Arch. Biol. Sci., Belgrade, 65 (3), 1007-1013, 2013 DOI:10.2298/ABS1303007M

DIET AND FORAGING HABITATS OF NON-BREEDING WHITE STORKS (*CICONIA CICONIA*) IN BULGARIA

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Abstract - The diet of non-breeding White Storks was studied by pellet analysis and included mainly insects (99.9%, n=28947) with a predominance of grasshoppers (Orthoptera, 76.1%), and beetles (Coleoptera, 26.1%). The bush crickets *Decticus albifrons/verrucivorus* were the most numerous prey (29.9% by items), occurring in almost all pellets (98% occurrence in pellets, n=147) and predominating in half of them (49.7%). The grasshopper associations in the pellets specify foraging mainly in mesophytic grasslands that usually replace abandoned fields and overgrown pastures with a low level of grazing. The xerophytic grass-shrubby habitats, not rare on stony terrains, were of less importance, providing around 20% by prey. The typical aquatic inhabitants and the use of carrion around villages were exceptions in the study diet. The number of innutritious materials in the pellets rose when the White Storks hunted on nippy and agile grasshoppers and decreased when the main pray was slower beetles taken from the ground. The roosting of non-breeding White Storks disappeared when their preferred feeding habitats were ploughed up in the following years.

Key words: White Stork, *Ciconia ciconia*, diet, foraging habitat

INTRODUCTION

The White Stork (*Ciconia ciconia*) is predominantly a long distance migrant whose depleted breeding population in Europe is increasing mainly in the western parts of the breeding range (BirdLife International, 2004, 2012; Sanderson et al., 2006). Its international protected status is Least Concern (BirdLife International, 2012). The Bulgarian breeding population, with 4818 pairs in 2004, increased by 14.7% compared to 1994, but it is listed as a "vulnerable" bird in the Bulgarian Red Data Book (BirdLife International, 2004; Golemanski, 2011). The Western Black Sea flyway passes through the country. Spring migration lasts from the beginning of March until mid-May, but flocks with up to 250 non-breeding birds migrate on their way northwards till mid June. Flocks up to 100 non-breeding birds wander in the lowlands in the summer (Simeonov et al., 1990; Milchev and Kovachev, 1995). About two thirds of all the White Stork population belongs to the non-breeding fraction and a large part of it migrates to Europe (Van den Bossche et al., 2002).

The diet of the breeding White Storks has been well studied in many parts of its range where this opportunistic carnivore preys upon varied small vertebrates (usually mammals and amphibians) and larger invertebrates (mainly insects and earthworms Lumbricidae) in predominantly open areas and wetlands (Pinowska and Pinowski, 1985; Pinowski et al., 1986; Sackl, 1987; Glutz von Blotzheim and Bauer, 1987;

del Hoyo et al., 1992; Johst et al., 2001). Recently, a more often foraging at rubbish dumps was described (Blanco, 1996; Kruszyk and Ciach, 2010; Tortosa et al., 2002; Peris, 2003). The habitat preference and the diet of non-breeding White Storks are poorly known in Europe thought this fraction of mainly three- and four-year-old birds has a key importance for the dynamics and the conservation of the breeding population (Antczak et al., 2002; Antczak and Dolata, 2006).

The aim of this study was to determine the food spectrum and main preys of non-breeding White Storks in Bulgaria by pellet analysis. Most insects are habitat specific and their proportions in the pellets could indicate the habitat preference of the feeding White Storks.

