Ornis Hungarica 15-16: 35-43. 2008

Habitat selection of migrating waders in the Hortobágy National Park, Hungary

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Végvári, Z. and Weszelinov, O. 2008. Habitat selection of migrating waders in the Hortobágy National Park, Hungary. – Ornis Hung. 15-16: 35-43.

We studied habitat selection of migrating waders in Hortobágy during spring and autumn migration periods between 1997-1999. We compared the habitat use of waders in drained fishponds and marshlands. Habitat availability was different between these two types of habitat since fishponds are usually drained in the autumn while marshes are provided by larger surfaces of suitable wader habitat (wet mud or shallow water) in spring due to autumn and winter precipitation. Fishponds, which are generally larger, attracted more waders in autumn whereas the smaller marshes were selected by more birds in spring. The effect of the density of grazing animals on wader numbers was also investigated. We found significant relation between the number of waders and grazing density in wader habitats. The conservation of waders migrating across alkaline grasslands needs the timing of draining the fishponds and the spatial distribution of grazing to be built in management plans.

A vonuló partimadarak élőhelyválasztását vizsgáltuk a Hortobágyon a tavaszi és őszi vonulási időszakban 1997-1999 között, illetve a partimadarak élőhelyválasztását hasonlítottuk össze szikes mocsarakban és lecsapolt halastavakon. Az élőhelykínálat különbözött ezen két típus között, ugyanis a halastavaknak rendszerint nagyobb része áll csapolás alatt ősszel, mint tavasszal, illetve a mocsarak a téli csapadék révén tavasszal kínálnak gyakrabban megfelelő élőhelyet a vonuló partimadarak számára. Így a halastavak, melyek átlagosan nagyobbak a mocsaraknál, több partimadarat vonzottak ősszel, mint tavasszal, míg a mocsaraknál fordított volt a helyzet. Emellett vizsgáltuk a legelő állatok egyedsűrűségének hatását az átvonuló partimadarak mennyiségére. A partimadár-élőhelyeken az a kapcsolat szignifikánsnak adódott. Eredményeink alapján a szikespusztákon átvonuló partimadarak védelme érdekében szükség van a halastó-lecsapolások időzítésének, valamint a legeltetés térbeli eloszlásának a kezelési tervekbe való beépítésére.

Key words: waders, Charadriidae, migration, Hortobágy, conservation, reconstruction

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1. Introduction

Habitat selection of migrating waders (Charadriidae) is well studied in coastal (Burger *et al.* 1977, Myers Myers 1979, Connors *et al.* 1981, Kelsey Hassal 1989, Gudmundson *et al.* 1991, Clark Niles 1993, Colwell Landrum 1993, Botton *et al.* 1994, Wiersma Piersma 1994) and prairie wetlands (Colwell Oring 1988, Skagen Knopf 1994) as well as in river valleys (Weisbrod *et al.* 1993). However relatively few studies examined habitat use of waders in marshes and alkaline grasslands (Kovács 1990, Ecsedi 1992a, Ecsedi 1992b, Kovács 1993) and fishponds (Kovács 1977, Kovács 1984a, Kovács 1990). However its study would be important since these grasslands are used by tens of thousands of migrating waders as a stopover site (Kovács 1990).

Besides some wader species like Kentish plover *Charadrius alexandrinus* and Collared pratincole *Glareola pratincola* breeding in this area suffered serious decline in the last decade with only very few studies focusing on them. Some studies have suggested the importance of grazing in alkaline habitats (Székely 1998), however its general impact on avian habitat use remained unstudied. Since wader habitat restorations has just recently started in Hortobágy (Kovács 1984b, Kovács 1992, Ecsedi 1993) studying habitat use in migrating waders is essential.

The aim of this study was to investigate the habitat usage of migrating waders thus describing the charasteristics of the most used wader habitats in Hungarian alkaline wetlands for better conservation measures. We analysed the effects of wader habitat composition, the spatial density of domesticated animals grazing in the area and differences between artificial and natural wetlands.

Wader migration was studied in spring and autumn of 1997, 1998 and 1999 in the Hortobágy, the largest alkaline grassland in Central Europe. Natural wetlands received more rainfall than in the past few years so waders could make use of both natural and artificial habitats.

