Ornis Fennica 74: 179–185. 1997

Nestling diet of the Spotless Starling *Sturnus unicolor* and the European Starling *Sturnus vulgaris* in a sympatric breeding area

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Received 4 March 1997, accepted 18 June 1997

The diet of nestlings of Spotless and European Starlings (*Sturnus unicolor* and *S. vulgaris* respectively) was analysed in a sympatric area in north-eastern Spain. Results showed that the nestlings were fed mostly with insects (94% of prey in the Spotless Starling and 95% in the European Starling); some of the Arthropoda and Gasteropoda were also recorded. The Syrphidae (Diptera) and Chrysomelidae (Coleoptera) constituted the main food, especially in the Spotless Starling. The Scarabeidae (Coleoptera) and the Lepidoptera were the most important secondary prey for the Spotless Starling, whereas secondary prey items for the European Starling were the Araneida, the Acrididae (Orthoptera) and the Lepidoptera. These data agree with the general results obtained from other study areas, but differed because of the high frequency of the Diptera in the diet of the Spotless Starling and the total absence of the Lumbricidae in the diet of the European Starling in our study area. Significant differences were recorded in the diet of the nestlings of the two species, although the two weeks difference in the breeding phenology of the two species could explain these differences. Probably for the same reason, significant differences between broods were also recorded for the Spotless Starling. Nevertheless, the width of the diet niche did not show any significant difference between the two species at either the individual or population levels. Furthermore, the results of the Morisita Index indicate a very high niche overlap, suggesting that both species exploited, to a large extent, the same food sources.

1. Introduction

The Spotless Starling and the European Starling are two closely related species. In the present century, both species have expanded their breeding ranges (Bernis 1960, Delvingt 1961, Berthold 1968, Taitt 1973, Feare 1984). Thus, several areas of sympatry have arisen in north-eastern Spain since the 1970s (Motis et al. 1983, Peris et al. 1987, Ferrer et al. 1991). More recently, new areas of sympatry appeared in south-eastern France (Cambrony 1990, Cambrony & Motis 1994, Kayser & Rousseau 1994).

The present study was carried out in the oldest and largest area of sympatry, where both spe-

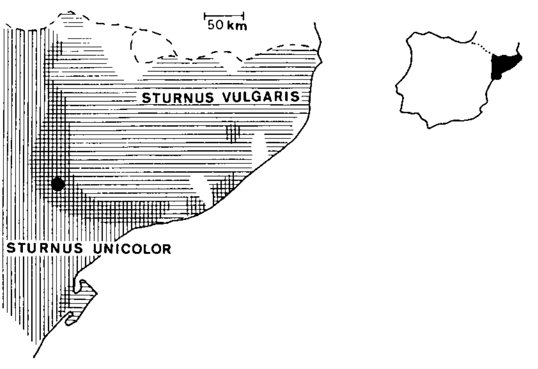

Fig. 1. The 1984 range of the two species in NE Spain and the situation of the study area (black dot).

cies breed frequently in mixed colonies (Motis 1994). A few cases of mixed pairs have been found, and some of these produced fledglings (Motis 1993). For allopatric areas there are different studies describing the diet of the two species, especially that of nestlings (Peris 1980, Pascual 1992, Pereira de Almeida 1995 for the Spotless Starling; Kluijver 1933, Dunnet 1955, Havlín & Folk 1965, Gromadzki 1969, Bogucki 1974, Moeed 1980, Tinbergen 1981, Moore 1988 for the European Starling). These studies showed that the two species share a similar diet, feeding mainly on invertebrates. Nevertheless, differences in the habitats of the study areas prevented an evaluation of the precise degree of overlap between the diets of the two species.

In the present study area, the two species showed similar requirements in general habitat and breeding sites; moreover, the two species feed in the same places, and form mixed feeding groups (Motis 1986, 1994). Nevertheless, the diet of the two species in sympatry had not been described until now. The aim of this study is to compare the diet of the nestlings of the two recent sympatric species.

2. Material and methods

The studied nests were located in two close villages (Castelldans, Llardecans) in the province of Lleida (Fig. 1). In this area, the two species breed together, mainly under tiles on roofs. The area is intensively cultivated for cereals and olive and almond trees.

