

Diets of desert mule deer in altered habitats in the lower Sonoran Desert

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We conducted microhistological analyses of feces to identify diets of desert mule deer (*Odocoileus hemionus eremicus*) in four areas of central and western Sonora, Mexico, to evaluate seasonal variation in forage classes, and compare diets of mule deer and cattle in altered habitat with buffelgrass (*Cenchrus ciliaris*). For mule deer, we identified 96 plant species, 69 of which have not previously been reported as forage for this wild herbivore. From these species, 44 occurred in the mule deer diet $\geq 1\%$. Browse was the most important forage class consumed by mule deer at all study areas (77–88%). Forbs comprised an average of 5–10% of the diet of mule deer among all areas. Use of succulents was highly variable among areas, but chainfruit cholla (*Opuntia fulgida*) occurred consistently in all areas and most seasons. Grass species were consumed the least by desert mule deer throughout the areas and seasons. Buffelgrass was not important in diets of desert mule deer. Conversely, buffelgrass was the most important forage species for cattle. Also, two of the most important browse species (i.e., mesquite [*Prosopis juliflora*] and ironwood [*Olneya tesota*]) for mule deer were the most important browse species for cattle. Desert mule deer and cattle shared 45 forage species from central Sonora. However, biological overlap of diets occurred only for spring (Morisita coefficient = 0.67). Plant diversity in diets of mule deer was slightly different among areas and seasons. The Shannon-Wiener (H') index was different only between the area with higher precipitation and the area with lowest precipitation. Our data contribute to understanding the primary resources for desert mule deer in altered habitats of the Lower Sonoran Desert.

Key words: buffelgrass, cattle, diet diversity, diet overlap, Mexico, *Odocoileus hemionus eremicus*, Sonora

Desert mule deer (*Odocoileus hemionus eremicus*) inhabit the southwestern United States and northwestern Mexico (Heffelfinger 2000). Diets of desert mule deer have been described in the southwestern United States (Krausman et al. 1997) including California (Marshal et al. 2004), Arizona (Urness et al. 1971, McCulloch 1973, Anthony 1976, Anthony and Smith 1977, Short 1977, Krausman et al. 1989), New Mexico (Anderson et al. 1965, Boeker et al. 1972), and Texas (Krausman 1978, Leopold and Krausman 1987). However, diets of desert mule deer have not been described from the Sonoran Desert, Sonora, Mexico. The Plains of Sonora and the Central Gulf Coast subdivisions of the Sonoran Desert have distinctive biotic characteristics (Brown 1994). Furthermore, these regions have been overgrazed by cattle (Camou-Healy 1994) and transformed into pasture lands dominated by buffelgrass (*Cenchrus ciliaris*). The introduction of buffelgrass is one of the most visible landscape changes in the central Sonoran rangelands. This exotic was introduced in an effort to solve erosion problems and boost forage on cattle pastures. By the 1990s, buffelgrass stands covered 1.2–1.6 million ha of Sonoran rangeland (Yetman and Burquez 1994, Burquez-Montijo et al. 2002). The effects of buffelgrass on wildlife and native vegetation are unknown, although tentative suggestions have been made that the grass is not favorable to native wildlife (Bock and Bock 1988, Martin et al. 1998). Because these extensive buffelgrass stands likely influence forage for desert mule deer, we wanted to know if, and how, they did. Our objectives were to determine diets of desert mule deer from central and western Sonora, Mexico, and compare diets of desert mule deer and cattle in habitat with buffelgrass pastures.

MATERIALS AND METHODS

Study areas.—We conducted diet analyses in 4 areas of central and western Sonora, Mexico (Figure 1). Study Area 1 was on Rancho San Luis-CIPES, 54 km north of Hermosillo in the central region of Sonora, Mexico (29° 32' N, and 29° 35' N, 111° 01' W and 111° 08' W; CETENAL 1974). This area encompasses 20,500 ha of the Plains of Sonora Subdivision of the Sonoran Desert (Brown 1994). Approximately 5,600 ha (27%) were converted from native vegetation to buffelgrass. Elevations ranged from 450 to 550 m on flats and plains to 551 to 750 m in rough terrain (e. g., Sierra La Cobriza). Soils were recent alluvium, weathered from granitic rocks 2–6 m deep (Hendricks 1985). Average annual precipitation was 320 mm (Livestock Research Center State of Sonora 1989). Precipitation was bimodal; approximately 60% occurred between July and September, and 40% occurred between November and March. The remaining months were usually dry. Summer rainfall occurred as thunderstorms. Annual mean temperature was 23°C. Daytime temperatures averaged 34°C, but frequently exceeded 40°C during June through August. Night-time temperatures averaged 8°C in winter, and approached 0°C in December, January, and February.