2. Methods

Field work was carried out in the Hortobágy National Park (47°30'N, 21°10'E, 87 m a.s.l.) which preserves the largest unbroken alkaline steppe in Europe. Protected areas cover 82,200 ha (grasslands interspersed with alkaline marshes: 64.6%, fishponds: 1.9%, woodlands: 3,1%). The climate is moderate continental, with hot summers and severe frosts between late October and the second half of March. The average rainfall is 300-500 mm per year; mean temperature is around 10°C.

Wader habitats can be found in mudflats of fishponds drained during fishing as well as in open marshlands with patches of shallow water or wet mud surfaces. Altogether 66 fishponds were built after the water regulation measures of the River Tisza covering altogether 5,543 hectares. The total surface of each fishpond varies between 8 and 749 ha. 13 of them are already covered by reed *Phragmites communis* and 51 of them could be suitable for roosting and foraging for waders when drained. Natural wetlands cover about 10,000 hectares in Hortobágy while only 15 larger alkaline marshlands provide habitats for waders in altogether 850 hectares. The area of these marshes range between 1-500 ha. Fishponds are characterised by surrounding beds of reed *Phragmites communis* and reed-mace *Typha angustifolia* of variable width. Vegetation cover in marshlands generally includes patches of common spike-rush *Eleocharis palustris*, rushes *Juncus* sp., Maritime bulrush *Bolboschoenus maritimus*, bulrushes *Schoenoplectus* sp., reed and reed-mace.

Five of the six marshes of the study area were grazed by sheep or cattle. These animals grazed from early April to mid November in all three years on constant grazing areas. There was no change in grazing density in any of the years and grazing areas. Sheep and cattle grazed in the whole area except for patches covered by tussocks and water. In marshes only grazing animals produce manure and no artificial manuring occurs to improve pas-

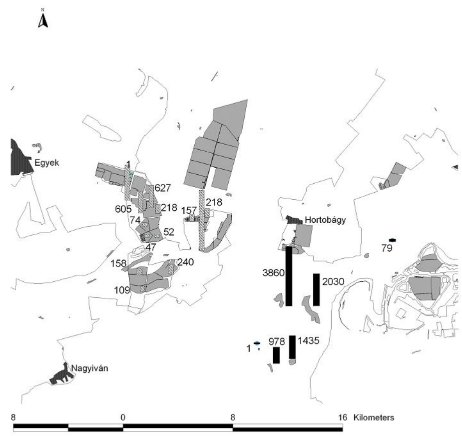

Fig. 1. Map of the study area. Bars indicate peak numbers of waders (filled: marshes, dashed: fishponds).

ture quality. The number of grazing animals, the size and location of each grazing area was constant for at least five years in the study area.

All fishponds in the study area are intensively used by the State Fish Farm putting in considerable amounts of nutrients (mostly organic manure) (Kovács B. unpublished data), that may lead to the existence of rich soil invertebrate communities like chironomid larvae which was proved to be an important food item of feeding waders in drained fishponds (Székely 1992). Organic manure is put into fishponds in order to increase plankton productivity, an essential food item of the carp.

Nutrient input in marshes by grazing animals is less than in fishponds (10 q/ha and 50-100 q/ha on average, respectively; Budai M. unpublished, Loch Nosticzius 1992).

The study was carried out in the central and south-eastern part of the National Park in the spring (late March-late May) and autumn (middle August-middle October) migration periods in 1997-1999.

We selected 23 of 51 (52.9%) artificial fishponds covering altogether 1183 ha (21.3% of total fishpond surface) and 6 of 15 (40%) natural marshes covering 292 ha (34.3% of total marsh surface suitable for waders, in order to use representative wetland blocks with similar management types in the national park side (Fig. 1.).

All wetland units of the study area in the national park were synchronously surveyed by two experienced observers 1-2 times a week on foot or vehicle. We performed counts at fixed points of a standard transect, so the sampling effort was constant during the study. We made complete counts of wader species occurring in each wetland unit and measured wetland characteristics by spacing and from maps. The estimation of bird numbers is thought to be complete since drained fishponds have no vegetation at all on the muddy bottom and marshland vegetation is very short and sparse giving few opportunities for waders to remain unnoticed. The term *suitable habitat* was defined as wet mud-shallow water habitats with little or no vegetation as suggested by previous studies (e.g. Skagen & Knopf 1994).