The food samples were obtained using the ligature method (Kluijver 1933, Johnson et al. 1980): plastic-coated wires were placed around the necks of each of the nestlings for a period of two hours per nest. After the collar was removed, the nestlings were fed with minced meat to compensate for the lost food. The sampling unit was the total prey items per nest obtained from each visit.

Differences in food items related to the age of the nestlings, brood size, and the time of day were found by Peris (1980) in the Spotless Starling and Kluyver (1933), Coleman (1977), Tinbergen (1981) and Moore (1986) in the European Starling. For this reason, samples were obtained from nests of different brood sizes and from nestlings of all ages from 3 to 18 days at a larger period of time. In total, 29 nests (95 nestlings) of the Spotless Starling and 14 nests (44 nestlings) of the European Starling were controlled. Most nests were sampled more than once, with a minimum of one week's interval between samples. We obtained 65 samples from Spotless Starling nests (32 from the first brood and 33 from the second brood) and 36 samples from European Starling nests. One chick died during sampling. The total items obtained were 912 from Spotless Starlings and 914 from European Starlings. Traces of grass were not considered in the analysis.

In the study area, the majority of the population of the two species is double brooded (Motis 1994). The samples of the Spotless Starling were obtained from 27 April to 17 May (first brood) and from 1 to 21 June (second brood) in 1983; the samples of the European Starling were obtained from 5 May to 1 June (second brood) in 1983.

We used taxonomic criteria to establish prey categories following the suggestions of Cooper et al. (1990), based on the family level, to avoid analytical difficulties arising from an excess of groups with many zero counts. Furthermore, to avoid difficulties arising from categories poorly represented in the data matrix, when comparing relative frequencies of each prey category between species, we grouped the prey at the order level separating larval and adult stages because of their different typological characteristics. All the orders poorly represented were grouped in one taxonomic category (other prey).

To assess the relevance of the different prey categories in the diet, the following descriptors were used: number of prey items (N); numerical percentage (%N); and percentage of occurrence (percentage of sampling units containing the prey category, %P). Comparisons of diet composition were made using the G test (Zar 1984). The width of the trophic niche was measured by Brillouin's Diversity Index (Pielou 1975), and a jack-knife procedure was used to estimate diversity at the population level, together with the associated variance (Zahl 1977). Comparison of diversities was performed using a modified t-Student statistic (Zar 1984). The Morisita Index was used to measure the niche overlap between the two species (Krebs 1989).

3. Results

In the study area, the two species occurred in similar breeding and feeding sites. In 40 feeding groups, ranging from 4 to 96 individuals, 92.5% were mixed groups.

Table 1 shows the diet descriptors of the two species at the taxonomic level. The nestlings of the two species were mostly fed with insects (94% of prey items in the Spotless Starling and 95% of prey items in the European Starling); we also found some other prey items from the Arthropoda and some from the Gasteropoda. With respect to plant food, cherries appeared with an appreciable frequency (percentage of occurrence, %P = 12–17).

The Syrphidae (Diptera) and the Chrysomelidae (Coleoptera) stand out as the main resource consumed by starling nestlings, especially the Spotless Starling. With respect to secondary prey items (%P < 40 and %N < 10), the Scarabaeidae (Coleoptera) and the Lepidoptera were the most relevant for the Spotless Starling, whereas the European Starling showed a slightly higher diversity of secondary prey types, such as the Araneida, Acrididae (Orthoptera) or Lepidoptera. The amount of the Apoidea (Hymenoptera) consumed represents 21.9% of the total prey items for the European Starling (see Table 1), but the Apoidea were not considered an important prey species because they were all obtained from only one nest sample (%P = 2.8).