Vegetation in Rancho San Luis was representative of the arbosuffrutescent desert-scrub in the Plains of Sonora Subdivision of the Sonoran Desert (Shreve and Wiggins 1964, Brown 1994). Shrubs and small to medium sized trees dominated overstory vegetation. Common species were ironwood (*Olneya tesota*), mesquite (*Prosopis juliflora*), paloverde (*Parkinsonia microphyllum*), bird-of-paradise (*Caesalpinia pumila*), brittle bush (*Encelia farinosa*), and snakewood (*Condalia* spp.) Understory vegetation was represented by perennials including woolly tidestromia (*Tidestromia lanuginosa*), milkweeds (*Euphorbia* spp.), and ambrosia (*Ambrosia* spp.), and grasses including false grama (*Bouteloua diversispicula*), spidergrass (*Aristida ternipes*), sixweeks threeawn (*Aristida adscensionis*),

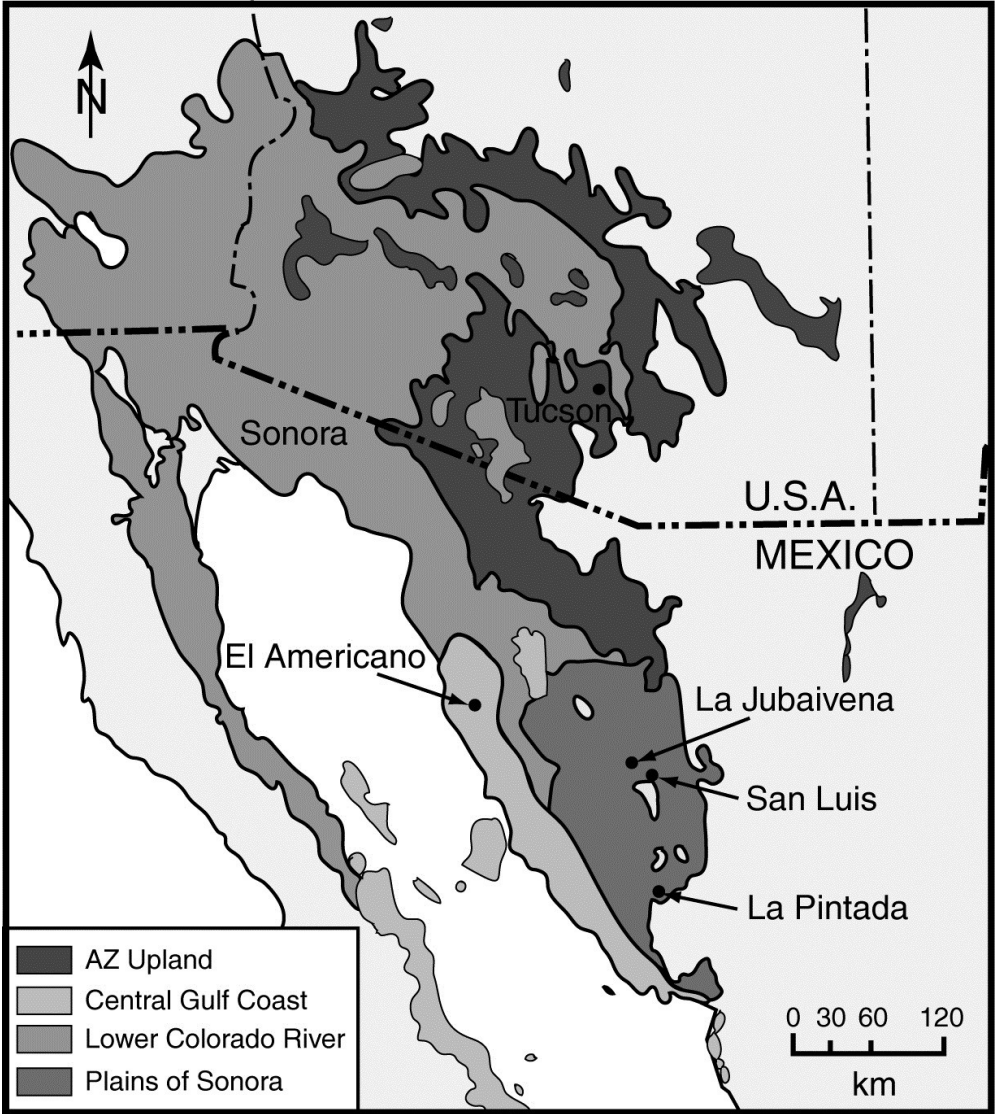


FIGURE 1.—Locations of areas in which diet composition of desert mule deer and cattle was investigated, Sonora, Mexico, 1991–2004.

false sideoats (*Bouteloua reflexa*), and bristlegrass (*Setaria macrostachya*). Cacti were present, but sparse. Common cacti were organ pipe cactus (*Stenocereus thurberi*), and chainfruit cholla (*Opuntia fulgida*). This area was used for cattle production and the condition of rangeland was considered good to excellent (Navarro et al. 1986).

Study Area 2 was on Rancho La Jubaivena and adjacent lands. This area was located 54 km north of Hermosillo and 14 km west of Study Area 1 in the central region of Sonora, Mexico (29° 34' N and 29° 41' N, 111° 12' W and 111° 18' W; CETENAL 1974). Elevations ranged from 500–650 m. Climate, soil, and vegetation were similar to Study Area 1. The core of the study area comprised 10,500 ha of native arbosuffrutescent scrub surrounded by buffelgrass pastures. This area has been overgrazed by cattle. Understory vegetation was very scarce, bare ground was common, and erosion was evident.

Study Area 3 was on Rancho La Pintada located 52 km south of Hermosillo, at the northwest base-plains of Sierra Libre, central Sonora, Mexico (28° 38' N and 28° 42' N, 110° 57' W and 111° 01' W). This area was located in the southern portion of the Plains of Sonora Subdivision of the Sonoran Desert. Native desert scrub has also been converted to buffelgrass pastures on >50% of the land. Average annual precipitation was 260 mm. Temperature regimes were 1–2°C warmer than area San Luis and area La Jubaivena. Common shrubs and tree species included ironwood, mesquite, paloverde, bird-of-paradise, brittle bush, sanjuanico (*Bonellia macrocarpa*), and catclaw mimosa (*Mimosa distachya* var. *laxiflora*). The cacti present were organpipe cactus, chainfruit cholla, teddybear cholla (*Opuntia bigelovii*), and barrel cactus (*Ferocactus* spp.). Herbaceous vegetation was scarce where native vegetation occurred.

