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FORAGING BEHAVIOR OF VULTURES IN CENTRAL FLORIDA

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Abstract.—Black Vultures (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*) overlap widely in their use of carrion and habitat types in the southeastern United States. I used a point count road survey method to study differences in vulture foraging behavior in central Florida. Black Vultures foraged at higher altitudes and in larger groups than Turkey Vultures (mean group size: Black Vultures 2.3 ± 2.0 SD, Turkey Vultures 1.7 ± 1.9 SD). Density over all point counts was higher for Turkey Vultures (0.80 individuals/km^2 ± 0.13 SD), than for Black Vultures (0.43 individuals/km^2 ± 0.36 SD). There were significant differences in the seasonal pattern of density observed between species. Turkey Vultures were most numerous in winter, probably due to an influx of migratory individuals.

The seven species of cathartid vultures are primarily carrion-eating scavengers. In many parts of North and South America, morphological and behavioral differences allow two or more species to coexist. Interspecific competition is reduced through differences in habitat use, foraging strategies, carcass size preferences, patterns of arrival at carcasses, and status in interspecific dominance hierarchies (Wallace and Temple 1987, Houston 1988, Lemon 1991, Gomez et al. 1994, Kirk and Houston 1995). In southeastern North America, Black and Turkey vultures overlap in their use of carrion (Yahner et al. 1986, Coleman and Fraser 1987) and habitat types (Stewart 1978, Coleman and Fraser 1989).

My objective in this study was to investigate differences in the foraging behavior of Black and Turkey vultures in central Florida. Information on how vultures locate carrion will help to understand how they partition resources and coexist in central Florida. Both Black and Turkey vultures have undergone population declines in parts of the southeastern United States in recent decades (Coleman and Fraser 1990, Rabenold 1990). Information on vulture life histories will be useful for future management and conservation efforts.

STUDY AREA AND METHODS

The study site was located in Osceola and Orange counties in central Florida, near the town of Kissimmee. The landscape surrounding the study area was a mixture of for-

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ested and open habitats (pasture); 51.7% of the land was used as farmland with 75.3% of this used as rangeland (Florida Office of Agricultural Statistics pers. comm.). Two permanent Black Vulture communal roosts were located within six km of the starting point of the road survey route. Mark-resighting data indicated that several thousand Black Vultures used this roost system during the study (Stolen 1996).

Point counts were based on the point transect method (Fuller and Mosher 1987). Point counts were conducted twice monthly from January through December 1993, between six and nine h after sunrise (n = 22). Each survey took approximately two h. Six stations at 8 km intervals were chosen along a 48 km route. At each station I stopped and scanned the sky for vultures for five min using 8.5 × 42 binoculars. I recorded the species, number, estimated altitude, estimated distance, and behavior for each observation. Birds that were observed within 200 m of each other at roughly the same altitude were recorded as a group.

Estimated altitude was recorded as: low (0-50 m), medium (50-250 m), and high (250+ m). I calibrated my height categories by observing vultures flying near a 150 m tower with cross-beams at regular intervals, after I had practiced placing birds within the three height classes. Distance was estimated as: near (0-200 m), medium (200-700 m), and far (700+ m). I calibrated distance categories by measuring distance to flying birds after I had practiced placing birds within the three distance classes. Distances for calibration were measured using a Bushnell 1000 m parallax-type range finder. Surveys were not conducted in rain, overcast conditions, or in high winds.

I modeled the association between species of vulture and altitude using a proportional odds model, a statistical regression-type model for ordered categorical response variables (Agresti 1996). Altitude of observations was treated as a multicategory logit, and species of vulture as the explanatory variable. To reduce any bias caused by obstruction of birds at low altitude and far distance, only near and medium distance observations were included in analysis of foraging altitude and density. Data from the six stations were pooled for each survey. Density was estimated based on the fixed-radius point count method (Verner 1985). I made no adjustment for detectability because I believe that I was able to detect all birds flying within 700 m of the observation points. Density measures were calculated based on a total area of 9.24 km^2 (six circular plots with radius of 700 m each). All observations were used for analysis of group size. Distributions of group sizes were compared using the Kolmogorov-Smirnov comparison of frequency distributions.

