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VARIATIONS IN DIETS OF NESTING COMMON RAVENS

RICHARD B. STIEHL[1] AND STEVEN N. TRAUTWEIN[1]

ABSTRACT.—We investigated variation in the diets of Common Ravens (*Corvus corax*) nesting near Malheur National Wildlife Refuge in southeastern Oregon in the spring and summer of 1976 and 1977. We made microscopic examinations of 1413 regurgitated pellets and other nondigested remains collected near the nests. Mammals, primarily rodents and lagomorphs, made up 39.2% of the sample. Birds (including eggs) comprised 37.8% of the diet. Management of Common Ravens as potential nest plunderers requires a detailed analysis of diets, but the low mean numbers of egg remains (1.33 ± 1.5) found at nests within sagebrush suggests that ravens selecting this type of nesting habitat are probably not nest plunderers. The wide variability in the frequency of eggs in the diets of ravens nesting in wetland habitats suggests that no general assumptions may be made concerning their roles as predators on waterfowl eggs. *Received 7 June 1988, accepted 1 Oct. 1990.*

Studies of the food habits of the Common Raven (*Corvus corax*) have come largely from Europe (Feilden 1909a, b; Lockie 1955; Mylne 1961; Ratcliffe 1962; Holyoak 1968). However, raven diets have been documented in Virginia (Harlow et al. 1975), Wyoming (Dorn 1972), and the Arctic slope of Alaska (Temple 1974). Conner et al. (1975) and Conner and Adkisson (1976) noted that some ravens relied on carrion from road kills and garbage dumps for food. Nelson (1934) investigated the food preferences of ravens in southeastern Oregon, and Maser (1975) noted predation by ravens on Rock Doves (*Columba livia*) in the same general area. These studies indicate that Common Ravens are omnivorous and opportunistic feeders. Ravens also are active predators (Temple 1974), scavengers (Feilden 1909b, Dorn 1972, Conner and Adkisson 1976), and nest plunderers (Nelson 1934). Reports by Dorn (1972), Harlow et al. (1975) and Ratcliffe (1962) suggest that ravens consume at least some vegetable material and Ross (1925) reports the influence of domestic livestock production on the diet of Common Ravens. Predation of ravens on eggs has been classified as a persistent and sometimes serious problem for waterfowl management (Braun et al. 1978). Between 1969–1977, studies at Malheur National Wildlife Refuge indicated that avian predators destroyed approximately 20% (range 8% to 41%) of waterfowl and Sandhill Crane (*Grus canadensis*) nests (Littlefield 1975). Although potential avian predators of eggs in the area include Common Ravens, California and Ring-billed gulls (*Larus californicus* and *L. delawarensis*), Common Crows (*C. brachyrhynchos*), and Black-billed Magpies (*Pica pica*), Braun et al.

[1] Dept. of Biology, Southeast Missouri State Univ., Cape Girardeau, Missouri 63701.

(1978) suggested that Common Ravens were the major avian egg predators, perhaps because ravens are considered more numerous on the refuge than are the other species. Nelson (1934) made a limited study of the stomach contents of ravens collected during June in southeastern Oregon and found a great diversity of food items, but his study was limited to a small portion of the waterfowl nesting season. We report here on food habits of the nesting population of Common Ravens from February through August.

STUDY AREA AND METHODS

The study area included Malheur National Wildlife Refuge located in Harney County, Oregon, U.S.A. This large (73,250 ha) area is about 118 to 119°W longitude and 42 to 43°N latitude at an elevation of 1350 m. The major land forms consist of alkaline lakes and marshlands covering 32,400 ha, river valley uplands supporting *Carex* and other submerged and emergent flora, and extensive rimrock areas of volcanic and fault block origin. On the plateaus of the surrounding area above the rimrocks, typical Great Basin desert vegetation of sagebrush (*Artemisia* sp.) and greasewood (*Sarcobatus* sp.) form the dominant communities. The extensive rimrock formations provide locations for nest sites and suitable habitat for a nesting population of 40 to 50 pairs of Common Ravens (Stiehl 1978, 1985).

Regurgitated pellets comprised the majority of the 1413 food items collected near 32 active raven nests from 1 March to 15 July 1976 and 28 February to 31 July 1977. A nest-centered plot about 20 m in diameter was searched for pellets and other debris (e.g., skeletal remains and egg shells) at least once per week throughout the study periods. Collected materials were sealed in plastic bags, which were dated and identified. Pellets were air-dried, weighed, and dissected with the aid of a 7×–30× stereo microscope. The number of different food items was recorded for each pellet. Hair and bone fragments were identified by comparison with reference material from the mammal collection at Portland State University, or from pellets collected from captive wild ravens fed known diets, or keyed using Hall and Kelson (1959), Ingles (1965) or Verts (1971). Eggshell fragments were identified by comparison to specimens in the collection at Malheur National Wildlife Refuge or keyed to species using Reed (1965). Fish were identified by comparison of scales or skeletal remains to known representatives.