Study Area 4 was on Rancho El Americano and its surrounding lands, 25 km north of Puerto Libertad, in Pitiquito, Sonora, (30° 00' N and 30° 17' N, 112° 17' W and 112° 43' W). This area encompassed 83,000 ha where physiognomic and vegetation characteristics represented two of the Subdivisions of the Sonoran Desert: Central Gulf Coast and Lower Colorado River Valley. The southern and western portions of the area of study were plains inclined to the sea that were part of the Central Gulf Coast Subdivision of the Sonoran Desert. The central and northern portions of area El Americano coastal plains merged into rough terrain and northern plains with characteristics of the Lower Colorado River Valley Subdivision (Shreve and Wiggins 1964, Brown 1994). Elevations ranged from 150–500 m in coastal plains and from 500–750 m in desert mountains (i.e., Sierra Aguirre and Sierra Picu). Precipitation was also bimodal with 70% of it occurring during summer. Average annual precipitation was 180 mm. Annual mean temperature was 23°C. Vegetation in coastal plains was characteristic of the sarcocaulous desert-scrub and vegetation in foothills and northern plains was microphyllous desert-scrub (Shreve and Wiggins 1964, Brown 1994). Common plants in the sarcocaulous area were elephant tree (*Bursera microphylla*), and lomboy bushes (*Jatropha cuneata* and *J. cinerea*). Also present were creosote bush (*Larrea tridentata*), burrobrush (*Ambrosia dumosa*), brittlebush with the cacti cardon (*Pachycereus pringlei*) and teddy bear cholla. Microphyllous desert in foothills and northern plains included creosote bush, ocotillo (*Fouquieria splendens*), blue paloverde (*Parkinsonia florida*), paloverde, burro bush, brittlebush, and lomboy bush. Common cacti were organpipe cactus, saguaro (*Carnegie gigantea*), barrelcactus and pencil cholla (*Opuntia arbuscula*). Riparian associations contained ironwood, mesquite, paloverde and catclaw acacia (*Senegalia greggii*). Buffelgrass was present but in lower proportions than in the other three areas. Small and localized areas converted to buffelgrass represented <2% of area El Americano. Cattle grazing was common year-round in all four areas; however, stocking rates were lower in area El Americano where rangeland offered a comparatively reduced amount of forage for cattle.

