COMPARATIVE UTILIZATION PATTERN OF TROPHIC RESOURCES BY WHITE STORKS *CICONIA CICONIA* AND CATTLE EGRETS *BUBULCUS IBIS* IN KABYLIA (ALGERIA)

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RÉSUMÉ

Les régimes alimentaires ont été étudiés par l'analyse de 150 pelotes de réjection fraîchement récoltées d'avril à août 1995 pour la Cigogne blanche et 150 autres de novembre 1994 à octobre 1995 pour le Héron garde-bœufs. Dans la vallée du Sébaou, en Kabylie (Algérie), les insectes dominaient tant dans le régime alimentaire du Héron garde-bœufs que dans celui de la Cigogne blanche et représentaient respectivement 97,1 et 92,7 % du nombre de proies, ainsi que 57,2 et 67,4 % de la biomasse. Les coléoptères furent les plus nombreux, mais ne représentaient que 7,1 et 8,2 % de la biomasse ingérée. Les orthoptères représentaient respectivement 47,3 et 58,8 % de la biomasse ingérée et semblaient surtout capturés lorsque l'occasion s'en présentait. Les variations du régime alimentaire des deux espèces d'un site à l'autre et au cours de l'année correspondaient aux disponibilités et à la phénologie locales des proies. Le régime alimentaire du Héron garde-bœufs et celui de la Cigogne blanche étaient très similaires en ce qui concerne les espèces-proies, mais une analyse plus détaillée a montré une nette ségrégation de ces dernières par la taille, fait souvent rattaché à des différences de morphologie du bec et de la taille entre espèces sympatriques. Dans la vallée du Sébaou comme ailleurs, le Héron garde-bœufs et la Cigogne blanche apparaissent comme des prédateurs opportunistes qui, lorsque les proies sont abondantes, sélectionnent celles qui leur conviennent le mieux, mais se contentent de ce qu'elles trouvent lorsque celles-ci sont rares. Ceci explique certainement en grande partie le succès de l'expansion récente du Garde-bœufs en Algérie.

SUMMARY

The diets of White Storks and Cattle Egrets were studied by analysis of rejection pellets in the Sébaou valley, Kabylia, Algeria. 150 pellets from each species were collected, from April to August 1995 for the White Stork and from November 1994 to October 1995 for the

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Cattle Egret. Insects predominated in similar proportions in the diet of the two species, and represented respectively 97.1 and 92.7% in prey number as well as 57.2 and 67.4% in biomass. Coleopterans were the most numerous prey, but were only 7.1 and 8.2% in biomass. Orthopterans were 47.3% of the biomass ingested by the White Stork, and 58.8% of that ingested by the Cattle Egret, and seemed to be captured opportunistically, when human activities disturbed them. Variations in the diet of the two species, between colonies and during the course of the year, corresponded to the local availability and phenology of prey. The diets of the White Stork and Cattle Egret were very similar in terms of prey species, but differed sharply in prey size, which may be related to the birds' different body size and bill morphology. As elsewhere, Cattle Egrets and White Storks in the Sébaou valley are opportunist predators which, when prey is abundant, select those items which suit them best, but can live on what they find when prey becomes scarce. This may largely explain the successful recent range expansion of the Cattle Egret in Algeria.

INTRODUCTION

During recent years, Kabylian agrosystems have been the subject of research aimed at a better understanding of their functioning. Predator-prey relationships have been studied through the diets of raptors and ciconiiforms (Boukhemza, 2001; Boukhemza *et* al., 1995, 2000; Hamdine *et al.,* 1999; Si Bachir *et al.,* 2001). Nevertheless, comparisons between the diets of different species have been hardly made. Both the White Stork *Ciconia ciconia* and Cattle Egret *Bubulcus ibis* live in sympatry in the Sébaou valley, and it seemed interesting to us to know how these two species, the former rare and regressing, the second common and expanding, share the trophic resources of the biotopes where they live. The aims of this study are to give both qualitative and quantitative information on the diet of the Cattle Egret and the White Stork, to show how they use foraging habitats in Kabylia, and to evaluate the availability of trophic resources in some of these habitats. This will lead to a better understanding of the global feeding strategies of these two species, and how they contribute to the equilibrium of the ecosystem. As the White Stork leaves Kabylia on migration during fall and winter, we will compare the diets of the two species only for the period April-August, when they occur together in the Sébaou valley.

The diet of the Cattle Egret is well-documented all over the world, but quantitative studies of the availability of trophic resources and their use by these birds are still scarce (Bredin, 1983; C. Voisin, 1991). In the Mediterranean region, in spite of the works of Doumandji *et al.* (1992) and Si Bachir *et al.* (2001), data on the dietary requirements which determine the reproductive success of the Cattle Egret are lacking, while breeding sites requirements are better known (Hafner & Fasola, 1992).

The White Stork has recently showed a decline in number, linked to a lower survival rate, in the western part of its distribution area (Zink, 1967; Lebreton, 1978; Rheinwald *et al.,* 1989). Its diet has been widely studied in Europe (Lazaro & Fernandez, 1991). In Algeria the first dietary study on White Stork, taking seasonal differences and biotope use in account, was conducted in 1992 (Boukhemza *et al.*, 1995), followed by other studies related to the food, to the habitat use and to the trophic resources (Boukhemza *et al.,* 1997; Boukhemza, 2001).

METHODS

This study was conducted in the Oued Sébaou valley, a sub-littoral region supporting important agricultural activities, especially market gardening and production of citrus fruits, with some cattle grazing meadows, fallow land and thickets (Boukhemza *et al.,* 1995). The diets of both the White Stork and Cattle Egret were each determined by analysing the contents of 150 rejection pellets, which consist of undigested material expelled by the birds through their mouths. White Stork pellets were collected monthly from April to August 1995, and Cattle Egrets pellets also monthly, from November 1994 to October 1995. They were gathered in the following localities:

— Baghlia. 48 White Stork pellets and 28 Cattle Egret pellets collected at a mixed colony of White Storks (32 pairs) and Cattle Egrets (58 pairs) established on Plane trees *Platanus orientalis* at the southern entrance of the town of Baghlia;

— Tadmaït. 83 White Stork pellets collected at a colony of 12 White Stork nests established on a *Casuarina* sp. tree, at the main entrance of the town and near buildings;

— Chaïb. 19 White Stork pellets collected under 14 White Stork nests in an *Eucalyptus* sp. tree near the Oued Rebta and the road to Fréha;

— Drâa Ben Khedda. 85 Cattle Egret pellets collected under a roost of about 65 Cattle Egrets in an *Eucalyptus* sp. tree near the east entrance of the town;

— Oued Aïssi. 37 Cattle Egret pellets collected under a mixed colony of Cattle Egrets (195 pairs) and White Storks (18 pairs) established in *Eucalyptus* sp. trees near buildings, on each side of the main road to Tizi-Ouzou.

The pellets were dried at 80 °C in an oven for 20 hours. Their elements were separated under tap water, using three sieves with meshes of decreasing sizes, and the elements thus recovered were dried. Then the contents of each pellet was examined in a Petri dish containing alcohol. Masses were expressed in terms of dried weight, after 24 hours dehydration at 90 °C. Biomasses were calculated by reference to the mass of fresh specimens captured in nature, or, when this was not possible, from literature data.

