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Variability of the entomatic diet of the Hooded Crow *Corvus corone cornix* in the western Po Valley

E. BARBERO, C. PALESTRINI and A. ROLANDO

Dipartimento di Biologia Animale, Via Accademia Albertina, 17

Abstract — A study was performed on the entomatic food supply of the Hooded Crow *Corvus corone cornix* in two different areas of the Po Valley. Significant differences were observed in geographical, seasonal and monthly terms. The analysis of the stomach contents in terms of the abundance of a given taxon/stomach did not correspond in general with the classical analysis of the frequencies with which the various taxa were found. The data obtained confirm the broad-based behaviour of the species and reveal that the Crow takes advantage of the local availability on an and hoc basis.
Within the framework of this behavioural model, however, the species is able to select certain crop types if they are actractive (the rice-fields in spring-summer), and appears to be ready to takes advantage of the concentration of prey in given sites (Formicidae in nests, Diptera pupae in dung) and their seasonal behaviour (Staphylinidae wintering under stones).

Introduction

The food supply of the Crow *(Corvus corone)* has been extensively studied, in a number of cases even in relation to problems of environmental management. These studies, which are normally performed by analysing the frequency with which foods are found (Houston 1977, Jollet 1984, Studer-Thiersch 1984, Fasola *et al.* 1986, Silvano and Boano 1991), usually take into account all the components of the diet.
The present study has regarded the diet of the Hooded Crow *(Corvus corone cornix)*. The aim was to make a closer analysis of the entomatic component alone in relation to the season and eco-geographical conditions, combining an analysis of the frequency with which taxa are found (expressed as the number of stomachs containing the various taxonomic groups) with an evaluation of the abundance of insects per stomach. It was therefore possible to check whether or not the two methods of analysis provide the same results.

Material and Methods

The analysis was based on the stomach contents of adult Hooded Crows shot in two different areas of the Western Po Valley, namely the Ticino Natural Park (May 1989, May and June 1990) and the Province of Cuneo (from September 1987 to August 1988). Crows were only shot by authorized personnel within the framework of the population control programmes approved by the Region of Piedmont. Only those stomachs containing entomatic remains were included in the study.
Insects were identified with a binocular microscope using identification tables which are normally available in the current specialist literature (Chatenet 1986, Chinery 1987).
Data relating to the frequency of findings were compared using the chi-square contingency test, considering the total of the absolute frequency with which individual taxa were found as samples. In order to quantify the entomatic content in terms of the number of individuals per stomach, reference was made to the identifiable portions of each item (especially heads) and likewise only those stomachs containing the taxon in question were examined. Given that the exoskeleton of insects is always made of chitin, it was implicitily assumed that the degree to which the various insect groups were digested would substantially remain constant. The abundance of prey hardly ever conformed to a normal distribution and therefore parametric tests were performed following logarithmic normalization.

Results

a) Geographical differences

The results of the processing of data obtained from the examination of the stomach contents of Hooded Crow from the Province of Cuneo highlighted that

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Table 1 - Systematic list of taxa found in stomachs showing the number of stomachs containing that taxon (N) and its percentage (N/total number of stomachs).

TAXA	TICINO NATURAL PARK		PROVINCE OF CUNEO			
	Spring-Summer		Spring-Summer		Autumn-Winter	
	N	%	N	%	N	%
Orthoptera	5	4.0	9	3.6	2	2.2
Dermaptera	0	—	7	2.8	0	—
Hemiptera	4	3.2	8	3.2	1	1.1
Lepidoptera	0	—	8	3.2	0	—
Diptera adults	2	1.6	13	5.1	4	4.5
Diptera pupae	0	—	8	3.2	4	4.5
Coleoptera Carabidae	55	44.3	137	54.2	28	31.5
Coleoptera Staphylinidae	3	2.4	7	2.8	11	12.3
Coleoptera Scarabaeidae	21	16.9	69	27.3	16	18.0
Coleoptera Tenebrionidae	0	—	5	2.0	4	4.5
Coleoptera Elateridae adults	29	23.4	37	14.6	3	3.4
Coleoptera Elateridae larvae	8	6.5	4	1.6	0	—
Coleoptera Curculionidae	6	4.8	95	37.5	11	12.3
Hymenoptera Formicidae	17	13.7	17	6.7	3	3.4
Total number of stomachs	**124**		**253**		**89**	

