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DIET OF COMMON RAVENS ON EL HIERRO, CANARY ISLANDS

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Abstract.—The Common Raven (*Corvus corax*) on El Hierro, an oceanic island in the Canary archipelago, is omnivorous. Although ravens from five regions on El Hierro showed qualitatively similar diets, there were considerable quantitative differences. Diet in wet and dry pastureland was made up principally of animals: invertebrates at Jinama (frequency of occurrence in pellets = 84.8%) and high levels of vertebrates at Bascos (60%). Spring was characterized by the consumption of vertebrates (frequency in pellets = 48.5%), summer by invertebrates (77.1%), and autumn/winter by a diet of plant material (92.6% and 96.9%, respectively). While diets in many continental environments are often characterized by vertebrates throughout the year, ravens on El Hierro tend to be omnivorous, including many insects and wild fruits in their food.

DIETA DE *CORVUS CORAX* EN EL HIERRO, ISLAS CANARIAS

Sinopsis.—La dieta del cuervo (*Corvus corax*) en la isla de El Hierro, Islas Canarias, es omnívora. Aunque cinco zonas estudiadas no mostraron gran variación respecto al tipo de alimento, hubo considerables cambios cuantitativos. En los pastizales de Bascos (seco) y Jinama (húmedo) la dieta consistió básicamente de materia animal. Hubo invertebrados en abundancia en Jinama (frecuencia de aparición en egagrópilas = 84.8%) y restos de vertebrados en el de Bascos (60%). Desde el punto de vista estacional, la primavera se caracterizó por el consumo de vertebrados (frecuencia de aparición en egagrópilos = 48.5%), el verano por el consumo de invertebrados (77.1%), y durante el otoño y el invierno se alimentaron intensamente de materia vegetal (92.6% y 96.9%, respectivamente). Mientras la dieta del cuervo se caracteriza básicamente por la presencia de vertebrados en los ecosistemas continentales, en áreas insulares, como El Hierro, el ave es omnívora, incluyendo en su dieta abundantes insectos y materia vegetal.

The Common Raven (*Corvus corax*) is markedly omnivorous in the majority of the habitats it occupies (Cugnasse and Riols 1987, Géroudet 1980, Harlow 1922). However, the majority of its diet is composed of only a few food types (Nogales and Hernández 1994). In most of its range the diet consists primarily of vertebrates and arthropods, although small amounts of plant remains are found in a high number of pellets.

The diet of the Common Raven has been the subject of only a small number of studies, despite the bird's wide distribution (Engel and Young 1989, Ewins et al. 1986, Temple 1974), and the only thorough study of spatial and temporal variation in diet was done in Idaho by Engel and Young (1989). Almost all the studies of diet have been undertaken in continental zones or inshore islands. There are practically no studies of the raven's diet on oceanic islands (Nogales and Hernández 1994).

