FOOD HABITS OF BLACK AND TURKEY VULTURES IN PENNSYLVANIA AND MARYLAND

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Abstract: In 1983 and 1984, we studied black (*Coragyps atratus*) and turkey (*Cathartes aura*) vulture foraging behavior in Pennsylvania and Maryland by observing 21 radio-tagged vultures and collecting 134 regurgitated pellets. Radio-tagged vultures consumed 21 different kinds of carrion. Domestic animals were consumed more often (62%) than wild ones (38%). Black vultures fed more on large carrion (>20 kg) than did turkey vultures. Remains in pellets indicated greater use of wild sources of carrion than did observation of radio-tagged birds, possibly because large, domestic carrion was more digestible. Sixty-five percent of feeding was initiated from 3 to 7 hours after sunrise. Black vultures fed earlier, foraged in larger groups, fed longer at fewer locations, and fed closer to the main communal roost than did turkey vultures. Vultures' use of domestic carrion makes the establishment of feeding stations a practical method of supplementary feeding. The 2 species may benefit unequally from feeding programs because of different foraging strategies.

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Although black and turkey vultures are present in many areas of North America, both species are declining in some regions (Brown 1976). These species have been little studied, and the causes of reported declines are unknown. Both species weigh approximately 2,000 g, and Prather et al. (1976) reported that captive turkey vultures consume approximately 140 g of food each day, yet little is known about food habits or feeding behavior of either species. The few existing reports about these species' food habits are either anecdotal (Pearson 1919) or are based primarily on regurgitated-pellet analysis (Thiel 1976, Paterson 1984, Prior 1986, Yahner et al. 1986). Although this method can provide information about some of the prey eaten, highly digestible items tend to be underestimated, and carrion with a large component of indigestible material is overestimated.

Food availability may be an important factor in communal roost dynamics, shifts in vulture distribution, and competition between the species. To add to the understanding of vulture foraging dynamics we determined the species of animals that made up their food resource, the origin of these animals (domestic or wild), the distribution of carrion used (small and dispersed vs. large and clumped), and differences between the 2 species' food habits.

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STUDY AREA

We conducted the study within a 71,000-ha study area (circle with 15-km radius) centered on a large communal vulture roost in Gettysburg National Military Park. The roost is frequented by 400–800 vultures during winter; 70% were turkey vultures (Wright 1984). A 2nd, smaller communal roost of approximately 100 wintering vultures, was located 4 km south of the primary roost. Several hundred black and turkey vultures are year-round residents of the area (Coleman 1985). Eighty percent of the study area was in Adams County, Pennsylvania; 20% was in Carroll and Frederick counties, Maryland.

Cattle, hog, poultry, and dairy farming were the dominant farming practices in the 3 counties (Md. Dep. Agric. 1983, Pa. Crop Rep. Serv. 1983). Adams County (136,000 ha) had a total of 1,260 farms in 1983; 67% raised cattle, 11% dairy cows, 8% sheep, 25% swine, and 19% chickens. There were 41,010 ha of row crops; 44,600 beef and dairy cattle 2,400 sheep; 24,000 swine; and 1,800,000 chickens (Pa. Crop Rep. Serv. 1983).

Forests occurred along the Allegheny mountains in the west and along a diabase rock for-

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mation oriented northeast-southwest through the middle of the study area (Brown 1962). Elevation ranged from 100 to 450 m. The area had a mean annual precipitation of 105 cm and a frost free period of 200 days.

METHODS

Vulture food habits and foraging behavior were studied by observation of radio-tagged birds and by regurgitated-pellet analysis. Thus, we were able to detect easily digested items that might have been overlooked by pellet analysis alone, as well as small items that could be missed when using only observation of radio-tagged birds. While observing radio-tagged vultures we also determined where, when, and for low long the birds ate.

