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# Territory size and habitat preference of the Eurasian crane (*Grus grus* L.) during late breeding season in South Central Sweden

Monica Pettersson  
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Mikael Åkesson

Handledare: Mikael Hake

Institutionen för naturvårdsbiologi  
Grimsö forskningsstation  
SLU  
730 91 RIDDARHYTTAN

Nr 127  
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## ABSTRACT

Territory size and habitat preference of 10 Eurasian crane (*Grus grus* L.) families in South Central Sweden were studied during the breeding season, using radio telemetry. In addition the habitat composition of the territories was analysed. Territory sizes ranged from 0.8 to 6.0 km<sup>2</sup> with a mean of 2.1 km<sup>2</sup>. Forest was the most common habitat in the territories (62.3%) followed by farmland (13.6%) and marshland (9.4%). Clear-cut made up 8.2% of the territories, lake 2.4% and other land 4.2%. The habitat use of the cranes was non-random. Forest was significantly underused and there was a clear tendency for a preference of farmland. The cranes sometimes covered long daily distances within the territories (up to 3 km), even before the young were fledged. Pre-migratory excursions outside the territory were observed for two of the families. One family made only one excursion before leaving the territory, but the second made numerous ones during a period of two weeks before they left. Night-roosting sites used in the different territories were the same except for two families, which switched between sites 1-2 km apart. Analyses failed to detect any correlation between date of migration and the age of the young, or between migration and habitat composition, implying that some other factors may be important for the parents' decision on when to leave.

**Keywords:** Eurasian crane, *Grus grus*, territory size, habitat composition, habitat preference

## INTRODUCTION

The Eurasian crane (*Grus grus* L.) breeds in a wide-ranging area in the northern hemisphere from Scandinavia and north-east Europe through Asia to north-central China and North-eastern Siberia, but also in Turkey and Caucasus (Cramp 1980). It winters on the Iberian Peninsula as well as in North Africa, the Middle East, Pakistan, India and southern and eastern China (Archibald & Meine 1996). In Sweden, the species occurs during the breeding season, i.e. between mid-March and early October (Bylin 1980, SOF 2002). The majority of the Swedish population winter in holm-oak woodlands and cultivated areas in Spain and Portugal (Almeida & Pinto 1995).

The Eurasian crane has increased numerically in Europe during the latest decades (Alon 2003, Hake 2003, Leito et al. 2003a, Mewes 2003, Prange 2003, Salvi 2003). The population of the Eurasian crane in Europe 2002 was estimated at 260,000 birds, with 160,000 birds migrating through the western part of Europe and 100,000 birds through eastern Europe (Prange 2002). According to Arvidsson et al. (1992) the number of breeding pairs in Sweden was 12,500 in 1980. A more recent estimation of the Swedish population size performed by Skyllberg et al. (2003) reveals an autumn population of 23,000 pairs and additional 20,000 yearlings and sub-adults, giving a total of 66,000 birds. Thus Sweden harbours a large part of the Eurasian crane population in Europe. The Swedish population may serve as a source of re-establishment and dispersal into areas where the crane previously has gone extinct as a breeding species, i.e. in many countries in Europe (e.g. Cramp 1980), and it is of primary importance that it is protected.

A large part of the cranes migrating through Sweden use three main gathering sites: Kvismaren (59°11'N / 15°22'E), Hornborgasjön (58°19'N / 13°34'E) and Tåkern (58°21'N / 14°48'E). This pattern of gathering at few major sites is consistent with the migration trough Europe, with well-known sites like Rügen-Bock, Germany (54°30'N / 13°15'E) and Lac du Temple, France (48°21'N / 04°25'E). Due to the dependence on few stopover sites on migration, and the fairly slow reproductive ability of the species (e.g. Cramp 1980, see below), the Eurasian crane might be subject to a fast decline in numbers. Therefore it is important to know as much as possible about its ecology. To protect the Eurasian crane in Sweden, more knowledge is needed about breeding ecology and habitat requirements during the breeding season. Acquisition of such information will permit more accurate estimates of population sizes and how many breeding pairs a certain area theoretically can harbour. The knowledge may also be vital to be able to recover the population in case of an incipient decrease. Also, as the crane population has increased, there has been an increase in crop damage caused by the birds in agricultural areas. This is very obvious in Sweden (c.f. Hake 2002), where there has been an increase in compensation for crop damage made by cranes from almost zero to about 50,000 € during the last 20 years 2002 (Wildlife Damage Centre, Grimsö). This increase has made it important to develop methods for preventing the damage. An important part of this work is to collect more information about the ecology of the species.

Few studies have dealt with the breeding ecology of the Eurasian crane, possibly because it is difficult to observe the species without affecting its behaviour. However the technology of telemetry has made it possible to study the breeding behaviour without disturbance, not only in cranes and other birds, but also in behavioural studies of other animal species. The few surveys done recently on breeding ecology of the Eurasian crane have mainly focused on the size of the breeding territory (e.g. Nowald 1999, and Hake 2003) and have been carried out using radio telemetry. Results presented in Hake (2003) for pairs breeding in South Central

and Northern Sweden using the method of Minimum Convex Polygon (MCP), to estimate the size of the home range, show a mean territory size of 1.02 km<sup>2</sup> (n=5) before the young fledged. The mean territory size after fledging was 2.12 km<sup>2</sup> (n=6). In the same study, there was a tendency of larger territories for birds breeding in the northern compared to the southern parts of the country. In Germany, a study made in two subsequent years on the same territory revealed a territory size of 1.03 km<sup>2</sup> the first year and 0.49 km<sup>2</sup> the second, also using the MCP-method (Nowald 1999). These results are in accordance with the information given in Cramp (1980), who states that the size of the territories may vary between 0.5 km<sup>2</sup> and 4 km<sup>2</sup>.

### **Objectives**

The aim of this study is to gain more knowledge on territory size and also on other important aspects of the breeding ecology of the Eurasian crane, e.g. habitat composition of territories and whether the cranes have any preference for some habitats during the breeding season. In addition, the effects of habitat composition of the territories and the age of the young on the date of migration will be evaluated.

## **METHODS**

### **Study species**

The Eurasian crane breeds in wetlands throughout the range of distribution (Archibald & Meine 1996). In Sweden, cranes often breed in bogs with sparse occurrence of trees although sheltered by forest, but reed vegetation in connection to eutrophic lakes is also frequently used as nesting habitat (Bylin 1980, SOF 2002). Leito et al. (2003b) put forward that the size of the habitat in which the nest is located affects the breeding success. Thus it is better to breed on a large bog instead of a small one, which probably is due to an increased ability to observe an approaching predator.

