

INSECTS IN THE WHITE STORK *Ciconia ciconia* DIET AS INDICATORS OF ITS FEEDING CONDITIONS: THE FIRST DIET STUDY IN SLOVENIA

Žuželke v prehrani bele štorke *Ciconia ciconia* kot indikatorji njenih prehranskih razmer: prva raziskava prehrane vrste v Sloveniji

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Prey remains found in the pellets of the White Stork *Ciconia ciconia* are known not to reveal the actual prey intake by the White Storks. The exceptions are the chitinous remains of insects that are quite well preserved in the pellets, and thus potentially good indicators of the actual intake of White Storks. Since insects are selected by White Storks in proportion to their abundance in the environment, they can be used as indicators of the quality of the bird foraging habitat. A preliminary test of this was carried out at three nests in NE Slovenia differing in their breeding success in 1997. In contrast to habitat analysis around the nest the proportions of Orthoptera and Coleoptera in the pellets corresponded well to the breeding success. Orthoptera species were dominant in high success, and Coleoptera (especially Carrion beetles Silphidae) in low success nests. In this paper the value of insects in White Stork pellets as indicators of the quality of the bird foraging microhabitat patches is set out. However, the indicative power of these insects needs to be tested further.

Key words: White Stork, *Ciconia ciconia*, diet, Slovenia, insects, indicators

Ključne besede: bela štorclja, *Ciconia ciconia*, prehrana, Slovenija, žuželke, indikatorji

1. Introduction

The diet of the White Stork *Ciconia ciconia* is relatively well known all over its distributional range in Europe (e.g. PINOWSKA & PINOWSKI 1985, SACKL 1987, DZIEWIATY 1992, MUŽINIČ & RAŠAJSKI 1992, RÉKÁSI 2000, ANTČAK *et al.* 2002, TSACHALIDIS & GOUTNER 2002). Most diet studies used pellet analysis, although it was established that prey remains found in pellets do not reveal the only prey intake by the Storks (PINOWSKI *et al.* 1991, MUŽINIČ & RAŠAJSKI 1992). For example, earthworms Lumbricidae and amphibians Amphibia are mostly missing in the pellets since this prey is almost entirely digested, and other vertebrate prey e.g. mammals, birds and fish, are usually underestimated. On the other hand, chitinous remains of insects are quite well preserved in pellets (e.g. PINOWSKI *et al.* 1991), probably resembling well also the actual intake by White Storks. Almost all diet studies in Europe have confirmed that insects are,

besides small mammals, the most important prey taken by White Storks, and that their proportion increases towards southern regions (e.g. PINOWSKI *et al.* 1986, SACKL 1987, MUŽINIČ & RAŠAJSKI 1992, RÉKÁSI 2000, TSACHALIDIS & GOUTNER 2002).

Food availability strongly influences White Stork breeding success (TRYJANOWSKI & KUZNIAK 2002, TORTOSA *et al.* 2003, MASSEMIN-CHALLET *et al.* 2006), and breeding birds usually actively select areas with higher food abundance (ALONSO *et al.* 1991, JOHST *et al.* 2001, TORTOSA *et al.* 2002, JERZAK *et al.* 2006). Since the White Stork is generally not a sit and wait predator, but takes prey while walking (CRAMP 1994), invertebrates, i.e. insects, are selected in proportion to their abundance in the environment (SACKL 1987). Therefore a detailed analysis of insect prey in the White Stork pellets could be useful indicator of the White Stork feeding conditions, since insects are usually habitat specific and can reveal what kind and quality of habitat type the White Stork used for foraging. The

above cited references support the suggestion that White Stork forages at the best and most productive habitat patches available in the vicinity of its nest. The quality of foraging habitat can be estimated from the insect prey taken. This preliminary study was aimed to provide more insight into this problem, and to test if the specific insect prey composition in White Stork pellets corresponds to its breeding success better than a general analysis of the habitat surrounding the nest site. This study is also the first report on the White Stork diet from Slovenia.

2. Study area and methods

Three White Stork nests were selected in NE Slovenia, where the bulk of the Slovene White Stork population lives (DENAC 2001): (1) Trnovska vas (46°31'13"N, 15°53'13"E), (2) Lovrenc na Dravskem polju (46°22'26"N, 15°46'41"E), (3) Spodnja Gorica (46°25'5"N, 15°41'31"E). In 1997 the brood size and number of fledged young were determined for each nest, and the breeding success was expressed as the proportion of successfully fledged young.