during the spring-summer period (from March to August) the insects most frequently preyed on belonged to the order of Coleoptera which were found in 73% of the gastric contents analyzed.
Within this order, the most frequently found family was that of the Carabidae, present in 54.2% of cases, followed by the Curculionidae (37.5%), Scarabaeidae (27.3%) and Elateridae (14.6%). By calculating the mean number of individuals/stomach for each taxon, we obtained a series of data which do not reflect the same trend. The largest group was that of the Diptera (14.6 pupae/stomach) whereas within the order of Coleoptera, Carabidae were only present in gastric contents at a rate of 3.6 specimens per stomach, a finding which was lower than that of Elateridae (4.4). (Table 1).
From an analysis of the stomach contents of crows shot during the spring-summer period in the Ticino Park it again emerged that Coleoptera were the most preyed on insects: 65.3% of stomachs. The order of the frequency with which the various Coleoptera families were found only partially agreed with that found in the area around Cuneo.
Here too the most frequently found taxon was the Carabidae (44.3%), followed by the Elateridae (adults 23.4%), whereas the Curculionidae, which were fairly heavily preyed on in the area around Cuneo, were almost absent from the diet (Table 1).
By calculating the mean number of specimens identified per stomach, the results obtained do not follow the same pattern as the frequency data expressed in percentage: the family with the highest mean number of individuals/stomach was that of the Elateridae (7.2) followed by the Carabidae (2.9). Hymenoptera accounted for 3.2 individuals per stomach in relation to 4.5 found in the Province of Cuneo (Table 2).
The difference between the frequency of findings in the two areas was significant ($\chi^2 = 65.6$, d.f. = 13, $P<0.01$).
The differences between the mean rates with which individual taxa were found in the two areas were never statistically significant (Student's t test).

b) Seasonal differences

The study of the seasonal differences in the food supply was only possible in the area within the Province of Cuneo given that shooting took place almost every month.
From an examination of data relating to the autumn-winter period (from September to February) it emerged that the group of insects most heavily preyed on was again that of Coleoptera which were present in 53.2% of stomachs containing insects. Dermaptera were present in lower numbers compared to the spring-summer period and Lepidoptera were completely absent. Other differences were also observed within the order of Coleoptera: Carabidae (31.5%), Curculionidae

(12.3%) and Elateridae (3.4%) fell sharply, whereas there was a steep rise in the frequency of Staphylinidae (12.3%), which had been almost absent in the spring-summer period and, to a lesser extent, that of the Tenebrionidae (4.5%) (Table 1). In general terms, however, by comparing the frequency of findings in the spring-summer period with those during the autumn and winter, it was seen that the differences were statistically significant ($\chi^2 = 41.5$, d.f. = 12, $P<0.01$).
With regard to the number of individuals per stomach, the differences between the mean rates with which individual taxa were found in the two periods were never statistically significant (Student's t test) (cfr. Table 2).

c) Monthly variations
In the area around Cuneo, where crows were also shot throughout the autumn-winter months, a detailed analysis was made by taking into account data relating to each individual month.
The frequencies with which entomatic remains were found varied throughout the course of the year and in general followed the pattern outlined by seasonal data. By comparing the different frequency of findings each month, a number of significant differences emerged even between successive months (April- May, May-June), as well as, obviously, between different seasons (chi-square test).
The only significant variations with regard to the mean number of individuals per stomach were found in relation to Curculionidae when comparing data for April with those for May (t 4.2, d.f. = 79, $P<0.01$) and data for May with those for June (t 2.3, d.f. = 27, $P<0.05$).

d) Food supply differences between sexes
Differences between sexes relating to the frequency with which the various taxa were found were in general not significant, except for the spring-summer period relating to the Province of Cuneo ($\chi^2 = 20.6$, d.f. = 9, $P<0.05$).

Discussion

As is well known, the food supply of the Hooded Crow is extremely varied (Holyoak 1968, Houston 1977, Coombs 1978, Goodwin 1986, Fasola *et al.* 1986) and demostrates, among other aspects, a differentiation between the feeding patterns of nestling and adult crows (Lockie 1956, Yom-Tov 1975, Silvano and Boano 1991).
The geographical, seasonal and monthly differences

Table 2 - Abundance of insects per stomach. Two measurements of the central tendency are reported: the mean (mean number of individuals/stomach) and the median. SE = standard error, N = number of stomachs containing that taxon. Only taxa with more than five individuals are reported.

AREA	TAXA	MEAN	SE	MEDIAN	N
CUNEO Spring-Summer	Orthoptera	1.2	0.1	1	9
	Dermaptera	1.0	0	1	7
	Hemiptera	1.6	0.4	1	8
	Lepidoptera	1.4	1.1	1	8
	Diptera adults	3.6	1.2	2	1.3
	Diptera pupae	14.6	8.3	3.5	8
	Carabidae	3.6	0.5	1	137
	Staphylinidae	1.3	0.1	1	7
	Scarabaeidae	2.4	0.5	1	69
	Elateridae adults	4.4	1.4	2	37
	Curculionidae	3.8	0.5	1	95
	Hymenoptera	4.5	1.0	4	17
CUNEO Autumn - Winter	Carabidae	5.0	1.6	2	28
	Staphylinidae	1.6	0.3	1	11
	Scarabaeidae	1.6	0.2	1	16
	Curculionidae	1.8	0.3	1	11
TICINO Spring-Summer	Carabidae	2.9	0.4	1	55
	Scarabaeidae	1.3	0.1	1	21
	Elateridae	7.2	1.9	4	29
	Hymenoptera	3.2	0.7	2	17

revealed in this study appear to suggest a variation in feeding patterns which is determined by the abundance and local availability of prey in the area. The geographical differences observed in the frequency with which certain taxa were found by comparing the two areas may in fact be explained on the basis of different local availability.