Overall differences in abundance between the species were analyzed using a Wilcoxon Signed-rank test. I used a contingency table analysis to test for differences in seasonal abundance between species. Seasons, based on vulture breeding seasons and Turkey Vulture migratory periods (Jackson 1988a, 1988b), were: Spring (March-May), Summer (June-August), Fall (September-November) and Winter (December-February). All statistical analysis were performed using SPSS (Norusis 1993) except for the proportional odds ratio which was performed using SAS (Stokes et al. 1995).

Results

Black Vultures foraged at higher altitudes than Turkey Vultures (Fig. 1). The proportional odds model fit well (goodness-of-fit test G^2 = 0.76, P = 0.38) and there was a significant association between species and altitude (likelihood-ratio test of H_0:$\beta = 0$, P = 0.0001). The odds that an individual was observed at a lower rather than a higher altitude were 7 times greater for Turkey Vultures than for Black Vultures (95% C.I. [4.07, 12.02]). The predicted probability of an individual being observed at low altitude was 0.094 for Black Vultures and 0.42 for Turkey

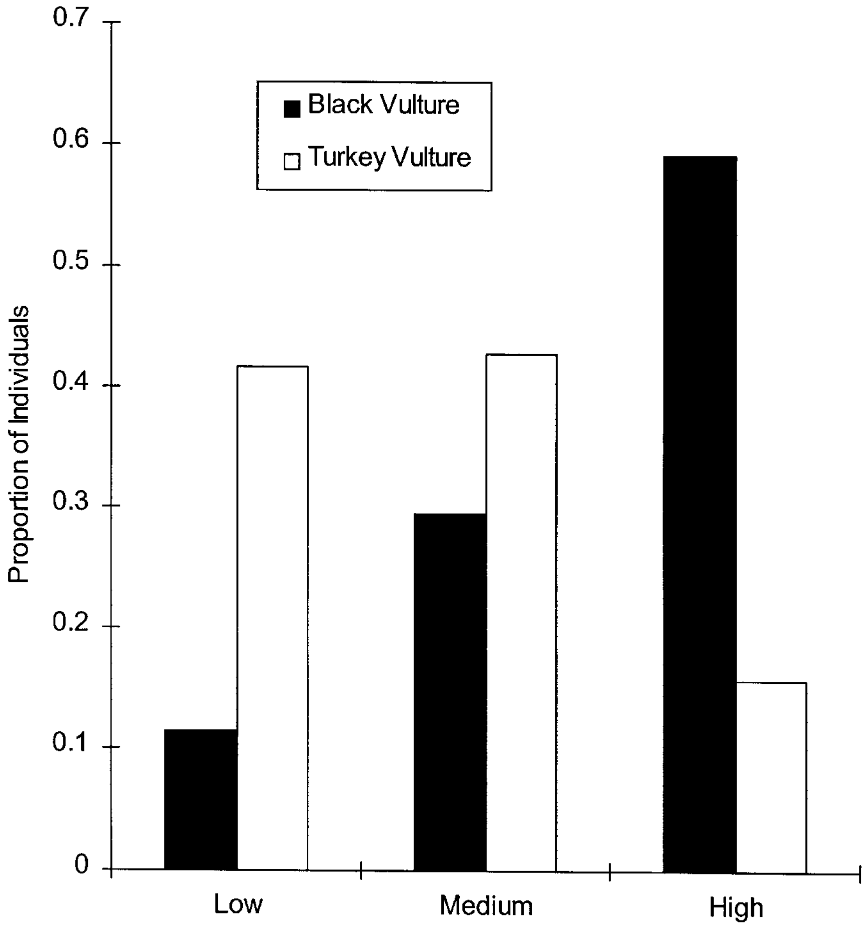

Figure 1. Proportions of foraging vultures observed in each of three altitude classes during surveys in central Florida. Altitude classes: low = 0 to 50 m, medium = 50 to 250 m, high = 250 m and above. Black Vultures foraged at higher altitudes than Turkey Vultures (Proportional Odds Model, $P = 0.0001$).

