Diet of the White Stork in Greece in Relation to Habitat

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Abstract.—Prey taken by breeding White Storks (*Ciconia ciconia*) were studied using pellets collected from 1993 to 1995 within its breeding area in Greece. Prey consisted of orthopterans, coleopterans, other insects, mollusks and vertebrates. The difference in the proportions of these taxa was significant among major foraging habitats (lakes, rivers, deltas and dry habitats). With the exception of the rivers, major habitats tended to group together in clusters, suggesting that similar prey types were available to the storks in common habitat types. *Received 20 June 2001, accepted 1 October 2001.*

Key words.—White Stork, *Ciconia ciconia*, diet, habitat, wetland, Greece.

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The White Stork (*Ciconia ciconia*) is a species that has been given much attention, primarily due to the rapid decline of its numbers during the twentieth century. Foraging habitat loss, especially of wetlands through agricultural intensification, has been recognized as one of the important factors leading to a decline in numbers in Europe (Rheinwald *et al.* 1989; Biber *et al.* 1994; Tucker and Heath 1994). Climatic change in the African winter quarters has also been suggested as an important factor, particularly those birds breeding in western Europe (Tucker and Heath 1994).

An appreciable part of the eastern European breeding population of the White Stork breeds in Greece (Tsachalidis and Papageorgiou 1996), where breeding starts in March and April (Goutner and Tsachalidis 1995), and eventually the birds depart on migration in August.

The aims of this study were to describe the prey of the White Stork in Greece, and to describe and compare the food types taken in different habitats.

METHODS

In Greece, most White Storks build nests on electric power poles in villages (Tsachalidis and Papageorgiou 1996). As a result, examining nests was possible using a hydraulic lift ("cherry picker") operated by technicians of the Public Power Corporation, after the power supply had been interrupted. In June and early July 1993 to 1995, intact pellets were collected from nests during a nestling banding program. Nests sampled were associated with one of a variety of habitats used by White Storks as feeding grounds, some of which are parts of wetlands protected by the Ramsar Convention. Pellets were examined in the laboratory and prey items were identified using suitable reference books and collections. For orthopterans (grasshoppers and crickets), the identifiable remains usually found in pellets were mandibles. The former included the short-horned grasshoppers and locusts and the latter the long-horned grasshoppers (bush crickets) the crickets and the Mole Cricket (*Gryllotalpa gryllotalpa*). The Mole Cricket, a numerically important prey, was identified to species by the characteristic structure of jaws and forelegs. Other insects were identified to family level. Intact insects were not found in pellets and we estimated the numbers of insects by dividing the number of mandibles of each group by two or by counting intact heads. For comparisons among areas and habitats, prey were grouped as Orthoptera, Coleoptera (beetles), other insects, mollusks and vertebrates. In cluster analysis, the orthopterans were further separated into *Gryllotalpa* and two suborders, Caelifera and Ensifera (Richards and Davies 1994), while beetles were divided into Scarabaeidae, Carabidae, Staphylinidae, Silphidae, Melolonthidae and Curculionidae. Other insects, mollusks and vertebrates were also included in the analysis.

Because breeding and feeding by many of the White Storks in Greece take place in habitats associated with wetlands (Tsachalidis and Papageorgiou 1996), we categorized the major habitat types used by each pair in our study areas in relation to the presence of three major wetland types (lake, river and delta) in the vicinity of the breeding areas (Table 1). Differences in prey categories between major habitats were compared using chi-square tests. Comparisons were made of proportions of prey types using cluster analysis (with Euclidean distances as distance measure and single linkage as a linkage rule) to search for potential similarities between groups of areas belonging to common major habitat types as prey types taken by the White Stork may change through the breeding season (Pinowska and Pinowski 1989; Mužinić and Rasajski 1992), the results of this

Table 1. Major habitat types, names of areas and villages where white stork pellets were collected.