Large and medium-sized mammals other than mule deer and cattle present in all four areas included white-tailed deer (*Odocoileus virginianus*), collared peccary (*Pecari tajacu*), mountain lion (*Puma concolor*), coyote (*Canis latrans*), antelope jackrabbit (*Lepus alleni*), and desert cottontail (*Sylvilagus audubonii*). Feral burros (*Equus asinus*) and black-tailed jackrabbit (*Lepus californicus*) were also present in area El Americano.

We determined seasons for our study areas from bimodal precipitation and temperature regimes (Krausman 1985). The seasons were cold-wet (winter: January to March), hot-dry (spring: April to June), hot-wet (summer: July to September), and cold-dry (autumn: October to December).

Methods.—We determined diets of desert mule deer and diets of cattle using microhistological identification of plant epidermal fragments in fecal material (Sparks and Malechek 1968, Pena and Habib 1980, Vavra and Holechek 1980). In Study Area 1 (Rancho San Luis), diets were determined during 1991 and 1992. Mule deer fecal pellets were collected from 1,200 permanent plots distributed along 24 sampling transects with 50 plots. Each group of plots was separated by 20 m, forming a 1,000-m long line. Each group of plots consisted of two 8-m² circular plots placed 3 m apart at each side of the line. The center of each plot was marked with a permanent stake in the ground. A 1.6-m cord served as radius in defining the circular plot when sampling. We obtained cattle fecal samples from permanent plots placed on areas of major animal concentrations (e.g., watering, resting, salt licks). Cattle fecal plots were 20 m x 2 m and were marked at each corner with a 60-cm wooden stake. Sampling plots were set in paddocks with native desert scrub and not intentionally seeded with buffelgrass. However, buffelgrass had spread out naturally from contiguous seeded areas.

At the beginning of the study and previous to the collection period, all pellet plots were cleared of existing fecal material. Collection of fecal samples was initiated in January 1991 and completed in December 1992. All fecal droppings present in mule deer and cattle plots were collected every month during the study. Every pellet group from mule deer was treated as an individual sample. A portion (50–70 g) of collected cattle dung was considered as an individual sample.

We prepared composite fecal samples by month using 5 pellets from 5 to 12 individual samples for mule deer and 10 g of fecal material from 5 individual samples for cattle. We then prepared a pooled sample/animal species, season, and year.

In areas 2, 3, and 4 (Ranches La Jubaivena, La Pintada, El Americano) we collected pellets of mule deer in 2002, 2003, and 2004. We collected fresh fecal samples from each area from at least 18 pellet groups/month. We collected samples throughout the study area while conducting a radiotelemetry study of mule deer. For all 3 study areas we dried fecal samples at room temperature or in a forced-draft oven at 40°C for 72 hours and stored them in paper bags until analyses.