MATERIALS AND METHODS

Study area

The study area includes the valley of the Izvorska River with a large wetland around its influx into the Mandra reservoir to the north (protected area "Outfall of the Izvorska River") (2 m a.s.l., N42° 25` E27° 26`), and the surrounding slanting slopes with flat ridges at the foot of the wooded Strandzha Mountains to the south (120 m a.s.l., N42° 20` E27° 30`). The region falls into the Transitory Mediterranean Climatic Zone (Galabov, 1982). The open habitats of abandoned fields, arable lands used as dry meadows, abandoned and low exploited pastures, and arable lands predominated. The area is a traditional roosting place of flocks with up to 500 White Storks during the spring migration (Milchev and Kovachev, 1995). Nineteen pairs of White Storks bred there in three villages and separate farms in 2009. The number of non-breeding birds was determined by deducting the maximal number of 38 breeding birds from the total White Stork number in open areas: at least 104 non-breeding birds on 16.07.2009, 73 non-breeding birds on 27.07.2009. Three roosting places were found in single old oaks along the Izvorska River (11-15 m a.s.l.) on 27.07.2009. Two of them were almost dry-topped trees and the third was slightly affected by yearly fires. They were at distances of 817 m and 1640 m and 1470-2240 m away from the nearest village respectively from White Stork's nests.

Pellet analysis

Pellets in good preservation were collected from the surface of an up to 15 cm-thick layer beneath the oak most used for roosting on 27.07.2009 (N42° 22` E27° 27`). They therefore represented the food spectrum mainly from the last decades of July. The pellets were soaked in water, washed through a sieve (1 mm mesh) and dried in a laboratory. The remains were identified using suitable reference books and our comparative collections kept in the National Museum of Natural History, the Institute of Biodiversity and Ecosystem Research and the University of Forestry. Estimates of the minimum number of individuals (MNI) of invertebrates in every pellet were based mainly on head fragments, prothoraces and mandibles. The bones of vertebrates are highly digestible (Kosicki et al., 2006) and the MNI of mammals was based mostly on cranial and tooth fragments, hair remains, and on the horn scales of a tortoise.

Statistical analysis

The correlations between the proportions of prey taxa and indigestible food components in the pellets were calculated by Pearson correlation coefficient with arcsine transformed percentage data. The pattern of distribution of the prey taxa in the White Stork pellets was evaluated using principal component analysis (PCA). The samples were separate pellets, while the variables were the proportions of prey taxa in the respective pellet. The food components, except grasshoppers and beetles, were categorized into four higher taxa as Hemiptera, Hymenoptera, Arachnida and Vertebrata. The species variables are presented by arrows on the ordination diagram. The angles between the arrows represent the correlation between the proportions of preyed taxa. Most important in the analysis were species with longer arrows and sharper angles with the ordination axes. This is why we have erased the names of the taxa in the

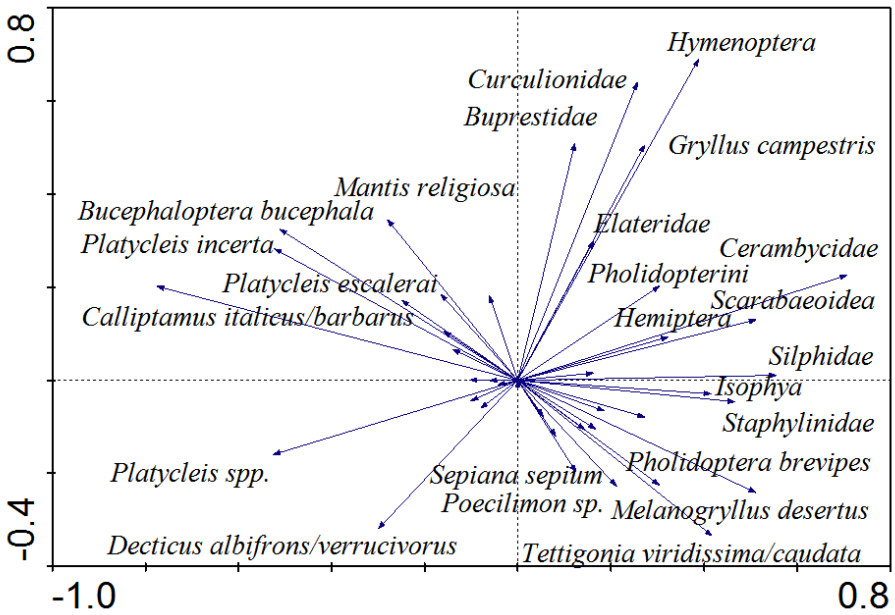

Fig. 1. PCA ordination of prey taxa in the diet of non-breeding White Storks (*Ciconia ciconia*) in Bulgaria. Arrows: prey taxa.

concentration situated close to the ordination center. The analysis was implemented with the CANOCO 4.5 software (ter Braak, 1990).

