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Autumn roost site selection by the Common Crane *Grus grus* in the Hortobágy National Park, Hungary, between 1995–2000

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One of the largest migration routes of the Common Crane *Grus grus* leads across the Hortobágy National Park in Hungary, where more than 60 thousand cranes — a considerable part of the European (mostly Finnish) breeding population — stage for more than two months. The aim of this study was to investigate factors that may attract the Common Crane to roost sites in the Hortobágy and the surrounding non-protected areas of Eastern Hungary during the autumn migrations from 1995 to 2000. We found that two types of wetlands were used by cranes for roosting: drained fishponds with shallow water, and shallow marshes with open stretches of water. Most cranes were observed between mid October and early November (31 600–64 000 birds). The cranes selected 23.8% of all possible roost sites. Although 84% of marshlands were selected, and only 2.9% of fishponds drained at least once during the investigation were chosen for roosting, 74.5–79.4% of the total population roosted in a single drained fishpond. The peak number of roosting cranes correlated positively with the size of roost site, its distance from human settlements and roads. The effect of the distance between feeding and roosting sites was significant (negatively) only when differentiating between roost sites used only for one year and roost sites used for several years. Although the Common Crane preferred drained fishponds to marshes over the whole area, marshes and drained fishponds were equally selected in protected areas. We suggest that all important roost sites should be protected, wildfowl hunting should not be permitted and fishing activities should be reduced in wetlands suitable for roosting during migration.

1. Introduction

Understanding habitat selection of protected animals is important in evaluating the importance of natural habitats for wildlife (Clark 1996). The protection of roost sites in migratory species is especially important since a large number of animals may be concentrated in these sites (Clark 1996, Prange 1996). Although roost site selection and roosting behaviour have been studied for several bird species (Clark 1996, Glahn *et al.* 1996, Hosken 1996, King 1996, Lane & Hassal 1996, Trivedi & Johnsingh 1996, Bull & Blumton 1997, Clarke *et al.* 1997, Hill & Cresswell 1997, Kent *et al.* 1997), relatively few studies have investigated them for the Common Crane (Folk & Tacha 1990). Nevertheless it is generally thought that Common Cranes occupy large, undisturbed wetlands with shallow water.

The population of the Common Crane in Europe has seen an increasing trend since it became extinct by the 17th century in much of western and southern Europe: the number and density of breeding pairs is increasing and its range is expanding to the West and North (Hagemeijer & Blair 1997). However the Common Crane is still thought to be a vulnerable species regarding its European Threat Status, and is a Species of European Conservation Concern (SPEC) included in Category 3 (Prange 1994).

The migration of Common Cranes takes place in autumn between mid-September and the arrival of the first permanent frosts (usually the second half of November) in the Hortobágy. Most of them arrive from Finland, the Scandinavian peninsula, the Baltic states and possibly from West Siberia, and they leave for North-East Africa after staging here for more than two months (Fintha 1993, Prange 1999).

Previous studies have indicated that the Hortobágy in Eastern Hungary is a very important region for the migration of the Common Crane: up to 65 000 cranes of the eastern flyway, a considerable part of the total estimated European breeding population of around 52 000–81 000 individuals (Birdlife International 2000), migrate through the Hortobágy in autumn (Fintha 1993, Rinne 1995, Alonso & Alonso 1996, Prange 1999). Peak counts of Common Cranes staging in the Hortobágy increased from 3000/year to 65 000/year between 1983 and 1992 (Fintha 1993). An increase in migration volume was observed in both the eastern (from Finland and the Baltic States via Hungary to NE Africa) and western (from Sweden and Norway via Germany and France to Spain) flyways (Rinne 1995, Prange 1996, Salvi 1996). For the past five years up to 300 birds have staged here over the summer. A strong northward spring migration takes place between late March and mid-April.

The cranes that pass over the Hortobágy roost in shallow marshes or drained fishponds. Some of these fishponds are protected while others are non-protected and also occupied by cranes (Kovács 1987, Fintha 1993, Sterbetz 1984). In the rest of the text 'drained fishponds' refers to fishponds with shallow water (less than 40 cm) while 'fishpond' refers to fishponds in any state. Although the presence of suitable, undisturbed roost sites is known to be one of the most crucial points in selecting a staging area for Common Cranes (Fintha 1993), the mechanism of selecting a roost site is not fully understood.