All microscopic analyses were conducted at the Range Management Laboratory of the CIPES Experimental Station (Centro de Investigaciones Pecuarias del Estado de Sonora A. C.), Carbo, Sonora. We prepared reference slides from plant material and slides from fecal samples for all areas using the method developed by Sparks and Malechek (1968) as described by Pena and Habib (1980) and Holechek (1982). We analyzed 5 slides for each year–season combination by examining 20 field slides under a compound phase-contrast binocular microscope (100 power; Sparks and Malechek 1968, Dearden et al. 1975, Todd and Hansen 1973, Gretchen and Dahl 1980). We computed the frequency for each plant species (Fracker and Brischle 1944) and converted them to relative particle density (Sparks

and Malechek 1968). We classified data as browse (e.g., parts from shrubs or trees), forbs (e.g., parts from herbaceous plants), grass (e.g., parts from Poaceae species), or succulents (e.g., cacti). The technician responsible for microhistological identification was experienced and was tested to ensure reliability (Holechek and Gross 1982, Krausman et al. 1989).

We used Morisita's similarity index (SI; Morisita 1959) as modified by Horn (1966) and presented by Krebs (1999) to quantify similarities of desert mule deer and cattle diets within seasons. We considered values of similarity ≥ 0.60 as biological overlap (Alcoze and Zimmerman 1973). We determined botanical diversity of mule deer diets for all study areas with the Shannon-Wiener index (H' ; Krebs 1999). We preferred the use of H' because this measure of heterogeneity is sensitive to the abundance of the rare species in a community (Hill 1973, Peet 1974). We generated a t -statistic for all possible paired comparisons among areas (annual diets) and seasons to test for differences in diversity indices. We tested diversity measures for differences ($P < 0.05$) by animal species, season, and years (Zar 1996).

RESULTS

Diets of Mule Deer.—Diets of mule deer at the four areas included 96 plant taxa: 45 browse, 33 forb, 12 grasses, and 6 succulents (Appendix I). In all study areas, at least 29% of plant species in the diet of mule deer only made up <1% of the diet: 29, 49, 51, and 58% for areas 1, 2, 3, and 4, respectively.

Browse was the most important forage class consumed by mule deer at all study areas (77%–88%; Appendix I). Browse species that contributed $\geq 10\%$ of the diet were mesquite, ironwood, *jojoba* (*Simmondsia chinensis*), bird-of-paradise, and fairy duster. Forbs comprised an average of 5 to 10% of the diet of mule deer from eight seasons among all four areas. *Moradia* (*Glandularia delticola*) was the only forb of 33 forb species that accounted for $\geq 5\%$ of the annual diet of mule deer.

Grass represented the smallest forage class consumed by mule deer in all areas. Combined grass species comprised <1 % of average annual diets in La Jubaivena and El Americano, 2% of diet in La Pintada, and 9% of diet in area San Luis.

Succulents were the most variable forage class in the diets of mule deer among the four areas. Succulent forage ranged from 2% in El Americano to 12% in La Pintada (Appendix I). Chainfruit cholla was the most consumed succulent species. This species occurred in diets in all areas and comprised between 6% and 10% of diets in San Luis, La Jubaivena, and La Pintada.

Diets of desert mule deer varied among areas, years, and seasons. In San Luis two species contributed >10% each and two species contributing 5–10% each, and comprised 59% of the annual diet of mule deer (Appendix II). In La Jubaivena (Appendix III) and La Pintada (Appendix IV) two species contributed >10% each, and 6 species contributed 5–10% each and made up 65 and 62% of the annual diet in those areas, respectively. In El Americano (Appendix V) *jojoba* accounted for >10% of the annual diet. *Jojoba* combined with 5 species that contributed 5–10% each made up >47% of the diet.

The seasonal contribution of browse was >75% for the majority of the seasonal diet in all areas. Forbs were more variable in the diet among season and areas. With the exception of autumn 1991 and 1992 in San Luis (Appendix II), forbs occurred in all seasons and areas of the study. The lowest variation in occurrence of forbs was in La Jubaivena with a seasonal average of 9% (Appendix III). Generally, forbs consumption increased

during or following a rainy season in summer or winter, when annual herbaceous plants appear. Occurrence of forbs was highest in autumn 2002 in El Americano (21%; Appendix V). The most commonly occurring forb species was moradia, which occurred (4–9%) in seven seasons in La Jubaivena (Appendix III) and in five seasons in La Pintada (Appendix IV). Prostrate sandmat (*Euphorbia prostrata*) had the highest occurrence (12%) in diets of mule deer for winter 2004 in El Americano; Appendix V).