We used the frequency of occurrence data in our analysis, as dissimilarities in compaction and density made it difficult to assign importance to volumetric differences. We identified and separated the items into seven groups: avian eggs; avian feathers and bones; mammal bones, teeth and hair; reptile bones and scales; fish bones and scales; insect body parts; and vegetation. We made the distinction between avian eggs and feathers/bones in order that active nest plunderers could be ascertained. Some obvious potential food sources, such as carrion from large mammals [e.g., domestic cattle (*Bos taurus*) and mule deer (*Odocoileus hemionus*)], are probably not proportionally represented when using only pellets and fragments in an analysis. In pellets, hair would comprise the only remains and is probably only ingested incidentally and in small amounts. Although cattle and deer have a considerable amount of nondigestible material (e.g., bone and hair), the bones are rarely, if ever, transported to the nest site. Our analysis also includes whole eggshells and bones of medium sized mammals (e.g., *Lepus*) collected in the areas near nest sites. Our analysis may be biased in favor of such items because they are large and more obvious in the field. Therefore, they are more likely to be collected. Thus, analysis based on pellets and other nondigestible materials contains inherent biases that will affect conclusions based on the data.

We then assigned each nest site to one of four categories, based on the general habitat surrounding the nest site and on the presence or absence of roads within 0.5 km of the nest site. We formed four unequal nest groupings. We partitioned wetland (WT) habitat nests as either wetland near road (WR) or wetland non-road (WN). Likewise we classified nests in sagebrush (SB) as either sagebrush near road (SR) or sagebrush in a non-road area (SN). The division of habitats into road and non-road areas is important because of the possibility for extensive carrion feeding by pairs nesting near roads. Carrion feeding was also considered important by Feilden (1909a, b), Nelson (1934), Mylne (1961), Ratcliffe (1962), Temple (1974), Harlow et al. (1975), and Conner and Adkisson (1976). Statistical analyses of the data (including ANOVA, Duncan's multiple range test, and *F*-test) were performed with the General Linear Models procedure of the Statistical Analysis Systems (SAS 1982).

RESULTS

Pellet analysis.—Pellets weighed an average of 2.8 g (range 1.6 to 4.7 gm) and contained one to five items. Table 1 summarizes the total occurrence and percent occurrence (number of items divided by total items × 100) for each category of items collected. As a group, mammalian food items had the highest occurrence (898/2202) and comprised 40.8% of the constituents in the sample. This type of food item was found in every nest of the sample population. Smaller mammals, including voles (*Microtus* sp.), mice (*Peromyscus* sp., *Paragnathus* sp., and *Reithrodontomys megalotus*), kangaroo rat (*Dipodomys* sp.), pocket gophers (*Thomomys* sp.), ground squirrels (*Spermophilus* sp. and *Ammospermophilus leucurus*), and shrews (*Sorex* sp.) comprised the largest component (59% or 530/898) of the mammalian constituent. The medium-sized mammals comprised 29.8% (268/898) of the mammalian food collected but contained the highest occurrence for a single species. Black-tailed jackrabbit (*Lepus californicus*) occurred 244 times, which was 11.1% of the mammalian food items. Also included in the medium-sized mammals were muskrat (*Ondatra zibethicus*) and yellow-bellied marmot (*Marmota flaventris*). Large mammals were represented by hair from domestic cattle (*Bos taurus*) and mule deer (*Odocoileus hemionus*) and comprised only 2% (18/898) of the mammalian component. This may be biased low due to the relatively low proportion of nondigestible material associated with such food which is ingested or transported to the nest. Unidentified mammals had a percent occurrence of 9.1% (82/898) and comprised 3.7% (82/2202) occurrence in the diet of the sample population.

