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THE MIGRATION ROUTES OF EURASIAN CRANES BREEDING IN ESTONIA

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Abstract. The current study provides an overview of the migration routes of the Eurasian Cranes breeding in Estonia. Recoveries of colour-ringed, radio- and satellite-tagged birds during 1997-2011 have been used. To date 276 Eurasian Cranes have been colour-ringed in Estonia. Since 1997 a total of 271 cranes have been marked with an individual country code. A total of 3810 recoveries of 221 marked cranes have been made, whereas 2257 observations of 201 individuals were made outside Estonia. The number of recoveries received by satellite telemetry is 20% (798), whereof 30 recoveries were made in the beginning of the 2000s and 768 since 2009. The highest number of recoveries outside Estonia has been made in Germany (683 recoveries of 147 individuals), followed by France (525 recoveries of 105 ind.) and Spain (601 recoveries of 92 ind.) and Hungary (94 recoveries of 28 ind.). Most of the recoveries derive from the West European flyway (221 recoveries of 183 ind., i.e. 83%), followed by the Central European flyway (32 ind., i.e 14%) and the East European flyway (7 ind., i.e. 3%). The distance between the breeding and the wintering areas along the West European flyway varies between 1100 km (North Germany) and 3300 km (West Spain), and along the Central European flyway between 1600 km (Croatia) and 2000 km (North Italy). The furthermost wintering area is located in northern Turkey, 2350 km along East European flyway. No recoveries of the Eurasian Cranes have been reported from the Ethiopian wintering area. The furthermost recovery (4200 km from tagging location) ever reported was of a satellite-tagged crane called Tom who however perished in Northern Sudan in 2009.

Introduction

Since 1992 the migration onset of the Eurasian Crane (*Grus grus*) in autumn and the endpoint in spring have been observed in Estonia (Rootsmäe & Lellep 1978, Leito et al. 2005, EOÜ 2011). The first overview of the migration paths within the limits of Europe, also comprising Estonia, was given by W. Libbert in 1936, yet due to insufficient data it did not provide an adequate picture neither of the migratory distribution and trends in Estonia nor of the connections to other regions related to migration. Subsequent overviews published during 1955 to 1995 provided a more precise picture of the migration of the Eurasian Cranes in Estonia however did not provide any information of the flyways of the Estonian breeding crane population (Tamm 1955, Veroman 1971, Keskpaik & Rootsmäe 1989, 1995, Shergalin et al. 1995). The reason probably lies in the fact that data was gathered by occasional or visual migration observations as well as radar observations, which do not provide any information about the whereabouts of the migration onset. Also there is no recovery data of a few metal-ringed crane nestlings. During 1975 to 2004, a total of 25 Eurasian Cranes were metal-ringed in Estonia. The first colour rings were applied to cranes in 1990, first radio transmitters in 1999 and satellite transmitters in 2001 (Leito et al. 2005). The first recovery of a colour-ringed Eurasian Crane outside Estonia was reported in 1998 (Leito 1998).

The first overview describing the flyways of the Eurasian Cranes ringed in Estonia was published a decade ago in the journal *Hirundo* (Leito & Ojaste 2001). The book *Sookurg* (Leito et al. 2005) also expands upon the migration routes and wintering grounds of the Eurasian Cranes breeding in Estonia but also includes data from May 2005. To this day (November 2011) an additional 130 young cranes have been marked and several thousand recoveries have been made. The current paper provides an overview of the flyways and wintering quarters of the Eurasian Cranes breeding in Estonia. No distinguishing between age classes was made and all recoveries are considered as equivalent. The most intriguing and novel information about the flyways of the cranes breeding in Estonia has been provided by tracking birds wearing GPS satellite transmitters. In the current paper part of this information is being discussed for the first time.

Material and methods

The current paper is covering recovery data of the Eurasian Cranes breeding in Estonia obtained by visual observations, radio- and satellite

telemetry by November 2011. A more precise description of the attaching as well as using methods of colour-rings and transmitters can be found in Leito & Ojaste (2001) and Leito et al. (2005). The country code for the Estonian cranes is a ring on the bird's left foot with the combination of white-black-white since 1997, white-blue-white since 2006 and white-yellow-white since 2011. So far three moulting adult cranes have been ringed, whereas the rest have been nestlings of 2.2-4.6 kg. All birds have been caught without using any device. So far a total of 276 Eurasian Cranes have been colour-ringed, whereof 271 birds were marked with an individual country code since 1997 (Fig. 1, Table 1). Recoveries are considered as encounters of tagged birds that were identified by a metal ring bearing a number and/or a colour code or by the means of radio- and satellite telemetry.