The following wetland characteristics were recorded each time (using 1:10000 geographical maps with the percentage of 'wetness' visually estimated in steps of 10%): total area of wetland, area of dry mud, wet mud (releasing water when trampled upon) , shallow water (where water depth is less than 8 cm), deep water surfaces (where water depth is greater than 8 cm), area and type of plant association of patches of tall vegetation (above 5 cm) and short vegetation (less than 5 cm), as well as density of grazing domesticated animals in the area. Accordingly, the following types of habitats were found in the study area: (1) dry barren and (2) wet barren patches; (3) shallow, open and (4) deep, open water patches; (5) wet patches covered by short mugwort *Artemisia maritima* (forming the *Artemisio-Festucetum* association); wet patches covered by (6) short and (7) tall meadow foxtail *Alopecurus pratensis* (forming the Alopecuretum pratensis association), (8) shallow and (9) deep water patches covered by meadow foxtail. In order to be able to assess the effects of nutrient supply to the total number, density and species composition of waders, the annual amount of manure input in different wetland units were measured as follows: in grazed areas this amount was computed using the grazing area, number and type of grazing breed: the size of the grazed area was multiplied by the grazing density and a breed-specific factor given by Loch & Nosticzius (1992). Grazing densities were calculated by dividing the size of grazing flocks by the average size of grazing area during the study period. In fishponds the annual manure input in different ponds were recorded by the staff of the local Fish Farm. In both cases the density of annual manure input was measured in q/ha units. In order to reduce the number of physical variables of wetlands, a principal components analysis was performed on the following variables: the proportion of the above-mentioned nine habitat types in percents of the total area of the wetland unit, total area of the wetland unit, the density of grazing animals (densities of different breeds of sheep and cattle were computed with different factors) (Hetey 1984), and density of annual manure input.

After that Spearman correlation coefficients were computed between extracted variables and the number of species, the total number of waders and density of waders in order to assess the importance of each variable in defining the best wader habitats.

We used SPSSPC+ V4.0 in all statistical analyses.

3. Results

3.1. General descriptive results

During the study we have recorded the presence of 26 wader species in the study area 1997-1999 in spring and autumn migration (Tab. 1.). Wader count totals were the highest during the spring migration of 1997 with 5622 individuals. During the autumn migration wader number totals were much less than observed in springtime (1563 in 1997, 1273 in 1998 and 1940 in 1999). However the number of species was only slightly different between seasons (17, 19 and 17 in spring, 19, 24 and 35 in autumn, respectively). However species composition differed between seasons: the commonest species were dunlin *Calidris alpina*, ruff *Philomachus pugnax*, black-tailed Godwit *Limosa limosa* and redshank *Tringa totanus* in spring, while in autumn common snipe *Gallinago gallinago*, curlew *Numenius arquata* and spotted redshank *Tringa erythropus* (Tab. 1.). Ruffs were dominating in marshes while black-tailed godwits were dominant in fishponds.

Habitat availability showed marked differences between seasons, since more fishponds were drained in autumn (47.8%) than in spring (30.4%). Waders migrating early in the spring used marshes and fishponds kept half-dry during winter.

Weather conditions were different between years: In 1997, wet mud or shallow water patches were continuously available in all studied marshes. In 1998, marshes were much drier than in the previous year following a, shortage of autumn and winter precipitation, and were frozen until late March. In April 1998 marshes were filled up with rain water after a drought lasting for several weeks. In 1999, a large flooding not seen since 1970 in early March totally filled up all marshes turning many grasslands into open lakes. A rainy season in April maintained this situation up to the middle of the same month. The total surface of wet mud or shallow water available was strongly fluctuating in all three years. Besides events like floodings, long rainy seasons are highly unpredictable. Late autumn situations were more uniform, since by this time marshes are usually filled up with water to some extent and many of the fishponds are being drained because of fishing technology reasons. Besides marshes in the study area have totally different water supply systems and capabilities to sustain water. Three of them are members of a 20 km long chain of marshes running from North to South collecting water from more elevated areas, while the other three ones are separate ones containing more stagnant water.

3.2. Effects of habitat variables

During the principal components analysis five factors were found with eigenvalues

Tab. 1. Peak counts of waders migrating across the Hortobágy in 1997-1999.

