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Group size and flight altitude of Turkey Vultures in two habitats in Mexico.—The efficiency of carcass exploitation by scavenger guilds is related to patterns of searching and finding carcasses, feeding behavior and the efficiency of one or two species in the guild to find carrion (Alvarez et al. 1976; Attwell 1963; Houston 1974, 1979, 1988; Kruuk 1967; Rodríguez-Estrella 1986). The Turkey Vulture (*Cathartes aura*) is present in every existing scavenger guild (Brown and Amadon 1968) and is perhaps the most important scavenger species due to its efficiency in finding and exploiting carcasses (Houston 1986). Turkey Vultures forage individually or in widely scattered small groups with other vulture species. However, limited information is available on their foraging habits where Turkey Vultures are allopatric with respect to other vultures and variations in group size may be related to the density of the species (Prior 1990). In this study, I analyzed whether the foraging group size of Turkey Vultures was related to population density or to other factors, such as carrion size and availability. The vultures were studied in two areas with similar population density (Hiraldo et al. 1991, this study), different carrion size and availability, and without the presence of other vulture species.

Methods.—I studied vultures in La Michilía (23°20′–23°30′N, 104°07′–104°20′W) and Mapimí (26°29′–26°52′N, 103°58′–103°32′W) Biosphere Reserves at Durango, México. La Michilía is an irregular high plain (elevation 2250 m) between two mountain ranges. The climate is semiarid with summer rains, annual mean precipitation of 567 mm, and an annual mean temperature ranging between 17.4°C and 20.7°C. Vegetation of La Michilía is dominated by oak-pine forests (*Quercus* spp., *Pinus* spp., *Juniperus* sp., *Arctostaphylos pungens*). The Bolsón de Mapimí is a basin crossed by small mountains within the playas of the alluvial plains (elevation 1000–1350 m). The climate is arid with summer rains and cool winters. The average annual precipitation is 264 mm. The annual mean temperature varies between 3.9°C and 33°C. The Mapimí reserve contains a xerofitic shrubland vegetation (*Larrea divaricata*, *Fouquieria splendens*, *Prosopis glandulosa*, *Opuntia* spp., and *Hilaria mutica*).

La Michilía was surveyed in early September 1981 and late March 1982. Mapimí was surveyed from late March through early September in 1985 and 1986. As I was not able to distinguish between residents and migrants, and knowing that foraging flight may differ between the two groups, I did not make observations during the months when migrants could be in the area. Observations of foraging groups were made opportunistically from a car and from elevated vantage points between 09:30 and 16:00 h in both areas. Following Rabenold (1983) and Prior (1990), birds were considered to be in the same foraging group whenever they were observed in the air within 1 km of one another and heading in the same direction. For every foraging individual and group, I recorded the time of day, altitude of flight, and type of flight (flapping or soaring). I used a clinometer on several objects of known altitude and distance to confirm the accuracy of the estimations. I analyzed group size and flight altitude differences using chi-square tests. These tests detected differences between the two study areas in the frequency of four size groups, at three heights (below

TABLE 1
FORAGING GROUP SIZE OF TURKEY VULTURES IN THE FOREST OF LA MICHILÍA AND THE
DESERT OF MAPIMÍ, DGO., MÉXICO

Group size	La Michilía		Mapimí	
	N	%	N	%
1	75	68.2	57	57.0
2	22	20.0	23	23.0
3	9	8.2	4	4.0
4	1	0.9	8	8.0
5	1	0.9	2	2.0
6	1	0.9	3	3.0
7	1	0.9	2	2.0
8	—	—	1	1.0
Mean group size	1.53		1.97	

50 m, between 50–100 m or above 100 m), and at three times of day. Differences in the mean group size (MGS) were analyzed using Kolmogorov-Smirnov two sample tests.