A total of 37 radio transmitters of the same type (model TW-5, Biotrack Ltd., mean weight 60 g, battery-driven, mean operational life 4 years) were used. All transmitters were attached to the back of the bird using a particular ribbon (*backpack* attachment). Also the radio direction finder (manual direction finder VR-500, Andreas Wagener GmbH) and the statistical analyses have remained the same. Transmitters may be located to 3-5 km, depending on landscape type and the bird's height above ground. From planes even up to 50 km. Findings from the plane, by using a special device, have located transmitter-tagged Eurasian Cranes in the wintering areas in Spain. Ground findings have located cranes besides Estonia and Spain also in France, Poland and Hungary.

Most considerable changes have occurred in terms of using satellite telemetry. Argos/GFT and North Star transmitters were used in 2001 (4 pcs.) and 2002 (4 pcs.). The transmitters weighed 60 g, had an operational life of 1-2 years and a positioning accuracy class of one acrsecond. In conjunction with German and Spanish colleagues these transmitters were attached to young cranes in West Germany (3 pcs.) and Aravu, Tartumaa (1 pcs.) in 2001 and in Põlvamaa (3pcs.) and Sikakurmu, Tartumaa (1pcs.) in 2002. The positioning database and positioning analysis database were located in the Max Planck Institute, Germany. Unfortunately, due to technical complications, the transmitters were operating unsteadily and thus a proper positioning for only three birds (a total of 30 GPS fixes) was obtained outside Estonia. Moreover, in terms of these birds, the only GPS available fix was provided by the German colleagues.

Since 2009, seven 105 g and one 40 g battery-driven Argos/GPS LC4 transmitters by Microwave Telemetry, Inc. have been used. The housing of the transmitter is hermetically sealed and therefore waterproof with an operating

temperature range of -15 to +45 °C. All transmitters were attached to crane nestlings (3.5-4.4 kg) by means of a ribbon harness (so-called *backpack* attachment). According to the manufacturer, the 40 g transmitter has sufficient battery power to operate for at least one year and the 105 g transmitter for two years. So far the maximum operating life has yet not been reached. The LC4 type transmitter takes a single GPS fix daily (at 10 am local time) and transmissions are sent every 10 days to the Euro-Africa centre of Argos Tracking and Environmental Monitoring by Satellite, in France. The GPS accuracy of the transmitter is ± 18m. Using the LC4 MTI GPS Data Parser program by Microwave Telemetry, Inc., Argos DS and DIAG are transformed into tabular files that in turn enables to import the data into Google Earth and then further display the GPS fixes on Earth's satellite or hybrid maps. The maps enable to check the intervals between GPS fixes and also produce image files.

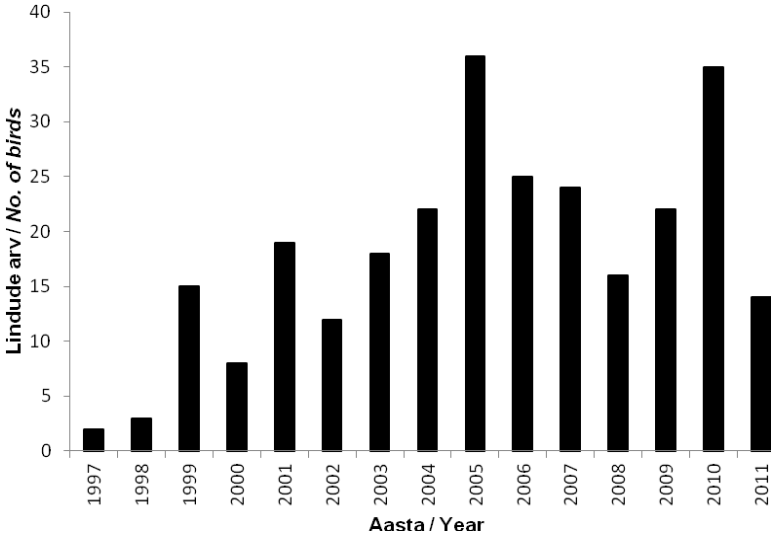

Figure 1. Colour-ringing of Eurasian cranes during 1997 to 2011.
***Joonis 1**. Sookurgede värvirõngastamine Eestis 1997–2011 aastate lõikes.*