The more abundant typological groups are detailed in Table 2. The G-test results revealed a significant difference in diet composition between the two species considering total data ($G = 138.4$, $df = 7$, $p < 0.001$) or the two broods of the Spotless Starling separately ($G = 143.1$, $df = 7$, $p < 0.001$ first brood; $G = 80.7$, $df = 7$, $p < 0.001$ second brood). The Spotless Starling consumed more of the Coleoptera and the Lepidoptera larvae whereas the European Starling showed a higher consumption of other prey and the Diptera adults. Nevertheless, in comparing the two broods of the Spotless Starling significant differences in diet composition appeared ($G = 194.18$, $df = 7$, $p < 0.001$), because in the first brood there was a high consumption of the Coleoptera and Lepidoptera larvae, whereas in the second brood the consumption of the adult forms of the Coleoptera and Orthoptera was greater.

On the other hand, the estimated width of the diet niche did not show any significant difference between the two species, at either the individual or population levels (Table 3). Furthermore, the results of the Morisita Index ($C = 0.8546$, range 0–1) show a very high degree of niche overlap between the two species.

4. Discussion

The results of this study are consistent with those obtained in other study areas: the diet of the two species was mainly composed of invertebrates, especially arthropods. In the Spotless Starling the commonest prey items were larval and pupal forms of the Lepidoptera, Coleoptera and Orthoptera (Peris 1980, Pascual 1992, Pereira 1995), which are what we found in our study. But some differences are worth noting, Pereira (1995) pointed out the importance of the Hymenoptera larvae in the diet, which was not the case in our area. Second, none of these authors found large numbers of the Diptera (Syrphidae) in the diet, but in our study area the Diptera were the most important prey items in the diet of the Spotless Starling (39% of prey items). In the European Starling, the Diptera larvae, the larval and pupal forms of the Lepidoptera, and the larval and adult forms of the Coleoptera and Lumbricidae were the most abundant prey items (Dunnet 1955, Havlín & Folk 1965, Gromadzki 1969, Bogucki 1974, Gromadzki & Luniak 1978, Tinbergen 1981). Our results were consistent with these authors, except for the

Table 1. Descriptors of the diet of nestlings of Spotless and European Starlings using taxonomic categories of preys (%N = numeric percentage, %P = occurrence percentage). Data from the two broods of Spotless Starling are pooled.

		Spotless Starling			European Starling		
		N	%N	%P	N	%N	%P
Gasteropoda:	Helicidae	10	1.1	13.9	2	0.2	5.6
	Unid. Gasteropoda	–	–	–	–	–	–
Araneida:	Lycosidae	1	0.1	1.5	3	0.2	5.6
	Unid. Araneida	4	0.4	6.2	20	2.2	27.8
Isopoda:	Oniscidae	5	0.6	7.7	6	0.7	11.1
Diplopoda:	Julidae	14	1.5	15.4	3	0.3	8.3
Quilopoda:	Scolopendridae	1	0.1	1.5	–	–	–
Embioptera:	Embiidae	1	0.1	1.5	–	–	–
Dermaptera:	Forficulidae	–	–	–	8	0.9	11.1
Orthoptera:	Tettigonidae	3	0.3	4.6	3	0.3	8.3
	Gryllidae	2	0.2	3.1	1	2.8	0.1
	Acrididae	16	1.8	13.9	17	1.9	25.0
Homoptera:	Cicadidae	1	0.1	1.5	2	0.2	5.6
	Cercopidae	9	1.0	4.6	7	0.8	14.0
Heteroptera:	Notonectidae	–	–	–	4	0.4	2.8
	Reduviidae	1	0.1	1.5	–	–	–
	Pyrrhocoridae	21	2.3	6.2	1	0.1	2.8
	Coreidae	1	0.1	1.5	–	–	–
	Pentatomidae	–	–	–	2	0.2	5.6
	Unid. Heteroptera	2	0.2	3.1	3	0.3	8.3
Coleoptera:	Carabidae	6	0.7	7.7	3	0.3	2.8
	Silphidae	–	–	–	5	0.6	8.3
	Staphylinidae	2	0.2	3.1	8	0.9	5.6
	Geotrupidae	4	0.5	4.6	–	–	–
	Scarabaeidae	90	9.9	38.5	4	0.5	11.1
	Buprestidae	1	0.1	1.5	–	–	–
	Alleculidae	18	2.0	7.7	3	0.3	8.3
	Tenebrionidae	10	1.1	10.8	5	0.6	11.1
	Cerambycidae	1	0.1	1.5	–	–	–
	Chrysomelidae	219	24.0	47.7	191	20.9	47.2
	Curculionidae	2	0.2	3.1	–	–	–
	Unid. Coleoptera	5	0.6	7.7	7	0.8	16.8
Hymenoptera:	Formicidae	4	0.4	6.2	2	0.2	5.6
	Apoidea	–	–	–	200	21.9	2.8
Trichoptera		–	–	–	1	0.1	2.8
Lepidoptera:	Sesiidae	–	–	–	1	0.1	2.8
	Pieridae	–	–	–	1	0.1	2.8
Unid. Lepidoptera		39	4.3	32.3	15	1.6	25.2
Diptera:	Rhagionidae	14	1.5	6.2	–	–	–
	Syrphidae	356	39.0	63.1	311	34.0	55.7
	Calliphoridae	–	–	–	1	0.1	2.8
	Unid. Diptera	19	2.1	7.7	61	6.7	14.0
Unid Insecta		11	1.2	13.9	3	0.3	8.3
Lacertidae		1	0.1	1.5	–	–	–
Prunus avium		18	2.0	12.3	8	0.9	16.8