In 1983 and 1984, we trapped, primarily with a rocket net, 133 black and 58 turkey vultures. We patagially tagged all the birds with cattle ear tags (Sweeney et al. 1985) and attached back-mounted radio transmitters to 21 birds. Between 22 June 1983 and 8 March 1984 we tracked 6 black vultures and 5 turkey vultures. After 8 March the number of birds was increased to 11 black vultures and 10 turkey vultures until the end of the study on 15 September 1984. On 270 days, we randomly selected and tracked 1 vulture for the entire day. The bird was continuously monitored and its position was determined every 45 minutes. We remained $\geq$200 m from the bird to prevent disturbance. When we observed a radio-tagged bird eating, we waited until it departed and then examined the site. Location and time of our 1st observation of feeding, time of the bird's departure from the feeding site, and the type or types of carrion present were recorded. We defined a feeding bout as feeding by a bird during 1 day on the same kind or kinds of carrion within a radius of 300 m. Only the 1st daily observation of a bird at each site was used in analysis of carrion selection and feeding initiation. Carrion was classified into 3 size classes: small, medium, and large (carcasses of animals <10, 10–20, and >20 kg live weight, respectively). When several dead animals were in the same location, we classified the carrion by the approximate total live weight. For analysis the observations were separated by season (winter = 15 Sep–14 Mar; summer = 15 Mar–14 Sep). These seasons corresponded with the time of large communal roosts and with the time of reproductive effort, respectively (Wright 1984, Coleman 1985, Sweeney and Fraser 1986). For comparison with the analysis of summer- and fall-collected pellets, we used observations of radio-tagged vultures from 15 June to 14 December.

On 8 October and 9 December 1983 and on 8 and 16 August 1984, we collected pellets from under 2 roosts used by both vulture species. By previously clearing the area of vulture pellets we ensured that the pellets collected were <2 weeks old. The pellets were oven dried, weighed, and dissected to identify prey remains. Hair in the pellets was identified to genus, or to species when possible, using surface scale patterns, shape, patterns in the hair medulla and cortex (Mathiak 1938, Williams 1938, Stains 1958), and comparison to a regional hair key. All white feathers were assumed to be from poultry. Some non-white feathers were vulture feathers, apparently ingested while preening. As with the observations of radio-tagged birds, carrion in pellets was classified as small, medium, or large. However, in pellets, we could not determine if >1 individual of each prey species was present.

RESULTS

Direct Observation of Feeding

We identified 21 different types of food during observation of 108 feeding bouts (Table 1). After 9 additional bouts we were unable to locate any identifiable remains. Cattle, swine, poultry, and ground hogs (*Marmota monax*) were the most frequently observed carrion sources. There was no significant difference in use of carrion type (domestic vs. wild) between vulture species (χ^2 = 0.33, df = 1, P = 0.565) (Table 1) or between winter and summer seasons (χ^2 = 0.09, df = 1, P = 0.762). Black vultures fed more often on carrion from domestic than from wild sources (67 vs. 35%, respectively; Z = 2.32, P < 0.020), whereas turkey vultures fed equally on domestic and wild sources (58 vs. 42%, respectively; Z = 1.73, P = 0.083) (Table 1). Black vultures fed more on large and less on small carrion than did turkey vultures (χ^2 = 9.31, df = 2, P = 0.010) (Fig. 1). Although there was some shift to use of larger carrion in the winter (36% in summer vs. 50% in winter, both species combined), this did not result in a significant seasonal difference in the size of carrion consumed when species were analyzed separately or collectively (χ^2 = 2.09, df = 1, P = 0.352).

Table 1. Items fed upon by radio-tagged vultures in Pennsylvania and Maryland, 1983–84.