Avian food items identified in the sample consisted of egg shells, bones or other fragments, feathers, and down. The avian-based food items constituted 38.4% (845/2202) of the diet based on percent occurrence. Although avian food items occurred in samples from all nest sites, the distribution did not appear to be even. The occurrence of avian items in the samples collected at nest sites ranged from 1.7% of the sample at one

TABLE 1
ANALYSIS OF PELLETS FOUND NEAR NESTS OF COMMON RAVENS

Species/item	Occurrence	% Occurrence
Avian		
Eggs	535	24.3
Feathers	245	11.1
Avian bones	52	2.4
Avian down	13	0.6
Mammalian		
Lepus califiornicus	244	11.1
Microtus sp.	208	9.4
Rodentia	115	5.2
Microtinae	90	4.1
Unidentified mammal	82	3.7
Peromyscus sp.	40	1.8
Ondatra zibethicus	22	1.0
Bos taurus	17	0.7
Dipodomys sp.	14	0.6
Lagurus curtatus	13	0.6
Reithrodontomys megalotus	13	0.6
Thomomys sp.	12	0.5
Perognathus sp.	9	0.4
Spermophilus sp.	3	0.1
Marmota flavaventris	2	0.1
Sorex sp.	2	0.1
Mustela sp.	1	Trace
Odocoileus hemionus	1	Trace
Ammospermophilus leucurus	1	Trace
Neotoma sp.	1	Trace
Reptilian		
Reptile parts	25	1.1
Fish		
Cyrpinus carpio	131	5.9
Fish (non *C. carpio*)	42	1.9
Insects		
Insect parts	188	8.5
Vegetation		
Plant material	78	3.5
Unidentified	3	0.1

nest site to 86.7% of the sample at another nest site. Six of the 32 nest sites accounted for 61.5% (520/845) of all the avian items collected. Egg shell remains found near the nest sites accounted for 63.3% (535/845) of the avian food and 24.3% (535/2202) of the diet. Other items collected (feathers and skeletal parts) comprised 36.7% (310/845) of the avian food and 14.1% (310/2202) of the total diet. Of the 2202 food items we analyzed, avian egg shells occurred 535 (24.3%) times. At least some avian egg shell was present in the collected items from 90.6% (29/32) of the pairs studied and ranged from 0% to 84.8% of the collected items at a nest site. Six of the 32 adult pairs studied accounted for 72.5% of the total egg shells collected. The importance of this food source may be overestimated, as nearly intact egg shells are easily located in the field. Whole egg shells collected near the nest sites accounted for 58.3% of the egg shell constituent and 14.2% of the total items collected. Waterfowl eggs comprised 48.8% (261/535) of the eggs collected and were collected at 21 of the 32 nest sites studied. Collections at four nest sites accounted for 72.4% (189/261) of the waterfowl eggs collected. Cinnamon Teal (*Anas cyanoptera*) comprised 39.8% (104/261) of the sample, followed by Gadwall (*A. strepera*) (73 [27.9%]), and Mallard (*A. platyrhynchos*) (46 [17.6%]). Other waterfowl species represented included Canada Goose (*Branta canadensis*), Northern Pintail (*A. acuta*), American Wigeon (*A. americana*), Redhead (*Aythya americana*), Ruddy Duck (*Oxyura jamaicensis*), and Canvasback (*A. valisineria*). The sample also included eggs of Ring-necked Pheasant (*Phasianus colchicus*), Common Raven, Killdeer (*Charadrius vociferus*), American Coot (*Fulica americana*), Wilson's Phalarope (*Phalaropus tricolor*), Long-billed Curlew (*Numenius americanus*), Sandhill Crane (*Grus canadensis*), American Avocet (*Recurvirostra americana*) and American Bittern (*Botaurus lentiginosus*).

Another indication of the use of avian food was the presence of feathers, down, and skeletal remains in the collection. Feathers constituted 29.0% (245/845) of the avian based and 11.1% (245/2202) of the total items collected. Skeletal remains comprised 6.2% (52/845) of the avian and 2.4% (52/2202) of the total. Down had a 1.6% (13/845) avian occurrence and 0.6% (13/2202) total occurrence in the sample. Most of the feathers and down were too decayed to be identified with certainty. Of 310 items, only 74 (23.9%) could be identified to species. Of the material that could be identified, 17.6% (13/74) was waterfowl (Cinnamon Teal, Gadwall, Mallard, and Canada Goose), but also included American Coot, and Sandhill Crane. Some of the feathers and skeletal items may reflect scavenging from carrion or theft from other predators.