Since cranes are highly sensitive to human disturbances (Fintha 1993), analysing preferences of their roost sites may help the authorities to outline various protection zone-limits and areas to be protected. The objectives of our study were (1) to report on the temporal variation in crane numbers in autumn, and (2) to investigate environmental variables influencing roosting numbers. The results of our study are supposed to help to plan a better protection scheme for cranes in Eastern Hungary.

2. Materials and methods

The observations were carried out in an area of 2130 km^2 including the northern part of the Hortobágy National Park (47°30′N, 21°10′E, 87 m a.s.l.) and some non-protected agricultural areas and fishponds surrounding it (Fig. 1). The Hortobágy National Park is the largest alkaline steppe in Central Europe. Protected areas in the National Park cover 80 200 ha (grasslands with marshes: 64.6%, fishponds: 1.9%, woodlands: 3.1%). The climate is moderate continental, with hot summers between June and August and severe frosts between the end of October and the second half of March. The average annual rainfall is 300–500 mm per year while the annual mean temperature is about 10°C.

The vegetation consists of mixed patches of *Phragmites communis*, *Typha angustifolia*, *Bolboschoenus maritimus*, *Juncus* sp., *Eleocharis palustris*, *Alopecurus pratensis*, *Glyceria* sp. and *Beckmannia eruciformis*. Our study area is surrounded by seven small towns (their distance from the borderline of the National Park varies between 0 and 2 kilometers) and includes three very small villages. Human movements are limited to three main roads and around 20 minor concrete roads and mud-roads. All marshes used by cranes as roost sites are included in the protected areas of the National Park, although up to 1999 only 2071 ha of fishponds were protected, where no wildfowl hunting is allowed. Since 1999, 83% of the surrounding fishponds (5200 ha) have been protected with more limited human disturbance.

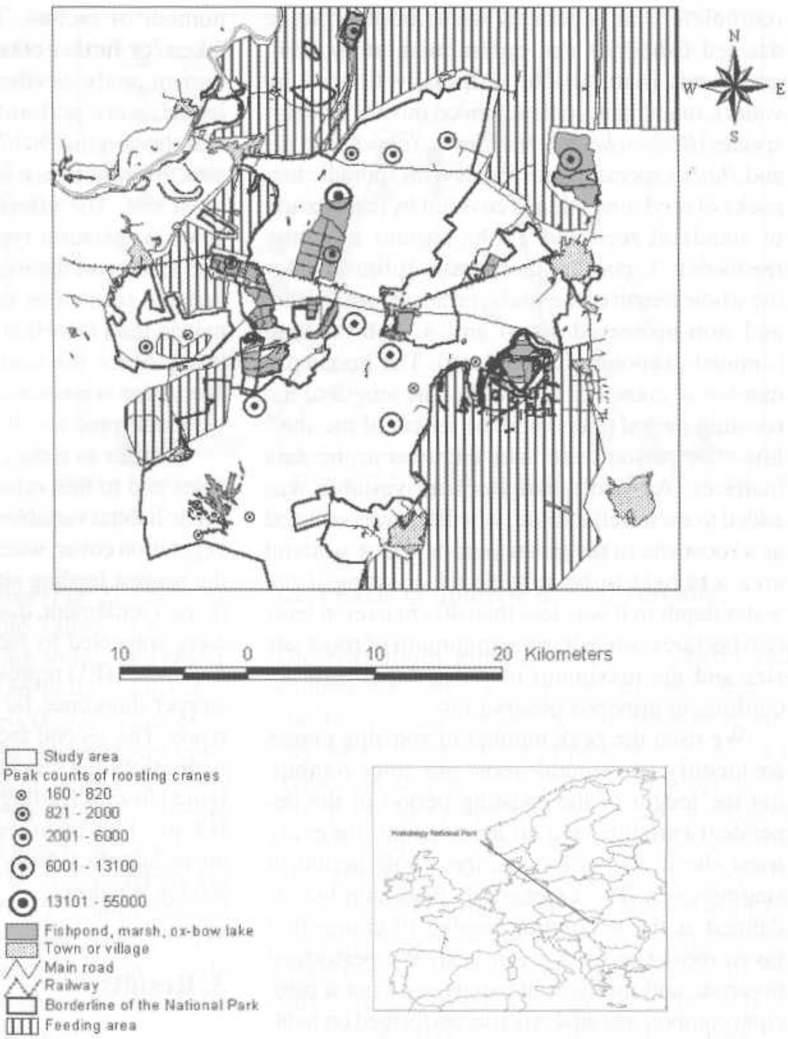

Fig. 1. Feeding areas and roost sites of Common Cranes staging in the Hortobágy between 1995–2000. Peak roost counts are also indicated. Roost sites shown outside fishponds are all marshes.