RESULTS

Food composition

The feeding range was based on an analysis of 147 pellets, which contained the remains of 28947 individuals distributed among 57 identified animal taxa (Table 1). The main prey were insects with a predominance of grasshoppers (Orthoptera) in 84.4% pellets (78.2%±13.5, range 42.4-98.8%), and beetles (Coleoptera) in the remaining 15.6% pellets (62.2%±11.5, range 47.9-95.8%). The 12 dominant minor taxa were from the same two insect orders, with only three pellets predominated by shield bugs, *Eurygaster* sp. (Hemiptera). Bush crickets (*Decticus albifrons/verrucivorus*) were the most numerous prey (29.9% by item) that occurred in almost all pellets (98% frequency of occurrence in pellets) and predominated in half of them (49.7%). Other invertebrates with all vertebrates formed only 0.1% by prey item.

Habitat preferences

Aquatic prey such as water beetles (Dytiscidae) and the freshwater crab *Potamon ibericum* were found with only three specimens, whereas inhabitants of grasslands formed the greatest component of the food. The arrangement of prey taxa according to their proportions in the pellets is presented in Fig. 1. Four groups of beetles (Cerambycidae, Silphidae, Scarabaeoidea, Staphylinidae) and the bush crickets *Pholidoptera brevipes*, *Isophya speciosa/rectipennis*, *Tettigonia viridissima/caudata, Melanogryllus desertus*, have a positive correlation with the first ordination axis (eigenvalue 0.119). This group of grasshoppers inhabits mainly mesophytic grass-shrubby habitats that usually replace abandoned fields and overgrown pastures with a low level of grazing. The bush crickets and grasshoppers *Platycleis incerta*, *Bucephaloptera bucephala*, *Calliptamus italicus/barbarus*, *Platycleis* spp. correlate with the negative part of this axis. They are common inhabitants of xerophytic grass-shrubby habitats, not rare on stony terrains. The habitat preferences of grasshoppers display the grouping of prey taxa in pellets mainly according to the gradient of moisture in grass-shrubby habitats. The negative part

Table 1. Diet of non-breeding White Storks (*Ciconia ciconia*) in Bulgaria according to pellet analysis (n=147 pellets): predominant taxon in the pellet: * 0.7-4.1% by pellets; ** 4.8-7.5%; ● 21.8%; ●● 49.7%; percentages less than 0.1 are shown as +.