Grasses occurred consistently in lower percentages of the mule deer diet throughout seasons in La Jubaivena, La Pintada, and El Americano (2002–2004; Appendices III–V). Moreover, grass species were <1% of the diet in all seasons at La Jubaivena and El Americano (Appendices III and V). However, use of grass species was different in San Luis (1991 to 1992; Appendix II). The use of grass forage was similarly low during spring and autumn (<1%) and winter ($\leq 4\%$). Contrarily, grass species comprised 45% and 19% (32% on average) in summers of 1991 and 1992, respectively. The highest seasonal percent of grass species were slender grama (*Bouteloua repens*; $\leq 12\%$), needle grama (*Bouteloua aristoides*; $\leq 10\%$), jungle rice (*Echinochloa colona*; $\leq 8\%$), and false sideoats (7%). Buffelgrass occurred in diets in San Luis ($\leq 5\%$), La Pintada ($\leq 3\%$), and La Jubaivena ($\leq 1\%$).

Succulent forage was used differently among areas and seasons. Mule deer consumed succulent species in all areas during all seasons. Highest seasonal average use of succulent species occurred in La Pintada (14%), followed by San Luis (10%), La Jubaivena (7%), and El Americano (3%). Occurrence of succulents was lowest during winter 2004 in El Americano (<1%; Appendix V), and highest during spring 2002 in La Pintada (28%; Appendix IV). The most used succulent species was chainfruit cholla ($\leq 26\%$) that occurred the most through the seasons in all areas.

Diets of Cattle.—Diets of cattle in the Rancho San Luis consisted mainly of grass, although browse was consumed year-round. We identified 57 plant species consumed by cattle: 20 browse, 22 forbs, 14 grasses, and 1 succulent species. However, 6 out of 20 browse species, 3 out of 22 forbs, and 11 out of 14 grasses contributed >1% of the average annual diet of cattle. Overall, grasses comprised 57% of the diet followed by browse (30%), forbs (9%), and succulents (4.5%; Appendix II). Grass and forbs comprised >65% of the annual cattle diet. Buffelgrass was the most important species in the cattle diet, accounting for 21% of the diet throughout the study. The highest use of buffelgrass occurred during summer (21–25%) and autumn (23–29%).

The highest use of browse occurred during spring, when the average (1991 and 1992) was 45%. The most commonly occurring browse in the diet of cattle was ironwood ($\leq 17\%$) and mesquite ($\leq 14\%$). Other browse species used by cattle were brittle bush (7%) and bird-of-paradise (5%).

Forbs comprised >9% of the cattle diet. The highest consumption of forb by cattle occurred during spring and summer. The most common forb species in cattle diets were flatsedge (*Cyperus* spp.; $\leq 2\%$), melon loco (*Apodanthera undulata*; $\leq 2\%$), and wild dwarf morning-glory (*Evolvulus arizonicus*; $\leq 1\%$).

Only one succulent (chainfruit cholla) occurred in the diet of cattle. With the exception of winter 1992 this species was used by cattle in all seasons. Highest occurrence of chainfruit cholla was in summer (5–6%) and autumn (2–7%).

Diet Overlap.—Mule deer and cattle used 77 of the same plant species in San Luis. However, only 45 plant species were used by both herbivores in at least 1 season. Overall there was no biological overlap of diets in San Luis (SI = 0.50). Morisita coefficients for

seasonal diets of mule deer and cattle were = 0.29, 0.67, 0.54, and 0.31 for winter, spring, summer, and autumn, respectively. Thus, overlap in diets of mule deer and cattle occurred only during spring.

Diet diversity.—Plant diversity in diets of mule deer was slightly different among areas and seasons. The Shannon-Wiener (H') diversity index was highest in El Americano (1.383), followed by La Pintada (1.341), La Jubaivena (1.284), and San Luis (1.217; Table 1). We generated a t -statistic for all possible paired comparisons among areas (annual diets) and seasons to test for differences in diversity indices. Statistical difference ($P < 0.05$) in diversity of mule deer diets was detected only between San Luis and El Americano. Diversity of cattle diet (1.327) was not statistically different than the diversity of mule deer diet (1.217) ($P > 0.05$) in San Luis.

TABLE 1.—Shannon-Wiener (H') diversity indices for diets of desert mule deer in central and western Sonora, Mexico 1991-1992 and 2002-2004. No statistical comparisons were made among areas within a single season.