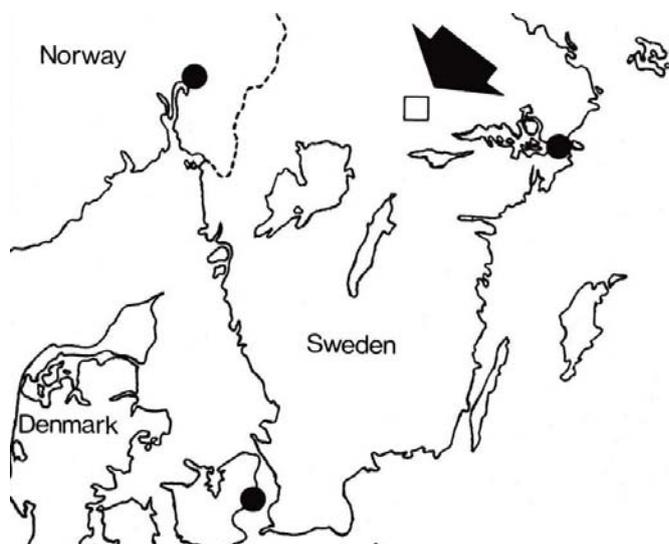
In the beginning of the breeding season, the crane couple immediately start to defend their territory by making unison calls (Archibald & Meine 1996). The nest is built like a platform made of stems, sedge leaves and other wetland plants, and is placed so that it is surrounded by water. Both sexes participate in the nest construction (Archibald & Meine 1996). The nest is 70-100 cm in diameter and 20-30 cm high (Cramp 1980). The eggs, normally 2, are laid a few days apart, in the study area normally around 15<sup>th</sup> of April. Replacement clutches may be laid as late as early June (M. Hake unpublished data). Thirty days after the eggs are laid, they hatch asynchronously, and after 8 – 10 ten weeks the young make their first flying trip (Cramp 1980).

Cranes have a diurnal behaviour of preening and foraging with the young during the day, and roosting close to or at their nest at night (Archibald & Meine 1996). Both males and females care for the young (Archibald & Meine 1996). In Sweden, cranes normally start reproducing when they are about four years old (Lundgren et al. 2003), and have a reproduction of one fledged young every 3<sup>rd</sup> to 4<sup>th</sup> year (Hermansson & Röper 2003, Bylin 1980). Predators on the Eurasian crane are mainly red fox *Vulpes vulpes* L. (Frändén 1958), but also Eurasian lynx *Lynx lynx* Kerr. (C. Wikenros pers. comm.), White-tailed eagle *Haliaeetus albicilla* L., and Golden eagle *Aquila chrysaetos* L. have been reported taking both juveniles and adult cranes (Ivanovsky 1995). Otherwise, human disturbance and human exploitation of suitable breeding grounds has been put forward as the greatest threat to the species (Archibald & Meine 1996).

The Eurasian crane is an opportunistic omnivore, feeding on e.g. roots, seeds, rhizomes, worms, berries, frogs, insects, bird chicks, and voles. In accordance with their generalist approach, they change their feeding strategies on a seasonal basis (Archibald & Meine 1996). Animal items are a more frequently used food resource during summer (Archibald & Meine 1996), and cultivated crops are more important at stopover sites in autumn (Hake 2003).

### Study area

The study was performed in an area surrounding Grimsö Wildlife Research Station (59°44' N / 15°28' E) in South Central Sweden (see figure 1). The area is situated within the boreal zone (Nilsson 1990) and is dominated by bogs and managed coniferous forest with mainly Norway spruce *Picea abies* (L.) H. Karst and Scots pine *Pinus sylvestris* L., but also Larch *Larix decidua* Mill. and deciduous trees such as Birch *Betula sp.* L. and Aspen *Populus tremula* L. occur. Furthermore, small lakes are frequent as well as small aggregated farmland areas. The vegetation period in the area lasts for 180-210 days (Sporrong & Wennström 1990).



**Figure 1.** Location of study area in South Central Sweden.

### Capture and marking of young cranes

The young cranes were captured in known breeding territories, which were localised in a survey made earlier in the season. If the crane family was standing on a field close to a road while passing with a car, a fast approach (i.e. running) towards the family was made, and the young captured by hand. The capturing was made when the young were 6 – 8 weeks old, i.e. during the period just before they fledge. Between 7 July and 17 August 2003, 12 young cranes from 10 families were captured and equipped with radio transmitters (THX-2, TVP Positioning, Lindesberg, Sweden, n=9, and TW-3 AA (x2), Biotrack, Wareham, UK, n=3). The transmitters weighed 70 grams and had an expected life of 5 years. They were attached as backpacks with a harness, made of a broad strap, around the body. The strap was elastic, allowing the young crane to grow to adult size. All cranes were also ringed with a unique individual combination of one metal ring and two plastic colour rings on the left tibia, and three plastic colour rings on the right tibia. Each individual was biometrically measured for wing and tarsus length and weight (see Appendix 2). Also, to estimate the relative age of the young cranes, a developmental growth index was recorded by measuring the length of the longest primary from the blood quills to the tip of the unfolded feather.

### Radio tracking

The positions for the 10 families were obtained during 8 July to 20 September, and were acquired by the standard triangulation method (Mech 1983), using a 4-element Yagi antenna

(Y4-FL, TVP Positioning AB) and a receiver (RX-98, TVP Positioning AB). Bearings were recorded and depicted on a map until a three-way crossing or a small triangle was obtained. The co-ordinates of positions acquired were analysed using the local Swedish co-ordinate system RT90 (Swedish grid). If the individuals were observed visually, no further radio tracking was necessary. Instead the position of the observed crane was noted on the map as a dot. Also, if visible, the habitat that they were seen on was recorded.

At first, each individual was positioned twice every second day, with at least 6 hours interval in order to assure positional independence ( $n=66$  positions). As the number of radio-tagged individuals increased, only one position per day was taken ( $n=279$  positions). This resulted in approximately one position of each individual per day from the day the young cranes were caught until they left their territory. The tracking occasions were spread over the daylight hours (03.00 a.m. – 10.00 p.m.), to reduce the risk that the positions should be biased towards habitat types used by the cranes at certain times during the day. Of the total number of positions ( $N=345$ , see table 1), 80 were taken during night-time in order to reveal the location of the night-roosting sites, and to investigate whether roosting sites remained the same throughout the study period. Night was defined as the period between one hour before sunset until sunrise. Also, in two families, a total of 16 positions (not included in the total number of 345 positions) obtained at the end of the study period was judged to be pre-migratory excursions (c.f. Hake 2003, Lundgren et al. 2003), and was therefore excluded from other analyses.