Items fed on[a]	No. (and %) of feedings: Black vulture (N = 11)	Turkey vulture (N = 10)	Total
Domestic			
All cattle	17 (27)	9 (18)	26 (23)
Calf	9 (14)	4 (8)	13 (12)
Cow	2 (3)		2 (2)
Afterbirth & offal from slaughtered cows	6 (10)	5 (10)	11 (10)
All swine	11 (17)	12 (24)	23 (20)
Pig	7 (11)	5 (10)	12 (11)
Piglet	4 (6)	5 (10)	9 (8)
Offal from slaughtered pigs		2 (4)	2 (2)
All poultry	9 (14)	4 (8)	13 (12)
Turkey	6 (10)	1 (2)	7 (6)
Chicken	3 (5)	3 (6)	6 (5)
Sheep	4 (6)	3 (6)	7 (6)
Kitchen scraps		1 (2)	1 (1)
Total domestic	41 (65)	29 (58)	70 (62)
Wild			
Groundhog	5 (8)	8 (16)	13 (12)
White-tailed deer	10 (16)	2 (4)	12 (11)
Adult	9 (14)	1 (2)	10 (9)
Fawn	1 (2)	1 (2)	2 (2)
Striped skunk (*Mephitis mephitis*)	2 (3)	3 (6)	5 (4)
Raccoon	2 (3)	1 (2)	3 (3)
Opossum	3 (5)		3 (3)
Insect larva		3 (6)	3 (3)
Eastern cottontail		1 (2)	1 (1)
Small mammal (Rodentia)		1 (2)	1 (1)
Turtle (Emydidae)		1 (2)	1 (1)
Bluegill (*Lepomis macrochirus*)		1 (2)	1 (1)
Total wild	22 (35)	21 (42)	43 (38)
Wild and domestic	63 (100)	50 (100)	113 (100)

[a] All animals, except larvae in cattle feces, were apparently dead when the vultures arrived.

Pellet Analysis

Dry weight of the 134 pellets averaged 2.54 g (SE = 0.05) and contained 15 different kinds of carrion (Table 2). Vegetation occurred in 88% of the pellets. Because the vegetation was probably consumed incidental to feeding on carrion, it was not included in further analysis. Nonwhite feathers, which occurred in 19% of the pellets, were considered vulture feathers and were also excluded from further analysis. Besides vegetation, poultry, swine, raccoon (*Procyon lotor*), opossum (*Didelphis marsupialis*), and white-tailed deer (*Odocoileus virginianus*) occurred most frequently (Table 2). The pellets collected in August showed greater use of small carrion (<10 kg) than did those collected in October and December (69 and 36%, respectively; χ^2 = 23.57, df = 2, P < 0.001). Small carrion may be less abundant in the winter when many small and medium-sized mammals are either hibernating or inaccessible due to snow cover. As with observations of radio-tagged vultures, there was no significant seasonal shift in the use of domestic and wild carrion. Pellet analysis showed greater use of wild carrion than did observation of radio-tagged birds (χ^2 = 4.37, df = 1, P = 0.037).

Feeding Periods and Periodicity

Sixty-five percent of radio-tagged birds arrived at feeding sites and 59% of all observed feeding took place from 3 to 7 hours after sunrise (Fig. 2). Black vultures arrived at carrion earlier than did turkey vultures (55% of black and 30% of turkey vulture arrivals were within 4 hours after sunrise, P = 0.011), but turkey vultures fed until later in the afternoon (P < 0.001) (Table 3). In winter, birds arrived at carrion

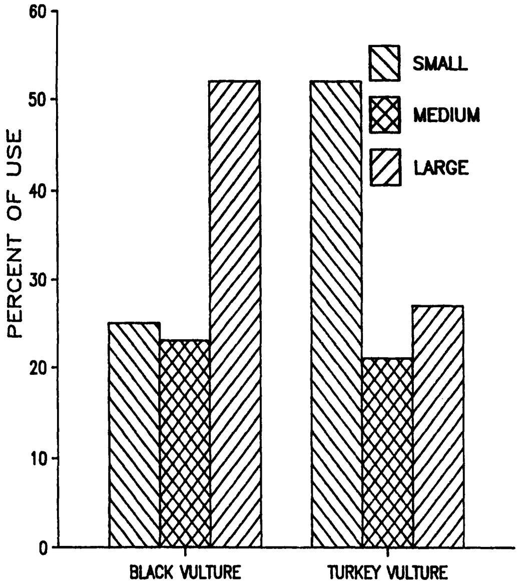

Fig. 1. Use (% of arrivals) of small (<10 kg), medium (10–20 kg), and large (>20 kg) carrion by black vultures (N = 60 arrivals) and turkey vultures (N = 48 arrivals), Pennsylvania and Maryland, 1983–84.

