TEXAS J. SCI. 58(2):169-184 MAY, 2006

CHARACTERISTICS OF A RINGTAIL (*BASSARISCUS ASTUTUS*) POPULATION IN TRANS PECOS, TEXAS.

Betty K. Ackerson* and Louis A. Harveson
Department of Natural Resource Management, Box C-16
Sul Ross State University, Alpine, Texas 79832
**Present address:*
USGS-Patuxent Wildlife Research Center, Beltsville Laboratory
% BARC-East, Building 308, 10300 Baltimore Avenue
Beltsville, Maryland 20705

Abstract.–Despite the common occurrence of ringtails (*Bassariscus astutus*) few studies have been conducted to assess population characteristics. The objectives of this study were to determine (1) habitat selection, (2) home range, (3) denning characteristics, and (4) food habits of ringtails in the Trans Pecos region of west Texas. Seventeen ringtails were captured between November 1999 and January 2001 using Havahart live box traps. Second- and third-order habitat selection was determined for a ringtail population using range sites, slope, elevation, and vegetation communities. Diets were determined from volumetric scat analysis. The mean summer and winter range sizes (100% Minimum Convex Polygon [MCP]) for ringtails (n = 5) were 0.28 ± 0.163 km^2 and 0.63 ± 0.219 km^2, respectively. Overlap between ringtail ranges averaged 33.3%. Ringtails preferred catclaw (*Mimosa biuncifera*), persimmon (*Diospyros texana*), oak (*Quercus* sp.) bottom and catclaw/goldeneye (*Viguiera stenoloba*), sideoats (*Bouteloua curtipendula*) slope communities. Rock dens were used exclusively by ringtails, with 80.6% of dens found on slopes between 30-60%. Plant (seeds and miscellaneous vegetation) and animal material were found in 74.6 and 86.6% of scats, respectively. Findings suggest that ringtails in Trans Pecos, Texas, are an important component of the ecosystem and that management practices should conserve canyon habitats and adjacent slopes for ringtails.

The ringtail is a common meso-carnivore in the southwestern United States and plays an important role in the ecosystem. Despite the common occurrence of this species, few studies have been conducted investigating its ecology. Many studies have focused on dietary information (Wood 1954; Toweill & Teer 1977; Trapp 1978; Alexander et al. 1994; Rodriguez-Estrella et al. 2000) and a few studies have focused on movements and activity patterns (Toweill 1976; Trapp 1978; Callas 1987; Yarchin 1994). However, little information exists on the ecology of ringtails in the Chihuahuan Desert. The purpose of this study was to describe ringtail ecology in the Trans Pecos eco-region of Texas. The

specific objectives of this study were to determine (1) habitat selection, (2) seasonal range size, (3) denning characteristics, and (4) food habits of ringtails in the Trans Pecos, Texas.

STUDY AREA

This study was conducted on the Elephant Mountain Wildlife Management Area (WMA) located 41.9 km south of Alpine, Brewster County, Texas. Elephant Mountain WMA lies in the south-central portion of the Trans Pecos ecoregion. The topography of the study area consisted of a single igneous mountain (Elephant Mountain, 1,891 m elev.) with numerous canyons and washes. Average annual temperature from 1961-1990 for the Alpine, Texas region was 18.4ºC. Average annual precipitation was 40.8 cm, with the majority of the precipitation occurring from June to September. Most precipitation was in the form of rain (USDA-NRCS 2000).

Elephant Mountain WMA lies between the Chihuahuan desert scrub and the desert grasslands, giving a mixture of vegetation types. Typical plants include creosotebush (*Larrea tridentata*), lechuguilla (*Agave lechuguilla*), sotol (*Dasylirion* sp.), yucca (*Yucca* sp.), mariola (*Parthenium incanum*), and low native grasses. Ackerson (2001) lists a variety of fauna that can be found on Elephant Mountain WMA, including potential ringtail predators and competitors (e.g., coyote [*Canus latrans*], bobcat [*Lynx rufus*] gray fox [*Urocyon cinereoargenteus*], raccoon [*Procyon lotor*], striped skunk [*Mephitis mephitis*], and great-horned owl [*Bubo virginianus*]).