The identification of arthropods and molluscs was made using the very rich collection of the Agronomic Institute of El-Harrach. Determination was not always possible to species level, especially when food items were fragmented. Rodents were identified after Barreau *et al*. (1991), and Insectivores after Vesmanis (1980). Identification of bird remains was done on the basis of their skulls (Cuisin, 1989). Amphibians were identified using a key developed by Boukhemza (1989), and fishes after their scales (Steinmetz & Müller, 1991). It is to be noted that prey with soft tissues, like earthworms and slugs, were digested without leaving recognizable remains in rejection pellets.

Sampling of prey species was made at five stations, in places representative of the biotopes frequented by the White Stork and Cattle Egret in Kabylia. Ground-living invertebrates, especially Coleoptera, were sampled with Barber pitfalls, ten of which were installed on a $10m^2$ area in each station, and were surveyed once per month. Orthoptera were sampled at the beginning of each month, in ten $10m^2$ squares at each station (J.-F. Voisin, 1986). Aquatic insects were collected with a ruffled net along the banks of the Oued Sébaou, following the advices of Lamotte & Bourlière (1969). Vertebrates (small Rodents and shrews) were captured with pitfall traps, and, in order to get an idea of micromammal fluctuations, we used the results

of an analysis of 400 rejection pellets from Eurasian Tawny Owl *Strix aluco* gathered in the study area (Hamdine *et al.,* 1999).

The composition of the diet of the White Stork and Cattle Egret is given as percentages of the number and biomass of ingested prey. Their occurrence frequency, that is the percentage of pellets containing a given prey species, is sometimes also given. The most relevant way to express the resources of a given biotope would be to express them in terms of "available food" for the birds. In order to estimate this we use Bredin's (1983, 1984) "monthly index of resource abundance", based on the results of our prey samplings. This index corresponds to the percentage of individuals of a given species, captured in a given biotope, related to the total number of captures in that biotope. It comprises four levels: absent ($n\ \% = 0$), small numbers ($n\ \% = 10$), abundant ($10 < n\ \% < 50$), very abundant ($50 < n\ \% < 100$).

The overlap of the dietary niches of the White Stork and Cattle Egret during their breeding periods was calculated using Sorensen's formula (Sorensen *in* Bachelier, 1978): $Q = 2C/A + B$, where A is the total number of prey-species listed in the diet of the White Stork, B the total number of prey species listed in the diet of the Cattle Egret, and C the number of prey that the two species have in common in their diets. Q is expressed as a percentage, 0% corresponding to totally different diets and 100% to identical diets. The dietary overlap is significant when Q is over 60% (Brown & Lieberman, 1973).

Using Struge's formula (Scherrer, 1984), we distributed the prey which we found in rejection pellets of the Cattle Egret and White Stork into seven size classes from 1 to 270 mm, with an interval of 30 mm.

RESULTS

Comparison of the global composition of the diet of the two species

We identified 5,999 prey in Cattle Egret pellets, and 4,721 in White Stork pellets (Table I). 114 species (42.7%) out of 267 were common to the two species (Table II).

Insects predominated largely in the diets of Cattle Egrets and White Storks in the Sébaou valley, representing respectively 97.1 and 92.7% in prey numbers and 57.2 and 67.4% in biomass. Coleoptera made up respectively 46.9 and 59.4% of the prey, but only 7.1 and 8.2% of the ingested biomass. The larger Orthoptera accounted for respectively 31.5 and 29.2% of the prey, but 47.3 and 58.8% of the ingested biomass. Cattle Egrets ate Hymenoptera and Dermaptera in small quantities (9.9 and 7.3% of the preys, respectively), but other insect orders were negligible (1%), as were gastropods. In the diet of the White Stork Dermaptera were very few (3.3%), and the biomass of the other orders was almost nil. Arachnids, gastropods, crustaceans and myriapods were captured only occasionally. Although they were represented by a small number of individuals (1.5%), vertebrates accounted for nearly half (42.5%) of the biomass ingested by the Cattle Egret. The White Stork ate fewer of them (0.9%), and they represented 26% of the biomass in its diet.

TABLE I

Frequency of prey items in the diets of the White Stork and Cattle Egret in the Sébaou valley (higher taxa) (n: number of samples; n % and b %: relative frequency and biomass percentage)

Taxa	Cattle Egret		White Stork	
	n %	b %	n %	b %
Vertebrata	1.53	42.51	0.89	26
Pisces	0.28	8.11	0.42	7.32
Amphibia, Anura	0.24	8.32	0.06	1.45
Reptilia, Sauria	0.03	1.13	0.06	1.98
Aves	0.17	5.08	0.11	3.97
Mammalia	0.63	19.88	0.23	11.27
Rodentia	0.35	11.09	0.23	11.27
Insectivora	0.28	8.79	0	0
Invertebrata	98.47	57.49	99.11	74
Gastropoda, Helicidae	0.08	0.02	1.17	0.24
Crustacea, Isopoda	0	0	0.02	0
Arachnoida	0.98	0.17	3.20	6
Scorpionidea	0	0	0.89	0
Solifugea	0.08	0	2.12	0
Aranea	0.88	0	0.19	0
Acarina	0.02	0	0	0
Myriapoda	0.33	0.06	2.08	0.36
Larva undetermined	0.20	0	0.57	0
Imagos undetermined	0.03	0	1.14	0
Chilopoda	0.05	0	0.36	0
Diplopoda	0.05	0	0	0
Insecta	97.07	57.24	92.65	67.41
Insecta ind.	0.02	0	0.02	0
Coleoptera	46.92	7.11	59.44	8.24
Orthoptera	31.52	47.28	29.25	58.79
Phasmoptera	0	0	0.02	0
Hymenoptera	9.82	0.56	0.38	0.02
Hemiptera	0.67	0.04	0	0
Homoptera	0.03	0	0.02	0
Diptera	0.18	0.01	0.02	0
Nevroptera	0.10	0	0.08	0
Dermaptera	7.30	0.82	3.30	0.33
Blattoptera	0.03	0	0	0
Odonata	0.02	0.02	0	0
Plecoptera	0	0	0.08	0
Embioptera	0.03	0	0.04	0
Mantoptera	0.35	1.38	0	0
Lepidoptera	0.02	0	0	0
Total taxa	221		153	

TABLE II

Frequency of prey items in the diets of the White Stork and Cattle Egret in the Sébaou valley (species) (n: number of samples; n %: relative frequency; N: 150 pellets were analysed for each species)