### **Home range calculation**

From the positions taken for each bird, a minimum convex polygon (MCP) was estimated using the data programme ArcView v3.2. The MCP method constructs a convex polygon based on a line connecting the outer positions (White & Garrot 1990). The area of the MCP was considered to be the size of the territory and was also used as the available area when making the habitat preference analyses. The MCP-method does not make any assumptions on how much the animal is visiting different parts of the estimated home range, which for example the estimators of bivariate normal ellipse do (White & Garrot 1990). This seems therefore to be a preferable method because, 1) there is little current scientific knowledge about how cranes move and behave in their breeding territories, and, 2) the mobility of the cranes enables them to use and travel through (or pass) habitats (e.g. water) that would hamper any ground living animal (Begon et al. 1996).

### **Habitat composition of the territories**

The digital T5 version of the topographical map “Gröna Kartan” (Scale 1:50 000, Metria, Gävle 1998) was used as basic layer for making the habitat- and preference analyses. Information on which crops that had been sown the present year was received from the County administrative boards of Örebro and Västmanland. Data on clear-cuts were received from the Regional forestry boards of Värmland-Örebro and Mälardalen, and from the governmental forest company SVEASKOG, Skinnskatteberg. These received data were implemented into the topographical map. Most of the data were principally given in data files compatible for analyses in ArcView v3.2. Other data obtained were digitalised into an ArcView compatible format. 13 different habitats were identified in the territories (see table 2). These habitat classes were rearranged to get a more general idea of the habitat composition in the territories, resulting in six habitat categories: “forest”, “clear-cut”, “farmland”, “marshland”, “lake”, and “other”. The combination was made on the basis of ecological and structural similarity of habitats. For the preference analysis, marshland and lake were merged into the category “wetland”. This was done because marshland and lake were sometimes

difficult to separate, as the lakes were mainly shallow and eutrophic, and thus suitable for feeding and night-roosting for the cranes. All habitats used in the analyses are presented in Appendix 1, in which a more specific description of the habitats is given.

### **Habitat preference**

Only the habitat preference within the territories could be analysed in this study, as the location of all crane territories in the study area was not known, and the birds were not captured randomly in the area (i.e. there was a higher probability to capture birds with fields in their territory). One can therefore not say how large the available area around an estimated home-range might be. Furthermore, the 80 positions obtained during night-time were excluded in the preference analysis, as positions obtained when the birds were at, or moved on to or from their night-roost could bias the result. The data for testing habitat preference consisted of the observed and expected numbers of observations in the different habitat categories: forest, clear-cut, farmland, wetland and other. Data on available habitat were transformed into integers in order to get the expected numbers of positions in each home-range. The formula used below, follow White & Garrot (1990):

$$\text{Expected (integer)} = \frac{\text{proportion of habitat in territory} * \text{total number of observations in the territory}}$$

To analyse whether the families' selection of habitats within the territory was non-random, a Chi-square test was performed. Each family was tested separately. In order to see whether it was a consensus result, Fisher's method for combining probabilities (Sokal & Rohlf 1995) was used. The method is applicable for obtaining an overall significance level when a given hypothesis has been tested numerically on similar datasets. The formula used for receiving the  $\chi^2$ -value is:

$$\chi^2 = -2 \sum \ln P$$

In order to investigate whether any particular habitat was preferred, a Wilcoxon signed rank test (StatView 1999), with a corrected *p*-value using Bonferroni correction (Sokal & Rohlf 1995), was used. The Bonferroni correction was done due to the execution of multiple tests on the same data. The correction is made by dividing the critical *p*-value, i.e. *p*=0.05, with the number of tests made. In this case the new critical *p*-value became 0.05/5=0.01. The data used in this test were the same 5 habitat categories that were used in the Chi-square test above, i.e. forest, clear-cut, farmland, wetland and other.

### **Correlation tests**

Farmland seems to be an important habitat for cranes at the staging areas in autumn (e.g. Hake 2003, Kjellander et al. 2003). In order to investigate whether the amount farmland is a limiting factor for territory size, the Spearman rank correlation test (SAS Institute 1999) was used. This test was also used in analyses of whether the amount of any habitat in the territories may have affected the parents' decision on when to leave the territory. In this analysis, territory 1 (see figure 1) was excluded, as the young in this territory were about three weeks younger than the young in the other territories, which were of similar age (see Appendix 2). Furthermore, as the age of the young may also affect the decision on when to leave, a similar analysis was made for the relationship between the age of the young and the date of departure from the territories. In the territories where siblings were marked, i.e. 1, 2 and 3, the age rank was based on the size of the smallest sibling at capture, as these individuals should be the limiting ones for the parents' decision on when to leave their territory.

## Migration

The date of departure is the median date between the last record in the breeding territory and the first zero observation.