Major habitat types	Areas	Villages	No. of pellets	Total no. of prey	Coordinates
Rivers				4104	
	Evros		26	639	
		Poros			40°53'54"N, 26°13'25"E
	Strymon		49	1036	
		Kumaria			41°11'45"N, 23°26'05"E
		Mitrusi			41°04'00"N, 23°28'10"E
	Axios		45	947	
		Kimina			40°36'38"N, 22°42'30"E
		Anatoliko			40°39'35"N, 22°43'30"E
	Pinios		29	1482	
		Omolio			39°53'41"N, 22°38'26"E
		Girtoni			39°44'37"N, 22°28'13"E
Deltas				7656	
	Nestos		113	5243	
		Eratino			40°57'06"N, 24°38'00"E
		Pondolivado			40°58'39"N, 24°31'30"E
		Ziloti			40°59'00"N, 24°90'30"E
		Dekarcho			40°55'20"N, 25°50'00"E
		Mangana			40°56'30"N, 24°51'50"E
	Sperchios		37	341	
		Megali Vrisi			38°53'49°N, 22°29'02"E
		Anthili			38°50'06°N, 22°29'32"E
	Amvrakikos		37	2072	
		Aneza			39°05'08"N, 20°55'42"E
		Philipiada			39°11'46"N, 20°53'09"E
Dry habitats				2237	
	Drama		27	1130	
		Megalokambos			41°06'30"N, 24°01'30"E
		Nikotsara			41°06'40"N, 24°03'10"E
		Nikiforos			41°02'30"N, 24°18'30"E
		Mavrovatos			41°06'35"N, 23°43'25"E
	Epirus		24	1107	
		Xirolofos			39°25'02"N, 20°30'29"E
		Kristalopigi			39°25'05"N, 20°33'50"E
		Karvuniari			39°24'11"N, 20°29'23"E
		Psathotopi			39°05'10"N, 20°57'06"E
Lakes				6746	
	Kerkini		58	2610	
		Kerkini			41°12'30"N, 23°05'10"E
		Limnochori			41°12'30"N, 23°12'00"E
	Koronia		70	2442	
		Agh. Vassilios			40°39'25"N, 23°07'00"E
		Nymfopetra			40°41'00"N, 23°20'08"E
		Kavalari			40°42'30"N, 23°03'30"E
	Artzan		40	1694	
		Vafiochori			41°40'40"N, 22°04'00"E

study represent the diet during the main fledging period of the species in Greece.

RESULTS

Insects, primarily orthopterans and coleopterans, were the main prey of the White Stork in all areas studied (Table 2). Orthopteran proportions ranged from 22% to 96% and Coleopterans from 4% to 79%, both in dry habitats. "Other insects" included Odonata, Heteroptera, Hemiptera and unidentified insects. The proportions of this category

Table 2. Percentages of prey individuals taken by White Storks in the areas studied. Percentages between 0.1 and 0.4 are shown as +.

Major habitat	Areas	Villages	Orthoptera	Coleoptera	Other insects	Molluscs	Vertebrates	No. of prey
River	Evros	Poros	56	41	+	1	1	639
	Strymon	Kumaria	30	67	2	+	1	801
		Mitrusi	23	63	12	-	2	235
	Axios	Kimina	41	54	3	1	1	698
		Anatoliko	26	71	1	-	2	249
	Pinios	Omolio	87	11	+	1	+	1348
		Girtoni	84	15	+	1	-	134
Delta	Nestos	Eratino	57	41	+	1	1	2577
		Podolivado	64	33	1	1	+	728
		Ziloti	50	44	4	1	1	399
		Dekarcho	30	70	+	-	-	227
		Mangana	39	34	24	2	1	1312
	Sperchios	M. Vrisi	40	30	20	-	10	10
		Anthili	35	32	27	1	5	331
	Amvrakikos	Aneza	28	72	-	-	1	356
		Philipiada	80	19	-	+	+	1716
Dry	Drama	Megalokambos	82	16	1	1	-	1049
		Nikotsara	22	78	-	-	-	27
		Nikiforos	64	28	4	4	-	25
		Mavrovatos	38	59	-	3	-	29
	Epirus	Xirolofos	93	6	-	-	1	629
		Kristalopigi	72	23	1	-	4	75
		Karvuniari	96	4	-	-	-	56
		Psathotopi	90	8	-	1	+	347
Lake	Kerkini	Kerkini	89	10	+	+	+	1564
		Limnochori	84	15	1	1	+	1046
	Koronia	Aghios Vassilios	62	35	1	2	1	1184
		Nymfopetra	59	39	-	-	2	226
		Kavalari	46	50	2	1	1	1032
	Artzan	Vafiochori	73	24	+	2	1	1694

were low except for part of the Nestos Delta and in the Delta of Sperchios (Table 2). Other prey types of storks were mollusks (terrestrial snails and freshwater bivalves) and vertebrates (small mammals, reptiles and birds). The proportions of insect prey categories varied among the areas studied, but they were always low. The highest proportion of mollusks in the storks' diet was 4% and vertebrates reached 10% in areas of dry and deltaic habitats respectively, but both results may be biased due to small sample sizes available in these areas (Table 2).