The present study examines the spatial and temporal variation of the

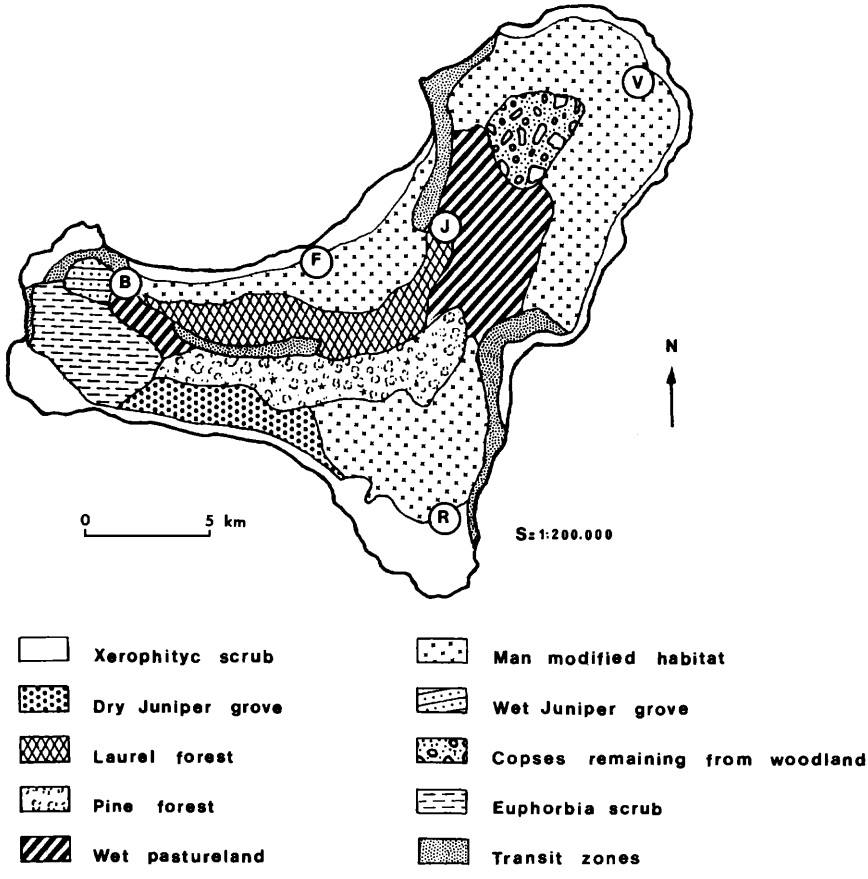

FIGURE 1. Habitats and sites on El Hierro where the pellets of Common Ravens (*Corvus corax*) were collected. V = Valverde Trash dump, F = Frontera Trash dump, R = La Restinga Trash dump, J = Jinama, B = Bascos.

raven's diet on an oceanic island, and compares its diet with continental zones.

STUDY AREA AND METHODS

The volcanic island of El Hierro (14°W, 27°N) is situated in the southwest Canary archipelago. It has an area of about 278 km^2 and the highest elevation is 1503 m. Forest habitats cover 15.6% of the island's land area, mixed habitats occupy 7.1%, and the remaining 70.8% is comprised of more open habitats (Fig. 1). Open habitats are characterized by xerophytic scrub on the lowest levels, and by agriculture and grazing activity at middle altitudes (400–800 m). Forested areas include groves of *Pinus canariensis* and *Juniperus phoenicea*, and laurel forest, which is made up

TABLE 1. Percentages of pellets of Common Ravens (*Corvus corax*) containing different food items at five sites on El Hierro (V = Valverde, R = La Restinga, F = Frontera, J = Jinama and B = Bascos), and at different seasons.