Results.—Turkey Vultures in La Michilía and Mapimí foraged solitarily in 68% and 57% of my observations, respectively (Table 1). The occurrence of groups was similar in both regions, except that groups of more than three individuals were significantly more frequent at Mapimí ($\chi^2 = 9.4$; $df = 1$; $P < 0.01$; Table 1). Differences were not found between the MGS of La Michilía and Mapimí (Kolmogorov-Smirnov, two sample test; $P > 0.05$). Dividing hourly observations into three periods (before 11:00, 11:00 to 14:00, and after 14:00) showed significant differences in group size with the time of day ($\chi^2 = 11.2$; $df = 2$; $P < 0.01$). Group size was higher between 11:00 and 14:00 in both La Michilía and Mapimí, although in Mapimí, Turkey Vultures began to fly earlier.

TABLE 2
COMPARISON OF FLIGHT ALTITUDE OF TURKEY VULTURES DURING FORAGING ACTIVITIES AT
LA MICHILÍA AND MAPIMÍ, DURANGO, MÉXICO

Flight altitude (m)	Group size			
	1	2	3	>3
0–50				
Michilía	41	8	1	0
Mapimí	39	13	3	10
50–100				
Michilía	24	3	3	1
Mapimí	18	7	1	3
>100				
Michilía	10	11	5	3
Mapimí	—	3	—	3

Turkey Vultures most often flew within 50 m of ground level in both La Michilía and Mapimí (Table 2). However, at La Michilía Turkey Vultures flew more often at altitudes above 100 m than they did at Mapimí ($\chi^2 = 15.6$; $df = 1$; $P < 0.01$; Table 2). Turkey Vultures foraged at Mapimí in groups larger than three individuals only at altitudes below 50 m, while at La Michilía groups of more than three individuals were observed at altitudes higher than 100 m.

Discussion.—Turkey Vultures in the forest of La Michilía and in the desert of Mapimí generally foraged at altitudes below 50 m, as reported by other authors for different habitats (Stager 1964, Coleman and Fraser 1987, Houston 1988). As has been observed in other regions (Stewart 1978, Rabenold 1983, Prior 1990), most of the time Turkey Vultures at La Michilía and Mapimí search solitarily or in pairs. However, in other forests of North America, they forage in larger groups than they do in La Michilía. Differences were noted between the MGS reported in other North American populations and those of northern Mexico (MGS 2.31, North Carolina: Prior 1990; 2.75, North Carolina: Rabenold 1983; 1.53, La Michilía: this study) ($P < 0.001$, Kolmogorov-Smirnov two sample tests). However, the mean group size reported in a forest in Southern Ontario (MGS 2.11: Prior 1990) is similar to that recorded in the La Michilía forest ($P > 0.05$, Kolmogorov-Smirnov, two sample test). Prior (1990) suggests that lower population densities of Turkey Vultures may be responsible for the small size of foraging groups. The density of Turkey Vultures in La Michilía has been estimated at 0.75 birds/km (Hiraldo et al. 1991) and in Mapimí at 0.53 birds/km (Rodríguez-Estrella, unpubl. data). These figures indicate a low population density in both regions, and the MGS of these two southern regions is similar to that of Ontario's Turkey Vulture population.

Factors other than population density could be responsible for foraging group size. Group size in Mapimí was not significantly larger than that in La Michilía, but Turkey Vultures in Mapimí flew at lower altitudes than those in La Michilía. The higher density and cover of the La Michilía vegetation does not seem to be an important factor since Turkey Vultures locate carrion mainly by smell (Bang 1964, Houston 1986). Probably the size of potential carcasses and their scarcity may explain this. The feeding habits of Turkey Vultures in both regions support this idea, since small and medium-sized prey comprised 78% of the items in the Mapimí diet (Rodríguez-Estrella 1993), whereas in La Michilía, they comprised 42% (Hiraldo et al. 1991). Also, the density of large mammals in Mapimí (i.e., Mule deer [*Odocoileus hemionus*]) seems to be lower than in La Michilía (i.e., White-tailed deer [*O. virginianus*]) (Ezcurra and Gallina 1981). Although Turkey Vultures consume smaller prey in areas where it coexists with the Black Vulture (Stewart 1978, Coleman and Fraser 1987, Hiraldo et al. 1991), the difference in the diets between Mapimí and Michilía, where Black Vultures are absent, probably reflects the availability of the prey sizes in both areas, particularly of the wild and domestic ungulates. On the other hand, Houston (1974) found that African vultures search for large carcasses at higher altitudes because they are able to cover a wider area in this way. Thus, Turkey Vultures may search in larger groups at higher altitudes in the forest of La Michilía because more profitable larger carcasses are available than in the desert of Mapimí, where a low flight is the most efficient method for finding small and medium carcasses.