total absence of the Lumbricidae. Gallego and Balcells (1960) found that the Spotless Starling consumed large amounts of cherries in orchard areas, and Havlín and Folk (1965) reported the same for the European Starling.

Qualitative and quantitative changes in the composition of the diet of the nestlings in relation to study areas, years, pairs, daily patterns or broods have been recorded in the two species (Gromadzki 1969, Peris 1980, Moore 1986). In the present study, the data were obtained from the same sites during one year only, and from a larger number of pairs and at different times of the day. The significant differences found in the composition of the diet of the nestlings, between the two species, could be due to the differences in their breeding phenology. In the study area, the majority of the population of the two species show a two-week difference in their laying dates, with the European Starling breeding first (Motis 1994). This asynchronism in the chick rearing dates between the species may explain the differences in their diets, which may be due to possible temporal variations in the abundance and availability of some prey species (see Wolda 1990, Dahlsteen et al. 1990). This explanation is supported by the significant differences found between the first and second broods of the Spotless Starling.

Nevertheless, the results of the study of the niche overlap between the two starlings shows that these species exploited, to a large extent, the same food resources. Our results confirm that the two starling species seem to share similar ecological niches, and therefore some form of competition may exist in the areas of sympatry.

Selostus: **Mustakottaraisen ja kottaraisen poikasten ravinto lajien yhteisellä esiintymisalueella**

Kirjoittajat tutkivat mustakottaraisen ja kottaraisen poikasajan ravintoa Luoteis-Espanjassa alueella, missä molemmat lajit esiintyvät. Molempien lajien

Table 2. Descriptors of the diet of nestlings at typological level for the commonest prey (%N = numerical percentage, %P = occurrence percentage).

	Spotless Starling				European Starling		
	N	(N 1st/N 2nd broods)	%N	%P	N	%N	%P
Orthoptera							
Larvae	9	(2/7)	1.0	10.8	10	1.1	19.4
Adult	12	(1/11)	1.3	12.3	11	1.2	19.4
Coleoptera							
Larvae	105	(96/9)	11.5	18.5	36	3.9	27.8
Adult	253	(65/188)	27.7	64.6	190	20.8	44.4
Lepidoptera							
Larvae	39	(35/4)	4.3	32.3	14	1.5	22.2
Diptera							
Larvae	300	(143/157)	32.9	61.5	275	30.2	55.6
Adult	89	(32/57)	9.8	35.4	98	10.7	44.4
Other prey	105	(38/67)	11.5	53.8	280	30.6	63.9
Total	912	(412/500)	–	–	914	–	–

Table 3. Diversity indices at both individual and population levels for the diet of Spotless and European Starlings.