Table 1. The number of colour-ringed birds, recoveries and flyways by counties. Flyways: SW – West European, SSW – Central European, SSE – East European.
***Tabel 1**. Sookurgede värvirõngastamise hulk, kohad ja rändesuunad Eestis maakonniti 1997–2011.*

Maakond *County*	**Rõngastatud linde** *No. of colour-ringed birds*	**Taasleitud linde** *No. of recoveries*	**Rändesuund** / *Flyway*			**Rändetee vahetus** *Switch between flyways*
			SW (is)	SSW (is)	SSE (is)	
Läänemaa	69	61	57	9	0	8 (13%)
Harjumaa	34	26	17	5	0	1 (4%)
Saaremaa	93	81	76	8	0	8 (9%)
Pärnumaa	11	6	5	3	0	2 (17%)
Raplamaa	16	11	9	2	0	1 (9%)
Lääne-Virumaa	1	0	0	0	0	0
Jõgevamaa	5	4	2	1	0	0
Tartumaa	5	4	3	2	1	1 (25%)
Põlvamaa	30	23	10	1	6	0
Võrumaa	1	1	1	0	0	0
Viljandimaa	6	4	3	1	0	1 (25%)
Kokku/*Total*	271	221	183	32	7	23 (10%)

Results

A total of 3810 recoveries of 221 marked Eurasian Cranes have been made, whereas 2257 observations of 201 individuals were made outside Estonia (Fig. 2, table 2). The number of recoveries received by satellite telemetry is 20% (n=798), whereof 30 recoveries were made in the beginning of the 2000s and 768 since 2009.

The highest number of recoveries outside Estonia has been made in Germany (683 recoveries of 147 individuals), followed by France (525 recoveries of 105 ind.) and Spain (601 recoveries of 92 ind.) and Hungary (94 recoveries of 28 ind.). Numerous recoveries (5 or more) have also been made in Sweden, Poland, Belarus, Ukraine and Turkey (Table 2).

Flyways and wintering grounds. Most of the recoveries derive from the West European flyway (221 recoveries of 183 ind., i.e. 83%), followed by the Central European flyway (32 ind., i.e 14%) and the East European flyway (7 ind., i.e. 3%). Considering the ratio of marked birds per different regions in Estonia and the number of observers along the flyways, there seems to be no remarkable preference for any of the three flyways. However, choosing a flyway obviously depends on the bird's geographical location in Estonia. For example cranes breeding in western Estonia mostly head south-west and also south but never south-east, yet cranes breeding in Eastern Estonia head in all three major directions but mainly to south-west and south-east.

West European flyway. The first country to pass during the autumn migration is Latvia. Usually cranes do not stop there and head directly to the major staging sites in Kaliningrad Oblast and northern Poland and Germany (Fig. 2-4). Key staging areas in Germany are the Rügen-Bock region in the northern coast and Rhin-/Havelluch region north from Berlin (staging sites named according to Prange 2010). Subsequently the cranes head for Spain, first passing France. Stopover sites in France are located in the northern part (Champagne-Ardenne), in the central part (Centre de la France) and also in the south-western part (Aquitaine) of the country. The foremost staging site for the cranes in Spain is Laguna de Galloconta. One radio-tagged crane has also crossed the Strait of Gibraltar twice (2007 and 2010 on December 30th and January 2nd respectively) and eventually reached Morocco.