	Cattle Egret		White Stork	
Taxa	n	n %	n	n %
1. Pisces, Cyprinidae, *Cyprinus carpio*	6	0.10	8	0.17
2. Cyprinidae, *Barbus barbus*	3	0.05		
3. Poecilidae, *Gambusia affinis*	5	0.08	6	0.13
4. Pisces spp.	3	0.05	6	0.13
5. Amphibia, Anura, Discoglossidae, *Discoglossus pictus*	11	0.18	3	0.06
6. Hylidae, *Hyla* sp.	7	0.12		
7. Hylidae, *H. meridionalis*	6	0.10		
8. Reptilia, Sauria, *Lacertidae* sp.	1	0.02	2	0.04
9. Geckonidae sp.	1	0.02		
10. Sauria sp.	1	0.02	1	0.02
11. Aves sp.	7	0.12	1	0.02
12. Aves sp. (egg).	1	0.02		
13. Passeriformes, Sylviidae sp.	1	0.02		
14. Fringillidae sp.			1	0.02
15. Turdidae, *Erithacus rubecula*	1	0.02	1	0.02
16. Columbiformes, Columbidae, *Streptopelia turtur*			1	0.02
17. Mammalia, Rodentia, Muridae, *Mus spretus*	11	0.18	2	0.04
18. Muridae, *M. musculus domesticus*	1	0.02	3	0.06
19. Muridae, *Apodemus sylvaticus*	5	0.08		
20. Muridae, *Rattus rattus*			2	0.04
21. Muridae, *R. norvegicus*			4	0.08
22. Gerbillidae, *Gerbillus campestris*	4	0.07		
23. Insectivora, Soricidae, *Crocidura russula*	17	0.28		
24. Gastropoda,Helicidae, *Helix* sp.	4	0.07	53	1.12
25. Helicidae, *H. aspersa*	1	0.02		
26. Helicidae, *H. aperta*			1	0.02
27. Helicidae sp.			1	0.02
28. Crustacea, Isopoda sp.			1	0.02
19. Arachnoida, Scorpionidae, *Scorpio maurus*			40	0.85
30. Buthidae, *Buthus occitanus*			2	0.04
31. Solifugea sp. 1, sp. 2	5	0.08	100	2.11
32. Aranea, Araneidae sp. 1, sp. 2	49	0.82	9	0.19
33. Phalangidae sp.	4	0.07		
34. Acarina, undetermined tick.	1	0.02		
35. Myriapoda spp., *larvae*	12	0.20	27	0.57
36. Myriapoda spp., adults	2	0.03	54	1.14
37. Chilopoda sp.	1	0.02	3	0.06
38. Chilopoda, Lithobiidae, *Lithobius* sp.	2	0.03		
39. Himantaridae, *Himantarium* sp.			14	0.30

TABLE II (continued)

Taxa	Cattle Egret		White Stork	
	n	n %	n	n %
40. Diplopoda, Iulidae, *Iulus* sp.	3	0.05		
41. Insecta spp.	1	0.02	1	0.02
42. Insecta, Coleoptera sp. 1, sp. 2, sp. 3	9	0.15	6	0.13
43. Coleoptera Scarabeidae, *Gymnopleurus* sp. 1, sp. 2	5	0.09	227	4.81
44. Scarabeidae, *Onitis* sp.1, sp. 2	7	0.12	15	0.32
45. Scarabeidae, *Anoxia* sp.			357	7.56
46. Scarabeidae, *A. emarginatus*			52	1.10
47. Scarabeidae, *Hybalus* sp.	70	1.17	72	1.53
48. Scarabeidae, *Copris hispanus*	6	0.10	164	3.47
49. Scarabeidae, *Oryctes* sp.			3	0.06
50. Scarabeidae, *O. nasicornis*	26	0.43	7	0.15
51. Scarabeidae, *Aphodius* sp. 1, sp. 2	8	0.14		
52. Scarabeidae, *Ontophagus* sp. 1, sp. 2	21	0.35	9	0.19
53. Scarabeidae, *Pentodon* sp.	21	0.35	57	1.21
54. Scarabeidae, *Bubas* sp.	27	0.45	15	0.32
55. Scarabeidae, *Pimelia* sp.			25	0.53
56. Scarabeidae, *Phyllognatus* sp.	1	0.02	55	1.17
57. Scarabeidae, *P. selenus*			18	0.38
58. Scarabeidae, *Scarabeus semipunctatus*	1	0.02	52	1.10
59. Scarabeidae, *Rhizotrogus* sp. 1, sp. 2	740	12.34	76	1.61
60. Scarabeidae, *Geotrogus* sp.	1	0.02		
61. Scarabeidae sp. 1, sp. 2*, larvae*	30	0.50	8	0.17
62. Carabidae, *Carabus morbilosus*	18	0.30	347	7.35
63. Carabidae, *Carabus* sp.	14	0.23	16	0.34
64. Carabidae sp. 1,…, sp. 13, *larvae*	803	13.38	99	2.08
65. Curculionidae sp.1, sp. 2, sp. 3	53	0.89	14	0.30
66. Curculionidae, *Anisorhynchus* sp.			2	0.04
67. Curculionidae, *Larinus* sp.			5	0.11
68. Curculionidae, *Baridius* sp.	2	0.03		
69. Curculionidae, *Apion* sp.	8	0.13		
70. Curculionidae, *Brachycerus* sp.	1	0.02	68	1.44
71. Curculionidae, *Lixus* sp.	4	0.07		
72. Curculionidae, *Otiorhynchus* sp.	43	0.72	1	0.02
73. Curculionidae, *Sphaenopterus* sp.	8	0.13	15	0.32
74. Curculionidae, *Hypera* sp. 1, sp. 2	9	0.15		
75. Curculionidae, *Rhytirhinus* sp.	4	0.07		
76. Curculionidae, *Leucosomus* sp.	1	0.02		
77. Curculionidae, *Sitona* sp. 1, sp. 2	16	0.27		
78. Buprestidae, *Julodis albopilosa*			32	0.68
79. Buprestidae, *Anthaxia* sp.	1	0.02	1	0.02
80. Buprestidae sp.	9	0.15	2	0.04
81. Tenebrionidae, *Opatrum* sp.	6	0.10	1	0.02
82. Tenebrionidae, *Pachychila* sp.	6	0.10	5	0.11

TABLE II (continued)

Taxa	Cattle Egret		White Stork	
	n	n %	n	n %
83. Tenebrionidae, *Erodius* sp.			12	0.25
84. Tenebrionidae, *Asida* sp.			11	0.23
85. Tenebrionidae, *A. silphoides*			5	0.11
86. Tenebrionidae, *Micositus* sp.			1	0.02
87. Tenebrionidae, *Blaps* sp.			3	0.06
88. Tenebrionidae, *Scaurus* sp.			2	0.04
89. Tenebrionidae, *Lithobaurus* sp.	30	0.50	2	0.04
90. Tenebrionidae, *L. planicollis*	2	0.03		
91. Tenebrionidae, *Tentyria* sp.	1	0.02		
92. Tenebrionidae sp.	19	0.32	2	0.04
93. Harpalidae, *Acinopus* sp.	2	0.03	1	0.02
94. Harpalidae, *A . megacephalus*	3	0.05	45	0.95
95. Harpalidae spp.			25	0.53
96. Cetonidae, *Potosia* sp.			7	0.15
97. Cetonidae, *Potosia cuprea*			13	0.28
98. Cetonidae, *Oxythyrea squalida*	29	0.48	32	0.68
99. Cetonidae, *Aethiessa floralis barbara*			12	0.25
100. Cetonidae sp.			1	0.02
101. Callistidae, *Chlaenius* sp. 1, sp. 2	180	3	23	0.49
102. Chrysomelidae, *Chrysomela* sp.	5	0.08	4	0.08
103. Chrysomelidae, *C. banksi*	3	0.05	1	0.02
104. Chrysomelidae, *C. sanguinolenta*	1	0.02	1	0.02
105. Chrysomelidae, *C. erythromera*	2	0.03		
106. Chrysomelidae, *Timarcha* sp.			2	0.04
107. Chrysomelidae spp.	13	0.22	1	0.02
108. Dytiscidae, *Hydroprinae* spp.	11	0.18		
109. Dytiscidae sp. 1, sp. 2, sp. 3	59	0.98	7	0.15
110. Dytiscidae, *Dytiscus emarginatus*	3	0.05	4	0.08
111. Geotrupidae, *Geotrupes* sp. 1	2	0.03		
112. Geotrupidae, *G. leavigatus*	4	0.07	454	9.62
113. Hydrophilidae, *Hydrophilus piceus*	4	0.07		
114. Hydrophilidae, *H. pistaceus*			35	0.74
115. Hydrophilidae spp.	1	0.02	1	0.02
116. Elateridae sp. 1, sp. 2, sp. 3	224	3.73	10	0.21
117. Histeridae, *Hister major*	1	0.02	33	0.70
118. Licinidae, *Licinus silphoides*	18	0.30	9	0.19
119. Staphylinidae, *Staphylinus* sp.	10	0.17	1	0.02
120. Staphylinidae, *S. olens*	48	0.80	12	0.25
121. Staphylinidae spp.	35	2	1	0.02
122. Scaritidae, *Scarites* sp.			2	0.04
123. Silphidae, *Silpha granulata*	15	0.25	83	1.76
124. Silphidae, *S. opaca*	17	0.28	89	1.89
125. Silphidae, *Silpha* sp.	1	0.02	1	0.02