MATERIALS AND METHODS

Trapping was conducted for 15 mo beginning in November 1999 by placing an average of eight Havahart live box traps (107 by 38 by 38 cm and 81 by 25 by 31 cm; Woodstream, Lititz, PA) 50 m apart in shaded areas where physical evidence suggested ringtail presence. Traps were baited with canned fish, set for six days, and

checked daily. Sampling effort was not equal for all months with most sampling occurring from November through March. No trapping was conducted from August through October 2000. Upon capture, ringtails were removed from traps and administered 0.07 cc tiletamine hydrochloride/zolazepam hydrochloride (Telazol®)/kg of body mass. Ringtails were observed until they recovered from sedation. Radiocollars with mortality sensors (Model 5902, Advanced Telemetry Systems, Isanti, MI) weighing 25 g were attached to ringtails. Sex and age class were determined for each individual. Then each individual was ear-tagged (Style 1005-4, National Band and Tag Co., Newport, KY), and various morphological measurements were taken. Ringtails were aged as juvenile or adult using crown-rump and ear and hindfoot length measurements (Richardson 1942; Toweill & Toweill 1978). All non-target species were released. All methods were approved by Sul Ross State University Animal Use and Care Committee.

Habitat selection.–A habitat map of Elephant Mountain WMA was produced using a digitized range site map (USDA-NRCS 1999) to determine second-order habitat selection (Samuel & Fuller 1996). Habitats around North Canyon and Double Windmill Canyon (core study area) of Elephant Mountain were further delineated using vegetation, elevation, and slope measurements (Ackerson 2001) for third-order habitat selection (Samuel & Fuller 1996). Vegetation characteristics were determined by delineating the communities using visual reconnaissance and a digital orthophoto quadrangle. Slope and elevation measurements were derived using a digital elevation model. A species list was then prepared for each community using the Braun-Blanquet method where each species within the community is assigned a rank (1-6) based on abundance and cover of the species (Smith 1996). Nomenclature of plants followed Hatch et al. (2001). Second- and third-order habitat selection was determined using simultaneous confidence intervals (Byers et al. 1984; Cherry 1998).

Seasonal ranges.–Ringtail locations were triangulated for radiocollared individuals at one randomly chosen time per day to determine seasonal ranges (Samuel & Fuller 1996). Coordinates of each ringtail location were determined and plotted on 7.5' USGS topographic maps. Seasonal ranges for each ringtail were determined using ArcView's Animal Movements Extension (Hooge & Eichenlaub 1997) using the minimum convex polygon estimator (100% Minimum Convex Polygon [MCP]); Mohr & Stumpf 1966) and adaptive kernel estimator (95%, 75%, and 50% ADK; Worton 1989). Data were separated into summer (April-September) and winter (January-March) seasons. Telemetry error was determined by triangulating and homing in on ringtail locations during daylight hours and using a global positioning system (GPS). The distance between the true and estimated locations was defined as the radial error.

Den characteristics.–Because ringtails are nocturnal, diurnal (day-use) sites were labeled den sites. Den sites were located by homing in on individuals during daylight hours (0800–1800 hrs) for four consecutive days to determine the number of consecutive days that dens were used. Dens were circled using telemetry equipment, flagged, and researchers then left the area to minimize disturbance. After ringtails left their den, measurements were taken including type of den, number of openings, size and direction of openings, internal size of den, vegetation, and slope. Den locations were marked using a GPS unit and imported into a GIS. Linear distance between consecutive den locations was measured in the GIS. Den use and characteristics were separated by seasons as defined prior. Rayleigh's test was used to determine if den openings were distributed uniformly around a circle (Zar 1999).

Food habits.–Ringtail scat was collected opportunistically, placed in plastic bags, marked with location and date, and frozen. Scat was determined to be ringtail based on size, smell, and location found (Elbroch 2003). In the lab, frozen scat was separated into categories (seed, arthropod, mammal, reptile, and other vegetation)

and the percent volume and frequency of each food category was determined. Scats were separated by the season they were collected. Reproductive season (15 March to 30 September) included breeding (March to April), parturition (May to June), and until the juveniles denned independently (September; Toweill 1976; Poglayen-Neuwall & Poglayen-Neuwall 1980). Non-reproductive season (1 October to 14 March) included the time when juveniles denned independently but remained in their maternal home ranges until the time of dispersal (Toweill 1976; Poglayen-Neuwall & Poglayen-Neuwall 1980). The difference in percent volume between seasons was determined using Mann-Whitney non-parametric test (Zar 1999).

Population characteristics.–Ringtail survival was determined using the Kaplan-Meier procedure with staggered entry (Pollock et al. 1989; White & Garrot 1990). Causes of mortality were determined by homing in on mortality signals. The immediate area was investigated for sign or cause of death and ringtails were necropsied to ascertain cause of death. A minimum population density was estimated using the minimum known number alive and applying that number to a buffer of 200 m on either side of the traplines (Ackerson 2001). Population size was estimated by extrapolating the number of animals based on canyon length and composition.