## RESULTS

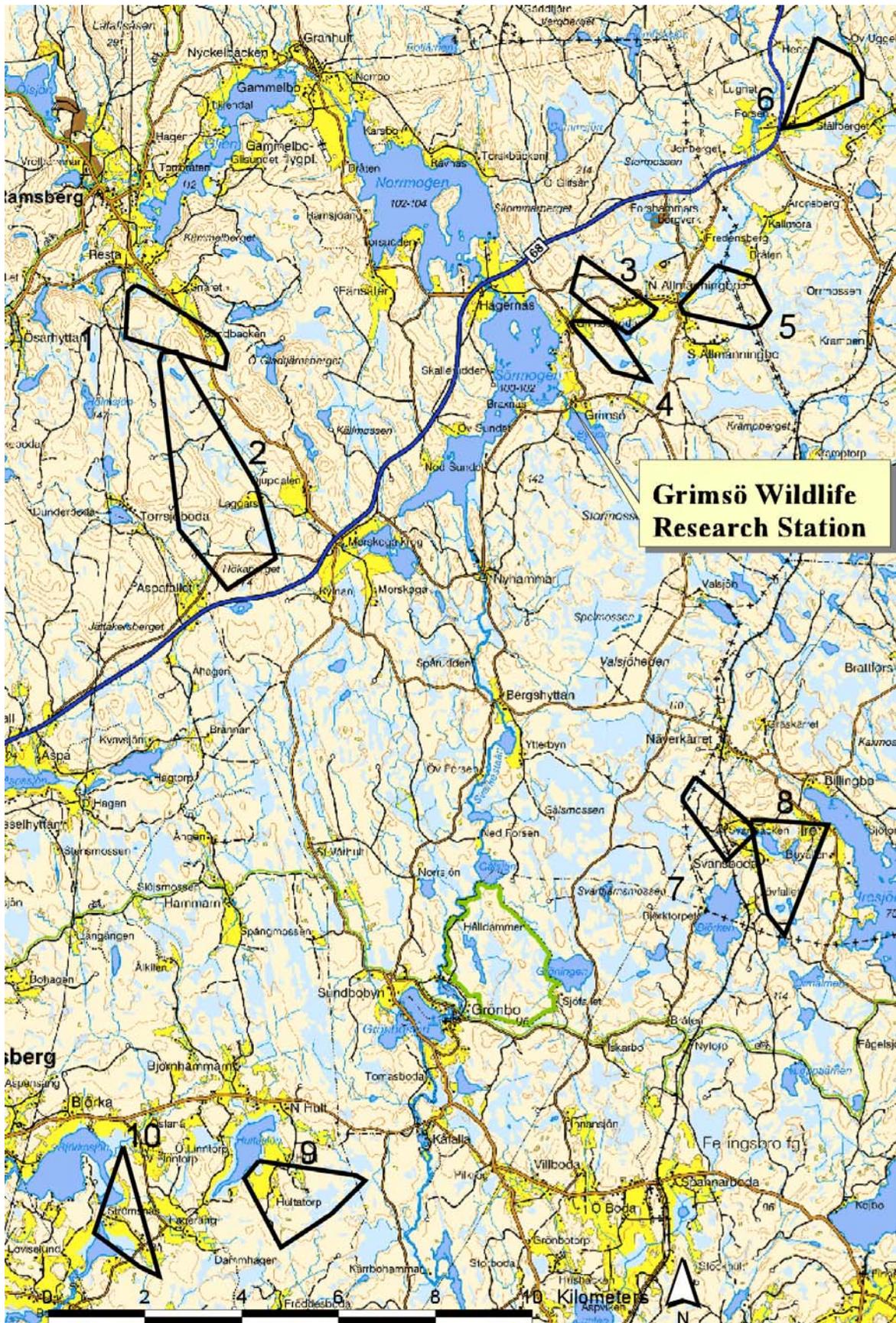
### Territory size and Movement

A geographical overview of the location of the territories is given in figure 2, in which the boundaries of all MCPs are shown. During the radio tracking period, 345 positions for all the 10 territories were obtained. The number of positions obtained and used for the home-range calculation and the habitat preference analyses for each territory are outlined, in table 1. The territory size for the 10 crane families varied in size between 0.8 km<sup>2</sup> and 6.0 km<sup>2</sup>, with a mean area of 2.1 km<sup>2</sup> (see table 1, figure 2). Noticeable is the size of territory 2, which was more than twice as large as the second largest one.

**Table 1.** Size of breeding territory for the 10 crane families studied in South Central Sweden 2003, the total number of positions used for the MCP analyses, and number of positions used in the analyses of habitat preference within the territories.

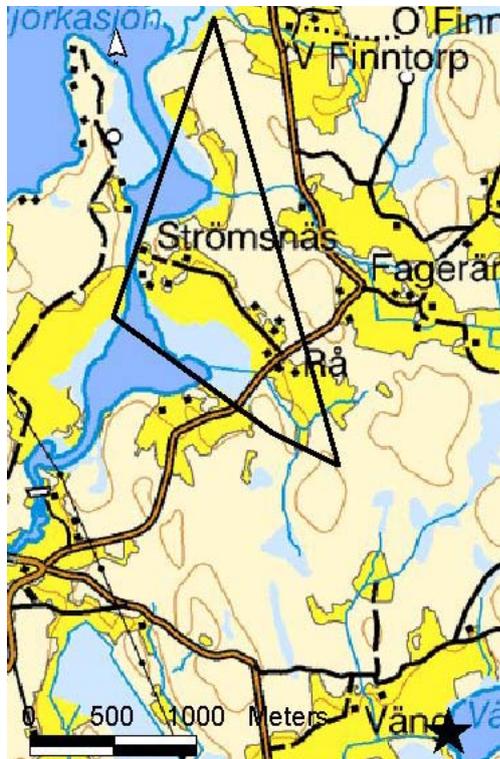
Territory	Individual	Area (km <sup>2</sup> )	Number of positions (MCP)	Number of positions (habitat preference)
1	SAJ1 & 2-03	1.8	31	21
2	LGJ2-03	6.0	29	23
3	NTJ1 & 2-03	1.3	37	29
4	GBJ1-03	0.8	37	30
5	NAJ1-03	1.5	37	30
6	SBJ1-03	1.8	32	25
7	BGJ1-03	1.2	43	30
8	NSJ1-03	2.2	45	32
9	SHJ1-03	2.4	34	28
10	STJ1-03	1.5	20	17
	Mean:	2.1	35	27
	SD:	1.5	7	5
	Total:		345	265

During the early radio-tracking period, the daily movements of the birds were sometimes considerable. Again, territory 2 distinguished itself, as the family in this territory moved at least 3 km during 36 h (31 July – 1 August) only one week after the marking, i.e. when the young were still not fledged. In the other territories, the longest movements recorded during 24 h were 1-1.5 km for six of the families and 2 km for three of the families. These records were made either before or after the young were considered to be fledged. These distances are one-way movements only, i.e. the birds were later observed at the starting point again. Moreover, the movement from one point to another is probably not straight, and one can therefore expect that the actual daily distances covered may be considerably longer.



**Figure 2.** Location of Grimsö Wildlife Research Station and the breeding territories of 10 crane families in South Central Sweden 2003. The numbers associated with the territories are the same as in the text, tables and figures, and in Appendix 2.

Towards the end of the radio tracking period, two families made excursions outside their territories before migrating south. In territory 1, one excursion was recorded (see figure 3). The excursion was made sometime between the 17 August (09:00 pm) and 19 August (01:00 am), and the family was gone from the territory on the evening of 19 August (20:00 pm).



**Figure 3.** Territory 10 (outlined), together with the location of the excursion site (star) made by the family before leaving the breeding territory in the study area in South Central Sweden 2003.

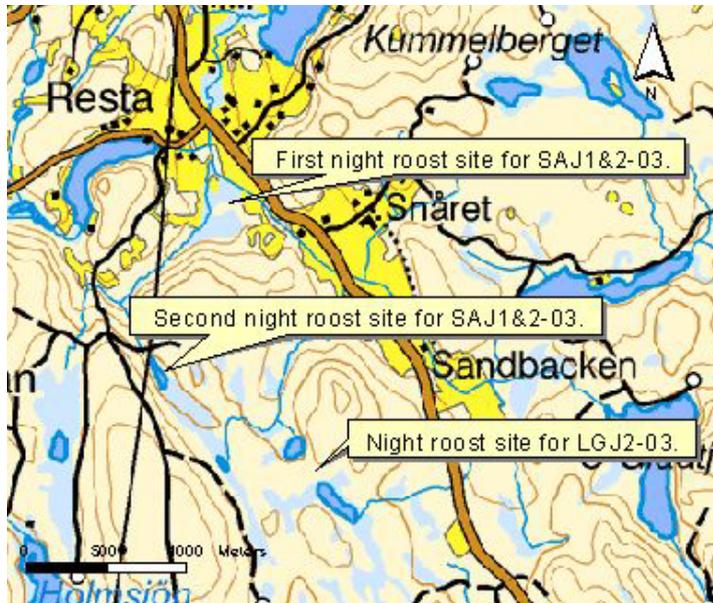
The family in territory 4 made numerous excursions to an area about 2 km NW of their territory (figure 4). This behaviour started 1 September and continued until they left the territory on 16 September.