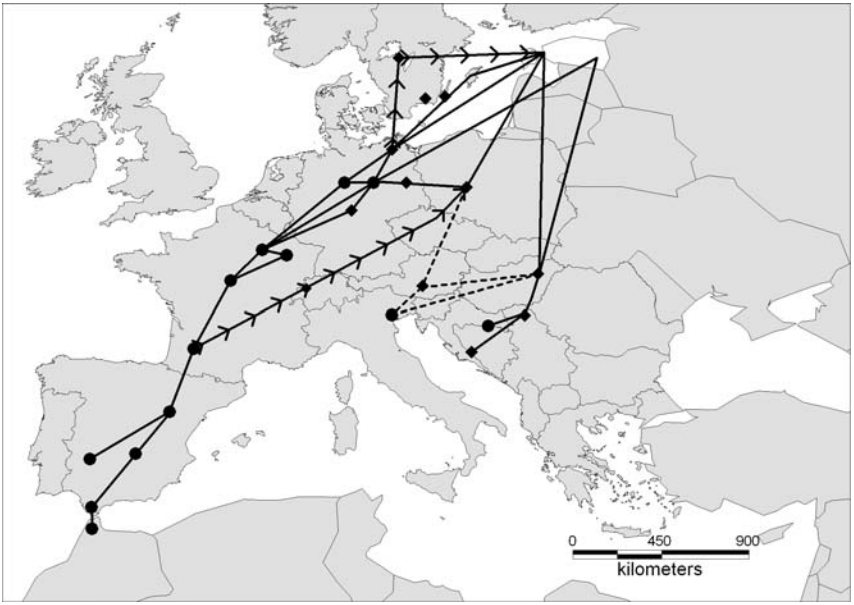

Figure 2. Migration routes of the Eurasian Cranes breeding in Estonia according to recoveries of colour-rings and radio-telemetry. Dots indicate staging and wintering sites, rhombi indicate only staging sites. Solid line indicates migration on both directions, dashed line the theoretical migration route and arrows the known unidirectional flight.

Joonis 2. *Eesti sookurgede rändeteed ja talvitusalad värvirõngastamise ja raadiojälgimise andmetel. Ringid on alad, kus sookured on lisaks peatumisele nähtud ka talvitumas; rombid on alad, kus sookurgi on nähtud ainult rändel; sirgjoonega on tähistatud mõlemasuunalised rändeliikumised, punktiiriga tõenäosed lennuteed ning nooltega ainult ühesuunaline liikumine.*

The key wintering sites on the West European flyway are Extramadura in western Spain and Laguna de Galloconta in north-eastern Spain, but also Aquitaine and Centre de la France in France. Information of occasional wintering has also been received from northern Germany. Spring migration usually follows the same path as the autumn migration. Yet a notable difference exists as some cranes instead of migrating from northern Germany to Estonia by heading north-west, they pass southern Sweden and cross Öland and Gotland (Fig. 2 and 4). During spring migration, some Eurasian Cranes may drift slightly southwards from their usual flyway and ignore the staging sites in north-western France and northern Germany. Latter tendency has been observed in two birds, one in Switzerland and another in the Czech Republic. These birds probably head directly towards Estonia by crossing Poland. As regards the West European flyway, the distance of the wintering grounds from Estonia usually

range from 1100 km (Northern Germany) to 3300 km (Western Spain). There are 1850 recoveries from the Eurasian Cranes along the West European flyway, whereby 1472 are visual observations, only 369 are GPS fixes of radio-tagged birds and 9 of satellite-tagged birds.

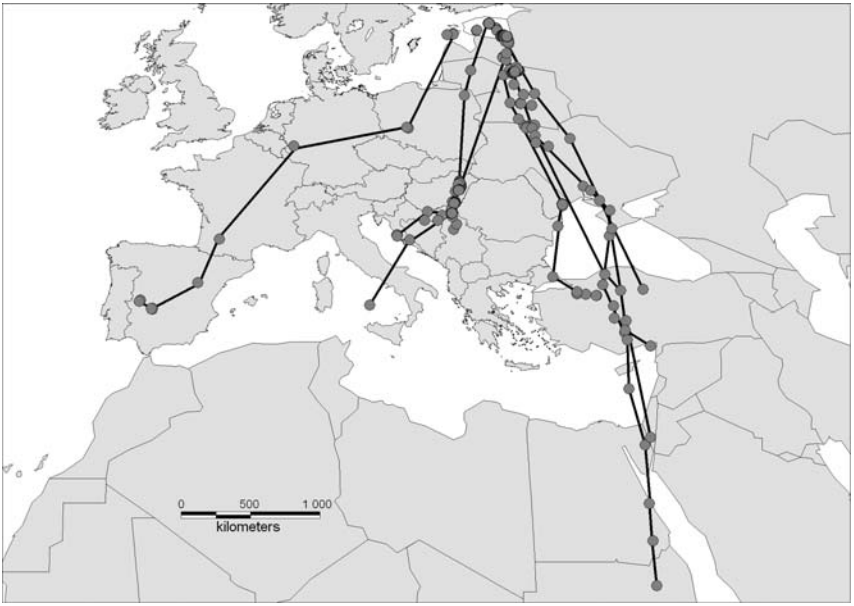

Figure 3. Flyways of the Eurasian Cranes breeding in Estonia according to satellite telemetry. Dots indicate received GPS fixes.
***Joonis 3**. Eesti sookurgede rändeteed satelliitjälgimise andmetel. Ringid näitavad GPS asukohamääranguid ning jooned nendevahelisi sirgjoonelisi ühendusi.*