RESULTS

Trapping occurred for a total of 983 trap nights (trap night = one trap open for one night) with 5.2% capture success (17 new captures and 34 recaptures). Ringtail sex ratio (male:female) was 1:0.96 and age ratio (adult:juvenile) was 1:0.23. Ringtail weights ranged from 0.7-1.75 kg ($\bar{x}$ = 1.2 ± 0.36 kg, n = 17). Non-target animals included gray fox, striped skunk, hog-nosed skunk (*Conepatus mesoleucus*), western spotted skunk (*Spilogale gracilis*), raccoon, and rock squirrel (*Spermophilus variegates*).

Table 1. Classification of slope and elevation for vegetation associations at Elephant Mountain WMA, Brewster County, Texas, 2000-2001.

Vegetation Community	Abbreviation	Slope (%)	Elevation (m)
Mesquite/black grama flat	MBGF	0-5	1,320-1,415
Catclaw/persimmon/black grama draw	CPBD	0-8	1,320-1,415
Catclaw/whitebrush flat	CWF	0-3	1,320-1,415
Catclaw/persimmon/oak bottom	CPOB	8-16	1,415-1,705
Catclaw/goldeneye/black grama slope	CGBS	3-16	1,320-1,415
Catclaw/whitebrush/sideoats slope	CWSS	16-30	1,415-1,705
Adolphia/whitebrush/sideoats slope	AWSS	16-30	1,415-1,512
Catclaw/goldeneye/sideoats slope	CGSS	≥ 16	1,512-1,705
Scrub oak/adolphia/sideoats slope	SOASS	≥ 16	1,415-1,801
Mountain laurel/sideoats slope	MLSS	≥ 16	1,512-1,705

Habitat selection.–There was 101 locations recorded for five ringtails in North Canyon and Double Windmill Canyon. The other 12 captured ringtails either died or slipped their collar before a substantial number of locations could be obtained. In this area of interest on Elephant Mountain, four range sites were found, Igneous Hill Mountain/Mixed Prairie, Igneous Hill Mountain/Desert Grassland, Gravelly/Mixed Prairie, and Foothill Slope/Desert Grassland. Ringtails preferred the Igneous Hill Mountain/Desert Grassland range site, with all 101 locations falling in this range site. Ten vegetative communities with associated slope and elevation were identified in North Canyon and Double Windmill Canyon (Table 1). Catclaw/persimmon/oak bottom and catclaw/goldeneye/sideoats slope communities were preferred by ringtails, and mesquite/black grama flat and scrub oak/adolphia/sideoats slope communities were avoided (Figure 1).

Seasonal ranges.–Sample sizes of ringtails in winter and summer were too small to compare seasonal ranges. However, winter ranges were larger than summer ranges using 100% MCP and 95%, 75%, and 50% ADK (Table 2). Using telemetry and den locations the mean summer range size at 100% MCP was 0.28 ±