**Figure 4.** Territory 4 (outlined) and the locations of the numerous excursions (stars) made by the family before leaving the territory in the study area in South Central Sweden 2003.

All the cranes studied spent the nights in the habitat wetland, and the night-roosting sites were the same throughout the study period for all except two of the families. The family in territory 1 first had their night-roosting site at a small and isolated pasture, holding wet areas. Two weeks after the capture, however, they changed their night-roosting site close to a mere quite

close to where the family in territory 2 had their night-roost (figure 5). This change of about 1 km occurred three days after the family in territory 2 left their breeding territory. The family in territory 1 then used this night-roosting site until they departed south, 19 days later.



**Figure 5.** Night-roosting sites for territory 1 (SAJ1&2-03) and 2 (LGJ2-03) in the study area in South Central Sweden 2003.

The family in territory 9 also changed their night-roosting site. Their first site was located just beside a fairly large lake, which harboured at least three additional crane families. At about four weeks after the capture, they changed their night-roost location to a forest bog, about 2 km east of the previous one. The family then left the territory one week after this change.

### **Habitat composition of the territories**

The overall proportions of habitats in the territories are presented in table 2, which also gives information about how the 13 original habitat classes have been merged into the final five.

The habitat composition differed considerably between territories (table 2). However, mean values show that forest (62.3%) was the main habitat in the ten territories, followed by farmland (13.6%), wetland (11.8%), clear-cut (8.2%), and other land (4.2%).

**Table 2.** Percentages (area) of the different habitats in the 10 territories studied in South Central Sweden 2003. The categories in bold (summaries of the categories below) were used in the analyses of habitat preferences within the territories.

Habitat category (%)	Territory										Mean	SD
	1	2	3	4	5	6	7	8	9	10		
<b>Forest</b>	<b>65.4</b>	<b>86.3</b>	<b>67.7</b>	<b>62.0</b>	<b>65.6</b>	<b>46.9</b>	<b>65.7</b>	<b>61.6</b>	<b>58.6</b>	<b>43.1</b>	<b>62.3</b>	<b>11.8</b>
<b>Clear-cut</b>	<b>16.1</b>	<b>7.8</b>	<b>2.4</b>	<b>12.8</b>	<b>3.9</b>	<b>17.6</b>	<b>7.1</b>	<b>3.2</b>	<b>5.9</b>	<b>4.6</b>	<b>8.2</b>	<b>5.5</b>
topographical map	14.2	7.5	2.4	12.8	0.0	17.1	7.1	1.0	5.9	4.6	7.3	5.8
clear-cut 2002-2003	1.9	0.4	0.0	0.0	3.9	0.5	0.0	2.2	0.0	0.0	0.9	1.3
<b>Farmland</b>	<b>14.8</b>	<b>1.8</b>	<b>20.1</b>	<b>10.9</b>	<b>4.7</b>	<b>22.0</b>	<b>13.0</b>	<b>12.5</b>	<b>14.1</b>	<b>22.0</b>	<b>13.6</b>	<b>6.8</b>
other farmland	1.1	0.1	1.8	0.4	1.9	0.0	0.0	0.0	3.7	2.1	1.1	1.2
mixed grain	0.0	0.0	0.0	0.8	0.5	0.0	0.0	0.0	0.0	1.8	0.3	0.6
oat	0.0	0.0	0.5	0.0	0.0	0.0	7.4	0.0	2.0	0.8	1.1	2.3
barley	0.0	0.0	4.8	4.4	0.0	0.0	0.0	2.2	0.0	2.9	1.4	2.0
salix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.3	0.4	1.2
fallow field	0.0	0.0	0.1	3.6	0.0	0.0	0.0	1.8	3.5	9.7	1.9	3.1
hay-field	13.8	1.7	12.9	1.7	2.3	22.0	5.6	8.6	1.0	4.4	7.4	6.9
<b>Wetland</b>	<b>2.0</b>	<b>3.7</b>	<b>3.9</b>	<b>13.1</b>	<b>24.5</b>	<b>8.6</b>	<b>9.5</b>	<b>18.4</b>	<b>17.2</b>	<b>16.6</b>	<b>11.8</b>	<b>7.4</b>
bog	1.9	3.2	0.0	11.4	24.5	8.6	1.5	2.5	17.2	0.0	7.1	8.3
undef. shoreline areas	0.0	0.0	2.9	1.7	0.0	0.0	6.4	5.7	0.0	6.2	2.3	2.8
lake	0.0	0.5	1.0	0.0	0.0	0.0	1.6	10.2	0.0	10.4	2.4	4.2
<b>Other land</b>	<b>1.7</b>	<b>0.4</b>	<b>5.8</b>	<b>1.1</b>	<b>1.4</b>	<b>4.9</b>	<b>4.8</b>	<b>4.3</b>	<b>4.2</b>	<b>13.6</b>	<b>4.2</b>	<b>3.8</b>
Total	100	100	100	100	100	100	100	100	100	100		

### Habitat preference within the territories

The relative distribution of positions among the different habitats in the territories is shown in table 3.