	Spotless Starling		European Starling				
	n	$\bar{x} \pm$ S.E.	n	$\bar{x} \pm$ S.E.	t	df	p
Ind. diversity	29	0.96 ± 0.09	14	0.84 ± 0.23	0.12	23	n.s.
Pop. diversity	29	2.51 ± 0.23	14	3.09 ± 0.33	– 0.33	38	n.s.

poikasten ravinto koostui etupäässä hyönteisistä (94–95%). Ravintoon sisältyi jonkinverran myös muita niveljalkaisia ja kotiloita. Hyönteisistä kukkakärpäset (Syrphidae) ja lehtikuoriaiset (Chrysomelidae) olivat molempien lajien poikasten pääravintoa. Mustakottaraisen poikasten ravinnossa tavattiin yleisesti myös lehtisarvisia (Coleoptera, Scarabeidae) ja perhosia (Lepidoptera). Kottaraisen poikasia ruokittiin pääravinnon ohella myös hämähäkeillä (Araneida), heinäsirkoilla (Acrididae) ja perhosilla. Luoteis-Espanjassa saadut tulokset ovat melko samanlaisia kuin muilla alueilla tehdyissä lajien ravintotutkimuksissa. Tämän tutkimuksen aineiston mukaan kaksisiipiset olivat kuitenkin korostuneemmin esillä mustakottaraisen ravinnossa kuin aiemmissa tutkimuksissa. Samoin aiemmista tutkimuksista poiketen luoteisespanjalaiset kottaraiset eivät ruokkineet poikasiaan madoilla (Lumbricidae) lainkaan. Lajien välisessä vertailuissa havaittiin merkitseviä eroja poikasajan ravinnon koostumuksessa, mutta erojen selityksessä voi olla keskimäärin kahden viikon ero pesinnän ajoittumisessa. Fenologiaerot mahdollisesti selittävät myös mustakottaraisella havaitun poikuettein välisen eron ravinnossa. Lajien ravintolokeron leveydet olivat kuitenkin hyvin samanlaiset sekä yksilö- että populaatiotasolla mitattuna. Samoin tulokset osoittavat, että eroista huolimatta ravintolokerot olivat suurelta osin päällekkäisiä eli lajit käyttivät jotakuinkin samoja ravintoresursseja.

References

Bernis, F. 1960: Migración, problema agrícola y captura del Estornino Pinto (Sturnus vulgaris). — Ardeola 6: 11–100.

Berthold, P. 1968: Die Massenvermehrung des Stars Sturnus vulgaris in fortpflanzungs-physiologischer Sicht. — Journal für Orn. 109: 11–16.

Bogucki, Z. 1974: A study on the diet of starling nestlings. — Act.Zool.Crecoviensia 17: 357–390.

Cambrony, M. 1990: L'Etourneau unicolore (Sturnus unicolor) nouvelle espèce pour l'avifaune des pyrénées-orientales. — La Mélanocephale 7: 57–63.

Cambrony, M. & Motis, A. 1994: Statut de l'Étourneau unicolore Sturnus unicolor en Languedoc-Roussillon en 1993. — Alauda 62: 135–140.

Coleman, J. D. 1977: The foods and feeding of starlings in Canterbury. — Proc. N. Z. Ecol. Soc. 24: 94–109.

Cooper, R. J., Martinat, P. J. & Withmore, R. C. 1990: Dietary similarity among insectivorous birds: Influence of taxonomic versus ecological categorization of prey. — Studies in Avian Biology 13: 104–109.

Dahlsteen, D. L., Cooper, W. A., Rowney, D. L & Kleintjes, P. K. 1990: Quantifying bird predation of arthropods in forests. — Studies in Avian Biology 13: 44–52.

Delvingt, W. 1961: Sur l'evolution des populations européennes de Sturnus vulgaris depuis un siècle. — Ann. Soc. Roy. Zool. Belg. 91: 29–38.

Dunnet, G. M. 1955: The breeding of the Starling Sturnus vulgaris in relation to its food supply. — Ibis 97: 619–662.

Feare, C. J. 1984: The Starling. — Oxford Univ. Press., Oxford.

Ferrer, X., Motis, A. & Peris, S. J. 1991: Changes in the breeding range of starlings in the Iberian Peninsula during the last 30 years: competition as a limiting factor. — J. Biogeography 18: 631–636.

Gallego, S. & Balcells, E. 1960: Notas biológicas sobre Sturnus unicolor en Lugo. — Ardeola 6: 339.