In addition to this the public is not allowed to access roost sites between 14.00 and 08.00 to minimize the disturbance of roosting cranes.

Roosting cranes were surveyed in the Hortobágy between 20 September and 15 November 1995–2000. We chose the autumn migration period since during the springtime there are fewer cranes roosting in the Hortobágy (Kovács 1987). One to three teams of observers stood in watchtowers at each roost-site and counted the cranes by binoculars and 20–40× telescopes at a distance of 200–500 m from the roosting cranes. We spent 2–3 days a week searching for roost-sites (drained fishponds and marshes with open water surface) and feeding areas. Roosting cranes were counted once a week. The counting period started three hours before sunset and ended one and a half hours after sunset in order to detect late-arriving flocks at full moon (Alonso *et al.* 1985). All fishponds and natural wetlands — mostly marshes — were checked in the study area (Fig. 1).

Besides the number of cranes the following variables were measured for each roost-site: 1. habitat variables: the area of open water surface (ha), vegetation cover (in 10%-s intervals), vegetation type, water depth at the deepest point (m), slope (tangent of the angle of inclination), distance from the nearest feeding site (km), distance from the nearest human settlement (km), distance from the nearest road (km); 2. vegetation type (completely unvegetated water bodies [some drained fishponds and natural alkaline ponds], grasslands [naturally or artificially flooded by water], marshlands characterised mostly by short species [*Bolboschoenus maritimus*, *Schoenoplectus* and *Juncus* species], grasslands with sporadic tussocks of reed, marshlands covered by the mixture of stands of reed and Typha species and pure reedbeds); 3. conservation status (protected for the whole length of the study, protected since 1999 and non-protected sites) and 4. habitat type (drained fishpond or marshland). The maximum number of cranes in a roost site, the length of the roosting period (days) and the length of the shallow-state period were later included in the data matrices. An additional Boolean variable was added to each wetland site: whether it was selected as a roost site in the given year or not. A wetland area was held to be suitable for roosting if the water depth in it was less than 40 cm over at least two hectares, since it is the minimum of roost site size and the maximum of water depth in it according, to previous observations.

We used the peak number of roosting cranes for identifying a suitable roost site, since combining the length of the roosting period in the dependent variable gave no information: for every roost site it was as long as the whole period of staging-over. The expression 'peak number' is defined as the maximum number of cranes in a given roost-site for a given year. We performed bivariate and multivariate analyses. First a principal components analysis was performed on habitat variables (area, vegetation cover, water depth, slope, distances from the nearest feeding area, human settlement and road) to elucidate relationships among them and to reduce them to a smaller number of factors. Three leading factors were taken for further consideration. After that discriminant analyses (the grouping variable was selected) were performed on the extracted factors and the original habitat variables in order to assess the importance of each variable in defining a roost site. The effects of categoric habitat variables (vegetation type, habitat type and protection status) on the maximum number of cranes in suitable roost sites were examined by non-parametric tests (Kruskal-Wallis and Mann-Whitney tests). Since the results of separate analyses for each year were similar, data from all six years were analysed together.

In order to reduce the number of habitat variables and to find relationships between them, numeric habitat variables (area of open water surface, vegetation cover, water depth, slope, distance from the nearest feeding site, distance from the nearest human settlement, distance from the nearest road), were subjected to factor analysis (Table 2). The first factor (F1) represents deep water bodies with steeper shorelines, far from human settlements and roads. The second factor (F2) combines variables with values that are characteristic for large wetlands lying close to feeding areas. The third factor (F3) is typical for open water bodies far from feeding areas. Statistical analyses were carried out by SPSS 9.0 for Windows.