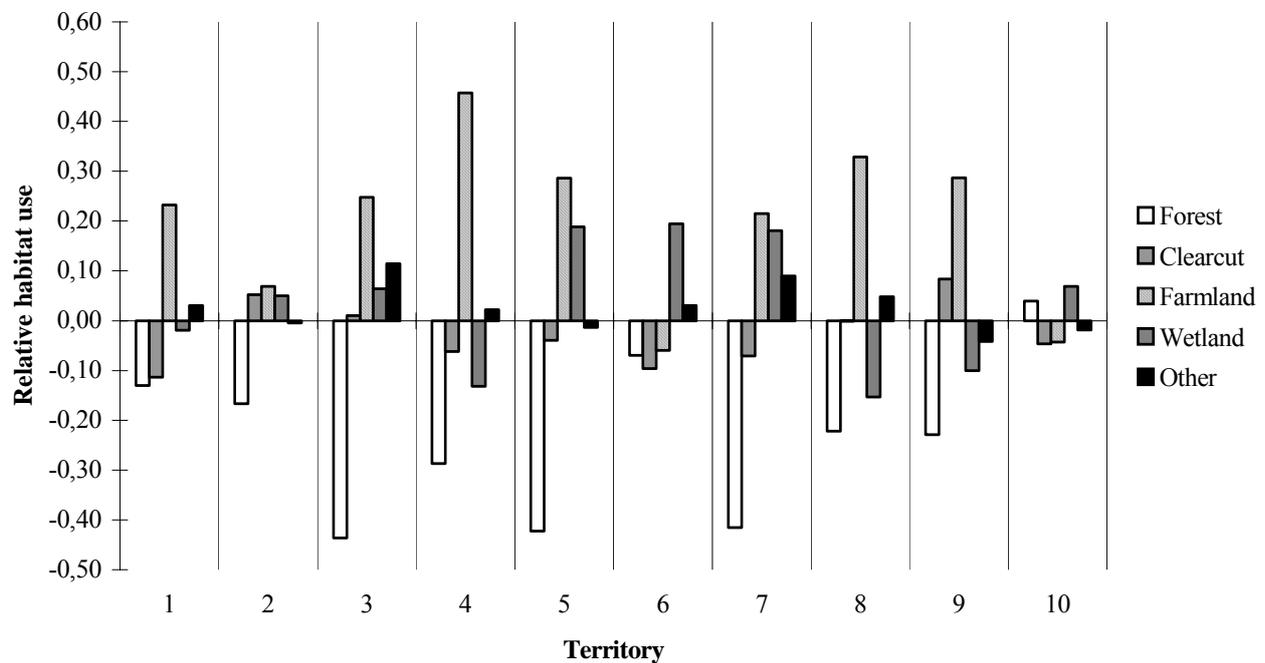
**Table 3.** The relative distribution (%) of radio-tracking positions (with mean and standard deviation), obtained in different habitats for 12 young cranes within 10 territories in South Central Sweden 2003. The categories in bold (summaries of the categories below) were used in the analyses of habitat preference within the territories.

Habitat category (%)	Territory										Mean	SD
	1	2	3	4	5	6	7	8	9	10		
<b>Forest</b>	<b>52.4</b>	<b>69.6</b>	<b>24.1</b>	<b>33.3</b>	<b>23.3</b>	<b>40.0</b>	<b>23.3</b>	<b>40.6</b>	<b>35.7</b>	<b>47.1</b>	<b>38.9</b>	<b>14.7</b>
<b>Clear-cut</b>	<b>4.8</b>	<b>13.0</b>	<b>3.4</b>	<b>6.7</b>	<b>0.0</b>	<b>8.0</b>	<b>0.0</b>	<b>3.1</b>	<b>14.3</b>	<b>0.0</b>	<b>5.3</b>	<b>5.2</b>
topographical map	4.8	8.7	3.4	6.7	0.0	4.0	0.0	0.0	14.3	0.0	4.2	4.7
clear-cut 2002-2003	0.0	4.3	0.0	0.0	0.0	4.0	0.0	3.1	0.0	0.0	1.1	1.9
<b>Farmland</b>	<b>38.1</b>	<b>8.7</b>	<b>44.8</b>	<b>56.7</b>	<b>33.3</b>	<b>16.0</b>	<b>33.3</b>	<b>46.9</b>	<b>42.9</b>	<b>17.6</b>	<b>33.8</b>	<b>15.4</b>
other farmland	0.0	0.0	6.9	3.3	0.0	0.0	0.0	0.0	3.6	0.0	1.4	2.4
mixed grain	0.0	0.0	0.0	3.3	3.3	0.0	0.0	0.0	0.0	5.9	1.3	2.1
oat	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	21.4	0.0	3.8	8.1
barley	0.0	0.0	10.3	30.0	0.0	0.0	0.0	28.1	0.0	0.0	6.8	12.2
fallow field	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9	11.8	3.0	6.4
hay-field	38.1	8.7	27.6	20.0	30.0	16.0	16.7	18.8	0.0	0.0	17.6	12.4
<b>Marshland</b>	<b>0.0</b>	<b>8.6</b>	<b>10.3</b>	<b>0.0</b>	<b>43.3</b>	<b>28.0</b>	<b>26.7</b>	<b>3.1</b>	<b>7.1</b>	<b>23.6</b>	<b>15.1</b>	<b>14.5</b>
bog	0.0	4.3	0.0	0.0	43.3	28.0	0.0	0.0	7.1	0.0	8.3	15.1
undef. shoreline areas	0.0	0.0	6.9	0.0	0.0	0.0	26.7	3.1	0.0	11.8	4.8	8.6
lake	0.0	4.3	3.4	0.0	0.0	0.0	0.0	0.0	0.0	11.8	2.0	3.8
<b>Other</b>	<b>4.8</b>	<b>0.0</b>	<b>17.2</b>	<b>3.3</b>	<b>0.0</b>	<b>8.0</b>	<b>16.7</b>	<b>6.3</b>	<b>0.0</b>	<b>11.8</b>	<b>6.8</b>	<b>6.6</b>
Total	100	100	100	100	100	100	100	100	100	100		

The number of observed and expected positions in the five different habitats was significantly different in eight of the ten territories (all  $p < 0.05$ , Chi-square test, figure 6). The families showing no significant difference from random habitat use were the ones in territory 2

( $\chi^2=9.29$ ,  $p=0.054$ ,  $DF=4$ ) and 10 ( $\chi^2=1.51$ ,  $p=0.82$ ,  $DF=4$ ). The combined probability from all tests, showed a clear significance ( $\chi^2=247.29$ ,  $p<0.001$ ,  $DF=9$  Fishers method for combining probabilities), which suggests that the habitat use of the cranes generally was non-random.

The Wilcoxon signed rank test, with the Bonferroni correction for the p-value (see methods section), showed that the habitat category forest was significantly underused ( $z=-2.701$ ,  $p=0.0069$ ,  $n=10$ ), and that there was a clear tendency for farmland to be overused by the birds ( $z=-2.497$ ,  $p=0.0125$ ,  $n=10$ ). In the remaining categories, i.e. clear-cut, wetland and other, no significant difference could be detected (all  $p>0.05$ , Wilcoxon signed rank test). This result indicates that forest is non-preferred, and that farmland is an important habitat in the crane territories (see figure 6). Even if farmland seemed to be the most important habitat for the cranes, there was no correlation between the amount of farmland in the territories and territory size ( $z=-1.036$ ,  $n=10$  territories,  $p=0.30$ , Spearman rank correlation test).



**Figure 6.** Relative habitat use for 10 crane families within their territories in South Central Sweden 2003. If the bar is above the zero-line, the habitat was relatively overused (i.e. preferred), and if the bar is below the zero-line, the habitat was underused (i.e. avoidance).