Table 1: Comparison of breeding success (proportion of fledged young to total number of young), diet composition (summarised data are marked in bold) and structure of surrounding habitat (categorized according to optimality of land-use types as foraging grounds) between three White Stork *Ciconia ciconia* nests in NE Slovenia in 1997 (+ indicates just the presence of plant material)

Tabela 1: Primerjava gnezditvenega uspeha (delež speljanih mladičev glede na velikost zalege), prehrane (zbirni podatki so označeni z mastnim tiskom) in strukture okoliškega habitata (kategorije so bile določene glede na optimalnost tipov rabe tal kot prehranjevališč) med tremi gnezdi bele štorke *Ciconia ciconia* v SV Sloveniji leta 1997 (+ označuje zgolj prisotnost rastlinskega materiala)

	Locality / Lokaliteta	Trnovska vas	Lovrenc na Dravskem polju	Spodnja Gorica	Total/ Skupno
Breeding success/ Gnezditveni uspeh	No. of young / Št. mladičev	4	3	3	10
	Proportion of fledged young (%) / Delež speljanih mladičev (%)	100.0	33.3	33.3	60.0
	Plantae	+	+	+	+
	<i>Talpa europaea</i>	0.0	2.7	2.6	2.2
	Arvicolidae	4.2	2.7	2.6	2.9
	Mammalia, indet.	0.0	2.7	0.0	1.5
	Mammalia, total	4.2	8.2	5.1	6.6
	Pisces	4.2	0.0	0.0	0.7
	Vertebrata, total	8.3	8.2	5.1	7.3
	<i>Carabus cancellatus</i>	0.0	2.7	0.0	1.5
	<i>Carabus granulatus</i>	8.3	4.1	0.0	3.7
	Carabidae, other / ostalo	0.0	0.0	7.7	2.2
	Carabidae, total	8.3	6.8	7.7	7.4
Diet/ Prehrana (%)	<i>Nicrophorus</i> sp.	0.0	1.4	0.0	0.7
	Silphidae, other / ostalo	0.0	30.1	28.2	24.3
	Silphidae, total	0.0	31.5	28.2	25.0
	Melolonthinae	0.0	8.2	10.3	7.4
	Scarabaeidae, other / ostalo	0.0	4.1	2.6	2.9
	Scarabaeidae, total	0.0	12.3	12.8	10.3
	Coleoptera, other / ostalo	16.7	32.9	35.9	30.9
	Coleoptera, total	25.0	83.6	84.6	73.5
	<i>Gryllotalpa gryllotalpa</i>	12.5	2.7	5.1	5.1
	Orthoptera, other / ostalo	54.2	5.5	5.1	14.0
	Orthoptera, total	66.7	8.2	10.2	19.1
	Insecta, total	91.7	91.8	94.9	92.6
	No. prey items / Št. plena	24	73	39	136
Surrounding habitat / Okoliški habitat (%)	Optimal / Optimalen	0.6	3.5	0.5	1.5
	Suboptimal / Suboptimalen	67.6	87.4	77.5	77.5
	Unsuitable / Neprimeren	31.8	9.1	22.0	21.0

Table 2: Test of differences between the three nests (TV – Trnovska vas, LDP – Lovrenc na Dravskem polju, SG – Spodnja Gorica) of the White Stork *Ciconia ciconia* in terms of the structure of the surrounding habitat (proportion of optimal, suboptimal and unsuitable foraging habitats) and of the insect part of the diet (ratio of Coleoptera to Orthoptera in the diet)

Tabela 2: Testiranje razlik v strukturi okoliškega habitata (delež optimalnega, suboptimalnega in neprimerne prehranjevalnega habitata) in v razmerju hroščev Coleoptera in kobilic Orthoptera v prehrani bele štorke *Ciconia ciconia* med tremi obravnavanimi gnezdi v SV Sloveniji (TV – Trnovska vas, LDP – Lovrenc na Dravskem polju, SG – Spodnja Gorica)

Comparison/ Primerjava	Surrounding habitat/ Okoliški habitat	Ratio of Coleoptera to Orthoptera in the diet / Razmerje hroščev in kobilic v prehrani
TV : LDP	$\chi^2 = 17.18$, $p < 0.001$	$\chi^2 = 36.19$, $p < 0.00001$
TV : SG	$\chi^2 = 2.49$, ns	$\chi^2 = 23.60$, $p < 0.00001$
LDP : SG	$\chi^2 = 8.04$, $p < 0.05$	$\chi^2 = 0.09$, ns

Between 5 and 12 Jul 1997, pellets under each nest were collected at the time of intensive growth of the young. Pellets were examined in the laboratory and prey items were identified using reference books and collections. Only the presence of plant material was recorded while, in animal prey items, we estimated the number of individuals by bone remains (vertebrate prey), mandibles (Orthoptera) or elytron remains (Coleoptera). Analysis of the surrounding habitat was carried out in a circle of 1500 metres radius around the nest, using the Corinne land use map (MKGP 2002) and GIS tool (Arc View 3.1). This is the distance covered by the majority of foraging flights (ALONSO *et al.* 1991). Based on published data (PINOWSKI *et al.* 1991, TSACHALIDIS & GOUTNER 2002, DENAC 2006A) we classified different land use types into three classes according to their suitability for the White Stork as foraging habitat: (1) optimal (extensive meadows, water bodies), (2) suboptimal (fields, extensive orchards, intensive meadows, bushy areas and areas in succession forest stage), and (3) unsuitable habitat (hop fields, vineyards, intensive orchards, forest and urban areas). In the analysis we made pair comparisons of the proportion of habitat types (3 classes) and the proportion of Orthoptera and Coleoptera in the diet (2 classes) with the χ^2 test, and compared the results with the differences in breeding success between the observed nests.