3. Results

The average number of roosting cranes was 1524.2 in fishponds (n = 6) and 4476.6 in marshes (n = 6; Table 1). The peak numbers of cranes were observed normally between the last week of October

Table 1. Minimum, average and maximum values of roosting cranes in different habitats, between 1995–2000. (F: fishpond, M: marsh)

	Minimum		Average		Maximum	
	F	M	F	M	F	M
1995	0.0	3000.0	1083.3	8825.0	39000.0	14650.0
1996	0.0	0.0	776.8	2116.7	30296.0	12000.0
1997	0.0	0.0	1165.0	2583.2	31640.0	5526.0
1998	0.0	350.0	1915.7	3962.5	55000.0	7500.0
1999	0.0	160.0	1594.7	3789.3	26000.0	13100.0
2000	0.0	500.0	2609.6	5583.3	47180.0	11600.0

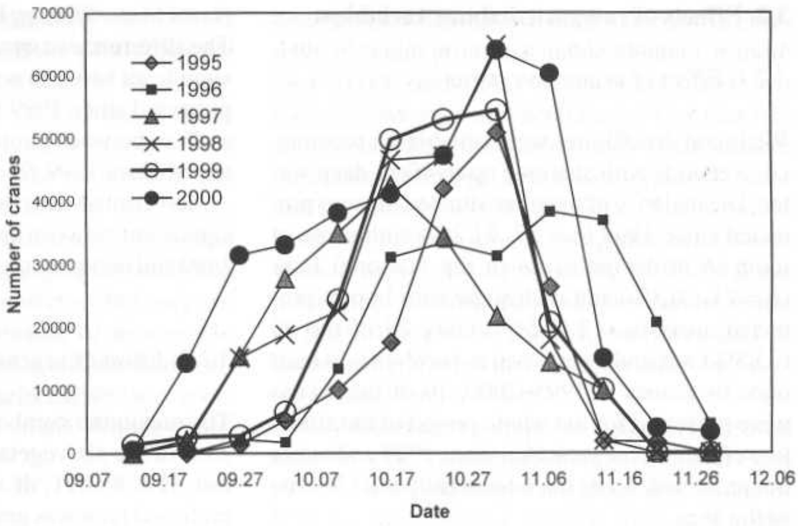

Fig. 2. Roost counts of Common Cranes in the Hortobágy between 1995–2000. Dates on the x-axis indicate dates of countings in each year.

and the first week of November (Fig. 2). The minimum, average and maximum values of roosting cranes in different habitats are shown in Table 1. The peak numbers of cranes are indicated in Fig. 2. In 1995 there was an extremely cold frost that swept the cranes out causing a sudden breakdown in the corresponding curve on Fig. 2, with a couple of hundred birds returning after the mild weather came back. In 1996 cranes stayed longer due to a warm period for the last two weeks of November. The situation was similar in 1997, 1998 and 1999 with more staging cranes in 1999 and 2000. In 2000 cranes were present all the year round in the Hortobágy. No roosting was observed outside the study area (Fig. 1) during the investigation.

During the day crane flocks fed in agricultural areas, mostly on maize stubbles (57.7%) and in some cases in grasslands (23.6%), alfalfa fields (5.7%) and abandoned agricultural areas (5.7%). Cranes used temporary marshlands and irrigation canals as drinking places.

In 1995 and in 1996 cranes used three roost-sites; six sites were used in 1997 and 1998, 11 in 1999 and 10 in 2000 (Fig. 1), although the differences between years in the number of available roost sites were not significant. One of these sites was used for roosting in each of the six years, a 412 ha drained fishpond (Lake Kondás) harbouring 74.5–84.8% of the total staging population. The other roost sites were temporarily flooded, 3–200 ha marshlands, part of them naturally, and part of them artificially filled up with water.

3.1. Effects of numeric habitat variables

The maximum number of cranes correlated significantly with all three habitat factors (Table 2). The discriminant analysis performed on these factors shows that the most important of them is F1 (typical of deep water bodies with a steep shoreline, far from human settlements and roads) for discriminating between selected and non-selected sites. F2 (typical for large wetlands close to feeding areas) is less important, while the role of F3 (typical for open water bodies far from feeding areas) is insignificant as shown in Table 3. In discriminating between roost sites selected only in one year and those selected for several years, we found F2 to be the most important (function coefficient: 0.381). F1 and F3 were much less important with function coefficients of 0.726 and –0.009, respectively.