### Migration

The date for leaving the territory among the studied crane families varied between 22 August and 20 September (table 4). There were no significant relationships between the date of departure and the relative occurrence of any of the five habitats in the territories ( $p>0.05$  for all tests,  $n=9$  territories, Spearman rank correlation test). Neither was there any relationship between the age of the young and the date of departure from the territories ( $z=0.56$ ,  $n=10$  territories,  $p=0.57$ , Spearman rank correlation test).

**Table 4.** *Date of departure from the breeding territories for the 10 crane families, studied in South Central Sweden 2003.*

Territory	Individual	Date of departure
1	SAJ1 & 2-03	20/9
2	LGJ2-03	28/8
3	NTJ1 & 2-03	29/8
4	GBJ1-03	16/9
5	NAJ1-03	1/9
6	SBJ1-03	22/8
7	BGJ1-03	3/9
8	NSJ1-03	4/9
9	SHJ1-03	22/8
10	STJ1-03	19/8
Median date:		30/8

## DISCUSSION

### Territory size and movements of the birds

The territory sizes recorded for the Eurasian crane families in this study are in accordance with earlier findings of Hake (2003), Nowald (1999) and the information in Cramp (1980). However, these studies present data on only a few territories situated in different areas, which makes a comparison difficult. One of the territories in this study (territory 2) was more than twice as large as the second largest one, and much larger than recorded in previous studies. The family in this territory also made the longest recorded daily movement (up to 3 km) of all the families in this study. One reason for this might be that territory 2 included more forest and less farmland compared to the other territories. Röper & Hake (2003) found a similar result in their study of Eurasian cranes breeding in northern Sweden, where the family whose territory included the highest proportions of forest and bogs moved over the largest area of the territory during their daily movements. Also, during the same time period as the present study was done, a similar study was made in Svartådalén, an area about 50 km ENE of Grimsö Wildlife Research Station (Hake et al, unpublished data). On the contrary to the general habitat composition in the Grimsö-area, Svartådalén is dominated by farmland. Comparing the results from these studies, it was obvious that the territories in Svartådalén were much smaller and included a much higher proportion of farmland than the ones at Grimsö. This suggests that there might be a relationship between territory size and the proportion of farmland in the territories. No significant correlation was found between the proportion of farmland and territory size for the territories in the Grimsö study area. This may, however, have depended on the small sample size (n=10), and that the variation in the proportion of farmland in the territories was too small (c.f. table 2).

The territorial borders of the cranes seem to be fixed during late breeding season. Territory 7 and 8 were situated close to each other. In addition, there was a third crane couple, which did not have any young but held a territory in between the two other territories. I never found that any of these families visited the same location during this study. Also, it was obvious that the neighbouring territories in this survey (i.e. territory 1 and 2, and territory 3 and 4) were not overlapping (see figure 2). Additional results supporting this conclusion were the change of night-roost location made by the family in territory 1 (see below), and the pre-migratory excursions made by the family in territory 4. In the latter case, another crane couple had their territory in the area visited during these excursions (Hake pers. comm.), and the family started to make the excursions after that couple had left the breeding area.

The change of night-roosting site, which occurred in the territories 1 and 9, has not previously been reported. On the contrary, Röper & Hake (2003) found that Eurasian cranes in northern Sweden, used the same night-roost location throughout the late breeding season. Swanberg & Lundin (1995) brought up hunting as a disturbing factor that may force the cranes to change their night-roost location. This could be the case in territory 9, as the local roe deer hunt began just prior to the change of night-roosting site. The family had previously visited the area of the second night-roost during daytime, and it is not likely that they took over another family's night-roost. For the crane family in territory 1, however, the reason for changing night-roost may have been to take over a better roosting site in an adjacent territory. This is supported by the fact that the neighbouring family (i.e. in territory 2) had their night-roost close to the second roost of the family in territory 1, and that the shift took place after that the neighbouring family had left. Also, I never tracked the family in territory 1 at their second roosting site before they started to use it.

### **Habitat composition of the territories**

Compared to earlier findings (Nowald 1999, Röper & Hake 2003), my results showed that the cranes had a higher proportion of forest and a lower proportion of farmland in the territories. This difference is probably caused by differences in the overall composition of the landscapes in the study areas. This is supported by the results from the similar study made in Svartådalen (Hake et al. unpublished data). This area is dominated by farmland, and thus the cranes studied had a much higher proportion of farmland in their territories than the birds at Grimsö.

Five of the families did not have any lake in their territories. This should not, however, be interpreted as that they did not have access to open water, as small water surfaces were not marked on the topographical map. Thus, there should have been no problems for the birds to find suitable nesting and night-roosting areas. Cranes normally place the nest so it is surrounded by water, and spend the night standing in shallow water (e.g. Cramp 1980).

Some data on habitat composition were missing in this study. The data for clear-cuts made between 1997 and 1999 could not be used in the analyses. However, when looking at the data from this period, few positions could have been assessed to these missing clearings, and this may have a minor influence on my results.

### **Preference of habitat**

Regarding the results on habitat preference of the cranes in general, it is important to point out that this study was done during the late breeding season only. If this study would have been done during another part of the breeding season, other results may have emerged. There was a significant difference between the observed and expected numbers of positions in the different habitats. Thus, the cranes seemed to actively choose where to be in their territories. Furthermore, my results showed that forest was significantly underused. Although this non-preference for forest, the cranes did not avoid the habitat completely (see table 3). During the capture, it was obvious that the faeces of the young cranes contained much remains of blueberries. This suggests that forest may also be an important habitat during late breeding season, although it was underused in study.

In the habitat category farmland, six different crops were included (see Appendix 1), and two of them were hay-field and fallow field. These can be considered being similar in the sense that they represent grassland habitat. This habitat made up 68 % of the total area of farmland in the territories, and the corresponding figure for the relative amount of tracking positions obtained in this habitat was 61%. This corresponds well with the results of studies on habitat

selection of non-breeding, young cranes made at stopover sites in late summer. In Hake (2003), 65.6 % of the crane observations made in the agricultural area Kvismaren (59°11'N / 15°22'E), a major staging area for the Eurasian crane in autumn, between 20 July and 8 August, were made on grassland, and a similar result was obtained by Kjellander et al. (2003) in the same area. Thus, although grassland was not overused in this study, it seems to be an important habitat in late summer for cranes in general.

Later in the season, the cranes frequently use stubble-fields. Between 22 August and 10 September, and 17 September and 8 October, 96.4% and 83.8% of the several thousand of cranes, which staged at Kvismaren, were found on stubble fields (Hake 2003), and Kjellander et al. (2003) found a strong preference for stubble fields in cranes staging in the same area from mid-August until late October. Hence, the cranes seem to change their preference for habitat as described by Archibald & Meine (1996). One important reason why the cranes at Grimsö moved to the stopover sites in agricultural areas before they continued the migration south (see below), may therefore be that there was not enough stubble fields in the territories and/or in the surroundings of the breeding areas.