	% Occurrence in the pellets								
	Site					Season			
Food items	V	R	F	J	B	Winter	Spring	Summer	Autumn
Mus sp.	1.3	—	—	—	—	2.1	1.2	0.6	0.8
Rattus sp.	3.4	1.3	6.3	1.8	14.9	2.1	6.6	1.5	3.1
Oryctolagus cuniculus	6.3	3.8	5.5	5.5	12.8	2.1	11.6	3.0	3.9
Cattle	3.2	12.8	9.5	3.3	19.1	12.5	17.3	5.7	5.8
Total Mammalia	22.3	16.6	21.3	9.7	36.2	17.7	33.2	10.2	13.2
Unidentified birds	3.9	6.4	3.2	2.8	2.1	5.2	7.2	2.1	1.2
Eggshell remains	12.6	5.1	22.8	1.8	—	12.5	14.5	5.1	7.4
Total birds	15.7	11.5	24.4	4.6	2.1	17.7	20.2	7.2	8.9
Gallotia galloti	1.3	1.3	1.6	0.9	4.3	—	2.6	0.3	0.8
Chalcides viridanus	—	—	—	—	2.1	—	—	0.3	—
Total Reptilia	1.3	1.3	1.6	0.5	6.4	—	2.6	0.6	0.8
Total fishes	7.1	7.7	6.3	0.9	4.3	1.0	4.9	5.7	3.9
Total Vertebrata	48.2	38.5	55.9	21.7	60.0	31.3	48.5	19.5	22.2
Acrididae	15.7	11.5	4.7	70.5	8.5	16.4	10.7	46.5	26.1
Tettigonidae	14.1	1.3	6.3	34.6	8.5	10.4	10.1	30.0	18.6
Scarabaeidae	2.1	15.4	14.2	3.2	40.4	14.6	16.2	7.2	0.4
Tenebrionidae	15.4	1.3	7.9	2.8	34.0	11.5	7.8	15.6	2.7
Other Arthropoda	11.3	7.7	14.9	10.6	40.4	26.0	16.2	8.4	10.9
Total Invertebrata	55.5	42.3	45.7	84.8	70.2	68.8	54.3	77.1	52.1
Total animal diet	76.2	65.4	68.5	84.8	83.0	85.4	78.3	84.3	65.8
Opuntia f. barbarica	33.5	74.4	32.3	13.8	36.2	77.1	59.2	11.1	29.2
Ficus carica	29.8	15.4	17.3	5.1	14.9	17.7	16.7	16.2	35.8
Myrica faya	5.8	—	4.7	12.9	21.3	13.5	2.3	0.6	18.7
Rubia fruticosa	23.8	19.2	54.3	1.8	38.3	9.4	28.0	28.5	7.4
Total wild fruits	85.1	94.8	87.4	54.3	100.0	92.7	90.5	66.6	86.8
Cosmopolitan herbaceous	17.3	7.7	5.5	11.5	14.9	12.5	11.8	17.4	13.2

TABLE 1. Continued.

Food items	% Occurrence in the pellets								
	Site					Season			
	V	R	F	J	B	Winter	Spring	Summer	Autumn
Cereals	25.7	20.5	16.5	15.2	10.6	12.5	13.0	6.0	5.4
Vegetative plant remains	62.6	62.8	62.2	50.7	63.8	65.6	67.9	51.0	63.4
Total vegetation diet	93.5	97.4	92.9	71.9	100.0	96.9	96.5	79.5	92.6
Inorganic remains	18.3	17.9	13.4	3.2	8.5	12.7	14.9	16.0	12.9
Grit	78.5	60.3	74.0	32.7	60.2	66.6	68.2	52.3	63.0
Total pellets analized	382	78	127	217	47	96	346	333	257

primarily of *Erica arborea* and *Myrica faya* (see Pérez de Paz et al. 1981 and references therein).

The total breeding population of Common Ravens on El Hierro has been estimated at 99–120 pairs, the second highest known density in the species' entire distributional range (Nogales 1994, 1995).

Fieldwork began in February 1986 and was completed in March 1987. At each of five sites, pellets were collected at the end of each of the four seasons (winter: December–February, spring: March–May, Summer: June–August, and Autumn: September–November); a total of 1032 pellets was counted. These five sites were the areas surrounding three trash dumps (at Valverde, La Restinga, and Frontera) and two prominent points (Jinama and Bascos) situated in the upper reaches of El Golfo (Fig. 1). The pellets were individually wrapped in aluminium foil *in situ* to maintain, as far as possible, the unit of regurgitation.

Pellets were analyzed under 16× magnification after the pellets had been soaked in water for about 30 min. Identification was achieved by comparison with a previously prepared collection, which included various types of mammal hair, seeds, and insects. Analysis of pellets was complicated by the differing degrees of digestibility of food items, which affect the presence or absence of certain remains (Engel and Young 1989). Because ravens scavenge and do not always eat the whole carcass of their prey, calculation of the mass of material ingested is not possible. Analysis of the pellets provides only an idea of their qualitative composition (Marquiss et al. 1978, Marquiss and Booth 1986).

In most studies of the raven's diet, parameters such as the percentage of occurrence of each food item per pellet are normally used together with the number of specimens of each item observed in the pellet. In the case of invertebrate prey and that of fruits and seeds (see Reynolds and Aebischer 1991), it was possible to estimate their relative importance with reasonable precision. For this reason, we used frequency of occurrence as the basic comparative unit, emphasizing the quantitative component only in those cases in which important variation was recorded in the numbers of invertebrates or seeds consumed.