The marked differences between the two areas, for example in relation to the frequency with which Curculionidae were found during the spring-summer, may be easily explained by strongly differentiated availability.

During the spring-summer Curculionidae are more abundant in the area around Cuneo (37.5% vs 4.8%) because there are widespread meadow areas here which would provide an ideal habitat for this flower-dependent entomofauna which, on the contrary, would find fewer sites of this nature in the wooded zone of the Ticino Valley and/or in intensively farmed areas of the Po Valley which surround the Park.

Geographical variations within the Po Valley are further confirmed when our findings are compared to the data reported by Fasola *et al.* (1986) from the plain around Pavia. Here the major differences concern the non-reproductive period when Staphylinidae and Tenebrionidae are absent from the diet.

However, it is important to point out that, in spite of the differences observed between one area and another, there are also marked similarities such as, for example, the constant predominance of Carabidae, which in fact were the most heavily preyed on insect group in absolute terms during every season, both in the two area studied and in the plain around Pavia (Fasola *et al.* 1986). Geographical differences in the overall diet between plain farmed areas and mountain areas have been reported on at least two previous occasions (Studer-Tiersch 1984, Silvano and Boano 1991).

Even the marked seasonal and monthly variations found here reflect the environmental availability. For example, it is obvious that the diminution of the capture rate of many taxa during the autumn-winter period should be correlated to the effective contraction of their populations.

The abundance of individual taxa per stomach did generally not provide results in line with those obtained from an examination of the frequency with which taxa were found. In many cases, the taxon which was found most frequently was not that found in greatest abundance per stomach. This result was not completely unexpected given that only those stomachs containing at least 1 specimen of the taxon in question were taken into account. Moreover, certain insects which are frequently captured by crows, but in reduced numbers, as for example the Carabidae, are not very gregarious and it is therefore probable that the predator captures one at a time (in many cases the median value was in fact 1). On the contrary, some groups, like Diptera, especially at the larval and pupal stages, and Formicidae, which are also not frequently preyed on, are concentrated in particular sites and when the predator discovers this source of food (carrion, dung, nests, etc.) it is clear that it takes advantage by consuming them in large numbers.

This interpretation is backed by direct observations on feeding behaviour in nature (Rolando, unpublished data) and this is therefore an ulterior confirmation of the Hooded Crow's opportunistic behaviour.

As far as concerns any trophic differences between sexes, our data indicate the existence of a different diet in one case only (spring-summer, Province of Cuneo), but its statistical significance is limited and the indication does not appear to be very convincing. However, it is worth recalling that behavioural differences linked to the different body size of the sexes have been described in relation to the Carrion Crow (Holyoak 1970).

There is no doubt that the Hooded Crow has a comprehensive food strategy. According to certain studies the species does not appear to make any choice in terms of the use of resources in the form of different types of crops (e.g., corn fields, ploughed fields, mowed grass). In other words, the frequency of use of a certain crop would solely depend on its availability within the area (Baglione *et al.* 1990). Nevertheless other observations have suggested that certain resources are positively selected or avoided (Saino 1992, Rolando and Palestrini 1993). In the Ticino Natural Park it was found that there was a tendency to use the rice-fields during the spring and summer with a frequency which was considerably higher than that expected in relation to their availability (Rolando unpublished data). It is also possible to interpret the increased use of Staphylinidae in winter (area around Cuneo) given that Hooded Crows are able to dislodge these Coleoptera from their winter quarters (stones, bark, etc.). In general it can be said that the feeding strategy of the Hooded Crow implies the use of both cultivated areas and the insects they contain in relation to their availability.

Within the framework of this behavioural model, however, the species is able to select certain crop types if they are actractive (the rice-fields in spring-summer), and appears to be ready to take advantage of the concentration of prey in given sites (Formicidae in nests, Diptera pupae in dung) and their seasonal behaviour (Staphylinidae wintering under stones).

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Riassunto — È stato condotto uno studio sull'alimentazione entomatica della Cornacchia grigia in due diverse aree della Pianura Padana. Sono state evidenziate significative differenze a livello geografico, stagionale e mensile. L'analisi dei contenuti stomacali in termini di abbondanza di un certo taxon/stomaco non è risultata essere congrua, in genere, con quella classica relativa alle frequenze di rinvenimento dei vari taxa. I dati ottenuti confermano il comportamento generalista della specie ed indicano che la Cornacchia sfrutta volta per volta la disponibilità locale delle prede.
Nell'ambito di tale modello di comportamento, tuttavia, la specie sarebbe in grado di selezionare certe tipologie agricole (le risaie in primavera-estate), e sembra essere pronta a sfruttare la concentrazione delle prede in determinati siti (Formicidi nei nidi, pupe di Ditteri nello sterco) ed il loro comportamento stagionale (Stafilinidi svernanti sotto le pietre).

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