sooner after sunrise and departed earlier than in summer (Table 3). This was true both when the species were analyzed individually and when analyzed jointly ($P < 0.05$). The earlier arrival in winter could be due to higher communal foraging efficiency, a greater need for food, or the shorter days requiring earlier initiation of foraging. Black vultures had fewer feeding bouts/day than did turkey vultures ($\bar{x}$ = 1.16 and 1.26 bouts/day respectively; Student's t = 2.74, P = 0.004). Furthermore, black vultures fed longer than did turkey vultures. Fifty-five percent of black and only 33% of turkey vulture feeding bouts lasted >35 minutes (Kolmogorov-Smirnov J = 1.37, P = 0.047).

Foraging Flights

Flights were primarily over the farmland in the eastern half of the study area (Coleman 1985), and black vultures fed closer to the main communal roost than did turkey vultures. Mean distances of feeding sites from the main communal roost were 5.86 and 7.75 km, respectively (Student's t = −2.64, P = 0.009). Foraging black vultures were found in larger groups ($\bar{x}$ = 10.11) than were turkey vultures ($\bar{x}$ = 4.88; χ^2 = 10.15, df = 2, P = 0.006 for difference in proportions in groups of 1–5, 6–10, and 11-45 individuals).

Table 2. Vulture (black and turkey) food selection (%), as determined by carcass visitations and by regurgitated pellets collected under 2 communal roosts, Pennsylvania and Maryland, late summer and fall, 1983–84.

Food item	Visitations (N = 58)	Pellets (N = 134)
Domestic		
Cattle	28	6
Swine	17	14
Poultry	7	19
Sheep	5	1
Dog		1
Cat		<1
Horse		1
Total domestic	57	42
Wild		
Groundhog	12	5
White-tailed deer	10	10
Striped skunk	5	8
Raccoon	5	13
Opossum		10
Insect larva	5	<1
Eastern cottontail		6
Small mammal (Rodentia)	2	5
Turtle (Emydidae)	2	
Bluegill	2	
Total wild	43	58
Wild and domestic	100	100

DISCUSSION

Direct Observation of Feeding vs. Pellet Analysis

There was greater use of cattle and lesser use of poultry carrion by radio-tagged vultures than was suggested by the pellets. Some items, such as offal and afterbirth, did not show up at all in the pellet analysis, presumably because they were completely digested. Small items, such as eastern cottontails (*Sylvilagus floridanus*) and other small mammals, were more common in the pellets than in observations of radio-tagged vultures. Such items may have been totally consumed and, therefore, were undetected by observation of radio-tagged birds. Furthermore, observations of radio-tagged vultures during summer and fall suggested that they fed most often on cattle, swine, groundhog, and deer carrion, whereas pellet contents indicated that they fed mostly on poultry, swine, racoon, opossum, and deer. The reasons for these differences and the higher frequency of wild carrion in the pellets are not immediately clear, but inability to distinguish remains from multiple feeding bouts contained within 1 pellet may be a contributing