Prey	Number of specimens	% by N	Occurrence in pellets (%)	Mean number in pellet SD, Min.-Max.
HEMIPTERA: Heteroptera subtotal	633	2.2	23.1	18.6±32.8, 0-108
Ceraleptus sp.	1	+	0.7	0-1
Coreus marginatus	1	+	0.7	0-1
Eurygaster sp. *	588	2.0	18.4	21.8±34.5, 0-103
Eurygaster austriaca	22	0.1	6.1	2.4±2.6, 0-9
Aelia sp.	9	0.3	5.4	1.1±0.4, 0-2
Aelia rostrata	11	0.4	4.8	1.6±1, 0-3
Carpocoris sp.	1	+	7.5	0-1
MANTODEA *Mantis religiosa*	21	0.1	7.5	1.9±2.1, 0-3
ORTHOPTERA subtotal	20684	71.5	100	140.7±67, 3-376
Tettigoniinae gen.spp.	40	0.1	8.2	3.3±5.5, 0-20
Decticus albifrons/verrucivorus ●●	8657	29.9	98.0	59.7±32.2, 0-154
Platycleis (*Platycleis*) spp. *	2229	7.7	78.2	19.2±21.8, 0-119
Platycleis (*Platycleis*) *escalerai*	200	0.7	12.9	10.5±16.4, 0-68
Platycleis (*Tessellana*) *incerta*	508	1.8	43.5	7.9±12.2, 0-77
Sepiana sepium	31	0.1	7.5	2.8±2, 0-7
Metrioptera cf. *roeselii ambitiosa* *	102	0.4	19.7	3.5±5.3, 0-26
Pholidopterini gen.sp.	15	0.1	7.5	1.4±1.2, 0-5
Pholidoptera fallax	2	+	0.7	0-2
Pholidoptera brevipes *	1668	5.8	54.4	20.6±31.3, 0-129
Bucephaloptera bucephala	307	1.1	32.7	6.4±7.5, 0-34
Pachytrachis gracilis/Rhacocleis germanica *	134	0.5	4.8	19.1±40.2, 0-110
Rhacocleis germanica	10	+	5.4	1.25±0.7, 0-3
Tettigonia viridissima/caudata *	469	1.6	61.9	5.1±6.2, 0-35
Saga cf. gracilis	6	+	4.1	0-1
Tylopsis lilifolia	14	+	5.4	1.8±1.2, 0-4
Isophya speciosa/rectipennis	174	0.6	15.0	7.9±13.3, 0-45
Poecilimon sp. (cf. brunneri)	16	0.1	5.4	1.8±1.6, 0-6
Gryllinae gen.sp.	1	+	0.7	0-1
Gryllus campestris	5	+	0.7	0-1
Melanogryllus desertus **	2904	10.0	97.3	20.2±23.9, 0-157
Modicogryllus truncatus	15	0.1	5.4	1.9±2.1, 0-7
Gryllotalpa sp.	8	+	4.8	1.1±0.4, 0-2
Calliptamus italicus/barbarus **	2541	8.8	72.8	23.7±28.8, 0-130
Acrida ungarica	2	+	0.7	0-2
Gomphocerinae/Oedipodinae gen.spp. *	616	2.1	61.9	6.7±23.8, 0-224
Aiolopus sp.	10	+	2.0	3.3±4, 0-8
COLEOPTERA subtotal	7564	26.1	100	51.5±44.9, 2-227
Dytiscidae	2	+	1.4	0-1
Carabidae ●	5687	19.6	100	38.7±41.5, 1-185
Staphylinidae	78	0.3	23.1	2.2±1.6, 0-7
Silphidae	307	1.1	55.1	3.7±4.7, 0-26
Scarabaeoidea *	277	1.0	59.9	3.1±4, 0-29
Buprestidae	37	0.1	11.6	2.2±2, 0-9
Elateridae	1	+	0.7	0-1
Tenebrionidae	14	+	6.1	1.6±0.7, 0-3
Cerambycidae *	1118	3.9	46.3	16.4±29.1, 0-209
Culrculionidae	18	0.1	10.9	1.1±0.3, 0-2
indet Coleoptera	25	0.1	10.2	1.7±1.6, 0-7
HYMENOPTERA subtotal	18	0.1	9.5	1.3±0.6, 0-3
Chrysididae	15	0.1	7.5	1.4±0.7, 0-3
Formicidae	3	+	2.0	0-1
Insecta ordo	1	+	0.7	0-1
INSECTA subtotal	28921	99.9	100	196.7±77.3, 43-419
ARANEI	3	+	2.0	0-1
OPILIONES	7	+	4.1	1.2±0.4, 0-2
CRUSTACEA *Potamon ibericum*	1	+	0.7	0-1
INVERTEBRATES subtotal	28932	99.9	100	196.8±77.3, 43-419
REPTILIA *Testudo graeca/Eurotestudo hermanni*	1	+	0.7	0-1
MAMMALIA subtotal	14	+	8.8	1.1±0.3, 0-2
Crocidura leucodon	1	+	0.7	0-1
Microtus arvalis/rossiae meridionalis	9	+	5.4	1.1±0.4, 0-2
small mammals	3	+	2.0	0-1
Carnivora - carrion	1	+	0.7	0-1
VERTEBRATES subtotal	15	0.1	9.5	1.1±0.3, 0-2
TOTAL	28947			196.9±77.3, 43-419