Vultures. The predicted probability of an individual being observed at high altitude was 0.58 for Black Vultures and 0.17 for Turkey Vultures.

Mean group size of Black Vultures was 2.3 (±2.0 SD), and of Turkey Vultures 1.7 (±1.9 SD); the median group size was two and one, respectively, while the modal group size was one for both species (Fig. 2). Comparison of the distribution of group sizes showed that overall Black Vultures were observed in larger groups than were Turkey Vultures (Kolmogorov-Smirnov z = 1.7820, $P = 0.004$, $n = 59$ for Black Vulture groups and $n = 123$ for Turkey Vulture groups).

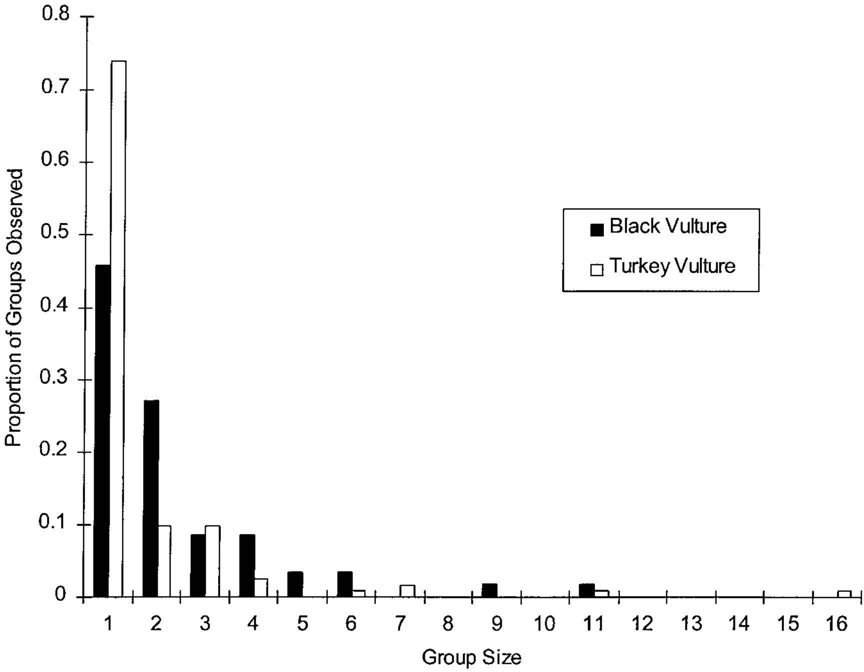

Figure 2. Group sizes of foraging vultures observed during surveys in central Florida. Black Vulture groups tended to be larger than Turkey Vulture groups (Kolmogorov-Smirnov Test, $P = 0.004$). Number of individuals: Turkey Vulture $n = 210$; Black Vulture $n = 136$. Number of groups: Turkey Vulture $n = 123$; Black Vulture $n = 59$.

Density of pooled point count surveys was greater for Turkey than Black vultures (0.80 ± 0.13 SD ind./km^2, and 0.43 ± 0.36 SD ind./km^2, respectively, Wilcoxon Signed-rank test $P = 0.0002$). The number of Turkey Vultures observed during point counts ranged from 0 to 25; the number of Black Vultures ranged from 0 to 12. There was a significant difference in the seasonal pattern of abundance between species ($G^2 = 18.62$, $P = 0.001$). Evaluation of cell counts revealed that winter counts contributed the most to the observed association between species and season. Turkey Vultures were more abundant in winter and less abundant in spring than during the other seasons; Black Vulture abundance changed little throughout the year but was higher in summer and fall than in winter and spring (Fig. 3).

