. One area (Laguna de Gallocanta) is intensively cultivated with cereal, some sunflower and some maize, and tree vegetation is totally absent.

Interannual fidelity to wintering areas

We were able to track a total of six adult pairs in consecutive winters: families A, F, G and H, where one of both adults was radiotagged, and families C and D, where offspring from consecutive years were marked. Four of these pairs selected the same wintering area in both years, one of them (family C) changed in the third winter. Of two adults (families F and H) with known wintering site during three years, one repeated all three winters and the second changed to a nearby area in the second winter (Table 1). Regarding the juveniles, there were the same proportions of second-year, independent birds, that either repeated in their second winter seasons the wintering pattern of their parents and used the same wintering areas (ten birds), or shifted to different areas at 103–400 km from those of their parents (eight birds). Of five birds for which we have data from three winters, two used the same area in all three winters, one repeated the first two winters and changed in the third, and the remaining two birds changed every winter. The only bird for which we have data from four winter seasons spent midwinter in a different locality in each of these winters (bird C2, see Table 1).

DISCUSSION

Winter distribution

Most radiotagged cranes (76% of families) spent the winter in Spain, and a smaller percentage (9%) in Arjuzanx, southwest France. The rest (15%) probably wintered in non-surveyed areas of France (mainly Lac du Der Chantecoq in the north) or the Iberian peninsula (probably fewer, as only five or six small sites were not included in our aerial searches). They could also have wintered in Morocco, where recent reports have suggest about 2000 wintering cranes (Thévenot 1985a, 1985b). However, fewer birds have probably wintered in Morocco during recent years, as deduced from the overall northward shift of the wintering area of the species (Alonso *et al.* 2003, Salvi *et al.* 1996, Salvi 1999).

Since 1990 an increasing proportion of the European crane population has remained in France throughout the whole winter (P. Petit, S. Avignon & A. Salvi, pers. comm.; European Crane Migration Database 2007), attracted by the higher availability of agricultural food resources (Génard *et al.* 1992, Salvi *et al.* 1996, Salvi 1999, Avignon & Loubeyres 2003). A similar northward shift has been described within Iberia, where the use of Gallocanta lake in northeast Spain as both a staging area and wintering site has increased during the last two decades, reaching peak numbers of over 60 000 birds (Alonso *et al.* 1994). Our current results support the increase observed in France, where some immatures spent their second or third winter after having wintered as first-year birds with their parents in Spain (three radiotagged birds, families G1-96, P1-97 and F1-97). We did not record any cases following the opposite trend, i.e. a shift southwards from France to Spain in successive winter seasons.

It is interesting that our small sample of radiotagged cranes, all coming from a relatively small breeding area in northern Germany, dispersed over practically all of the wintering range, from northern France to southern Spain. Moreover, their winter distribution in Spain was apparently random, as reflected by crane counts of the whole wintering population (Alonso & Alonso 1990, Sánchez *et al.* 1998). As an example, the highest number of marked cranes was found at Navalvillar de Pela, currently the most important wintering area in Spain, with more than 25 000 birds in midwinter.

The birds wintering in sites at the northwest border of their Iberian winter range (e.g. Borbollón, Gabriel y Galán) did not use the main migratory route through Gallocanta to central Spain. They probably flew

through the northwestern Iberian corridor, from the western Pyrenees to northwestern Spain, and then southwards to reach Extremadura. Observations of migrating flocks confirm that a small number of cranes still use that route, which was more important 50 years ago, before most of the wetlands in northern Spain were drained and cultivated. However, our results show that most cranes remain faithful to their migratory route from year to year. The percentage of cranes (56%) using Gallocanta as a staging area was lower than expected from our previous estimates (about 90% of all cranes wintering in Spain, Alonso & Alonso 1990). As peak autumn counts at Gallocanta were 42 239 and 62 000 birds in 1996 and 1997, respectively (J. Sampietro, pers. comm.), our results suggest that the total numbers of cranes migrating through western Europe (70 000 to 80 000 birds, Alonso & Alonso 1990, Sánchez *et al.* 1998) were probably underestimated, and support most recent estimates (over 100 000 birds, Alonso *et al.* 2003, Prange 1999, 2003, 2005).

Migration phenology

The absence of the expected negative correlation between the date of departure from Germany and arrival in Gallocanta indicates that birds do not migrate faster to compensate for a late departure. The duration of the migratory trip probably depends more on weather and food conditions at each staging area throughout the migratory route (Alonso *et al.* 1994). The more frequent and prolonged autumn staging of cranes at Gallocanta agrees with the usually much higher numbers of birds found at this area in autumn (30 000–60 000 birds) compared to spring (15 000–30 000 birds) (Alonso & Alonso 1996, J. Sampietro, pers. comm.). Of all birds located wintering in Spain, 30% never returned to the vicinity of their natal areas after spring migration.

Wintering site fidelity

Most adult cranes with young showed interannual winter site fidelity, but still a significant proportion (about 20–30%) changed their wintering site once during the three winter seasons studied. Immature cranes were less faithful to their wintering sites: half of them dispersed to areas different from those used by their parents and migrated along a different route, especially in their second spring migration. A number of these two- to four-year-old birds used different wintering areas in successive years. This mobility of immature subdominant cranes has also been shown within a single wintering area, where they tend to shift their foraging site with much higher frequency than dominant adults (Alonso *et al.* 1997). Site fidelity is thus more marked in older adult pairs. An extreme end result of this site fidelity is the strong territorial behaviour shown by a small number of crane families, which defended the same feeding territory in several consecutive winters (Alonso *et al.* 2004).

Site fidelity was probably higher before agricultural intensification five decades ago, when most wintering localities were occupied by smaller wintering groups (Alonso & Alonso 1990). Nowadays the increasing use of large farming areas such as Gallocanta and Pela in Spain, or Arjuzanx and Chantecoq in France, with huge concentrations of 10 000 to 40 000 birds, has resulted in a decrease in numbers at many other sites. This process has been described in detail for Gallocanta, and is mainly a consequence of the increase in food availability and protection of roosting sites from hunting activities (Bautista *et al.* 1992, Alonso *et al.* 1994). Our data indeed suggest that birds wintering in small and more distant localities are still showing the highest site fidelity, while those wintering in areas closer to the large concentrations show a higher aggregation tendency, which is more marked among immature birds than adults (Alonso *et al.* 2003).

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