The difference in the proportions of the five prey types mentioned above was highly significant among the four major habitat types $\chi^2_{12} = 1240$, $P < 0.0001$, Fig. 2). The proportions of orthopterans were highest in dry habitats, with lower proportions in lakes, rivers and delta habitats. The relative proportions of coleopterans graded as: rivers > deltas > lakes > dry habitats. Proportions of all other prey types were low, but of "other insects" were high in three delta areas.

A cluster analysis for proportions of prey types used by the storks, revealed similarities among areas belonging to common major habitat types (Fig. 3): Dry habitats were clustered in one group, deltas in two separate groups and two out of three lakes in a loose group. Rivers were greatly dispersed in the cluster.

DISCUSSION

The use of pellets in the description of the White Stork diet may produce biases,

because some prey types may not leave identifiable remains (Lázaro 1982; Mužinić and Rasajski 1992). Samples from the area near Lake Kerkini probably contained fish as we found scales on the beaks of nestlings, although no fish remains were detected in pellets. In addition, no amphibian remains were found, although they would be expected in pellets collected from nests in the vicinity of aquatic habitats. In a study of White Stork prey in Portugal, insect remains dominated in pellets (97%), fish were found to be a minor diet constituent (3%) and amphibians were absent. In contrast, the proportions of fresh prey types collected from the same nests were much different (insects 6%; fish 51%; amphibians 26%) (De Barros and Moura 1989). Pellets from a study in the central Balkans contained both fish and amphibian remains (Mužinić and Rasajski 1992). While the absence of fish and amphibian remains may be due to their rapid digestibility, the examples illustrate potential areas of biases in the analysis of White Stork pellets.

In this study, it was impossible to collect dietary information on the White Stork based on other material, such as prey remains or observation at feeding grounds and nests due to the extensive areas visited and the short time available. Despite possible biases, the results from different study areas are comparable.

Our findings suggest that the types of prey taken by White Storks in Greece are similar to those found in other parts of the range (Cramp and Simmons 1984; De Barros and Moura 1987; Pinowska and Pinowski 1989; Mužinić and Rasajski 1992). The most important part of the storks' diet in Greece was insects, especially orthopterans and coleopterans. Orthopterans and coleopterans have also been found to constitute a very important source of food for the White Stork in many parts of its range, including Poland (Pinowska *et al.* 1991), Hungary, East Prussia (Cramp and Simmons 1984; Rekasi 1989), central Balkans (Mužinić and Rasajski 1992), Algeria, Tunisia and Israel (Dallinga and Schoenmakers 1987) and they seem to be a favored prey. Orthopterans and coleopterans are associated with a variety of natural and anthropogenic habitats such as irrigated and cultivated land, both predominating in the major habitat types studied. The preponderance of other types of insect prey in some river deltas may reflect the diversity of habitats available in these ecosystems.

Sites with similar major habitats tended to group together in the cluster analysis, suggesting that similar prey types were available in similar sites. Separation of sites was due to the varying composition of particular prey types of storks (Appendix 1). Thus, near the River Strymon, the storks fed on a much lower proportion of Ensifera (Orthoptera) and a higher proportion of Carabidae (ground beetles) than in other rivers. In samples from the River Evros and River Pinios areas, the proportions of Ensifera, Scarabaeidae and Carabidae were markedly different. The proportions of these prey groups were also different among lakes. It is not easy to explain the clustering of deltas in two different groups and the close association of the Nestos Delta and Amvrakikos Delta although situated at a great distance apart (Fig. 1). Each delta varies in the habitat structure and extent (as indicated in Zalidis and Matzavelas 1994).

The numbers of breeding White Storks in Greece had declined from about 5,000 pairs in 1965 (Martens 1966) to 2,387 pairs in 1993 (Tsachalidis and Papageorgiou 1996).

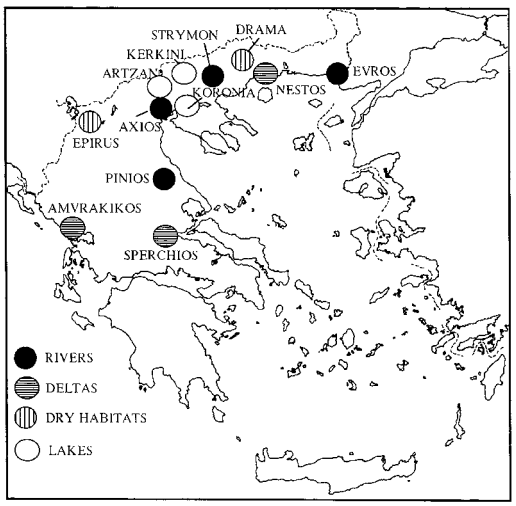

Figure 1. Map indicating the areas in Greece where the diet of the White Stork was studied. Different dots represent different major habitats.