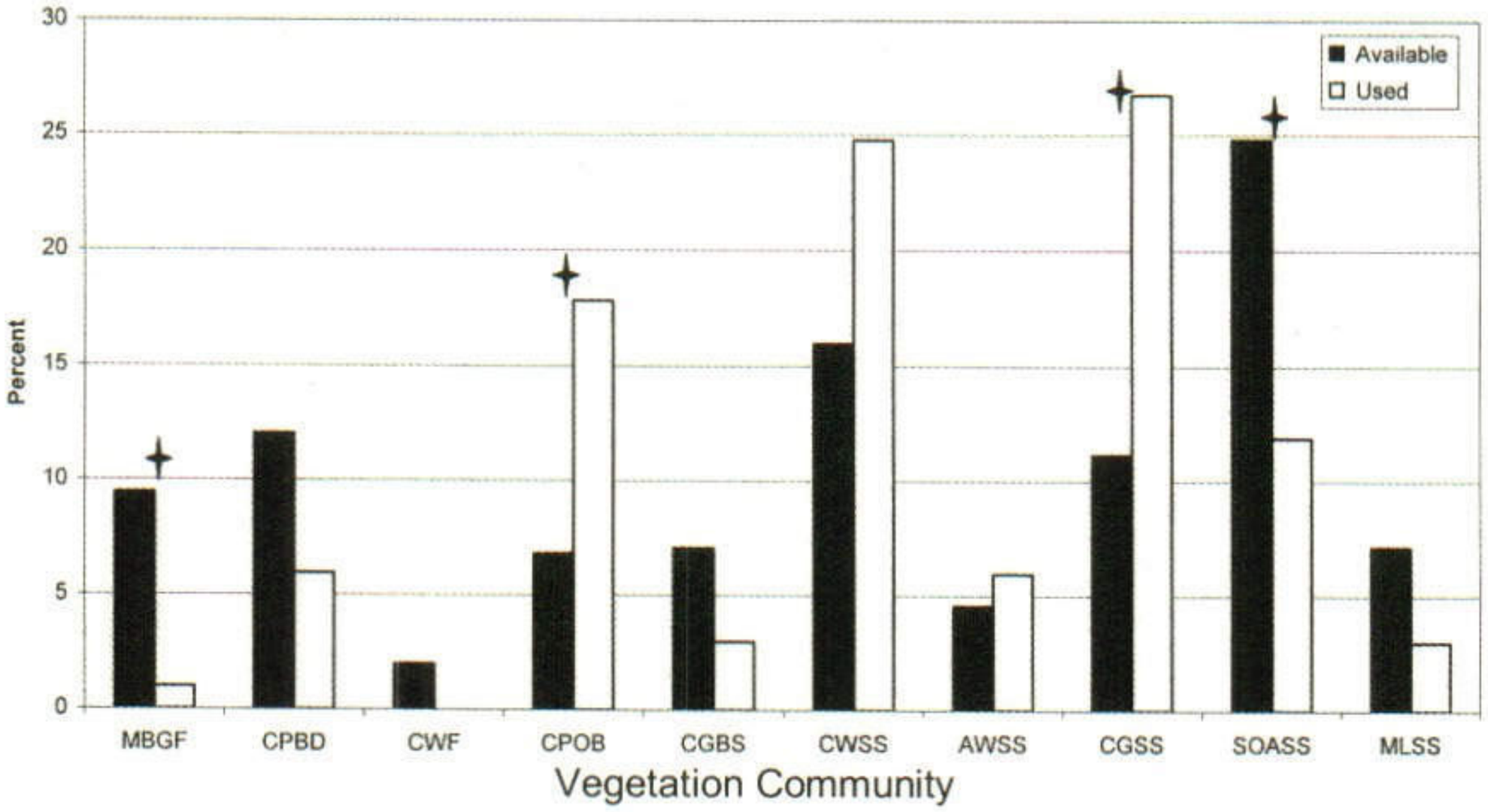

Fig. 1. Comparison between percent vegetation communities available and percent vegetation communities used within ringtail home ranges at Elephant Mountain WMA, Brewster County, Texas, 2000-2001. (✦ Indicates significant difference between use and availability; MBGF = mesquite/black grama flat, CPBD = catclaw/persimmon draw, CWF = catclaw/whitebrush flat, CPOB = catclaw/persimmon/oak bottom, CGBS = catclaw/goldeneye/black grama slope, CWSS = catclaw/whitebrush/sideoats slope, AWSS = adolphia/whitebrush/sideoats slope, CGSS = catclaw/goldeneye/sideoats slope, SOASS = scrub oak/adolphia/sideoats slope, MLSS = mountain laurel/sideoats slope).

0.163 km^2. The mean winter range size was 0.63 ± 0.219 km^2. Calculated telemetry error for 23 locations was 178.2 ± 129.22 m.

All ringtail ranges in North Canyon overlapped to some extent (range = 17.5-46.6%) (Table 3). Only two pair of ringtails had overlapping ranges in the same season. All ringtails in North Canyon shared a common area of overlapping ranges (0.06 km^2). Four vegetation communities (catclaw/persimmon/oak bottom, catclaw/whitebrush/sideoats slope, allthorn/whitebrush/sideoats slope, catclaw/goldeneye/sideoats slope), and two slope classes (16-30%, and 30-60%) occurred in this common area of overlap.

Den characteristics.–Measurements were taken from 40 different den sites that were located from April 2000-January 2001. Rock dens were the only type of den ringtails used at Elephant

Table 2. Seasonal range sizes (km^2) calculated for ringtails at Elephant Mountain WMA, Brewster County, Texas, 2000-2001.

Individual[a]	*n*	Season	MCP[b]	ADK[c]		
			100%	95%	75%	50%
F02	24	Summer	0.400	0.221	0.054	0.263
F03	23	Summer	0.335	0.548	0.122	0.061
F18	12	Summer	0.091	0.143	0.076	0.036
F21	20	Winter	0.784	0.912	0.309	0.092
M22	17	Winter	0.474	0.493	0.117	0.050

[a]F = female, M = male
[b]Minimum convex polygon
[c]Adaptive kernel

Table 3. Percent overlap of ringtail home ranges in North Canyon, Elephant Mountain WMA, Brewster County, Texas, 2000-2001.

Individuals[a]	Overlap Area (km^2)	Overlap (%)
F02.F03	0.171	46.56
F21-F02	0.187	31.51
F21-F03	0.233	41.58
M22.F02	0.096	21.96
M22-F03	0.113	17.53
M22-F21	0.249	39.65

[a]F = female, M = male

Mountain WMA. The mean length of stay in a den was 2.2 ± 4.62 days (range = 1-27 days). The mean distance traveled between consecutive dens was 186.4 ± 199.61 m (range = 0-580 m).