The Central European flyway. Cranes heading south-west in autumn usually have short stopovers in Latvia, Lithuania or Poland before reaching a more important staging site in eastern Hungary (Fig. 3 and 4). From Hungary migration takes them to Serbia, Croatia, Bosnia-Herzegovina and Italy. One bird has also been sighted in the southern part of Austria. Wintering cranes have been sighted in North Italy and Croatia. A number of Eurasian Cranes also migrate to Tunisia as in 2010 one satellite-tagged bird, starting from Croatia, has been documented to cross the Adriatic Sea and Italy but perished the following day in the Tyrrhenian Sea on its way to Tunisia. There is no data of the spring migration of the Estonian Eurasian Cranes along the Central European flyway since no ringing control is carried out in spring and all three satellite-tagged

cranes following the Central European flyway perished either during their first autumn migration attempt or on their winter grounds. The distance between the setout of the autumn migration and the wintering grounds in Croatia and northern Italy lie 1600 and 2000 km respectively. Along the Central European flyway altogether 197 recoveries of the Eurasian Crane have been made, including satellite tracking data of 100 and visual observations of 97 individuals.

The East European flyway. In autumn, the Eurasian Cranes following the East European flyway first head for Belarus. Some birds may have short stopovers in eastern Latvia while others head directly to northern Belarus (Fig. 3). Migration continues crossing Ukraine, the Black Sea, Turkey, the eastern part of the Mediterranean Sea, Israel, the Sinai Peninsula, the Red Sea, the eastern part of Egypt and Sudan until reaching Ethiopia. Satellite-tagged birds have shown different migration strategies. After a short stopover in Belarus, three satellite-tagged birds out of six had a longer stay in the staging area in southern Ukraine (near Odessa and in Askania Novas that lies on the Crimea Peninsula). Stopping only for the purpose of roosting, three birds continued migration from Belarus to the south coast of Turkey, where in 2011 one bird remained for a longer period and another headed for Sinai Peninsula where on October 21 it probably perished. The third satellite tagged crane reached northern Sudan on November 11 in 2009 and perished. The majority of all the recoveries (a total of 192) on the East European flyway derived from satellite transmitters (190 GPS fixes), yet any of the Estonian satellite tagged Eurasian Cranes has ever reached Ethiopia. A sole satellite-tagged crane was under visual observation and was photographed in northeast Turkey on December 16 in 2010. One recovery of a colour-ringed crane was made in Israel, however, the colour combination at the right foot remained unregistered on account of which the individual remained unidentified.

Altogether 23 cranes have switched their migration routes (Table 1, Fig. 2). Mostly cranes exchange the West European Flyway for the Central European flyway or vice versa, but also an exchange between the West European Flyway and the East European Flyway is known.

Table 2. Recoveries of marked cranes by countries.
Tabel 2. *Eestis märgistatud sookurgede taasleiukohad riigiti.*

Riik/piirkond *State/range*	Lindude arv *No. of birds*	Vaatluste arv *No. of recoveries*	Märkused *Notes*
Austria *Austria*	1	1	
Bosnia-Hertsegovina	1	1	
Eesti *Estonia*	157	1553	
Egiptus *Egypt*	1	3	Only Argos data
Hispaania *Spain*	92	601	
Horvaatia *Croatia*	3	14	
Iisrael *Israel*	2	2	
Itaalia *Italy*	1	52	
Leedu *Lithuania*	1	1	Only Argos data
Läti *Latvia*	3	6	Only Argos data
Maroko *Morocco*	1	2	
Poola *Poland*	10	12	
Prantsusmaa *France*	105	525	
Rootsi *Sweden*	11	21	
Rumeenia *Romania*	1	1	Only Argos data
Saksamaa *Germany*	147	683	
Serbia *Serbia*	4	28	
Soome *Finland*	8	20	
Sudaan *Sudan*	1	2	Only Argos data
Šveits *Switzerland*	1	1	
Tšehhi *Czech Republik*	1	2	
Türgi *Turkey*	5	50	Only Argos data
Tüürreeni meri (Itaalia) *Tyrrhenian Sea (Italy)*	1	1	Only Argos data
Ukraina *Ukraine*	6	18	Only Argos data
Ungari *Hungary*	28	94	
Vahemeri *Mediterranean Sea*	1	1	Only Argos data
Valgevene *Belarus*	7	110	Only Argos data
Venemaa *Russia*	4	5	
Kokku /*Total*		3810	