3. Results and discussion

Insects were the most numerous White Stork prey since they constituted more than 90% of prey items in all three searched nests (Table 1). This was according to expectations since the White Stork population in Slovenia is in the species' southern distributional range in Europe (ARAÚJO & BIBER 1997), where the proportion of insect prey in diet is relatively high (MUŽINIČ & RAŠAJSKI 1992, RÉKÁSI 2000, TSACHALIDIS & GOUTNER 2002). The proportion of vertebrate prey was low, but this can be underestimated, for the reasons discussed in the introduction. When comparing the three nests significant differences were found in the habitat structure or optimality around the nest (Table 2). The nest at Lovrenc na Dravskem polju (LDP) had the highest proportion of optimal habitats and the lowest of unsuitable ones, while there was no statistically significant difference between the nests in Trnovska vas (TV) and Spodnja Gorica (SG) – the proportion of optimal foraging habitats in the nest vicinity was low in both. However, there was no correlation with breeding success since it was high at TV and not at LDP (Table 1).

Further, we tested whether the composition of insect prey items from White Stork pellets – which should resemble relatively well the prey species proportions taken by feeding White Storks – corresponded to breeding success. In the more successful nest (TV) Orthoptera species were dominant, while in the less successful nests (LDP, SG) Coleoptera species prevailed significantly (Tables 1 & 2). Thus the insect prey structure in the diet appears to correspond very well to the actual breeding success of the White Stork. When considering only the beetle prey species, we found that in the less successful nests the most abundant were Carrion beetles Silphidae, otherwise completely absent from the more successful nest. Two possible explanations may account for this in terms of the general ecology of Carrion beetles (KOCH 1989): (1) the White Storks were feeding predominantly on carcasses where carrion beetles can be very numerous or (2) that the White Storks used mainly dry areas for foraging, where Carrion beetles are more abundant than Carabid beetles Carabidae, which are also an abundant beetle prey group. We speculate that the higher proportion of Carrion beetles in the diet indicates that White Storks were feeding either in less favourable dry areas or in areas with lower amounts of suitable prey, and were therefore forced to take carrion to a greater extent.

In general White Storks select specific habitats or even microhabitat patches for foraging (ALONSO *et al.* 1991, JOHST *et al.* 2001), and these can vary in

optimality. However, individual birds have individual foraging strategies influenced for example by competition, quality of individuals or environmental factors (DENAC 2006A & B), and they can also feed quite far away from the nest (JOHST *et al.* 2001).

It is therefore almost impossible to identify in which way foraging areas influence the breeding success of White Storks. I therefore propose the use of insect prey remains, which are relatively well preserved in the White Stork pellets, as indicators of the quality of foraging microhabitat patches. To estimate the indicator power of insects in the White Stork diet more studies are needed with larger nest samples included.

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4. Povzetek

V predhodnih raziskavah je bilo ugotovljeno, da ostanki plena, najdenega v izbljuvkih bele štorke *Ciconia ciconia*, ne odsevajo dejanske strukture plena, kot ga je ptica zaužila. Izjemna so le hitinski ostanki žuželk, ki so v izbljuvkih dobro ohranjeni in naj bi dejansko odsevali tudi število živali, ki jih je štorlja uplenila. Upošteva dejstvo, da štorlja pleni žuželke glede na njihovo dejansko številčnost v okolju, bi bilo mogoče uporabiti žuželke kot indikatorje kakovosti prehranjevalnega habitata bele štorke. To hipotezo smo preliminarно testirali na primeru treh gnezd v SV Sloveniji z različnim gnezditvenim uspehom v letu 1997. V nasprotju z analizo habitata okoli gnezda se je analiza deleža kobilic Orthoptera proti hroščem Coleoptera v izbljuvkih dobro ujemala z ugotovljenim gnezditvenim uspehom preučevanih štorke. Kobilice so bile pogostejše v izbljuvkih ob zelo uspešnem gnezdu, hrošči (zlasti mrharji Silphidae) pa v manj uspešnih gnezdi. V prispevku je na podlagi tega predstavljen pomen žuželk v izbljuvkih bele štorke kot indikatorjev kakovosti prehranjevalnega mikrohabitata vrste. Za oceno indikatorske moči žuželk pa bi bile potrebne dodatne raziskave v prihodnosti.

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