The mean area of den openings was 290 ± 245 cm^2 (range = 120-1,023 cm^2). The number of den openings per den ranged from 1-4 ($\bar{x}$ = 2.1 ± 0.75). For dens with multiple openings, the distance between den openings ranged from 6.5-102 cm ($\bar{x}$ = 79 ± 27.8 cm). Den openings were not distributed uniformly 360° ($\bar{x}$ = 243 ± 69.5°; r = 0.477; $P \leq 0.05$). Separating the den openings by canyon, both

North Canyon and Double Windmill Canyon dens were not distributed uniformly 360° ($\bar{x} = 265 \pm 41°$, $r = 0.78$, $P \leq 0.05$, and $\bar{x} = 155 \pm 62°$, $r = 0.56$, $P \leq 0.05$, respectively). The volume of ringtail dens ranged from 0.004-0.279 m^3 ($\bar{x} = 0.074 \pm 0.069$ m^3). The slope surrounding dens averaged 35.1 ± 11.8%, with 80.6% of ringtail dens occurring on slopes between 30-60%. Ringtail dens were located in six different vegetation communities, with dens primarily occurring in catclaw/persimmon/oak bottom and catclaw/goldeneye/sideoats slope communities.

Food habits.–Plant material in the form of seeds and miscellaneous vegetation was found in 50 of 67 scats, and animal material (mammals, arthropods, and reptiles) was found in 58 of 67 scats (Table 4). There was no difference in the percent volume of seed ($P = 0.776$) or miscellaneous vegetation ($P = 0.388$) in ringtail diets at Elephant Mountain WMA between seasons. Of the plants represented during the reproductive season, 52.2% of scats contained persimmon seeds. *Mahonia* sp., *Celtis* sp., *Juniperus* sp., *Ephedra* sp., *Sapindus* sp., and unidentified members of the Fabaceae and Cactaceae families were represented as seed in ringtail scats 47.3% of the time during the reproductive season. During the non-reproductive season all scats contained persimmon seeds, with only one other plant (a member of the Fabaceae family) occurring with a trace amount.

There was no difference in the percent volume of arthropods in ringtail diets at Elephant Mountain WMA between seasons ($P = 0.589$). During the reproductive season, arthropods (Coleoptera, Orthoptera, Neuroptera, Scorpionida, Lepidoptera, Spirobolida, and Dermaptera) accounted for 69.0% of the animal matter. Arthropods were represented by four orders (Coleoptera, Orthoptera, Scorpionida, and Neuroptera) during the non-reproductive season, accounting for 63.9% of the animal matter. There was no difference in the percent volume of mammals present in ringtail diets at Elephant Mountain WMA between seasons ($P = 0.862$). Sciuridae and Muridae families were represented as bones, hair, and other fragments in scats during the reproductive season accounting for

Table 4. Percent volume (V) and percent frequency of occurrence (F) of food categories found in 67 ringtail scats at Elephant Mountain WMA, Brewster County, Texas, 2000-2001.

	Season[a]					
	Reproductive (n = 32)		Non-reproductive (n = 12)		All seasons (n = 67)	
Food Category	V	F	V	F	V	F
Vegetation	50.9	72.2	64.6	88.9	50.5	74.6
Seed	40.9	72.2	43.1	100	35.9	76.1
Misc. vegetation	9.9	42.6	21.5	66.7	14.6	46.3
Animal	49.2	87.0	35.4	77.8	49.4	86.6
Mammal	14.3	42.6	13.3	22.2	21.9	38.8
Arthropod	34.6	55.6	22.1	88.9	27.3	62.7
Reptile	0.3	5.6	0.0	0.0	0.2	4.5

[a] Reproductive season was 15 March – 30 September and non-reproductive season was 1 October – 14 March (Toweill 1976).

37.9% of scats containing animal matter. Mammalian fragents were found in 30.0% of scats containing animal matter, with Muridae being the only family represented in mammals during the non-reproductive season. Reptiles (Eublepharidae and Iguanidae) were only found in the reproductive season in 10.4% of the scats.

Population characteristics.–Annual survival rate for ringtails at Elephant Mountain WMA was 0.191 ± 0.0990 (n = 17), with the majority of mortalities occurring in spring. Mortalities were recorded as avian (n = 3), mammalian (n = 3), and unknown (n = 1). No mortalities were within two weeks of sedation, indicating no capture-related mortalities. The minimum population density for ringtails in North Canyon and Double Windmill Canyon from November 1999-November 2000 was 5.9 ringtails/km^2. North Canyon had a higher density (6.25 ringtails/km^2) than Double Windmill Canyon (3.42 ringtails/km^2). Using density results and extrapolating to the canyon and draws of Elephant Mountain, the minimum population estimate on Elephant Mountain was 59 ringtails.