### **Migration**

The date for leaving the territories varied a lot among the families, with a range of one month from the first (territory 10) until the last (territory 1) family departed. One possible factor affecting the decision on when to leave may be the habitat composition in the territory. Particularly the proportion of farmland may be important, as this habitat, as previously mentioned, has been shown to be important for the cranes in the autumn (Hake 2003 and Kjellander et al. 2003). This study did not reveal any correlation between departure date and the proportion of farmland in the territories. In the study performed simultaneously at Svartådalen, however, where the cranes had a much higher proportion of farmland in their territories, the families left considerably later (Hake et al. unpublished data) than the cranes in the Grimsö area. This suggests that the proportion of farmland in the territories actually may have an influence on the crane's decision on when to leave. An alternative explanation is that the proportion of farmland in the entire breeding area (i.e. Svartådalen) may affect the decision. This seems more likely, as several of the families in this area made many excursions outside their territories to adjacent farmland areas before leaving the breeding area (Hake et al. unpublished data).

I found no significant relationship between the age of the young cranes and migration date. The age of the young seems to be less important for the parents' decision on when to leave the territory. The circumstance that NSJ1-03 and SHJ1-03 had one sibling each, which were not captured, may have biased the result, but not to such an extent that it affected the result, considering the high p-value obtained in the test. So, why do the families leave their territories at a certain time? This study provides no clear answer to this question, which is not surprising giving the small sample size analysed. Another factor, which makes this question even more difficult to answer, is the different migration strategies adopted by different crane families. The long-term studies of Lundgren et al. (2003), at Tranemo in southern Sweden, have revealed a difference in the behaviour of families prior to leaving the territory. They found that some of the families join the big crane flocks at the stopover sites quite early in the autumn, while others remain in their territories. I found the same patterns of behaviour also in this study. In contrast to the other families, the birds in territory 4 made several pre-migratory excursions, and remained in the breeding area much longer than other families having young of the same age. This family had as much (or little) farmland in the territory as some of the other families, but anyway decided to remain in the territory. However, they extended their

home range two weeks before they left, and visited other farmland areas, while the other families quite early moved to stopover sites in agricultural areas further south (see below).

All families staged in agricultural areas after leaving their territories. Two families staged at Finnåker (59°32'N / 15°32'E), 23 km SE of Grimsö, and the remaining families staged at Kvismaren (59°11'N / 15°22'E), about 60 km S of Grimsö. Both these areas are dominated by farmland with suitable shallow lakes for night-roosting. The two families that staged at Finnåker later flew down to Kvismaren, and in late September, all families were located to this area. The families remained here for up to six weeks before they departed south in early October. All but one of the families (in territory 10) were then either seen or tracked in the Rügen-Bock area in north-eastern Germany, and five of the radio-tagged birds were tracked in Extremadura, central Spain in mid-December, probably at their wintering grounds (M. Hake, unpublished data).

### **Future studies**

Few studies have been done on the breeding biology of the Eurasian crane. I look forward to see more studies on different aspects of this topic, not only in Sweden but also throughout the breeding range of the species. It would, for instance, be interesting to investigate how the density of suitable breeding habitat, i.e. wetland, affects the territory size and location. It would also be interesting to see how the radio-tagged birds in this study behave when they come back to Sweden. Further radio tracking of these individuals may give us the opportunity to study the pre-breeding behaviour, which we today know very little about.

The breeding ecology of a species constitutes basic knowledge needed to be able to forecast the population development from certain assumptions. For the Eurasian crane, this basic knowledge is needed in the work to preserve and protect the species. Also, it is essential to know how it affects the surrounding environment and landscape, in this case because the conflicts in farmland areas close to important stopover sites are escalating. Therefore, it is important to monitor crane populations and the impact of cranes on different types of crops at the stopover sites. The information obtained from such surveys at stopover sites and further investigations on the breeding ecology would be very useful to guide measures to prevent crop damage and protect the Eurasian crane on long-term within its entire range of occurrence.

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#### INTERNET

[www.jagareforbundet.se/attjaga/soluppner/default.asp](http://www.jagareforbundet.se/attjaga/soluppner/default.asp) – 2003-10-21  
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**APPENDIX 1.** The different habitat classes identified in the study, and descriptions of what they include.

HABITAT	INCLUDES
Forest Clear-cut	coniferous and deciduous forests from the topographical map (T5 format, Metria Gävle) and the ones made during 2000-2003
Farmland	barley, fallow field, mixed grain, oat, hay-field, and other (including salix)
Marshland Wetland <i>(used in the analyses)</i>	bog, undefined shoreline areas, and lake (i.e. large water bodies) Marshland plus Lake
Other	grazing pastures, protected areas and other unused areas

**Appendix 2.** Information on capturing date, size at capture, age rank and date of departure from the territory for the 12 young cranes that were radio-tagged at Grimsö 7 July – 17 August 2003.

Territory <sup>1</sup>	Bird	Date of capture	Age rank	Wing (mm)	Tarsus (mm)	Weight (g)	Left the territory	Comments
1	SAJ1-03	17 August	10	330	265	3000	20 Sept	
1	SAJ2-03	17 August	-- <sup>4</sup>	385	285	3850	20 Sept	
2	LGJ2-03	21 July	9 <sup>3</sup>	380	265	3300	28 Aug	Had a sibling that was not radio-tagged.
3	NTJ1-03	16 July	7	355	245	3100	29 Aug	
3	NTJ2-03	16 July	-- <sup>4</sup>	435	275	3500	29 Aug	
4	GBJ1-03	20 July	6	405	260	-- <sup>2</sup>	16 Sept	
5	NAJ1-03	19 July	4	420	270	3650	1 Sept	
6	SBJ1-03	7 July	1	350	260	3000	22 Aug	
7	BGJ1-03	19 July	5	410	240	3100	3 Sept	Had an unmarked sibling that disappeared before leaving the territory.
8	NSJ1-03	18 July	2	445	270	3900	4 Sept	Had a sibling that was not captured.
9	SHJ1-03	17 July	3	425	255	3200	22 Aug	Had a sibling that was not captured.
10	STJ1-03	26 July	8	425	275	3200	19 Aug	

<sup>1</sup>Corresponds to the territory numbers in Fig 2.

<sup>2</sup>The weight was not measured.

<sup>3</sup>The age rank was based on the size of the unmarked sibling, which was considerably smaller at capture (wing=310, tarsus=250, weight=2700).

<sup>4</sup>The age rank was based on the size of the smaller sibling at capture (see methods section).