of the second axis (eigenvalue 0.062) correlates only with proportions of grasshoppers. Among them, *Tettigonia viridissima/caudata*, *Sepiana sepium, Poecilimon* sp. (cf. *brunneri*), *Pholidoptera brevipes* and *Melanogryllus desertus*, being generally early mesophilous species, may appear in arid habitats at the end of their life cycle, and *Decticus albifrons/verrucivorus* dominates the opposite side of the axis, being much more arid-tolerant. The catch of several very rare taxa (Hymenoptera, Curculionidae, Buprestidae, *Gryllus campestris*) correlates positively with this axis, but there is no clear habitat characteristic for the forming of this group. Only several bones of a carnivore mammal in a pellet indicated the use of carrion around the villages or along the roads.

Innutritious materials

All pellets contained some plant materials accidentally taken with the food: this quantity was not given. Pebbles (n=146, 80% up to 1 cm, occurrence 26.5% by pellets), pieces of *Unio* sp. valves (n=39, 0.3-3.5 cm, 9.5% by pellets), pieces of glass (n=6, 0.7-2.5 cm, 2.7% by pellets) and plastic (pieces, elastics, n = 6, 4.1% by pellets) were present in 48 pellets (32.7%, n=147). There is a highly significant correlation between the quantity of two natural materials, pebbles and valves (Pearson r=0.248, p<0.01), as well as between two artificial ones, glass and plastic (r=0.378, p<0.01), and an insignificant correlation between both groups. The total amounts of these innutritious materials in the pellets correlate positively with the catch of grasshoppers (*Decticus albifrons/verrucivorus* r=0.184, p<0.05, *Platycleis* sp. r=0.309, p<0.01, *Calliptamus* sp. r=0.330, p<0.01, *Bucephala bucephaloides* r=0.218, p<0.01), but negatively with the catch of some beetles (Staphylinidae r=-0.169, p<0.05, Cerambycidae r=-0.322, p<0.01, Carabidae r=-0.176, p<0.05) and the bush-cricket *Pholidoptera brevipes* (r=-0.226, p<0.01).

DISCUSSION

Food composition

Insects are important preys of the White Storks, both in their breeding and wintering ranges, but their place in the diet and the proportions of the different taxa vary vastly (Glutz von Blotzheim and Bauer, 1987; Sackl, 1987; del Hoyo et al., 1992). They are more frequent in the diets from the southern parts of the breeding range, where the share of grasshoppers increases (Alonso et al., 1991; Rékási, 2000; Sachalidis and Goutner, 2002; Vrezec, 2009). The White Storks prey selectively on insects larger than 1.5 cm (Sackl, 1987). In accordance with this, the most numerous insects in this study were bush crickets *Decticus albifrons/verrucivorus*, about 4-5 cm long, and the grasshoppers and crickets *Melanogryllus desertus, Calliptamus italicus/barbarus, Platycleis* (*Platycleis*) spp., *Pholidoptera brevipes*, 2-4 cm long, that formed together 62.2% by item. There are no data about the grasshoppers' associations in the study area, but the numerousness and the importance of the bush crickets *Decticus* is demonstrated by their predominance in the diets of some other local birds as well. They were the main prey of Black Storks (*Ciconia nigra*) (88.4% by item, n=3980) (Miltschev et al., 2000). The bush crickets *Decticus* formed 59% by number of insects (n=188) in the diet of the Rose-colored Starling (*Sturnus roseus*) in the next area (Miltschev and Tschobanov, 2002). They were the most abundant prey (25.5% by item, n=110) in the diet of the Lesser Spotted Eagle (*Aquila pomarina*) here (Milchev et al., 2010).