Five patches of feeding areas were found in the study area, varying between 135 and 11 000 hectares. The distance between roost sites and the nearest feeding area varied between 0.1–12.0 km. According to the results of the factor analysis discussed in the previous paragraph, the distance between a roost site and the nearest feeding area did not seem to play an important role in differentiating between selected and non-selected roost sites. However it was important in differentiating between roost sites selected only in one year and those selected for several years.

3.2. Effects of categoric habitat variables

3.2.1. Effect of protection status

We found that 80 sites were suitable for roosting, i.e. wetlands with shallow, up to 40cm deep water. The majority of them are situated in areas protected since 1999 (n = 57, 71.2%) with some of them in protected areas in the National Park (n = 21, 26.3%) and with some sites in non-protected areas (n = 2, 2.5%). Only 19 of the 80 (23.8%) wetlands were used as roost-sites at least once by cranes in 1995–2000. 16 of these sites were protected for the whole period of the study, two of them were protected since 1999 and one is not protected, being the largest fishpond (749 ha) in the area.

Peak counts of roosting cranes were not different between marshlands and drained fishponds during the investigation in the protected areas (normal approximation of Mann-Whitney U-test, Z = –1.087, P > 0.2 each year). This is probably because there was only one fishpond with a large number of cranes, while the selected marshes were all occupied by medium-large roosting flocks. The difference between peak counts of marshes and fishponds could not be analysed in non-protected areas because there was only one selected, non-protected fishpond. The peak number of roosting cranes was significantly different between selected and possible roost sites (non-protected sites and those protected since 1999) (normal approximation of Mann-Whitney U-test, Z = –9.090, P < 0.001). The difference in crane peak numbers was also significant between non-protected areas and those protected since 1999 (Z = –6.737, P < 0.001), as well as between protected areas and those protected since 1999 (Z = –9.748, P < 0.001).

In selected sites the above difference was not significant between protected plus protected since 1999 and non-protected plus protected since 1999.

3.2.2. Effect of vegetation type

The maximum number of cranes was different in each of the six vegetation types (Kruskal-Wallis test, H = 85.091, df = 5, P < 0.001). The most preferred type was grassland with patches of tussocks of reed (mean value of crane maximums is 5417) indicating visually controllable areas with deeper areas while the less preferred was the mixture of stands of reed and Typha (mean value: 662.5).

3.2.3. Effect of habitat type

Although there were only 13 marshlands (18%) out of 80 suitable sites, 11 of them (84%) were selected by cranes for roosting. Marshlands are nowhere effected by hunting and fishing in the area so they were not disturbed by hunters and fishermen. This might be the reason for choosing

Table 2. Correlations between factors (first three leading factors) extracted by principal components analysis and original habitat variables, and Spearman correlation coefficients between extracted factors and peak number of Common Cranes.

Factor	F1	F2	F3
Explained variance (%)	35.355	18.788	15.788
Cumulative variance (%)	35.355	54.133	69.922
Area	–0.023	0.829**	0.211**
Vegetation cover	0.212**	–0.385**	–0.609**
Water depth	0.903**	–0.018	–0.183**
Slope	0.771**	0.015	–0.157*
Distance from feeding areas	0.232**	–0.510**	0.690**
Distance from human settlements	0.797**	0.424**	0.045
Distance from main roads	0.575**	–0.198**	0.392**
Correlations between factors and peak number of cranes	0.549**	0.239**	–0.288**

*P < 0.05, **P < 0.01

even smaller marshes while only the largest drained fishponds are selected since fishponds are much more disturbed day and night by fishing activities. Although only two of the drained fishponds (2.9%) were selected by cranes — the largest ones in the area — the majority of the cranes roosted in the smaller of them (see figures above). The smaller one is situated in a protected area, where no wildfowl hunting occurs, while the larger one (749 ha) is not protected, but may not be very much disturbed because of its size. As mentioned before, marshlands and drained fishponds were not different in selected wetlands (normal approximation of the Mann-Whitney test, $Z = -1.434$, $P > 0.5$).