TABLE II (continued)

Taxa	Cattle Egret		White Stork	
	n	n %	n	n %
126. Anthicidae, *Anthicus* sp.	7	0.12	3	0.06
127. Anthicidae sp.	5	0.08		
128. Dermestidae, *Dermestes* sp.	34	0.57	3	0.06
129. Dermestidae spp.	25	0.42	3	0.06
130. Ptinidae, *Ptinus* sp.			8	0.17
131. Lucanidae spp.	1	0.02	15	0.32
132. Trogidae, *Trox* sp.	3	0.05		
133. Bruchidae sp.	1	0.02		
134. Coccinellidae, *Coccinella algerica*	1	0.02		
135. Coccinellidae, *Scymnus rufipes*	1	0.02		
136. Coccinellidae sp. 1, sp. 2	2	0.04		
137. Meloidae, *Meloe* sp.	1	0.02		
138. Meloidae, *Mylabris* sp.	1	0.02		
139. Scolytidae sp. 1, sp. 2	6	0.09		
140. Cicindelidae, *Cicindela* sp.	1	0.02		
141. Cicindelidae, *Cicindela flexuosa*	2	0.03		
142. Cicindelidae sp.	1	0.02		
143. Cerambycidae sp.	1	0.02		
144. Orthoptera, Caelifera spp.	8	0.13	2	0.04
145. Caelifera, Acrididae, *Anacridium aegyptium*			3	0.06
146. Acrididae, *Oedipoda* sp.	9	0.15		
147. Acrididae, *Acrida turrita*	1	0.02	1	0.02
148. Acrididae, *Locusta migratoria cinerascens*	34	0.57		
149. Acrididae, *Calliptamus* sp.	2	0.03	4	0.08
150. Acrididae, *Ailopus* sp.	177	2.95		
151. Acrididae, *A. strepens*	80	1.33	14	0.30
152. Acrididae, *Eyprepocnemis plorans*	418	6.97	4	0.08
153. Acrididae, *Tropidopola cylindrica*	2	0.03		
154. Catantopidae, *Pezotettix giornai*	727	12.12	49	1.04
155. Tetrigidae, *Paratettix meridionalis*	46	0.77		
156. Pamphagidae, *Pamphagus* sp.			111	2.35
157. Pamphagidae, *P. elephas*	9	0.15	414	8.77
158. Pamphagidae, *Ocneridia* sp.	6	0.10	57	1.21
159. Pamphagidae, *Acinipe* sp.	3	0.05	31	0.66
160. Pamphagidae sp.	13	0.22	4	0.08
161. Ensifera, Ephipigeridae, *Uromenus* sp.	2	0.03	87	1.84
162. Ensifera sp. 1, sp. 2	29	0.47	19	0.40
163. Tettigoniidae, *Platycleis* sp.	27	0.45		
164. Tettigoniidae, *Rhacocleis* sp.	7	0.12	10	0.21
165. Tettigoniidae, *Tettigonia* sp.	2	0.03		
166. Tettigoniidae, *Decticus albifrons*	1	0.02	396	8.39
167. Gryllidae, *Gryllus* sp. 1, sp. 2	56	0.93	59	1.25
168. Gryllidae, *Gryllus bimaculatus*	151	2.52	3	0.06

TABLE II (continued)

Taxa	Cattle Egret		White Stork	
	n	n %	n	n %
169. Gryllidae sp.	74	1.23	1	0.02
170. Gryllotalpidae, *Gryllotalpa gryllotalpa*	1	0.02	3	0.06
171. Gryllotalpidae, *G. vulgaris*	7	0.12	108	2.29
172. Phasmoptera, Phasmidae sp.			1	0.02
173. Hymenoptera sp.	4	0.07		
174. Sinipidae sp.			1	0.02
175. Ichneumonidae sp. 1, sp. 2	7	0.12		
176. Apidae spp.	13	0.22		
177. Formicidae, *Aphaenogaster* sp. 1, sp. 2	2	0.04		
178. Formicidae, *A. testaceopilosa*	25	0.42	2	0.04
179. Formicidae, *Cataglyphis bicolor*	22	0.37		
180. Formicidae, *Tetramorium biscrensis*	73	1.22	7	0.15
181. Formicidae, *Componotus* sp.	1	0.02		
182. Formicidae, *Messor barbara*	365	6.08	4	0.08
183. Formicidae, *Crematogaster scutellaris*	2	0.03	1	0.02
184. Formicidae, *Plagiolepis barbara*	7	0.12		
185. Formicidae, *Monomorium* sp.	2	0.03		
186. Formicidae, *M. salomonis*	3	0.05		
187. Formicidae, *Pheidole* sp.			1	0.02
188. Formicidae, *P. pallidula*	5	0.08		
189. Formicidae, *Tapinoma simrothi*	56	0.93	1	0.02
190. Formicidae sp.	1	0.02		
191. Chrysididae, *Chrysis* sp.	1	0.02		
192. Vespidae, *Vespa germanica*	1	0.02		
193. Mutilidae sp.	2	0.03	1	0.02
194. Eumenidae sp.	1	0.02		
195. Hemiptera sp. 1 (aquatic), sp. 2, sp. 3	12	0.20		
196. Pyrrocoreidae sp.	3	0.05		
197. Reduviidae spp.	15	0.25		
198. Lygaeidae sp. 1, sp. 2	7	0.12		
199. Coreidae sp.	1	0.02		
200. Pentatomidae sp.	1	0.02		
201. Pentatomidae, *Sciocorice* sp.	1	0.02		
202. Homoptera sp.	1	0.02		
203. Homoptera, Cicadellidae sp.	1	0.02	1	0.02
204. Diptera sp., adults, *larvae*	7	0.12	1	0.02
205. Caliphoridae, *Lucilia* sp.	3	0.05		
206. Syrphidae, *Cycloraphes* sp.	1	0.02		
207. Nevroptera sp., adults, *larvae*	6	0.10	4	0.08
208. Dermaptera, Labiduridae, *Anisolabis mauritanicus*	342	5.70	142	3
209. Labiduridae, *Labidura riparia*	62	1.03	10	0.21
210. Labiduridae, *Nala levidipes*	22	0.37		
211. Forficulidae, *Forficula auricularia*	12	0.20	4	0.08