We assumed independence of the pellet samples analyzed, because of the wide-ranging movements of the ravens, their high density on this small island (Nogales 1994), and the high numbers of birds observed daily in the areas around the pellet collection sites. Chi-squared tests were performed by using frequencies of occurrence in pellets for each food item. A two-way ANOVA with Scheffe's test for *a posterior* comparison (localities and seasons), was performed for the mean number of insects and seeds of the seven main food types (Sokal and Rohlf 1995). Statistical calculation was carried out using the SPSS statistical package.

RESULTS

Ravens on El Hierro were omnivorous ($\bar{x}$ = 4.2 items/pellet, SD = 1.9, n = 1,032). The diet was characterized by a high frequency of vegetable matter (present in 90.1% of the 1032 pellets analyzed) (Table 1). Plant

food consisted of various fleshy fruits and seeds, as well as buds and leaves. The animal component (primarily insects, mammals, and birds), made up an important proportion (present in 77.8% of pellets). Remains of refuse, material that probably originated from the trash dumps, were found in 14.4% of pellets.

Spatial pattern.—Although pellets from the three trash dumps were similar, they could be clearly differentiated from the Jinama site (located in the wet plains of Nisdafe). If we jointly compare the three trash dump sites against the Jinama site, there was a significantly higher frequency of invertebrates in the diet at Jinama ($X^2 = 67.4$, df = 1, $P < 0.001$), and at the Bascos site (located in La Dehesa) there was a higher percentage of vertebrates ($X^2 = 5.4$, df = 1, $P = 0.020$).

Temporal pattern.—Vertebrates occurred in the pellets more frequently during spring ($X^2 = 73.7$, df = 1, $P < 0.001$) and invertebrates more frequently during summer ($X^2 = 44.3$, df = 1, $P < 0.001$) (Table 1). The plant component of the diet, made up of fruits and vegetative matter, was of greater importance in spring, autumn, and winter ($X^2 = 59.6$, df = 1, $P < 0.001$). Refuse maintained a more or less constant occurrence throughout the year.

Patterns of spatio-temporal variation.—Acrididae were the most frequent group among the Orthoptera, with maximum frequency of occurrence and greatest number of prey being consumed at Jinama during summer (Fig. 2).

At Bascos, significantly smaller quantities of *Opuntia ficus-barbarica* fruits were consumed than at the other sites. When figs of *Ficus carica* were abundant, maximum consumption levels were in autumn and in the eastern parts of the island. The Jinama site, which borders on the laurel forest (Fig. 1), showed higher ingestion rates of *Myrica faya* fruits than occurred at other sites. Consumption was highest in winter, summer, and autumn. With *Rubia fruticosa*, Jinama differed significantly from all other sites. Despite having the lowest frequency of occurrence of *R. fruticosa*, more seeds per pellet were found there than at any other site. La Restinga had the fewest seeds per pellet, and differed significantly from all other sites (Fig. 2).

DISCUSSION

Among the five areas investigated on El Hierro there was spatial and temporal variation in diet. This fact was presumably due mainly to the distribution of the various food types, the abundance of each, and their seasonal availability, rather than the dietary preferences of the raven. For this reason, the diet in each region was influenced by the various habitats and indirectly by altitude. The raven's omnivorous nature allows it to take advantage of a variety of food resources which differ in availability throughout the year (Conner and Adkisson 1976, Engel and Young 1989, Jones 1980, White and Thanner-White 1985).