	Study Areas			
	San Luis 1991-1992	La Jubaivena	La Pintada 2002-2004	El Americano
Annual Basis	1.2166* ^a	1.2841	1.3409	1.3834*
Winter	1.0454 a ^b	1.2211	1.3686 a	1.2441 a
Spring	1.0478 b	1.2596	1.1253 a b	1.3279
Summer	1.3502 abc	1.2530	1.3222 b	1.3127
Autumn	0.9638 c	1.1964	1.2454 a	1.3533 a

^a Asterisk indicates a difference ($P < 0.05$) between areas in annual diets.

^b Same literal indicates a difference ($P < 0.05$) between seasons for the same area.

Seasonal differences were detected in diet diversity of San Luis, La Pintada, and El Americano. Diversity of diets of desert mule deer in La Jubaivena and cattle in San Luis were not different ($P > 0.05$) among seasons. Summer and spring had the first or second most diverse index in the majority of areas with the exception of El Americano (Table 1). Diversity of mule deer diet for summer in San Luis was higher ($P < 0.05$) than for other seasons. Winter had the highest diversity of mule deer diet in La Pintada, where more differences were detected in paired comparisons between seasons. Conversely, autumn had the highest diversity in Rancho El Americano, where the only difference detected was between autumn and winter.

DISCUSSION

Ninety-six plant species were identified in diets of desert mule deer from central and western Sonora. Of the 96 species identified, 69 species have not previously been reported as forage for desert mule deer: 30 browse, 25 forbs, 11 grasses, and 3 succulents (Appendix I). From these species, 44 occurred in the diet $\geq 1\%$, in ≥ 1 season, and in ≥ 1 area of our studies (Appendices II–V).

Composition of the diets of desert mule deer varied among areas, seasons and years in Sonora, Mexico. Similar variation in diets of mule deer has been observed in other areas of desert mule deer range (Krausman et al. 1997, Marshal et al. 2004). Studies from southwestern United States have demonstrated that browse is the dominant forage consumed by desert mule deer (McCulloch 1973, Krausman et al. 1997, Marshal 2004). Our studies indicate that browse was similarly the most important forage for desert mule deer throughout central and western Sonora, Mexico. Variation in composition of diets is strongly related to the variation on the availability of resources in the habitat (Krausman et al. 1989).

Desert mule deer used higher amounts of forbs during spring and summer. Some researchers found that forbs may become the annually dominant forage during wet years (Anderson et al. 1965). Thus, the contribution of forbs to the diets of desert mule deer is highly variable throughout their range. Such variation is related to spatial and temporal variation in precipitation regimes (Peek and Krausman 1996, Krausman et al. 1997). In central and western Sonora, climate characteristics are similar to the rest of the desert mule deer range. Generally, the availability of annual plants and perennial plants increases following rainy seasons. In our study the consumption of forbs varied by seasons and areas, with a range from 0–21% in diets of desert mule deer. With the exception of Rancho San Luis, desert mule deer used forbs $\geq 1\%$ during all eight seasons in all areas. The highest use of forbs by desert mule deer coincided with occurrence of precipitation in summer for the Plains of Sonora and early autumn for the Central Gulf Coast.

According to Krausman et al. (1997), grasses rarely occurred $>1\%$ and never exceeded 7% of the seasonal diet of desert mule deer throughout their range in the southwestern United States. Results of our study are consistent with reports by Krausman et al. (1997) for most of the seasons and areas. However, higher percentage of grasses occurred in summer (32%) at Rancho San Luis. The grasses consumed by mule deer were mainly native species. Five native grasses comprised $>65\%$ of the total consumption of grasses throughout the year. The non-native buffelgrass comprised $\leq 5\%$ of the summer diet of desert mule deer, and accounted for $<1\%$ of the annual diet. Thus, desert mule deer did not generally use buffelgrass regardless of the high availability of this forage in the study area.