TABLE II (continued)

N	Cattle Egret		White Stork	
Taxa	n	n %	n	N %
212. Plecoptera sp., larvae			4	0.08
213. Blattoptera, Blattodea, Blattidae, *Ectobius* sp.	1	0.02		
214. Blattidae, *Periplaneta americana*	1	0,02		
215. Odonata sp.	1	0.02		
216. Embioptera, adults	2	0.03	2	0.04
217. Mantoptera, Mantodea, Mantidae sp.	1	0.02		
218. Mantidae, *Empusa pennata*	1	0.02		
219. Mantidae, *Sphodromantis viridis*	4	0.07		
220. Mantidae, *Mantis religiosa*	15	0.25		
221. Lepidoptera sp.	1	0.02		
Totals	5,999	100	4,721	100
Total number of taxa	226		154	

Note: when not otherwise stated, invertebrate preys are adults.

OVERLAP OF THE FEEDING NICHES OF THE TWO SPECIES IN TIME

The overlap index between the food of the Cattle Egret and White Stork showed clear changes during the breeding period of these two birds, with a peak in May (Fig. 1). This peak was mostly due to the fact that, at this time, the two species

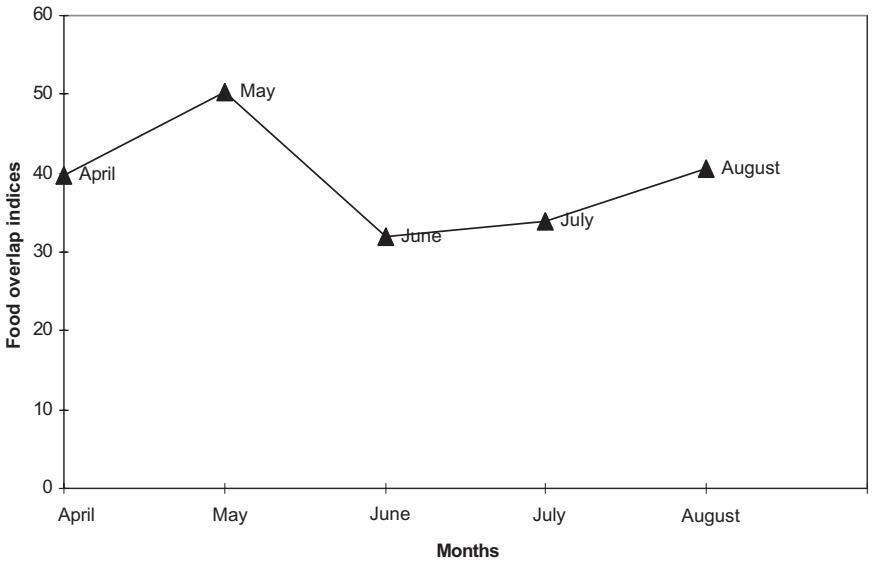

Figure 1. — Monthly variation of food overlap indices of the White Stork and the Cattle Egret in the Sébaou valley.

ate in common many coleopterans (30 species), orthopterans (6 species) and dermapterans (2 species). During the other months, the overlap index was always under 40%, confirming the separation of the two diets.

Dietary variations of the two species according to locality

Comparison of the dietary changes of the Cattle Egret and White Stork according to localities showed noteworthy similarities and differences (Tables III and IV).

In the White Stork, invertebrates made up more than 97% of the prey in the three sites where this species bred, with a Coefficient Variation (CV) almost equal

Table III

Comparison of the diet of the White Stork at three localities in the Sébaou valley (n %: relative frequency; m: arithmetic mean; sd: standard deviation; C.V.: variation coefficient; N: number of pellets analysed).

N	Localities					
	Tadmaït 83	Baghlia 48	Chaïb 19			
Taxa	n %	n %	n %	m	sd	C.V.
Vertebrata	0.37	2.06	1.25	1.22	0.48	56
Pisces	0.20	0.69	1.07	0.65	0.25	55
Amphibia	0	0.26	0	0.08	8.66	141
Reptilia	0.07	0	0.18	0.08	5.23	89
Sauria	0.03	0	0.18	0.07	5.56	112
Undetermined	0.03	0	0	0.01	0.01	141
Aves	0	0.43	0	0.14	0.14	141
Mammalia	0.10	0.69	0	0.26	0.21	116
Invertebrata	99.63	97.94	98.75	98.77	0.48	0.70
Gastropoda	0.77	1.54	2.50	1.60	0.50	44
Crustacea	0	0.09	0	0.03	0.03	141
Arachnoida	2.94	3.17	4.65	10.76	0.53	21
Scorpionidea	1.17	0.43	0.36	0.65	0.25	56
Solifugea	1.70	2.40	3.76	2.62	0.60	33
Aranea	0.07	0.34	0.54	0.31	0.13	61
Myriapoda	1.60	2.32	4.11	2.67	0.74	39
Insecta	94.33	90.82	87.48	90.87	1.97	3
Undetermined	0	0.09	0	0.03	0.03	141
Coleoptera	55.34	63.12	73.70	64.05	5.32	12
Orthoptera	36.18	20.24	10.73	22.38	7.42	47
Phasmoptera	0	0	0.18	0.06	0.06	141
Hymenoptera	0.40	0.26	0.54	0.40	8.08	29
Homoptera	0.03	0	0	0.01	0.01	141
Diptera	0.03	0	0	0.01	0.01	141
Nevropera	0.13	0	0	0.04	4.33	141
Dermaptera	2.07	6.95	2.33	3.78	1.58	59
Plecoptera	0.13	0	0	0.04	4.33	141
Embioptera	0	0.17	0	0.05	5.66	141

TABLE IV

Comparison of the diet of the Cattle Egret at three localities in the Sebaou valley (n%: relative frequency; m: arithmetic mean; sd: standard deviation; C.V.: variation coefficient, N: number of pellets analysed)