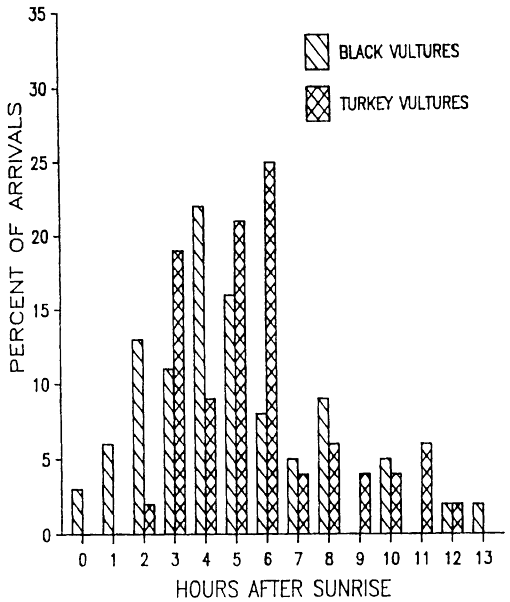

Fig. 2. Distribution of black vulture ($N = 64$ arrivals) and turkey vulture ($N = 53$ arrivals) arrival times at carrion, Pennsylvania and Maryland, 1983–84.

factor. Another possibility is that there was overrepresentation of turkey vultures in our pellet samples because of their greater number in the roosts. However, the difficulty of obtaining accurate summer roost counts and the possibility of different casting rates in the 2 species, made this hypothesis difficult to test.

Yahner et al. (1986) studied vulture food habits in the same area and found a greater frequency of sheep and deer hair and a lower frequency of swine hair than we did. Most of the differences between our results and those of Yahner et al. (1986) may be due to our pellets being collected in summer and fall and theirs being collected in mid-winter. The large component of sheep that Yahner et al. (1986) reported may result from the local lambing season in late December and January. The larger component of deer may result from the greater winter availability of car-killed deer in close proximity to the main roost (H. Greenlee and L. Haynes, pers. commun.).

Because of our inability to identify the species casting each pellet, and our inability to distinguish multiple feeding bouts from pellets, we believe that telemetry data provided the most unbiased estimate of carrion used by vultures in our study area. Telemetry also permitted us to detect differences in the 2 species' foraging behavior. However, observation of radio-tagged birds may produce an upward bias in estimates of the relative frequency of use of large carrion. On 9 occasions, when we were unable to find any food at the site located by telemetry, the entire food item apparently had been consumed. (On 1 occasion a careful search resulted in the discovery of the foot of a small mammal.)

Foraging Strategy

Although both species foraged over much of the same area and in the same open habitats (Coleman 1985), they used slightly different strategies. Radio-tagged black vultures often landed at a feeding site after a 1–3-km glide; this suggests that food was detected from a great distance or had been previously discovered. In 1 case, after offal from slaughtered cattle was dumped approximately 3 km from a soaring black vulture, the bird arrived at the carrion in just 11 minutes. Black vultures occasionally rose out of sight while we were tracking them; this rarely happened with turkey vultures. Stager (1964) and Haskins (1972) also reported higher soaring flight by black vultures.

Similar to foraging behavior observed by

Table 3. Mean time of arrival of and mean time of all observations of radio-tagged black ($N = 11$) and turkey ($N = 10$) vultures feeding at carrion, Pennsylvania and Maryland, 1983–84.[a]

	Hours after sunrise					
	Arrival			Feeding		
	$\bar{x}$	SE	N	$\bar{x}$	SE	N
Black vultures	5.23	0.34	64 a	5.66	0.20	161 e
Turkey vultures	6.30	0.33	53 b	6.79	0.24	107 f
Summer	6.19	0.33	75 c	6.59	0.21	166 g
Winter	4.86	0.31	42 d	5.31	0.19	102 h

[a] Wilcoxon rank sum test results (comparisons of): a to b, $S = 3{,}592$ ($P = 0.11$); c to d, $S = 2{,}079$ ($P = 0.23$); e to f, $S = 16{,}602$ ($P < 0.001$); and g to h, $S = 11{,}611$ ($P = 0.001$).