	Peak counts					
Species	**Spring**			**Autumn**		
	1997	**1998**	**1999**	**1997**	**1998**	**1999**
Recurvirostra avosetta	1	14	2	17	16	37
Charadrius dubius	35	22	0	5	10	22
Charadrius hiaticula	5	5	10	4	2	25
Charadrius morinellus	0	30	0	0	0	0
Pluvialis apricaria	1	0	2	0	0	1
Pluvialis squatarola	1	0	0	0	1	10
Vanellus vanellus	200	445	400	200	50	300
Calidris canutus	0	0	0	0	2	1
Calidris minuta	6	8	0	10	4	83
Calidris temminckii	1	1	0	1	1	0
Calidris ferruginea	2	6	1	0	4	85
Calidris alpina	77	42	300	2500	400	300
Philomachus pugnax	8	35	400	2000	3000	80
Gallinago gallinago	78	30	2	20	5	120
Limosa limosa	30	4	500	700	800	200
Limosa lapponica	0	0	0	0	1	0
Numenius phaeopus	0	42	0	1	3	1
Numenius arquata	500	350	31	12	41	300
Tringa erythropus	550	220	15	12	20	60
Tringa totanus	0	0	35	30	35	3
Tringa stagnatilis	0	0	3	1	2	0
Tringa nebularia	0	1	1	6	7	10
Tringa ochropus	1	0	0	1	1	3
Tringa glareola	40	10	10	100	25	4
Actitis hypoleucos	0	6	2	2	2	10
Arenaria interpres	0	2	0	0	2	1

greater than 1.0 (Tab. 2.). F1 represents (i.e. large values of is typical for) small, ungrazed wetlands where wet barren areas dominate with large densities of manure and the lack of tall vegetation is typical, i.e. mostly drained fishponds. F2 represents large, ungrazed wetlands with medium densities of manure where wet barren areas dominate, i.e. large drained fishponds and some large marshes. F3 represents medium-sized wetlands with bodies of open water, and wet patches of short vegetation (*Artemisietum* and *Alopecuretum*), i.e. medium-sized, grazed marshes. F4 is similar to F3 but without open water bodies, i.e. medium-sized, shallow, grazed marshes. F5 represents small, shallow, ungrazed wetlands with tall vegetation, typical for small marshes with ungrazed areas of Alopecuretum.

The correlations between dependent (number of species, total number of waders and density of waders) and extracted habitat variables are shown in Table 2. F1 and F2 are significantly correlated with all wader variables, with F2 showing a stronger correlation. It indicates a strong preference for large fishponds with wet barren surfaces with larger concentrations of organic manure. F3 is significantly, but less strongly correlated only with the number of waders. It indicates the temporary occurrence of large, homogenous flocks of waders in small, deep marshes, which is mostly typical in the springtime for ruffs, godwits and occasionally dunlins. F4 is significantly correlated with the number of species and the density of waders, but not with the number of waders, indicating the presence of mixed flocks in shallow, grazed, but small marshes. F5 is not correlated with either of the wader variables showing the lack of waders in tiny, ungrazed marshes overgrown by tall vegetation.

Previous observations have shown that cattle grazing decreases grass height and extension of barren surfaces in marshes to a larger extent than sheep do (Z. Végvári unpublished data).

3.3. Effects of habitat type

While the difference between the total number of waders was not significant between fishponds and marshes in spring (Mann-Whitney U-test, U=2057.5, P=0.069) it was significant in autumn (U=350.5, P<0.001). According to the results of principal components analysis

Tab. 2. Correlations between factors (first five leading factors) extracted by principal components analysis and original habitat variables, and Spearman correlation coefficients between extracted factors and wader variables.