	Localities					
	Drâa Ben Khedda	Oued Aissi	Baghlia			
N	85	37	28			
Taxa	n%	n%	n%	m	sd	C.V. en %
Vertebrata	2.24	0.95	0.69	1.29	0.47	52
Pisces	0.33	0.29	0.19	0.27	4.16	22
Amphibia	0.63	0.07	0.25	0.31	0.16	74
Reptilia	0.07	0.07	0	0.04	2.33	71
Aves	0.33	0	0	0.11	0.15	141
Mammalia	0.89	0.51	0.25	0.55	0.18	48
Rodentia	0.46	0.29	0.19	0.31	7.88	36
Insectivora	0.43	0.22	0.06	0.23	0.10	64
Invertebrata	97.76	99.05	99.31	98.70	0.48	0.70
Gastropoda	0	0.22	0.13	0.11	6.38	77
Arachnoida	1.05	1.25	0.63	0.97	0.18	26
Solifugea	0.07	0	0.19	0.08	5.54	90
Aranea	0.95	1.25	0.44	0.88	0.13	38
Acarina	0.03	0	0	0.01	0.01	141
Myriapoda	0.39	0.22	0.31	0.30	4.91	23
Undetermined	0.30	0	0.31	0.20	0.10	71
Chilopoda	0.10	0	0	0.03	3.33	141
Diplopoda	0	0.22	0	0.07	7.33	141
Insecta	96.31	97.36	98.25	97.30	0.56	0.81
Undetermined	0	0.07	0	0.02	2.33	141
Coleoptera	66.95	42.73	12.45	40.71	15.76	55
Orthoptera	12.11	30.47	69.29	37.29	16.85	64
Hymenoptera	5.50	18.80	10.57	11.62	3.87	47
Hemiptera	0.26	1.40	0.81	0.82	0.32	56
Homoptera	0.03	0.07	0	0.03	2.02	86
Diptera	0.20	0.37	0	0.19	0.10	80
Nevroptera	0.20	0	0	0.06	6.66	141
Dermaptera	10.73	3.30	4.19	6.07	2.34	55
Blattoptera	0.07	0	0	0.02	2.33	141
Odonata	0.03	0	0	0.01	0.01	141
Embioptera	0.03	0.07	0	0.03	0.02	86
Mantoptera	0.20	0.07	0.88	0.38	0.25	93
Lepidoptera	0	0	0.06	0.02	0.02	141

to zero, and vertebrates accounted for less than 3%. There was also almost no difference in the total consumption of insects (CV = 3). Nevertheless, coleopterans, orthopterans and dermapterans were taken in very different quantities, with variation coefficients of 12, 47 and 59% respectively. The storks at Chaïb and Baghlia captured large quantities of Coleoptera (73.7 and 61.3% of their preys), whereas those at Tadmaït took somewhat less (55.3%) and supplemented their diet with orthopterans (36.2%). Dermapterans were taken mostly at Baghlia (7%). These variations might be explained by differences in the biotopes where the storks of these three localities foraged, and where the diversity and abundance of the small fauna was not the same.

In Cattle Egrets, invertebrates also made up over 97% of the prey, with a CV almost equal to nil, and vertebrates less than 3%. There was no difference in insect prey as a whole (CV = 0.8%). Nevertheless, coleopterans, orthopterans, hymenopterans and dermapterans were very diversely represented according to localities, with CVs equal to 55, 64, 47 and 55% respectively. Cattle Egrets at Drâa Ben Khedda and Oued Aïssi took large numbers of coleopterans (66.9 and 42.7% respectively), whereas those at Baghlia took few (12.4%) and instead captured many orthopterans (69.3%). Hymenopterans were mostly eaten at Oued Aïssi (18.8%) and dermapterans at Drâa Ben Khedda (10.7% of the prey). These variations reflected differences in the local insects availability. At Drâa Ben Khedda, for instance, coleopterans were abundant. Grazed meadows harboured numerous species, particularly fairly large-sized Scarabaoidea such as *Copris hispanus, Oryctes nasicornis, Scarabaeus semipunctatus* and *Rhizotrogus* spp, while aquatic species, dytiscids and hydrophilids, lived near the banks of oueds and ponds. At Baghlia on the contrary, low crops and fallow lands were rich in orthopterans, especially acridians. At Oued Aïssi, foraging grounds were more diversified. Besides crops, there were wet natural meadows, thicket edges, ponds and rivers where the birds took more orthopterans and fewer coleopterans than at Drâa Ben Khedda.

Comparison of prey size

Most prey taken by the Cattle Egret and the White Stork were small-sized, measuring less than 30 mm, a category with about 1,000 prey in the diet of both species (Fig. 2). Cattle Egrets took predominantly small prey, coleopterans, scarabeids (> 900 individuals), carabids (> 800), and elaterids (224), as well as hymenopterans, particularly formicids (592), dermapterans, above all labidurids (438), and gryllids (281) among orthopterans. Very small prey taken by the White Stork were mainly represented by scarabaeids (> 1,000), the geotrupid *Geotrupes laevigatus*, (454), silphids (173) and curculionids (105). Dermapterans and hymenopterans were represented by only 156 and 18 individuals respectively. A more precise analysis of preys in the interval 1-30 mm was done by dividing this interval into 10 classes again using Struge's formula (Fig. 3). Differences only appeared in the size classes up to 12 mm. Preys under 3 mm, including many formicids (mostly *Tapinotus simrothi*) were exclusively eaten by the Cattle Egret. Preys with a length comprised between 4 and 12 mm, also mainly formicids, were eaten mostly by the Cattle Egret, but the share with the Stork increased regularly with prey length. Preys 13-30 mm long were eaten by the two species in about the same proportions, but the Stork took more coleopterans, mostly Geotrupidae, whereas the Egret captured more orthopterans, mostly Acrididae (Table I).

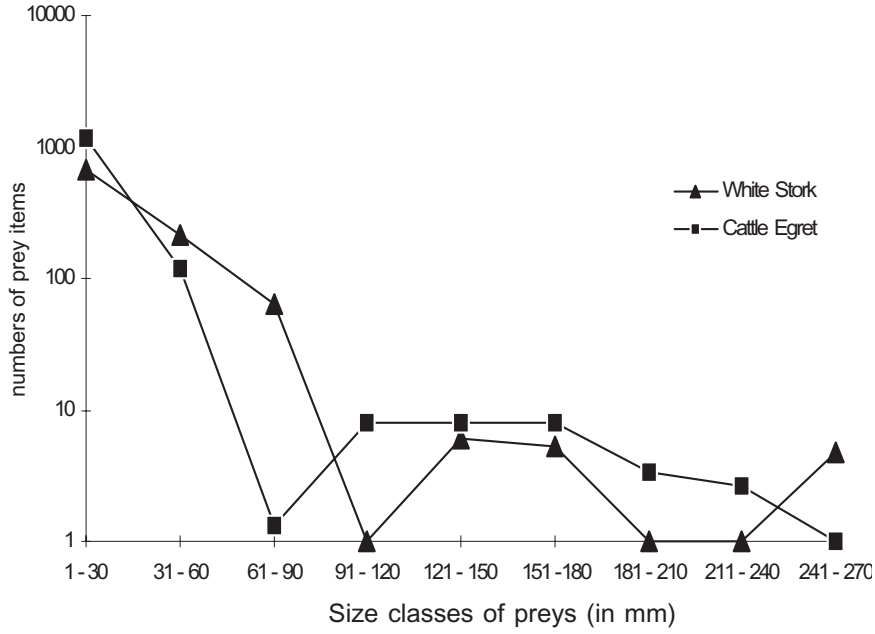

Figure 2. — Numbers of occuring items in the White Stork and Cattle Egret diets according to prey size classes.