Discussion

Foraging Behavior

Turkey Vultures foraged at lower altitudes than Black Vultures. This difference was expected given their difference in foraging strategy.

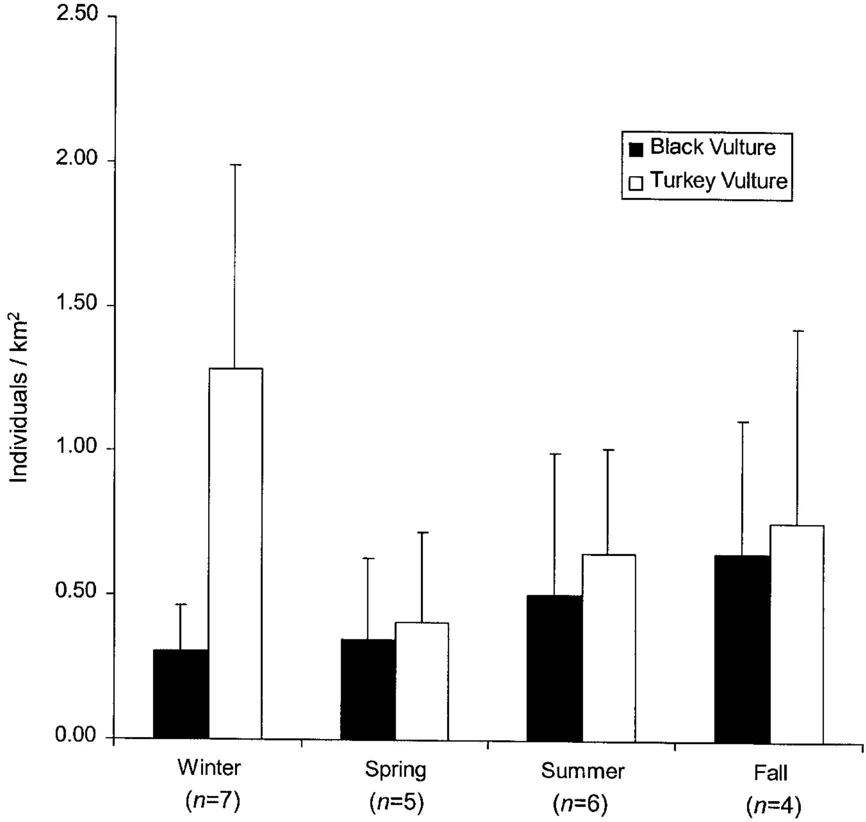

Figure 3. Seasonal density of foraging vultures in central Florida (error bar = 1 SD). Seasons: Winter = December through February, Spring = March through May, Summer = June through August, Fall = September through November. Seasonal pattern of abundance differed between species (Chi Square Analysis, $P < 0.001$). Turkey Vultures were most abundant in winter, probably because of the presence of individuals wintering in central Florida. Number of surveys is given beneath season.

Turkey Vultures locate carcasses primarily using olfaction and must remain close to the ground where odors are concentrated (Houston 1984, 1986). Black Vultures search for food visually, often using other vultures to locate carrion (Stewart 1978, Rabenold 1987a, Lemon 1991); they benefit by foraging at high altitudes where they can scan larger areas. In regions of their range lacking Black Vultures, Turkey Vultures maintain their unique foraging strategy and continue to use low altitude foraging (Prior and Weatherhead 1991b, Estrella 1994, Gomez et al. 1994).