DISCUSSION

Sex and age composition of ringtails in this study were similar to Trapp (1978), Toweill (1976), Callas (1987), and Yarchin (1994). The mean weight and morphological measurements were similar to previously recorded data from other studies in Texas (Toweill 1976; Toweill & Toweill 1978; Kortlucke 1984).

Differences in range size reported by Trapp (1978), Toweill & Teer (1982), Lacy (1983), Yarchin (1994) and this study were probably attributed to the method used, topography of study area, or resource abundance and distribution. Range size in this study using 100% MCP were larger ($\bar{x}$ = 0.416 km^2) than reported by Toweill & Teer (1982) who relied on den locations only. In addition, central Texas has rolling hills, whereas Zion Canyon, Utah (Trapp 1978) or the canyons in west Texas have steep slopes that could create physical boundaries to ranges.

Both intersexual and intrasexual range overlap were found in this study, contrary to previous studies that found primarily intersexual range overlap (Toweill & Teer 1982; Lacy 1983). Even though ranges appear to overlap, some ringtail seasonal ranges did not overlap simultaneously. However, the two largest overlaps in ranges occurred when the ringtails were being monitored at the same time. One of these pair was a male and a female with overlapping ranges by 39.7%. Lacy (1983) found intersexual range overlap to be 51%. The largest overlap found in this study was between two females (46.6%). However, caution should be used when interpreting results from range overlap because of the small sample size in this study.

There was a common area of overlap that all radio-collared ringtails in North Canyon shared (0.06 km^2) dominated by catclaw/ persimmon/oak bottom and the catclaw/goldeneye/sideoats slope communities with 16-60% slope. These two communities seem to be important for ringtails, as indicated by habitat selection results where catclaw/persimmon/oak bottom and catclaw/goldeneye/ sideoats slope communities were preferred. Physical characteristics of the catclaw/ persimmon/oak bottom community appear to be similar to Yarchin's (1994) and Toweill & Teer's (1982) riparian areas. The catclaw/

goldeneye/sideoats slope community appears to be similar to Trapp's (1978) blackbrush community because of the type of vegetation, but also because of the steep, boulder-strewn slopes of the community. Ringtails preferentially denned in the catclaw/goldeneye/sideoats slope community that has steep slopes. It is possible that ringtails forage on the slopes and canyon bottoms, but prefer to den on the slopes only. Ringtails have special adaptations that could allow them to escape predators and forage on these slopes better than other species. Slopes of the canyons may also provide additional food resources such as ephedra, *Opuntia* sp., and mast producing trees (i.e., Fabaceae).

Unlike previous studies, ringtails at Elephant Mountain WMA used only rock dens, with most dens occurring on the slopes of the canyon. Trapp (1978), Toweill (1976), Yarchin (1994), Lacy (1983), and Callas (1987) found ringtails use a variety of den types including rock dens, brushpiles, and tree dens. At Elephant Mountain WMA the riparian areas have trees and brushpiles. However, these areas have frequent flashfloods and potential competitors (foxes and skunks) were relatively abundant and able to traverse this terrain easily. Flashfloods may make these areas more dangerous and the competition from other species may make riparian areas less profitable to ringtails. The slopes, on the other hand, have little to no trees and brushpiles, but do provide cliffs, rock outcrops, and crevices that provide protection from predators. In addition, ringtails may use rock dens to maximize thermoregulation as suggested by Toweill (1976), Callas (1987), and Yarchin (1994).

Ringtails at Elephant Mountain WMA rarely used the same den consecutively, with a mean stay of 2.17 days. Ringtails in central Texas (Toweill 1976), California (Callas 1987), and Arizona (Yarchin 1994) seldom used dens consecutively. Toweill (1976) found ringtails in central Texas to have an average den stay of 1.58 days for males and 2.25 days for females, and Callas (1987) found that California ringtails never denned in the same den consecutively.

The mean distance between den sites reported for this study was smaller ($\bar{x}$ = 186.36 m) than reported by Toweill (1976) ($\bar{x}$ = 306 m).

This disparity could be due to the method used to calculate the distance. In this study, the distance was measured between consecutive dens using a straight route with GIS software and included dens that were used consecutively (i.e., distance = 0 m). With this method, less activity by females would be able to be detected. Dens may be more available at Elephant Mountain than in central Texas, where Toweill (1976) conducted his study. Greater availability of dens may decrease the distance required between dens.