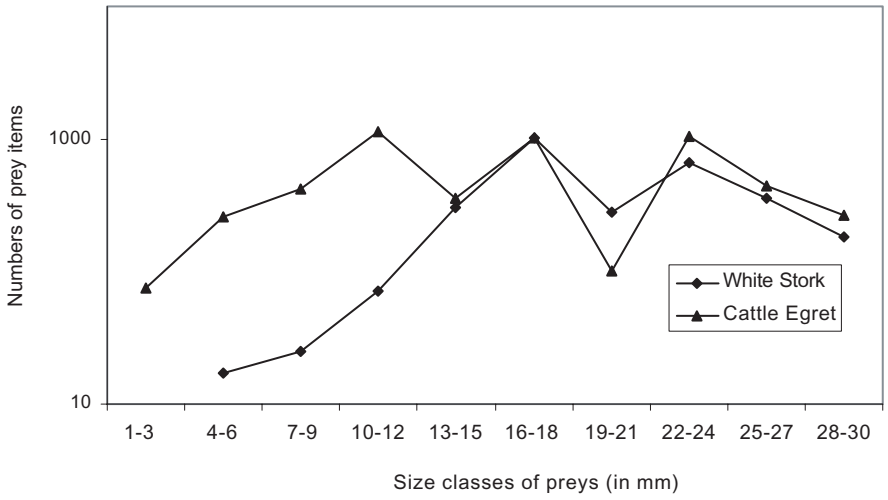

Figure 3. — Numbers of occuring items in the White Stork and Cattle Egret diets according to prey size classes in the category 1-30 mm.

The most important difference between the diets of the two birds were for prey between 61 and 90 mm. The White Stork took these readily (about 100 individuals) notably orthopterans of the genus *Pamphagus* (525), whereas this category was

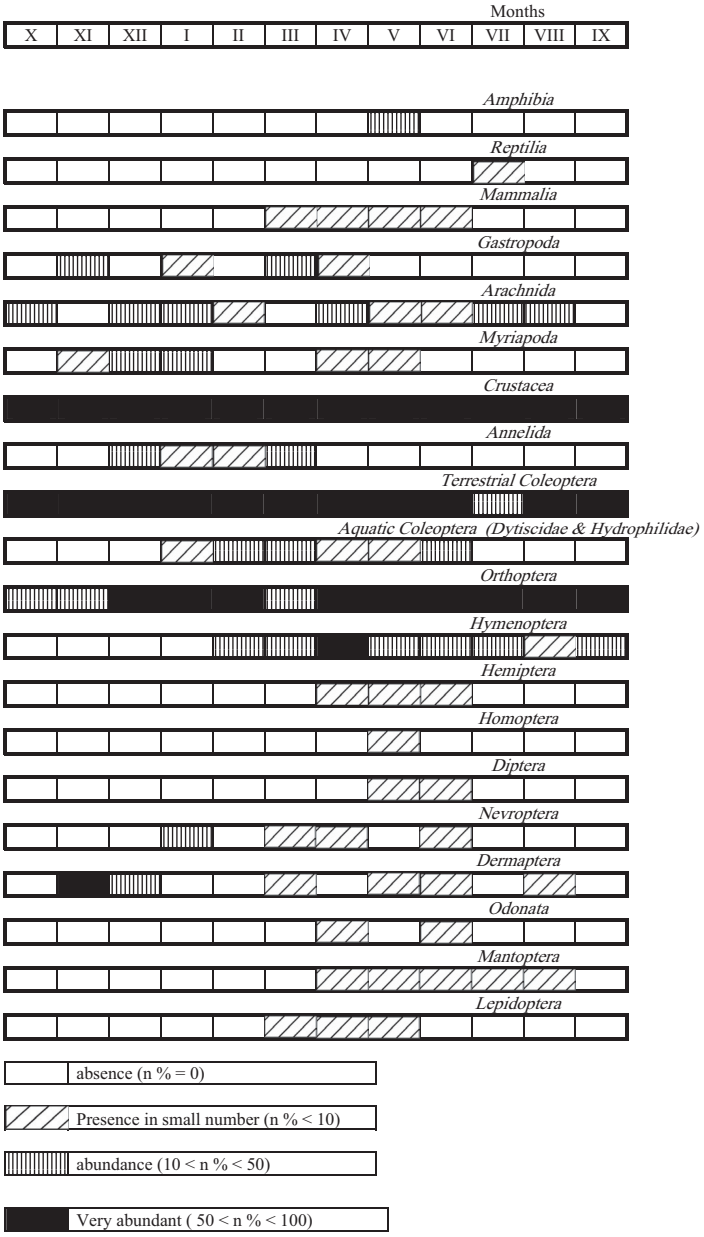

Figure 4. — Monthly availabilities in active animal preys in the five stations sampled from October 1994 to September 1995. (n%: relative frequency in numbers of taxa)

almost nil in the Cattle Egret. Prey with a size larger than 91 mm were not frequent. The Cattle Egret took fish and birds, which were almost absent from the diet of the White Stork. The Cattle Egret captured also five *Apodemus sylvaticus* and four *Gerbillus campestris*, which fell into the category 211-240 mm. The largest prey of all were four *Rattus norvegicus* taken by the White Stork. There were thus unambiguous differences in the size of the prey captured by the Cattle Egret and the White Stork only in the 61 to 90 mm size range.

Prey availability

Only three groups of potential prey were present all over the year, and were often abundant or very abundant (Fig. 4): Crustacea, terrestrial Coleoptera and Orthoptera. The class Crustacea was of negligible significance as food for the White Stork and the Cattle Egret, whereas coleopterans were the most important in numbers of prey (59.4 and 46.9% respectively) and orthopterans in biomass (58.8 and 47.3%) (Tables I and II). The chick feeding period (April-June) was the time when available prey became the more diverse and abundant (Fig. 4), with the appearance of an additional 14th zoological group. On the contrary, the hot and dry summer was the period with least diversity and abundance of prey, a total of eight groups only being present. Reptiles and Dermaptera were marginal in terms of numbers, but reptiles were rewarding in terms of biomass (Table I and Fig. 4). At this time Orthoptera were exceedingly numerous, and widely taken. Autumn and winter, when storks had left the Sébaou valley, experienced lower temperatures and rains, and preys were more diverse, seven zoological groups being present, sometimes in good numbers, in addition to the three present all the year round, which still represented the main source of food for the Cattle Egrets (Table I, Fig. 4).

DISCUSSION

White Storks in the Sébaou valley ate almost exclusively insects, as is the case in other regions of the Palaearctic (Skovgaard, 1920; Bouet, 1936, 1956; Haverschmidt, 1949; Dolderer, 1953; Schierer; 1962, 1967; Baudoin, 1973; Melandro *et al*., 1978; Metzmacher, 1979; Guitian Rivera, 1982; Lázaro, 1986; Rabaça, 1988; Lázaro & Fernández, 1991; Pinowski *et al*., 1991, 1996; Musinic & Rasajski, 1992). The predominancy of coleopterans in relation to other orders in the diet of these two birds has been underlined by several authors in Europe, among others in Spain by Melandro *et al*. (1978), in Portugal by Rabaça (1988), and in France by Schierer (1962, 1967). This predominancy of coleopterans was not regularly found in samples from European agrosystems. Thus, Guitian Rivera (1982) and Lázaro & Fernández (1991) gave 86.96 and 43.36% orthopterans for such biotopes in Spain and Sackl (1987), 67.7% orthopterans and 24.1% coleopterans in Austria. These two insect orders were also very important in the diet of the Oriental Stork *Ciconia boyciana* (Winter, 1991). Dallinga & Schoenmakers (1987) showed a positive correlation between the decrease in numbers of orthopteran populations and that of White Storks in their breeding area.