The diet at the three rubbish tip sites was fairly similar. All three localities are located between human-modified habitat and xerophytic scrub

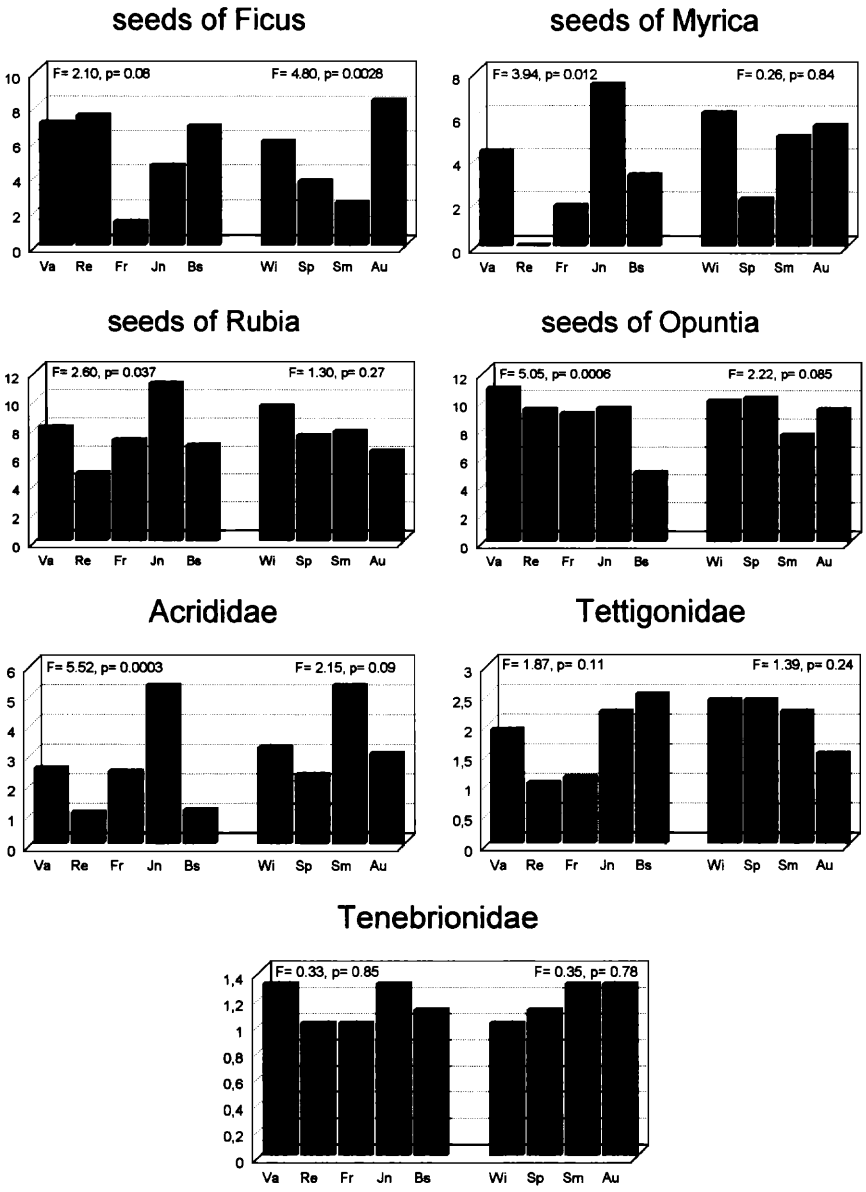

FIGURE 2. Spatial and temporal variability recorded in the mean numbers of invertebrates and seeds per pellet of Common Raven (*Corvus corax*) in a two-way ANOVA. V = Valverde Trash dump, F = Frontera Trash dump, R = La Restinga Trash dump Tip, J = Jinama, and B = Bascos. W = winter, Sp = spring, Sm = Summer, and A = Autumn. Opuntia = *Opuntia ficus-barbarica*, Ficus = *Ficus carica*, Myrica = *Myrica faya*, and Rubia = *Rubia fruticosa*.

TABLE 2. Frequency of occurrence (percentages) of the principal components of the diet of the Common Raven (*Corvus corax*) in pellets found in various parts of its geographical distribution. The symbols ≫ indicate that the proportions of these foods are substantially higher than the associated figure (exact quantities were not provided in all cases).