Gromadzka, J. & Luniak, M. 1978: Pokarm pisklat szpaka, Sturnus vulgaris L. W. Warszawa. — Act. Ornith. 8: 275–285.

Gromadzki, M. 1969: Composition of the food of the Starling, Sturnus vulgaris L., in agrocenoses. — Ekol. Polska 16: 287–311.

Havlín, J. & Folk, C. 1965. Potrava a vyznam spacka obecného, Sturnus vulgaris L. — Zool. Listy. 14: 193–208.

Johnson, E. J., Best, B. & Heagy, P. A. 1980: Food sampling biases associated with the "ligature method". — Condor 82: 186–192.

Kayser, Y. & Rousseau, E. 1994: Premières données sur l'Étourneau unicolore (Sturnus unicolor) dans le sud de la France. — Nos Oiseaux 42: 369–378.

Kluijver, I. H. N. 1933: Bijdrage tot de biologie en der ecologie van der Spreeuw (Sturnus vulgaris vulgaris L.) gedurende zijn voortplantingstijd. — Versl. Meded. Plantenziekt. Dienst. 69: 1–145.

Krebs, Ch. J. 1989: Ecological methodology. — Harper and Collins, New York.

Moeed, A. 1980: Diet of adult and nestling starlings (Sturnus vulgaris) at Hawke's Bay, New Zealand. — N. Z. J. Zool. 7: 247–256.

Moore, J. 1988: Dietary variation among nestling Starlings. — Condor 88: 181–189.

Motis, A. 1986: Els estornells com espècies antropòfiles. Alguns aspectes de la seva nidificació. — In: Enciclopèdia Catalana (ed.), Història Natural dels Països Catalans, 12: 410–415.

Motis, A. 1993: Mixed breeding pairs of European Starling Sturnus vulgaris and Spotless Starling Sturnus unicolor in the north-east of Spain. — Butll. G. C. A. 9: 19–23.

Motis, A. 1994: Territorialitat interspecífica de Sturnus vulgaris L. i Sturnus unicolor Temm., dues aloespècies en contacte secundari: hàbitat de cria, conducta agonística i cants territorials. — Ph.D.-thesis. Universitat de Barcelona.

Motis, A., Mestre, P. & Martinez, A. 1983: La colonización y expansión del Estornino Pinto (Sturnus vulgaris) y del Estornino Negro (Sturnus unicolor) en Cataluña (NE de la Península Ibèrica. — Misc. Zool. 7: 131–137.

Pascual, J.A. 1992: Reproducción y alimentación del Estornino Negro (Sturnus unicolor) en un rebollar. — Ph.D.-thesis. Universidad Complutense de Madrid.

Pereira de Almeida, J. F. 1995: Aspectos da bioecologia de reproduçao do Estroninho-preto (Sturnus unicolor Temminck, 1820) numa área de montado de azinho (Quercus rotundifolia) no Baixo Alentejo. — M.Sc.-thesis. Universidade de Lisboa.

Peris, S. 1980: Biologia del estornino negro (Sturnus unicolor) II, Dieta del pollo. — Doñana Acta Vertebrata 7: 249–260.

Peris, S. J., Motis, A. & Martinez, A. 1987: La distribución del Estornino Negro (Sturnus unicolor Temm.) y del Estornino Pinto (Sturnus vulgaris L.) en la Península Ibèrica: aumento del area de nidificación en ambas especies. — Actas VIII Bienal Real Soc. Esp. Hist. Nat. 21–24 Sept. Pamplona: 151–156.

Pielou, E. C. 1975: Ecological diversity. — John Wiley and Sons, New York.

Taitt, M. J. 1973: Winter food and feeding requirements of the Starling. — Bird Study 20: 226–236.

Tinbergen, J. M. 1981: Foraging decisions in Starlings (Sturnus vulgaris L.). — Ardea 69: 1–67.

Wolda, H. 1990: Food availability for an insectivore and how to measure it. — Studies in Avian Biology 13: 38–43.

Zahl, S. 1977: Jackknifing an index of diversity. — Ecology 58: 907–913.

Zar, J. H. 1984: Biostatistical analysis. — Prentice Hall International, New Jersey.