The combined remains of insects, fish, vegetation, and reptiles had a 21.1% (464/2202) occurrence in the sample population. Remains occurred

TABLE 2
MEAN FREQUENCY OF GROUPED FOOD ITEMS IN THE DIETS OF COMMON RAVENS IN FOUR HABITATS

Food group	Habitat groupings (N)[a]						
	AN(32)	WT(26)	WN(16)	WR(10)	SB(6)	SN(2)	SR(4)
Eggs	16.1	19.3	18.6	20.4	1.8	0.5	2.5
Birds	9.3	9.9	10.2	9.4	6.9	1.0	9.8
Mammal	26.7	22.8	23.6	21.5	44.1	12.0	60.2
Reptile	0.7	0.6	0.3	0.6	2.2	0.5	3.0
Fish	5.2	6.1	8.1	2.6	1.2	0.0	1.8
Insect	5.6	4.3	4.6	3.8	11.7	6.0	14.5
Vegetation	2.4	2.2	2.2	2.1	3.2	3.5	3.0

[a] AN = All nest sites studied; WT = All wetland nest sites; WN = Wetland nest sites away from roads (non-road); WR = Wetland nest sites near roads; SB = All sagebrush (upland) nest sites; SN = Sagebrush nest sites away from roads (non-road); SR = Sagebrush nest sites near roads.

at 78.1% (25/32) of the nest sites with insects in the diet. We did not attempt to identify the insects, but beetle (Coleoptera) elytra were quite common. Fish remains (scales and bones) were found 173 times (7.9% occurrence) and occurred at 23 (71.9%) of the nest sites. Most (131/173 = 75.7%) of the fish represented were carp (*Cyprinus carpio*). Of those nest sites which had fish in the diet, the occurrence ranged from 0.6% to 30.0%. Vegetation, in the form of partially digested grasses, was found at 18 (56.2%) nest sites and comprised only 3.5% (78/2202) occurrence in the diet of the sample population. Some of the vegetation in the sample may have resulted from the incidental ingestion of nest lining materials during nest building (Stiehl 1985). We suspect that much of the vegetation in pellets was ingested during consumption of stomachs of herbivores

TABLE 3
COMPARISON OF OCCURRENCE OF FOOD TYPES FROM ALL HABITAT TYPES

Food type	Mean number of items	Grouping[a]
Mammal	17.8	A
Eggs	11.2	B
Birds	6.0	C
Insects	3.6	C
Fish	3.0	C
Vegetation	1.6	C
Reptile	0.6	C

[a] Means with the same letter grouping are not significantly different ($P < 0.05$, Duncan's multiple range test).

TABLE 4

COMPARISON OF MEAN NUMBER OF MAMMAL PIECES FOUND IN THE FOUR HABITAT TYPES

Habitat type	Mean number of items	Grouping[a]
SR	42.2	A
WN	14.9	B
WR	14.8	B
SN	7.5	B

[a] Means with the same letter grouping are not significantly different ($P < 0.05$, Duncan's multiple range test).

(e.g., *Lepus californicus* and *Microtus* sp.). Harlow et al. (1975) reported similar suspicions. Reptilian food items occurred at 11 (34.4%) of the nest sites and comprised 1.1% (25/2202) of the occurrence. No attempt was made to classify further this fraction of the diet. Both snakes and lizards were present in our sample.

Diets based on habitat.—Table 2 summarizes frequency of the occurrence of grouped items from the two habitats (WT and SB), the four areas (WN, WR, SN, and SR) and all the nests studied in the population (AN). The results support the contention that Common Ravens feed opportunistically and suggest that birds which nest in different habitats may have different diets. Although non-random sampling procedures may contribute a bias in this statistical analysis, 94% of the refuge population of nesting ravens was sampled. Considering all nest sites, the mean number of mammal pieces/nest site (17.8) is highest, the mean number of egg pieces/nest site (11.2) is second, and all other food types were third with no significant difference among these other food groups (Table 3). ANOVA further indicated that differences in the number of mammal pieces among the nest sites are attributable to differences among the habitat types and that 34% of the variation in the number of mammal pieces is accounted for by the variation in the type of habitat ($P < 0.01$). Habitat we classified

TABLE 5

COMPARISON OF MEAN NUMBER OF REPTILE PIECES FOUND IN THE FOUR HABITAT TYPES

Habitat type	Mean number of items	Grouping[a]
SR	2.2	A
WR	0.5	B
SN	0.5	B
WN	0.2	B

[a] Means with the same letter grouping are not significantly different ($P < 0.05$, Duncan's multiple range test).