Group size was significantly larger for Black than Turkey vultures. This is also related to foraging strategy. Black Vultures forage in groups to take advantage of group feeding (Wallace and Temple 1987, Buckley 1996) and perhaps because individuals follow one another from communal roosts (Rabenold 1987a). Black Vultures also sometimes travel in family groups (Rabenold 1986, 1987b, Parker et al. 1995). A confounding factor in studying group foraging behavior in cathartid vultures is the difficulty in determining whether birds observed near one another are within a foraging group. Often during surveys I observed two or three Turkey Vultures foraging within several hundred meters of one another at different altitudes and moving independently. However, if one bird was to discover a carcass, the others could notice and join it at the carcass. Thus, vulture foraging groups may be dispersed more than 200 m, and I may have underestimated the number of vultures foraging in groups. It may not be meaningful to discuss foraging groups when foragers operate in a dispersed pattern within sight of one another (Kirk and Houston 1995).

Density Measures

Road survey methods are often used to estimate raptor abundance, and to investigate behavior; however, there are several concerns in using road survey methods (Fuller and Mosher 1981). Roads may coincide with geographic features and thus not be representative of the landscape. Some species may be attracted to, or repelled by, roads. Detectability may vary in different habitats along a survey route, biasing density measurements. Density estimates are based on measures of distances, which may be inaccurate (Verner 1985). Despite these concerns, road surveys can be useful if care is taken to control conditions. Vultures are good candidates for road surveys because they spend much of the day soaring and are highly visible.

Although road survey methods may not be suited to studies of vulture population demography (Hubbard 1983, Sweeny and Fraser 1986, Fraser and Coleman 1990), I believe that the road survey method I used was well suited to studying vulture foraging behavior. Vultures are large, conspicuous birds that are easily identified. They are active during specific time intervals and spend much of this time flying (Bunn et al. 1995). The survey route used during this study covered five different roads, none of which followed the same geographic features. I limited analysis of observations to those within 700 m to minimize bias due to visual obstruction. A weakness of fixed-distance methods is the potential bias caused by declining detectability with distance. Although it is possible to calculate detection functions and use these to correct for this bias (Verner 1985), I chose not to do so because I did not find a decline in detectability of flying birds within the transect strip.

My density estimates of vultures were specific to foraging vultures, and applied only to the time interval during surveys and to areas near roads. The time interval was chosen to maximize the number of foraging vultures observed. Density of Turkey Vultures was nearly twice that of Black Vultures; however, I may have underestimated the number of Black Vultures because they forage at higher altitudes than Turkey Vultures, and thus, are possibly less detectable. Density estimates of Black and Turkey vultures in central Florida were less than those observed by Kirk and Currall (1994) in Venezuela. Density of Turkey Vultures was less than that observed by Houston (1986) in Panama. Several authors have noted that the suitability of habitat and availability of carcasses is directly correlated with the density of vultures observed (Houston 1987, Hiraldo et al. 1991, Kirk and Currall 1994). Thus, central Florida habitat may not be as good for vultures as that in Central and South America.

The higher density of Turkey Vultures observed in winter than in other seasons may reflect migrants wintering in central Florida; the lower density observed in spring could be due to individuals attending nests. The lower density of Black Vultures observed in winter and spring than in summer and fall may also be caused by a change in behavior associated with breeding activity. Seasonal trends may also result from changes in the availability of carcasses between seasons; vultures need to spend less time foraging when food is more readily available. Changes in the abundance of vultures in an area also might have been caused by movement of individuals in response to changes in food availability (Stolen 1996).

Because they are easy to perform and relatively inexpensive, road surveys may represent the best option for assessing populations of vultures in a given area. Hubbard (1983) suggested that road count surveys of Turkey Vultures may be useful in assessments of local raptor communities, since Turkey Vultures are relatively easy to survey and share many conservation concerns with other raptors. Houston (1987) suggested that counts of cathartid vultures could be used for rapid assessments of mammal populations in Neotropical forest sites. For these reasons, it would be beneficial for more work to be done to standardize methodology and reduce variability of roadcount data. Future research should be directed at standardizing density measurements obtained from point counts.

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