4. Discussion

The discriminant analysis of factors representing habitat variables indicates that roost sites most preferred by cranes are characterised by a combination of the following characteristics: (1) large and relatively far from human settlements and roads with suitable conditions created by legal protection (2) relatively deep (up to 40 cm) (3) close to feeding areas.

Selected marshes were protected, medium-large (45–110 ha) wetlands generally far from human settlements (3–8 km) and not typically close to feeding areas (six sites were more than 5 km far from feeding areas. Selected fishponds were typically large (74–794 ha) wetlands generally nearer to human settlements (1.5–5 km) and closer to feeding areas (0.2–5.5 km) than marshes. This may be due to the fact that marshes are generally smaller thus easier to be disturbed by human activities nearby. Marshes were used by 160–13 100 cranes, while fishponds were used by 200–55 000 individuals.

It must be emphasized that peak numbers that are very high in some sites readily determine the result: although there are several sites (marshlands and fishponds as well) with a much less number of cranes, the result is greatly defined by the characteristics of some large, distant fishponds. However this result is in good accordance with field experiences.

These results emphasize the importance of the Hortobágy for the migration of the Common Crane since its roost sites having some of the above characteristics can provide suitable habitat for more than 60 000 birds. This becomes even more important if we take into account the fact that this area is one of the few staging-over areas suitable for cranes in Europe. It is also necessary to note that the number of selected roost sites increased from 3 to 11 during the investigation, which provides a higher degree of safety for the staging population. The nearest roost sites can be found in South-Hungary as the next stopover area in autumn migration, with only a few thousand staging cranes (Fintha 1993).

We found that two types of wetlands were used by cranes as roost-sites: drained fishponds and marshes with shallow water. The appearance of roosting cranes in the drained fishponds in the Hortobágy was observed simultaneously with their numbers decreasing in marshland roost sites in South-Hungary since the mid 1970's. Besides other factors like the creation of protected areas with limited human disturbance — especially hunting — wetland reconstruction and the fortunate but uncontrolled timing of the draining of fishponds could have played a role in the appearance of cranes in artificial habitats (Fintha 1993).

In 1999 more than 80% of the fishponds in the surrounding areas became protected, and two of them were used by cranes already in the first two years of protection due to limited disturbance. Nevertheless it is important to note that our results which show that these areas are less suitable than those protected since 1973 are due to the pres-

Table 3. Function coefficients of standardised canonical discriminant analysis. Grouping variable: Selected (with two values: selected or not selected).

Variable	Function 1
Factor 1	0.726
Factor 2	0.381
Factor 3	–0.009
Distance from human settlements	0.627
Water depth	0.591
Slope	0.345
Area	0.344
Distance from main roads	0.185
Vegetation cover	0.075
Distance from feeding areas	0.019

ence of wildfowl-hunting in the autumn period. This could have led to the coxistence of only a limited number of roost sites.

Although the number of drained fishponds selected for roosting is much lower than the number of selected marshes, their importance is shown by the fact that more than 70 percent of the cranes staging in the Hortobágy roost in a single drained fishpond, highlighting the need for a higher degree of protection of fishponds in the area.

Although the effect of fishpond size on peak roosting numbers could not be analysed because of the very low number of selected fishponds, it is possible that it was for their size that most cranes chose to roost in them. In the whole area the peak number of roosting cranes was significantly larger in protected than in non-protected areas suggesting a preference again towards undisturbed sites. Although the marshes, which are all situated in protected areas, are smaller in size on average, the peak numbers of roosting cranes were statistically not different between marshes and drained fishponds in protected areas, since there was only one fishpond with a large number of cranes while selected marshes were all occupied by medium-large roosting flocks. This is emphasized by the fact that 84% of the marshes were selected by cranes for roosting.

Although the distances between feeding and roosting sites did not play an important role in discriminating between selected and not selected roost sites, it was very important in discriminating between roost sites selected only in one year and those which are selected for several years, which corresponds to the results of other studies (Cox & Afton 1996, Alonso *et al.* 1984, Alonso *et al.* 1987) and the theory of refuging (Hamilton & Watt 1970). A rigorous testing of the effect of food quality distribution would require its spatial quantification and manipulation over the whole area, which was beyond the scope of this study.

The effects of distances from areas with enlarged human activities (cities, villages and roads) seem to play important roles in roost site selection, which indicates the importance of wetland reconstruction in conservation far from human activities.