Ringtail dens at Elephant Mountain WMA typically had openings facing down slope, which may be important in inclement weather (e.g., rain). North Canyon generally runs north-south with slopes facing east or west. Almost all dens were located on the west-facing slope and faced in a southwestern direction. Ringtails may have chosen this slope because of less human presence, climatic reasons, or habitat differences. The vegetation communities were different on the eastern and western slopes, where catclaw/goldeneye/sideoats slope community located on the western-facing slope of North Canyon was selected by ringtails. Ringtails in Double Windmill Canyon showed a preference for the north-facing slope, which contains the catclaw/goldeneye/sideoats slope community. Collectively, there were 18 den locations found in the catclaw/goldeneye/sideoats slope community.

Ringtails at Elephant Mountain WMA consumed more plant material in the non-breeding season and more animal material in the breeding season. Their foraging habits mirrored seasonal availability of food (Ackerson 2001). Similar trends in ringtail diets have been noted in previous studies (Wood 1954; Toweill & Teer 1977; Trapp 1978).

The survival estimates at Elephant Mountain WMA may have been lower than the actual survival due to the addition of radio-collars. However, no survival rates on ringtails have been previously published for comparison. Opossum (*Didelphis virginiana*) in Kansas (Kamler & Gipson 2004) had annual survival rates (0.02-0.21) lower than those found in the present study for ringtails. Compared to raccoons in Kansas (0.58-0.88; Kamler & Gipson 2004) and Texas (0.79-0.81; Gehrt & Fritzell 1999) annual survival rates for Trans Pecos

ringtails were much lower. Ringtails use dens with very small den openings. The battery of the radiocollar may have protruded from the neck and handicapped ringtails entering dens. In this study, there were a large number of ringtail mortalities in the spring, corresponding to dispersal and the breeding season. This may have increased a ringtail's exposure to predators. The primary predators in our study appear to be similar to those reported by Poglayen-Neuwall and Toweill (1988) and included great-horned owl, and to a lesser extent coyotes, raccoons, and bobcats.

In this study, the density of ringtails was greater than most previously reported (Toweill & Teer 1977; Trapp 1978; Yarchin 1994). Only Lacy (1983) reported densities greater than that reported for this study. Whereas, the ringtail density in Double Windmill Canyon is comparable to other studies, the density of ringtails in North Canyon was high. This may suggest a greater availability of resources in North Canyon than in Double Windmill Canyon.

Ringtails are important components of the Trans Pecos ecosystem. They provide food for larger predators, may impact arthropod and small mammal populations, and aid in seed dispersal. The canyons found in the Trans Pecos are an important area for ringtails where they use the canyon bottoms and the slopes for food and dens. Therefore, management practices should conserve the vegetation and structure of the slopes and bottoms of canyon habitats. Elephant Mountain WMA contains artificial water sources at several locations to provide water for wildlife. Although it would seem this management activity might benefit ring-tails, data from Black Gap WMA suggests that they do not frequent these water sources (only 4.7% of photographs from remote cameras contained ringtails) (Foster 2002). Instead ringtails may use pothole water and springs throughout much of the year and drink from artificial water sources only in low rainfall months. The results of this study suggest several possibilities for future research. First, the possible effects of radio-collars on ringtails and other species of similar size and behavior should be addressed. Second, additional data on survival rates of ringtail in a range of vegetation and habitats types are needed. Finally, ringtail food habits need to be related to productivity of an area.

ACKNOWLEDGMENTS

We thank Texas Parks and Wildlife Department for providing access to Elephant Mountain WMA and C. E. Brewer, S. P. Lerich, and R. Culpepper for help with fieldwork. R. J. Kinucan and J. M. Mueller reviewed earlier drafts of this manuscript. Financial support was provided by the Sul Ross State University Research Enhancement Program.

LITERATURE CITED

Ackerson, B. K. 2001. Characteristic of a ringtail population at Elephant Mountain Wildlife Management Area, Texas. Unpubl. M. S. thesis, Sul Ross State Univ., Alpine, 52 pp.

Alexander, L. F., B. J. Ferts & T. P. Farrell. 1994. Diet of ringtails (*Bassariscus astutus*) in Oregon. Northwest. Nat., 75(3):97-101.

Byers, C. R., R. K. Steinhorst & P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manag., 48:1050-1053.

Callas, R. 1987. Ringtail (*Bassariscus astutus*) den and habitat use in Northwestern California. Unpubl. M.S. thesis, Humboldt State Univ., Humboldt, 71 pp.

Cherry, S. 1998. Statistical tests in publications of The Wildlife Society. Wildl. Soc. Bull., 26:947-953.

Elbroch, M. 2003. Mammal tracks and sign: A guide to North American species. Stackpole Books, Mechanicsburg, 779 pp.

Foster, J. A. 2002. Guzzler use and habitat selection by desert bighorn sheep at Black Gap Wildlife Management Area, Texas. Unpubl. M. S. thesis, Sul Ross State Univ., Alpine, 55 pp.