According to literature data, vertebrates are typically present in low proportions, and may even be absent, in rejection pellets of White Storks (e.g. Schierer,

1962; Baudoin, 1973; Melandro *et al.,* 1978; Körös, 1991). However, Metzmacher (1979) noted important catches of Sparrows (*Passer* spp.) in Orania (western Algeria), and Pinowski *et al*. (1986) in Poland found bird remains in 7 pellets out of 66. Fish and mammals are very little caught, even if their biomass can be important. In other studies, mammals, and particularly rodents, were also noted in low proportions (Schierer, 1962, 1967; Baudoin, 1973; Rekasi, 1980). The low proportion of vertebrates in the diet of White Storks may be due to the difficulty of catching them, which the storks do only on occasions, such as when reptiles and small mammals are scared from their hiding places by human activity (Stammer, 1937; Schüz, 1962). Lazaro (1986) on his part found 30.2% earthworms (Lumbricines) in pellets from White Storks.

Variations in the diet of the Algerian White Stork from one colony to the other and during the course of the year were linked to local availability and phenology of prey and this is likely to happen elsewhere (Table III).

The food of the Cattle Egret in the Sébaou valley consisted almost exclusively of insects (Boukhemza *et al.,* 2000), as in other parts of the world: 92.1% by number of insects in South Africa (Siegfried, 1971), 85.1 in Mexico (Vasquez Torrez & Maquez Mayandon, 1972), 60.7 in Florida (Jenni, 1973), 96.1 in Mississipi (Hanebrink & Denton, 1969), 95.4 in Japan (Kosugi, 1960), 94.3 in Spain (Herrera, 1974), 82.0 in Camargue (France) (Hafner, 1977) (see C. Voisin, 1991 for more details). In the Maghreb, Valverde (1956) found a proportion of 97.4% insects in Morocco, Doumandji *et al*. (1992) 99.8 in Djurdjura (Algeria) and Doumandji *et al*. (1993) 96.8 in Orania.

In the Sébaou valley, coleopterans and orthopterans were the main insect groups eaten by the Cattle Egret (Boukhemza *et al.,* 2000), as in Morocco (Valverde, 1956), Camargue (Hafner, 1977) and other parts of the world (C. Voisin, 1991). As in other countries like South Africa (Siegfried, 1971), Mexico (Vasquez Torrez & Maquez Mayandon, 1972) or Spain (Herrera, 1974), dipterans, lepidopterans and arachnids were little taken, and in particular we did not find tabanids nor any other cattle attracted dipterans, the capture of which is rarely mentioned (Halley & Wayne, 1978; Snoddy 1969). We just found one tick, another very little mentioned food item for the Cattle Egret (Holman, 1946; Skead, 1963). As in the case of the White Stork, though little represented vertebrates were very important in terms of biomass (Table I), and seemed to be mainly taken when disturbed by humans or when heavy rains forced them out of their shelters. However, their occurrence frequencies showed that they were regularly taken, and the few data we have (Boukhemza, 2001) suggest that chicks ate proportionally more vertebrates, particularly amphibians, than adults, as is usually the case (C. Voisin, 1991). The variations of the diet of Algerian Cattle Egrets according to localities evidently reflected the local availability of prey (Table IV) also.

The quantitative and qualitative differences between the diets of the Cattle Egret and White Stork in the Sébaou valley may be explained by the fact that these predators possess a wide, mainly insectivore, potential trophic niche, which allows them to use somewhat different resources when they forage in the same biotopes. Both subsisted mainly on small prey (< 61 mm body length). However, White Stork ate more prey with a size comprised between 61 and 90 mm, and the Cattle Egret more prey between 91 and 120 mm. These dietary dissimilarities corresponded to ecological and behavioural dissimilarities which contributed to maintain the coexistence of these two predatory species, as for instance, association with cattle which allows Cattle Egrets to catch a high number of prey.

In all months except May the overlap index of the trophic niches of the Cattle Egret and White Stork was below 40%, which confirmed the dietary separation between the two species. In May, this index showed a peak at about 50%, which corresponded mainly to the capture of coleopterans by the two species (over 30 taxa), and secondarily of orthopterans and dermapterans. Authors like Porter & Dueser (1982) suppose that a positive correlation exists between overlap and competition, the smaller the overlap, the less intense the competition. This was probably the case with the Cattle Egret and White Stork in Kabylia, as their niche overlap was larger at a time when their alimentary needs were themselves larger, that is, during the chick-feeding period (Fig. 1). Some prey were taken by one species only, i.e., among coleopterans, some lucanids, bruchids, coccinellids, scolytids, cicindelids and cerambycids were taken only by the Cattle Egret, and some cetonids and buprestids by the Stork only. The White Stork and Cattle Egret show similar diets as far as prey species or taxonomic groups are concerned, but a more detailed analysis shows a clear separation of those diets by prey range size, a fact which may contribute largely to restrict feeding competition between the two species. The larger overlap of the trophic niches during the chick-feeding period is facilitated by the fact that this time of the year has the highest prey availability and diversity (Fig. 4), rendering competition between the two species less intense. On the contrary, competition between the White Stork and the Cattle Egret is probably enhanced in summer, when the most available and energetically rewarding preys are orthopterans. From mid-August to February, the Stork is absent from Kabylia and competition between the two species is then nil.

The food the birds take is rarely the only available one in the biotope they exploit, its choice is the result of a complex selection by the birds, which first select a given biotope to forage, and then, within this biotope, choose prey species among all those present according to criteria like size or energetic intake. The Cattle Egret and the White Stork share their trophic resources according to three modalities: their actual diets, feeding behaviours and habitats. In the Sébaou valley as elsewhere, they appear as opportunistic species which, when preys are abundant, select those which fit them best, but are able to live on what they find when preys are rare. This opportunistic behaviour may largely explain the successful recent range extension of the Cattle Egret in Algeria, where it can prove to be an auxiliary of agriculture by helping to keep down populations of noxious species. But, despite of this, the trophic segregation of the White Stork and Cattle Egret seems now sufficient to allow them to live in sympatry in Kabylia, according to the "principle of limiting similarity" (Dreux, 1980).

The results of this study allow us to express a few recommendations for the conservation of habitats used by the White Stork and Cattle Egret in Algeria. The distribution of waterbird colonies is not random, but depends on the extent and quality of foraging areas. Woods and groves used by the birds for breeding should be maintained in or near these areas. Feeding resources should be available continuously close to their nests. For that purpose, a mosaic of small meadows should be available for exploitation over the breeding period of the birds. Meadows should be flooded as breeding sites for amphibians, and fallow land available to supplement prey. Like in some other Mediterranean countries (Fasola & Alieri, 1992; Hafner & Fasola, 1992, 1997; Kushlan & Hafner, 2000) plantings could prove to be necessary in the short term.

For the conservation of the White Stork in Algeria, a programme with effective practical measures is urgently needed. Those measures should be conducted at both

a regional and national scale and coordinated with international programs, as it is already done in other countries of the western Palearctic.

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