			% Of occurrence						
Study area	Season	*n*	Vertebr.	Invert.	Cereals	Wild fruits	Total veget.	Remains	Reference
Alaska	winter	684	≫ 39.1	—	—	—	7.1	9.2	Temple (1974)
Virginia	winter	205	95.1	1.5	0.5	9.2	54.1	30.7	Harlow et al. (1975)
England	winter	433	≫ 39.3	10.9	—	—	43.7	—	Bolam (1913) In Coombs (1978)
Andalusia	win, spr	146	> 66.0	92.0	> 88.5	> 3.9	> 88.5	?	Soler and Soler (1991)
Wyoming	spring	111	76.0	33.0	—	—	10.0	< 5.0	Dorn (pers. comm.)
Virginia	spring	114	95.7	—	—	3.5	56.0	16.4	Harlow et al. (1975)
Scotland	spring	697	≫ 45.3	11.9	2.2	—	78.9	< 1.0	Marquiss et al. (1978)
Oregon	spring	1413	≫ 24.3	8.5	—	—	3.5	—	Stiehl (pers. comm.)
Wales	spring	450	92.0	5.0	—	—	< 1.0	< 1.0	Newton et al. (1982)
Wales	win, spr, sum	339	≫ 53.4	13.6	—	—	6.5	49.6	Newton et al. (1982)
Orkney	all year	945	> 80.0	8.0	10.0	1.0	10.0	< 1.0	Marquiss and Booth (1986)
Shetland	all year	540	≫ 52.8	12.0	7.0	3.2	7.0	37.8	Ewins et al. (1986)
Idaho	all year	574	80.8	72.9	90.1	24.9	96.5	43.7	Engel and Young (1989)
El Hierro	all year	1032	31.0	62.5	8.8	82.1	90.1	14.4	Present study

(Fig. 1). The low frequency of vertebrates detected in Nisdafe is worth pointing out. Although there are large numbers of sheep and cattle on these plains, it is an area which is more closely supervised by farmers than is the communal pastureland of La Dehesa (near the Bascos site).

Table 2 shows the results of the principal studies of the Common Raven's diet, permitting comparison of the frequencies of occurrence of the various food types. During winter on El Hierro, vegetable matter and invertebrates were of some importance, but vertebrates are the most important winter food item in continental habitats. Vertebrates reach the highest frequency of occurrence in El Hierro pellets during spring, when livestock, rabbits, and birds are important. The main difference from other geographical areas lies in the fact that, despite the year-round importance of vertebrates, invertebrates are consumed frequently.

It is during summer that vertebrates reach the lowest levels of occurrence on El Hierro and this corresponds to maximum consumption of insects, particularly Orthoptera (Acrididae and Tettigonidae). Taking into account the fact that a raven casts at least three pellets a day, and that the summer diet is based on Orthoptera, a raven may ingest more than 750 Acrididae or almost 120 Tettigonidae daily. Because the average mass of individual Acrididae is 0.6 g, and that of Tettigonidae 2 g ($n = 40$ for each), a raven can consume some 450 g of Acrididae and about 240 g of Tettigonidae daily. These calculations highlight the potentially important role played by the raven as a biological control agent of local Orthoptera plagues such as those that occur almost every summer on the wet plains of Nisdafe (Fig. 1). In other regions consumption of large numbers of insects in summer is well known (Engel and Young 1989, Nelson 1934), and corresponds, as on El Hierro, to a decline in the amounts of other food types generally consumed, despite their continuing availability.

The most striking feature of the autumn diet is the abundance of vegetable matter. On El Hierro, as in other parts of the world (e.g. Oregon, Idaho), the autumn diet is characterized by a gradual decline in insects and a moderate increase in vertebrates (Engel and Young 1989).

In short, while diets in continental environments are, in general, characterized by a predominance of vertebrates throughout the year, Ravens on El Hierro tend to be more omnivorous, their diet including abundant insects and wild fruits. This tendency to be more omnivorous on an oceanic island, in comparison with most of continental regions, has been documented for other bird species (Grant 1965, MacArthur et al. 1972).

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