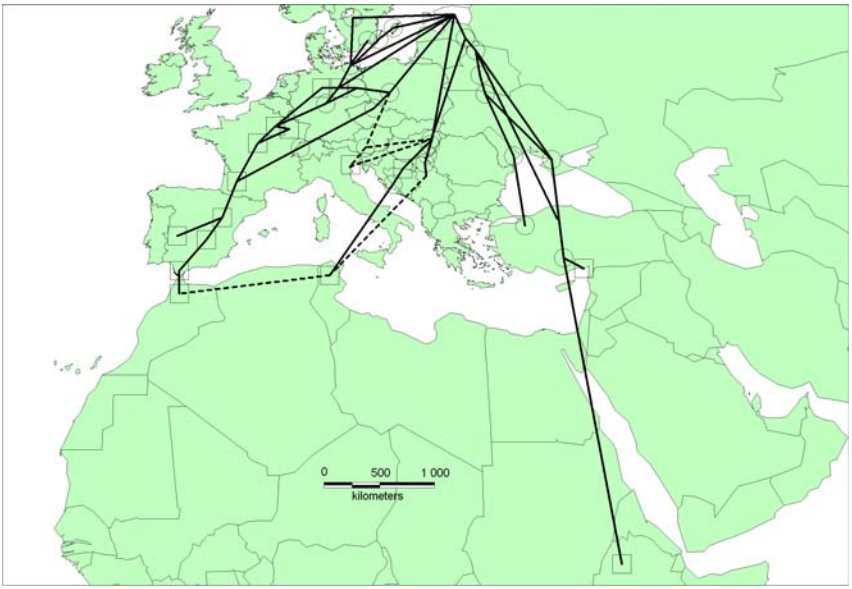

Figure 4. Generalised map of the flyways of the Eurasian cranes breeding in Estonia., Data was obtained by colour-ringing, radio and satellite telemetry. Dashed lines indicate theoretical migration routes, circles and squares indicate the main staging and wintering sites respectively.

Joonis 4. *Eesti sookurgede üldistatud rändekaart värvirõngastamise ja raadio- ning satelliitjälgimise andmetel. Punktiiriga on toodud tõenäolised lennuteed. Ruudud tähistavad talvitamispaiku ja ringid olulisemaid rändepeatuspaiku.*

Discussion

It appeared that the Eurasian Cranes breeding in Estonia use all three European flyways (Tables 1-2, Fig. 2-4). A novel discovery of the current study that Leito and Ojaste (2001) had not previously shown is that the cranes also migrate along the East European flyway. Factually this flyway is used only by a very small number of Eurasian Cranes breeding in Estonia (Table 1, Fig. 3, Lindude rändekaart 2011) which by itself is an interesting fact. According to satellite telemetry, also the Eurasian Cranes breeding in Finland that use the East European flyway are the ones that breed in the easternmost part of the country (Satellite cranes 2011).

The Eurasian Cranes breeding in the most eastern part use the most eastern flyway, yet a number of cranes breeding in East Europe migrate along the Central European flyway which is approximately twice as short. Furthermore, along the East European flyway there are several ecological barriers such as the Black Sea, the Mediterranean Sea, the Turkish and the Sinai highlands and the Nubian Desert. The reason why the majority of the Eurasian Cranes breeding in Finland use the Central European flyway (Rinne 2003,

http://www.satelliittikurjet.fi/) while the cranes breeding in Estonia use the West European flyway, remains unclear. Probably the relative importance of different migration routes has changed in time. There has been a rapid increase in the number of cranes using the West and the Central European flyways (Prange 2010, notes by Zolt Vegvari) while at the same time the number of cranes migrating along the East European flyway has probably remained at the same level whereby the number of individuals heading for Ethiopia has even declined (Nowald et al. 2010). Due to climate change, migration conditions differ among different migration routes, whereas the most substantial effect has been taken on the East European flyway. Moreover, there is a high poaching risk in Turkey (notes by Kerem Ali Boyla) and an increasing hunting pressure in Ethiopia as a result of an increasing food demand. These aspects need further investigation which already has been initiated in conjunction with researchers from other countries.

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