Beetles predominate usually among invertebrates (Pinowska and Pinowski, 1985; Sackl, 1987; Pinowska et al., 1991; Antczak et al., 2002; Kosicki et al., 2006; Vrezec, 2009) but they were displaced by the prevalent grasshoppers in this study. Heteropterans have been found in the diet of the White Stork by chance (Sackl, 1987; Mužinic and Rašajski, 1992; Antczak et al., 2002). The non-breeding White Storks preyed frequently upon these stinking insects and the shield bugs *Eurygaster* sp., about 0.9-1.4 cm long, predominated in three pellets. They are of the size of insects preferred by White Storks that in this case assimilated local concentrations of these shield bugs in their typical habitats: open grasslands and cereal fields during the first part of the summer. Voles are an important prey in the northern and more humid

parts of Europe (Tryjanowski and Kuźniak, 2002; Antczak et al., 2002; Kosicki et al., 2006), but have a rather low and unstable number in the study area as a result of the longer summer drought (Straka and Gerasimov, 1977). The White Storks, with their opportunistic feeding, very rarely took them. Respectively, voles were only 21.8% by number in the Lesser Spotted Eagle diet and 28% (n=1578 items) in the Barn Owl (*Tyto alba*) diet in this area; these are two birds that largely prey upon voles (Miltschev et al., 2004; Milchev et al., 2010).

Earthworms (Lumbricidae) are a substantial prey in habitats with moist soil and behind the working plough (Pinowska and Pinowski, 1985; Alonso et al., 1991; del Hoyo et al., 1992; Kosicki et al., 2006). Our pellet analysis ignored the earthworm share in the diet, but they could not be an important food in the region during the hot and arid summer months.

Habitat preferences

The White Storks usually collect their food in grassland areas and wetlands, where they prefer short vegetation up to 40 cm tall (Pinowski et al., 1986; Sackl, 1987; Glutz von Blotzheim and Bauer, 1987; Pinowska et al., 1991; del Hoyo et al., 1992). Meadows in river valleys were the most important foraging habitat of the non-breeding birds in Poland, which preyed more on the inhabitants of dryer habitats than the breeding birds there (Antczak et al., 2002; Antczak and Dolata, 2006). The typical aquatic inhabitants were an exception in the study diet and the basic food was collected in grasslands. The main foraging method of the White Stork is strutting about and locating prey by sight in preferable foraging patches of good quality (Alonso et al., 1991; del Hoyo et al., 1992; Pinowska et al., 1991). Therefore, the grasshopper associations in the pellets specify foraging mainly in mesophytic grasslands that usually replace abandoned fields and overgrown pastures with a low level of grazing. The xerophytic grass-shrubby habitats, not rare on stony terrains, were of less importance, providing around 20% of prey. The importance of carrion around villages or along roads is comparable to this of the wetland inhabitants.

Mesophytic grasslands have formed since 1996, when the fields here were almost totally abandoned as a result of the economic crisis in Bulgaria. The first roosting of non-breeding White Storks on electric poles was observed here in 2005 (Milchev unpubl. data). The intensive cultivation of fields has been renewed since 2010 as a result of agricultural payments when Bulgaria became part of the EU. The roosting of non-breeding birds disappeared when their preferred feeding habitats were ploughed up.

Innutritious materials

White Stork pellets contain different natural and artificial innutritious materials (Sackl, 1987; Mužinic and Rašajski, 1992; Vrezec, 2009) from those of the closely related Black Stork (Miltschev et al., 2000). Their number in the pellets rose when the White Storks hunted on nippy and agile grasshoppers. An opposite tendency existed when the main prays were slower beetles taken from the ground. The low content of innutritious materials also accompanied the occurrence of the bush-cricket *Pholidoptera brevipes*. The latter usually stays on the ground or on low branches and leaves. When frightened, it falls to the ground and remains stationary (Chobanov unpubl. data).

The low number of artificial materials (pieces of glass, plastic) in the pellets correlates with the absence of such contamination in the area and with the poorly attended outskirts of villages that are foraging habitats of the non-breeding White Storks.

Acknowledgments - We express our deep gratitude to B. Georgiev for his consultations and the identification of beetles, and to N. Spassov for the identification of the bones of a carnivore mammal. Part of the comparative material of Orthoptera was collected with the financial support of the Orthopterists' Society Small Grants Program to D. Chobanov in 2007-2008.

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