4.1. Recommendations for conservation management

After water regulations carried out at the turn of the 19th century many of the marshlands lost their original source of water. Thus marshland reconstruction — which means providing wetlands with artificial water courses — became a very important conservational project. It led to the successful revitalization of quite a few marshlands, with some of them providing roost sites for cranes as well (Kovács 1987).

As the number of cranes crossing Hungary and roosting in the Hortobágy is very high and stable at this level, it is of the utmost importance to keep human activities far and limited, especially in protected areas. Besides it is important to legally protect all sites suitable for or actually selected by cranes. The preference of cranes for undisturbed sites shows that disturbance caused by wildfowl hunting or fishing activities in protected and non-protected fishponds may result in reduced preference for selecting such sites. In protected areas cranes chose drained fishponds which were far from human settlements and roads or were large enough not to suffer from disturbances. Thus it would be highly recommended to drain fishponds in the crane migration period (mid-September to mid-November) so that cranes may choose from various sites to roost in to maximize their chances of survival during migration by choosing sites closer to feeding areas (Cox & Afton 1996) and thus minimizing daily energy costs (King 1974) or sites with lower risk of predation. The degree of human disturbance seems to be low since the number of staging cranes also increases in sites close to areas that are easily accessible by the public. On the other hand the implementation of marshland reconstructions in strictly protected areas — where hardly any human activity occurs besides traditional grazing — would offer suitable roost sites for cranes, meeting the criteria outlined above. Creating such habitats for staging-over could increase the survival chances of the Common Crane on its long way from Northern Europe to Africa (Tucker & Evans 1998).

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Selostus: **Kurkien syksyinen levähdyspaikanvalinta Unkarissa, Hortobágyn luonnonpuistossa vuosina 1995–2000**

Yksi kurkien syksyisistä päämuuttoreiteistä kulkee Unkarissa sijaitsevan Hortobágyn luonnonpuiston kautta. Alueella levähtää parin kuukauden aikana jopa yli 60 000 kurkea, joista valtaosa on Suomessa pesiviä yksilöitä. Kirjoittajat tutkivat, mitkä tekijät vaikuttavat kurkien syksyiseen levähdyspaikanvalintaan? Valtaosa kurjista havaittiin lokakuun puolivälin ja marraskuun alun välisenä aikana. Kurjet käyttivät lepäily- ja ruokailualueina pääasiassa joko kuivattuja kala-altaita tai vetisiä suoalueita. Vuosittain käytössä oli 3–11 levähdysaluetta. Käytössä olevien levähdysalueiden määrä on vuosien myötä kasvanut. Päivisin kurjet ruokailivat pääasiassa maissipelloilla. Potentiaalisista 80 levähdyspaikasta oli käytössä 23.8 %. Potentiaalisista suoalueilla sijaitsevista levähdyspaikoista oli käytössä 84 %, kun taas vähintään kerran tutkimusajanjakson aikana kuivatetuista kala-altaista käytettin levähdysalueena vain 2,9 % kohteista. Vaikka levähdysalueina käytettyjen kala-altaiden kokonaismäärä (2 aluetta) oli pienempi kuin lehvähdysalueina käytettyjen suoalueiden kokonaismäärä (11 aluetta), valtaosa (74,5–79,4 %) koko kurkimäärästä käytti levähdysalueenaan yhtä ainoaa kuivattua kala-allasta, Kondásjärveä. Kirjoittajat arvioivat elinympäristön rakenteen merkitystä lehvähdysalueilla havaittuihin kurkien huippumääriin. Erotteluanalyysin mukaan suosituimmat levähdysalueet olivat kooltaan suuria, sijaitsivat kaukana asutuksesta ja teistä, olivat lähellä kurkien käyttämiä ruokailualueita ja veden syvyys alueilla oli suhteellisen suuri. Useammin kuin kerran käytössä olleiden lehvähdysalueiden läheisyydessä sijaitsi kurjille sopivia ruokailualueita. Kirjoittajat ehdottavat, että kaikki tärkeät kurkien levähdysalueet tulisi suojella. Lisäksi metsästys tulisi kieltää ja kalastusta rajoittaa kurkien levähdysalueiksi sopivilla kosteikkoalueilla.

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