Stewart (1978) and Rabenold (1987), black vultures returned repeatedly to large, dependable sources of carrion. They often flew directly from the night roost to previously used carcasses, thereby feeding earlier than turkey vultures. They also remained at carcasses longer and congregated in larger groups than did turkey vultures. As was observed by Wright (1984), turkey vultures were farther from the main roost during much of the day. They spent more time in the air than did black vultures, presumably looking for new sources of carrion. Positions determined by regular sampling with radio telemetry (1,595 turkey and 1,837 black vulture observations) showed turkey vultures flying 32% of the time vs. 11% for black vultures. They fed more often, on smaller carcasses, and for shorter periods than did black vultures. The long, low flights of turkey vultures may afford them better opportunity for location of small carrion by sight and olfaction. The high flight of black vultures may permit them to see other vultures, at great distances, feeding on carcasses. Although black vultures feed earlier in the day by flying directly to previously located carrion, turkey vultures may be able to coexist with the more aggressive black vulture (Haskins 1972) by finding many small sources of carrion and feeding on new carrion before black vultures arrive. Current competition with black vultures, however, may have little to do with turkey vulture selection of small carrion, as Prior (1986) also found them feeding primarily on small carrion in an area devoid of black vultures. Additionally, because both species evolved in environments with a wider array of prey and competitors than exist presently, current interactions provide only limited insights into the evolutionary pressures that shaped the behavior of the 2 species.

MANAGEMENT IMPLICATIONS

Carrion from farm sources, usually in open habitats, is an important component of the Pennsylvania and Maryland vulture food resource. This may be the case over much of the eastern United States; other studies show a similar dependence on carrion from domestic sources (Paterson 1984, Sweeney and Fraser 1986, Yahner et al. 1986). However, this was not the case for turkey vultures in southern Ontario (Prior 1986). In the mid-Atlantic states dependable carrion, in conjunction with secure roosts and nesting areas (Coleman 1985), may make large congregations of vultures possible.

The availability of carrion from domestic sources is highly dependent on the enforcement of and compliance with animal disposal laws. Most states have laws requiring farmers to burn or bury dead livestock. In areas where food resources limit vulture numbers or have caused their decline, domestic carrion could be made more available by the relaxation of dead-animal laws to permit the establishment of vulture "restaurants" (Culverwell 1984). Black vultures would benefit most from such feeding stations because of their greater use of large, dependable sources of carrion. In fact, if black vultures are limited by availability of dependable sources of carrion and compete with turkey vultures for other resources, such as nest sites (Coleman 1985), establishment of vulture restaurants may allow increased numbers of black vultures to displace turkey vultures from these resources.

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ESTIMATING PRAIRIE FALCON AND GOLDEN EAGLE NESTING POPULATIONS IN NORTH DAKOTA

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Abstract: Stratified random sampling of 23.3-km² units was used in 1983 and 1984 to estimate the nesting populations of prairie falcons (*Falco mexicanus*) and golden eagles (*Aquila chrysaetos*) in western North Dakota. Based on independent estimates from the 2 years, the nesting population estimates and 95% confidence intervals were 107 ± 94 pairs of prairie falcons and 95 ± 79 pairs of golden eagles. Biases in surveys for prairie falcons were assessed in 1984. No differences were found between 1st and 2nd aerie visits in the number of adult prairie falcons present at occupied sites or in their response distances. There was no seasonal trend in response distances of adults. Up to 22% of all occupied aeries might not be seen during a single ground survey. Nesting failures and lack of responses to observers reduced survey accuracy. To account for bias, the prairie falcon population estimate was adjusted to 125 ± 94 pairs. Alternative survey methods probably could increase the precision of the estimates.

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Stewart (1975) considered prairie falcons uncommon and local in the badlands and on adjacent plains along the Little Missouri and Missouri rivers in North Dakota. However, records he summarized provide little information about the present nesting population. Stewart said that nesting golden eagles were "fairly common" in west and northcentral North Dakota along the Little Missouri River, but he noted few records of nesting elsewhere in the state.

Recent changes in land use in western North Dakota led to a need for information for management of prairie falcons and golden eagles. The primary objective of this study was to determine the size and distribution of nesting populations of these raptor species in western North Dakota in 1983 and 1984. The estimates were to be statistically valid and based on logistically practical surveys. A subsidiary objective was to assess problems with the survey methods.

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