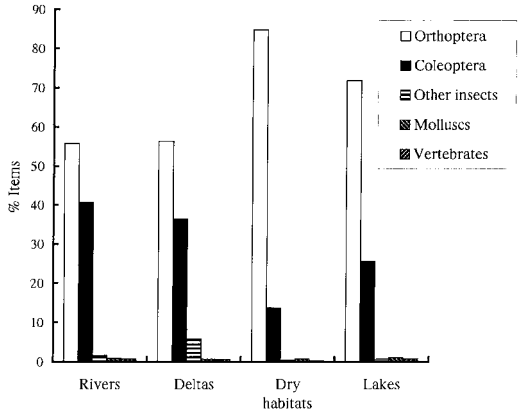

Figure 2. Main prey categories of the White Stork in relation to the major habitats used. Data of each respective major habitat were compiled.

The decline was attributed to deterioration of breeding sites and probably pollution (Tsachalidis and Papageorgiou 1996). The role of the loss and deterioration of the feeding habitats in this decline is unknown. However, over 60% of the wetland habitats in Greece disappeared in the second half of this century mainly due to agricultural intensification (Psilovikos 1990). Negative effects on the wintering grounds resulting in decline of the White Stork numbers breeding in Greece though possible, are unknown although such effects have been found in White Storks breeding in western Europe and wintering in Africa. A further study should investigate the feeding ecology of this bird in Greece, especially focusing on the adequacy and quality of the existing foraging habitats in relation to the breeding distribution and productivity of the White Stork.

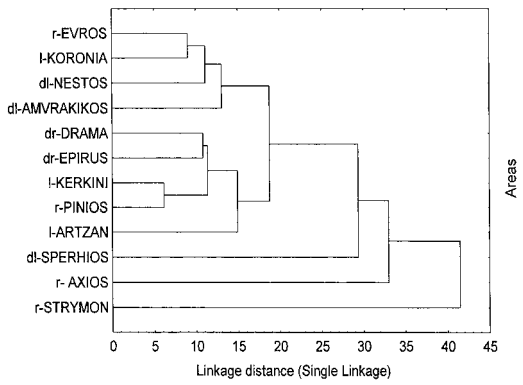

Figure 3. Cluster analysis indicating the relationship of the areas studied with regard to the prey taken by the White Stork. r: Rivers; dl: Deltas; dr: Dry habitats; l: Lakes.

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LITERATURE CITED

Biber, O., P. Enggist, C. Mart and T. Salathè (Eds.). 1995. Proceedings of the International Symposium on the White Stork (Western population). Basel 1994.

Cramp, S. and K. E. L. Simmons (Eds.). 1984. The birds of the western Palearctic. Oxford University Press, Oxford.

Dallinga, J. H. and S. Schoenmakers. 1989. Population changes of the White Stork *Ciconia ciconia* since the 1850s in relation to food resources. Pages 231-262 *in* White Stork. Status and conservation. Proceedings of the First International Stork Conservation Symposium, Walsrode, 14-19 October 1985 (G. Rheinwald, J. Ogden and H. Schulz, Eds.). Dachverband Deutscher Avifaunisten. Rheinischer Landwirtschafts-Verlag, Bonn.

De Barros, P. and D. Moura. 1989. Breeding, feeding and mortality factors in White Stork *Ciconia ciconia* populations nesting in Portugal in 1985. Pages 405-414 *in* White Stork. Status and conservation. Proceedings of the First International Stork Conservation Symposium, Walsrode, 14-19 October 1985 (G. Rheinwald, J. Ogden and H. Schulz, Eds.). Dachverband Deutscher Avifaunisten. Rheinischer Landwirtschafts-Verlag, Bonn.

Goutner, V. and E. Tsachalidis. 1995. Time of breeding and brood size of White Storks *Ciconia ciconia* in north-eastern Greece. Die Vogelwarte 38: 89-95.

Lázaro, E. M. 1982. Contribution al estudio de la alimentation de la ciguena blanca *Ciconia c. ciconia* (L.) en Espana. Unpublished Ph.D. Thesis, Catedratico de Vertebrate, Facultad de Biologia de la Universidad Complutense, Madrid.