TABLE 6

F-TEST FOR VARIABILITY IN THE NUMBER OF FOOD ITEMS FOUND AT WETLAND NEST SITES VERSUS SAGEBRUSH NEST SITES

	Sagebrush nests			Wetland nests				
Food item	N	SD	Variance	N	SD	Variance	*F* value	*P*
Egg	6	1.52	2.27	26	20.89	436.42	192.26	<0.01
Fish	6	0.98	0.97	26	660.00	43.61	44.96	<0.01
Reptile	6	2.97	3.87	26	0.69	0.48	8.06	<0.01
Insect	6	7.84	61.47	26	3.94	15.54	3.96	<0.01
Mammal	6	23.85	568.67	26	13.16	173.10	3.28	<0.05
Vegetation	6	2.40	8.40	26	2.32	5.38	1.25	n.s.
Bird	6	5.57	31.07	26	6.60	43.53	1.40	n.s.

as SR has a significantly higher number of mammal pieces (42.25) than the other three habitat types (Table 4). The differences between road (WR and SR) habitats and non-road (WN and SN) habitats have no effect on the number of mammal pieces found at a nest site, but more mammal pieces were found in sagebrush (SB) habitats than in wetland (WT) habitats. Even though the differences are not significant, ravens which nest in wetland (WT) habitats appear to consume much more birds (including eggs) than ravens which nest in sagebrush (SB) habitats. For all nesting habitats, mammals and birds comprise the majority of the diet and reflect the largely carnivorous diet of the Common Raven. In three of the four habitat types, reptiles comprised the smallest food group. ANOVA showed that the variation in the number of reptile pieces among nest sites is attributable to variations among habitat types. Habitat we classified as SR has a significantly higher number of reptile pieces (2.2) than the other

TABLE 7

F-TEST FOR VARIABILITY IN THE NUMBER OF FOOD ITEMS FOUND AT ROAD NEST SITES VERSUS NONROAD NEST SITES

	Road nest sites			Nonroad nest sites				
Food item	N	SD	Variance	N	SD	Variance	*F* value	*P*
Fish	14	1.73	2.99	18	7.85	61.63	20.61	<0.01
Reptile	14	1.52	2.31	18	0.57	0.33	7.00	<0.01
Mammal	14	21.14	446.86	18	10.85	117.70	3.80	<0.01
Insect	14	6.64	44.11	18	3.50	12.24	3.60	<0.01
Bird	14	7.37	54.34	18	5.73	32.81	1.66	n.s.
Egg	14	20.06	402.59	18	19.42	377.29	1.07	n.s.
Vegetation	14	2.41	5.79	18	2.45	6.02	1.04	n.s.

three habitat types (Table 5). Thirty-three percent of the variation in the number of reptile pieces is accounted for by the variation in the type of habitat ($P < 0.01$). We found no significant difference in the number of vegetation items among the habitat types. It is found infrequently in all habitats except sagebrush (SB). The differences in the diets were analyzed by comparing the variability within the number of food items of each food group found among all habitats. These analyses are summarized in Table 6 and Table 7. Table 6 reveals significant differences in the amount of variation in the number of food items (egg, mammals, reptile, fish, and insects) between wetland habitats (WT) and sagebrush habitats (SB) ($P < 0.01$). Ravens which nest in wetland habitats are apparently more variable in their consumption of eggs and fish. Ravens which nest in sagebrush habitat are apparently more variable in their consumption of mammals, reptiles, and insects. We found no significant differences in the variability in the number of bird and vegetation food items between wetland and sagebrush habitats. When we compared the differences in variability between non-road locations (WN and SN) and road locations (WR and SR), we found significant differences ($P < 0.01$) in the variation in the number of food items of mammal, reptile, fish, and insect origin (Table 7). Regardless of the ecological habitat (wetland or sagebrush), Common Ravens which nest near roads apparently have greater variability in their consumption of mammals, reptiles, and insects. Ravens which use nest sites away from roads apparently have greater variability in their consumption of fish. We found no significant differences in the variability in the number of bird, egg, and vegetation food items between road and nonroad areas.

Our analysis of the data indicates that although there is great variation in the diets of Common Ravens near Malheur National Wildlife Refuge, certain conclusions may be made which may be useful in their management in relation to waterfowl nesting success. The low mean number of eggs (1.33 ± 1.5) in sagebrush areas (SB and SR) suggests that ravens nesting in these habitats have little impact on waterfowl nests through nest plundering. The higher mean (13.5) for nest sites in wetland habitat indicates that nest plundering does occur in these habitats, but the high variability (SD = 20.89, see Table 6 and 7) suggests that only some of the ravens nesting in wetlands are nest plunderers. If reduced waterfowl nest predation is a management objective, then Common Ravens nesting away from wetland areas should receive minimal attention. Further, ravens nesting in wetland areas may or may not be serious threats to waterfowl production. For effective and prudent management of nest plunderers, a more detailed analysis of the diet of the ravens nesting near a waterfowl production area must be completed. Such an analysis of the diets may provide a basis for selective control of predators on National Wildlife Refuges as suggested by Braun et al. (1978).

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