Gehrt, S. D. & E. K. Fritzell. 1999. Survivorship of a non-harvested raccoon population in South Texas. J. Wildl. Manag., 63:889-894.

Hatch, S. L., K. N. Gandhi & L. E. Brown. 2001. A checklist of the vascular plants of Texas. Texas Agricultural Experiment Station, Texas A&M Univ. System, College Station, 158 pp.

Hooge, P. N. & B. Eichenlaub. 1997. Animal movement extension to Arcview. Version 2.0. Alaska Biological Science Center, U. S. Geological Survey, Anchorage, Alaska.

Kamler, J. F. & P. S. Gipson. 2004. Survival and cause-specific mortality among furbearers in a protected area. Am. Midl. Nat., 151:27-34.

Kortlucke, S. M. 1984. Variation in *Bassariscus* (Mammalia:Procyonidae). Unpubl. Ph.D. dissertation, Univ. of Kansas, Kansas City, 207 pp.

Lacy, M. K. 1983. Home range size, intraspecific spacing, and habitat preference of ringtails (*Bassariscus astutus*) in a riparian forest in California. Unpubl. M.S. thesis, California State Univ., Sacramento, 64 pp.

Mohr, C. O. & W. A. Stumpf. 1966. Comparison of methods for calculating areas of animal activity. J. Wildl. Manag., 30:293-304.

Poglayen-Neuwall, I. & I. Poglayen-Neuwall. 1980. Gestation period and parturition of the ringtail, *Bassariscus astutus* (Lichtenstein, 1830). Z. Saugetierkd, 45(2):73-81.

Poglayen-Neuwall, I. & D. E. Toweill. 1988. *Bassariscus astutus*. Mamm. Species, 327:1-8.

Pollock, K. H., S. R. Winterstein, C. M. Bunck & P. D. Curtis. 1989. Survival analysis of telemetry studies: the staggered entry design. J. Wildl. Manag., 53:7-15.

Richardson, W. B. 1942. Ring-tailed cats (*Bassariscus astutus*): their growth and development. J. Mammal., 23:17-26.

Rodriguez-Estrella, R., A. R. Moreno & K. G. Tam. 2000. Spring diet of the endemic ring-tailed cat (*Bassariscus astutus insulicola*) population on an island in the Gulf of California, Mexico. J. Arid Environ., 44:241-246.

Samuel, M. D. & M. R. Fuller. 1996. Wildlife radiotelemetry. Pp. 370-418, *in* Research and management techniques for wildlife and habitats. 5th Ed. (T. A. Bookhout, ed.) The Wildlife Society, Bethesda, 740 pp.

Smith, R. L. 1996. Ecology and field biology. 5th Ed. Harper Collins College Publishers, New York, 740 pp.

Toweill, D. E. 1976. Movements of ringtails in Texas' Edwards Plateau Region. Unpubl. Ph.D. dissertation, Texas A&M, College Station, 76 pp.

Toweill, D. E. & J. G. Teer. 1977. Food habits of ringtails in the Edwards Plateau region of Texas. J. Mammal., 58(4):660-663.

Toweill, D. E. & J. G. Teer. 1982. Home range and den habits of Texas ringtails (*Bassariscus astutus flavus*). Pp. 1103-1120, *in* Worldwide Furbearer Conference (J. A. Chapman and D. Pursley, eds.), Frostburg, Maryland, 2056 pp.

Toweill, D. E. & D. B. Toweill. 1978. Growth and development of captive ringtails (*Bassariscus astutus flavus*). Carnivore, 1:46-53.

Trapp, G. R. 1978. Comparative behavioral ecology of the ringtail and gray fox in southwestern Utah. Carnivore, 1:3-32.

USDA-NRC. 1999. Digitized range site map of Elephant Mountain Wildlife Management Area. U.S. Department of Agriculture, Natural Resource Conservation Service, National Soil Survey Center, Lincoln Nebraska

USDA-NRC. 2000. Taps, Climate data. U.S. Department of Agriculture, Natural Resource Conservation Service, National Water and Climate Center, Portland, Oregon. ftp://ftp.wcc.nrcs.usda.gov/support/climate/taps/tx/48043.txt

White, G. C. & R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, 383 pp.

Wood, J. E. 1954. Food habits of furbearers of the upland post oak region in Texas. J. Mammal., 35(3):406-415.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology, 70:164-168.

Yarchin, J. C. 1994. Home range use by ringtails in a southwestern riparian area. Pp. 156-164, *in* Managing wildlife in the Southwest symposium. (P. R. Krausman, and N. S. Smith, eds.), 262 pp.

Zar, J. H. 1999. Biostatistical analysis. 4th Ed. Prentice Hall, Upper Saddle River, New Jersey, 663 pp.

BKA at: backerson@usgs.gov