Factor	F1	F2	F3	F4	F5
Explained variance(%)	18.51	13.40	11.71	11.15	10.55
Cumulative variance (%)	18.51	31.91	43.62	54.76	65.32
Spearman correlation coefficients between extracted factors and wader variables					
Number of species	0.249**	0.546**	0.078	0.110*	0.000
Number of waders	0.209**	0.506**	0.118*	0.083	-0.021
Density of waders (1/ha)	0.193**	0.356**	0.020	0.106*	0.054

**: Correlation is significant at the 0.01 level (2-tailed)
*: Correlation is significant at the 0.05 level (2-tailed)

this is because of the larger density of organic manure and the larger area of mudflats in the fishponds. The differences in habitat availability between fishponds and marshes are much more expressed in autumn, when several fishponds are drained simultaneously. Another principal difference between marshes and fishponds in the study area is that all marshes are protected thus are without hunting and fishfarming while in fishponds these factors may cause considerable disturbance. However fishponds better provided by nutrients are used by larger numbers of waders which may indicate that food availability is a more important factor in choosing feeding area than disturbance caused by fishing and hunting. Since hunting was only allowed in fishponds, its effects on habitat selection were not possible to analyse separately. As the whole of the study area is protected, the analysis of the effects of protection was also not possible. Besides, there was no difference between years (Kruskal-Wallis test, χ^2=3.946, *df*=2, *P*=0.139).

4. Discussion

Alkaline marshes and drained fishponds offer suitable habitat for migrating waders in their stopover area in Hortobágy, as shown in previous studies (Kovács 1984a, Kovács 1990). Habitats suitable for migrating waders have markedly changed during the past 50 years. Almost all marshes were alkaline ponds with very sparse or no vegetation at all due to traditional intensive grazing all over the Hortobágy (Horváth Szabó 1981, Molnár 1998, Hetey 1984). Numbers of grazing animals have suffered a serious decrease after the Second World War due to economic reasons (Molnár 1998). Since then marshes are slowly but gradually were becoming grown over by tall vegetation, especially reed and reed-mace (Horváth Szabó 1981) resulting in the considerable loss of wader habitats.

Fortunately fishponds were started to be built in the turn of the century offering large areas of suitable habitat for waders during fishing. Although the timing of draining the fishponds is not planned to provide habitat for migrating waders, fortunately there are always drained fishponds during the autumn migration (Aug-Sept) due to economic reasons. It is important for waders to replenish fat reserves since many of the marshes dry out during the summer. In springtime, the draining of fishponds is less frequent. However, in some years there can be found one or two fishponds left half-dry during the winter. In early springtime fishponds have an advantage over marshes by melting sooner and in case of winter drought only fishponds can provide waders with suitable habitats. In springtime, at least a few marshes are filled up with water due to autumn precipitation and winter snowfall thus providing wader habitat in shallow areas. Artificially flooded marshes are also used to be filled up during the autumn not to disturb late summer breeding attempts (Kovács 1984b, Ecsedi 1993). This sort of seasonal asymmetry is reflected in the seasonal differences between the habitat use of fishponds and marshes by waders. Species that migrate in considerable numbers in spring are dominant in marshes while waders migrating in autumn in large numbers make more use of fishponds.

The input of organic material into

wader habitats plays an important role in attracting waders, which may be the cause of the high density of invertebrate fauna in nutrient-rich soils or the accessibility of prey is in short-grazed grasslands .

Since vegetation height did not correlate significantly with grazing numbers, highly significant correlations between the number of grazing animal units and wader numbers may reflect the role of animals in producing organic material.

Wader habitat reconstruction in Hortobágy may play a very important role in conservation management plans since many protected and endangered wader species use this area as a stopover site (Kovács 1990, Kovács 1994). Significant correlations between the surface area of wet mud/shallow water and wader numbers indicate the opportunistic way of using wetland as shown in other studies (Skagen Knopf 1994). Thus habitat reconstruction for waders may be easier than for species showing strong site-fidelity which is also shown by the high attractivity of artificial habitats for waders (Kovács 1984b, Kovács 1990, Ecsedi 1993).

In autumn the majority of migrating waders use drained fishponds, so it would be very important to drain fishponds after one another in order to have available wader habitat during the whole of migration period, i.e. from mid July to late October.

The importance of grazing activities in creating wader habitats also shown by previous studies suggests that more waders could be attracted to more grazed marshes in spring when only a few fishponds are available for them. Since many wader species migrating across the area are broad-front migrants, it could be recommended to create a network of wader habitats in the area where there would be drained fishponds in both migration periods and the spatial distribution of grazing activities would be more evenly distributed and concentrated in marshland areas.

Acknowledgements. We thank the staff of the Hortobágy Fish Farm for providing technological data.

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