Martens, J. 1966. Brutvorkommen und Zugverhalten des Weissstorchs *C. ciconia* in Griechenland. Die Vogelwarte 23: 191-208.

Mužinić, J. and J. Rasajski. 1992. On food and feeding habits of the White Stork *Ciconia c. ciconia*, in the central Balkan. Ecology of Birds 14: 211-223.

Pinowska, B. and J. Pinowski. 1989. Feeding ecology and diet of the White Stork *Ciconia ciconia* in Poland. Pages 381-396 *in* White Stork. Status and conservation. Proceedings of the First International Stork Conservation Symposium, Walsrode, 14-19 October 1985 (G. Rheinwald, J. Ogden and H. Schulz, Eds.). Dachverband Deutscher Avifaunisten. Rheinischer Landwirtschafts-Verlag, Bonn.

Pinowska, B., L. Buchholz, S. Grobelny, P. Stachowiak and J. Pinowski. 1991. Skipjacks Elateridae, weevils Curculionidae, orthopterans Orthoptera and earwings Dermaptera in the food of White Stork *Ciconia ciconia* (L.) from Mazurian Lakeland. Zaklad Ochrony Przyrody i Zasobow Naturalnych Polskiej Akademii Nauk. Studia Naturae-Seria A. 37: 87-106.

Psilovikos, A. 1990. Changes in Greek wetlands during the 20th century: the case of Macedonian inland waters. Pages 182-195 *in* Conservation and management of the Greek wetlands. Proceedings of workshop, 16-21 April 1989 (P. A. Gerakis, Ed.). WWF, IUCN and Laboratory of Ecology, School of Agronomy, Aristotelian University of Thessaloniki, Thessaloniki.

Rekasi, J. 1989. Nahrungsbiologische untersuchungen am Weissstorch *Ciconia ciconia*. Pages 397-402 *in* White Stork. Status and conservation. Proceedings of the First International Stork Conservation Symposium, Walsrode, 14-19 October 1985 (G. Rheinwald, J. Ogden and H. Schulz, Eds.). Dachverband Deutscher Avifaunisten. Rheinischer Landwirtschafts-Verlag, Bonn.

Rheinwald, G., J. Ogden and H. Schulz (Eds.). 1989. White Stork. Status and conservation. Proceedings of the First International Stork Conservation Symposium, Walsrode, 14-19 October 1985. Dachverband Deutscher Avifaunisten. Rheinischer Landwirtschafts-Verlag, Bonn.

Richards, O. W. and R. G. Davies. 1994. Imms' general textbook of Entomology. Vol. 2: Classification and Biology. Chapman & Hall, London.

Tsachalidis, E. and N. Papageorgiou. 1996. Distribution status and breeding of the White Stork *Ciconia ciconia* in Greece. Avocetta 20: 101-106.

Tucker, G. M. and M. F. Heath. 1994. Birds in Europe. Their conservation status. Birdlife Conservation Series No. 3, Cambridge.

Zalidis, G. and A. Mantzavelas (Eds.). 1994. Inventory of Greek wetlands as natural resources (first approximation). Greek Biotope/Wetland Centre, Thessaloniki.

Appendix 1. Percentages of prey individuals taken by White Storks used in the cluster analysis (Fig. 3). Percentages between 0.1 and 0.4 are shown as +.

Major habitat	Areas	Ensifera	Caelifera	*Gryllotalpa*	Scarabaeidae	Carabidae	Staphylinidae	Silphidae	Melolonthidae	Curculionidae	Molluscs	Vertebrates	No. of prey
River	Evros	50	5	2	17	19	-	2	3	1	1	1	639
	Strymon	15	1	13	8	58	-	2	1	-	+	1	1036
	Axios	23	1	14	8	23	-	+	24	4	1	1	947
	Pinios	81	2	4	1	4	-	+	6	+	1	+	1482
Delta	Nestos	47	7	1	11	19	-	+	8	1	1	1	5243
	Sperchios	34	5	10	12	29	-	2	1	-	1	7	341
	Amvrakikos	54	4	13	9	19	-	+	+	+	+	+	2072
Dry habitats	Drama	67	6	6	8	8	-	2	2	-	1	-	1130
	Epirus	75	9	7	3	4	-	+	1	-	+	+	1107
Lake	Kerkini	84	2	2	3	6	+	+	2	-	+	+	2610
	Koronia	49	3	3	11	25	+	1	3	+	1	1	2442
	Artzan	68	5	0	3	20	-	1	+	-	2	1	1694