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LITERATURE CITED

- ALVAREZ, F., L. ARIAS DE REYNA, AND F. HIRALDO. 1976. Interactions among avian scavengers in southern Spain. *Ornis Scand.* 7:215–226.
- ATTWELL, R. I. G. 1963. Some observations on feeding habits, behaviour and inter-relationships of northern Rhodesian vultures. *Ostrich* 34:235–247.
- BANG, B. G. 1964. The nasal organs of the Black and Turkey vultures: a comparative study of the cathartidae species *Coragyps atratus* and *Cathartes aura septentrionalis* (with notes on *Cathartes aura falklandia*, *Pseudogyps bengalensis* and *Neophron percnopterus*). *J. Morphol.* 115:153–184.
- BROWN, L. AND D. AMADON. 1968. Eagles, hawks and falcons of the world. McGraw-Hill, New York, New York.
- COLEMAN, J. S. AND J. D. FRASER. 1987. Food habits of Black and Turkey vultures in Pennsylvania and Maryland. *J. Wildl. Manage.* 51:733–739.
- EZCURRA, E. AND S. GALLINA. 1981. Biology and population dynamics of white-tailed deer in Northwestern Mexico. Pp. 77–108 in *Deer biology, habitat requirements and management in western North America* (P. F. Pfolliott and S. Gallina, eds.). Publ. Inst. Ecología 9, México.
- HIRALDO, F., M. DELIBES, AND J. A. DONAZAR. 1991. Comparison of diets of Turkey Vultures in three regions of northern Mexico. *J. Field Ornithol.* 62:319–324.
- HOUSTON, D. C. 1974. Food searching in Griffon Vultures. *East Afr. Wildl. J.* 12:63–77.
- . 1979. The adaptations of scavengers. Pp. 263–286 in *Serengeti dynamics of an ecosystem* (A. R. E. Sinclair and M. N. Griffiths, eds.). Univ. Chicago Press, Chicago, Illinois.
- . 1986. Scavenging efficiency of Turkey Vultures in tropical forest. *Condor* 88:318–323.
- . 1988. Competition for food between Neotropical vultures in forest. *Ibis* 130:402–417.
- KRUUK, H. 1967. Competition for food between vultures in East Africa. *Ardea* 55:171–193.
- PRIOR, K. A. 1990. Turkey Vulture food habits in southern Ontario. *Wilson Bull.* 102:706–710.
- RABENOLD, P. P. 1983. The communal roost in Black and Turkey vultures—an information center? Pp. 303–321 in *Vulture biology and management* (S. R. Wilbur and J. A. Jackson, eds.). Univ. California Press, Berkeley, California.
- RODRÍGUEZ-ESTRELLA, R. 1986. Los vertebrados carroñeros de un bosque de encino-pino: comportamiento alimentario e interacciones. Bachelor's thesis, Escuela Nacional de Ciencias Biológicas, IPN, México.
- . 1993. Ecología trófica y reproductiva de seis especies de aves rapaces en la Reserva de la Biosfera de Mapimí, Mexico. Unpubl. M.Sc. thesis, Universidad Nacional Autónoma de México, México, D.F.
- STAGER, K. E. 1964. The role of olfaction in food location by Turkey Vulture (*Cathartes aura*). *Contr. Sci.* 81:1–63.
- STEWART, P. A. 1978. Behavioral interactions and niche separation in Black and Turkey vultures. *Living Bird* 17:79–84.

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