Large areas of central Sonora have been seriously overgrazed (Aguirre 1980). Consequently, poor herbaceous cover and extended bare-ground areas are very common (Navarro et al. 1986, Johnson 1990). During the period of study Rancho San Luis, in particular, had large areas with good cover and well-established native grasses. This is a distinctive characteristic of the Plains of Sonora rangelands in good condition. Most of the extensive level areas in the Plains of Sonora were formerly covered by summer-active root perennial grasses and are described as Sonoran savanna grassland (Brown 1994). Differences in availability of grasses may have caused the differentially higher consumption of grasses in Rancho San Luis, in comparison to the rest of the areas and to other areas of the desert mule deer range. Some researchers have reported high consumption of grass by other mule deer. For example, Hungerford (1974) reported that grasses made up 4–47% in summer diets of mule deer in the Kaibab Plateau of Arizona. Neff (1974) equally reported that grasses comprised $\geq 32\%$ of mule deer diets in Beaver Creek, northcentral Arizona. However, comparisons should consider that methods for diet determination were different than methods in our study. Therefore, consumption of grass in central Sonora is not conclusive and it is necessary to conduct more research to clarify differential use of forage under varied rangeland conditions. Studies should also consider previous research on the physiological adaptations of mule deer. It is been presumed that mule deer lack capability to

digest grasses because of their small rumen-to-body-weight ratio (Hanley 1982). Mubanga et al. (1985) reported that confined mule deer had digestive problems and limited forage intake when high proportions of grass were offered in the diet.

In a comparative view of diets between desert mule deer and cattle (using the same rangeland simultaneously in Rancho San Luis), browse was notably important for both herbivores. Although grass and forb forage classes together comprised >65% of the annual cattle diet, browse averaged 30% of seasonal diets. Similar use of browse by cattle was reported previously for a similar area in the same region (Velasquez-Caudillo 1997). Buffelgrass was the most important forage species in cattle diets. This exotic grass was highly used by cattle in the area of study. The highest use of this grass species occurred during summer and autumn. During these seasons, forage availability of buffelgrass increased due to favorable rain and temperature conditions. Seasonal use of forbs presented a similar tendency in the diet of both herbivores. Forbs comprised the lowest used foods by mule deer and cattle. This tendency is likely a response to a proportionally lower availability of forage from these plants. Browse, the most important forage class in the desert mule deer diet, was not the most important in cattle diet. However, the two most important browse species for mule deer were also the most important browse species for cattle (i.e., ironwood and mesquite). Similar to desert mule deer, cattle used succulents during all seasons in Rancho San Luis, but chainfruit cholla was the only succulent used by cattle, ranging from 3–5% of their diet.

Desert mule deer and cattle shared 45 forage species from central Sonora. However, biological overlap occurred only for the spring season. The diets of desert mule deer in central and western Sonora were highly diverse. Shannon-Wiener indices confirmed that desert mule deer adjust spatially and temporally to differences in availability of forage resources. There was a gradient in diversity of diets of desert mule deer that related to the gradient of precipitation. Diversity of diets increased as amount of rain decreased among areas and seasons.

Desert mule deer use forage species that are widely distributed throughout their range and species that occur particularly in the Plains of Sonora and Central Gulf Coast Subdivisions of the Sonoran Desert. Natural distinctive characteristics plus habitat alteration caused by extensive management for cattle in these regions require special consideration. Buffelgrass is widespread throughout the Plains of Sonora but this exotic grass is not highly used by desert mule deer. Moreover, the reduction of cover and browse from shrubs and trees in those altered habitat represents a challenge for wildlife managers and the conservation of desert mule deer in northwest Mexico. The identification of primary resources for desert mule deer and the relationships to each other is essential to enhance habitat conditions.

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APPENDIX I: PERCENT RELATIVE DENSITY OF PLANT SPECIES IN ANNUAL DIETS OF DESERT MULE DEER, CENTRAL AND WESTERN SONORA, MEXICO, 1991-1992 AND 2002-2004.

Species ^a	Areas and periods of study			
	1991-1992		2002-2004	
	San Luis Carbo	La Jubaivena Carbo	La Pintada Hermosillo	El Americano Pituquito
Browse (45 species)				
Indian mallow (<i>Abutilon abutiloides</i>) 1	<1			
Pringle's abutilon (<i>Abutilon incanum</i>)		<1	<1	<1
Whitehorns acacia (<i>Vachellia constricta</i>)		<1		
Sweet acacia (<i>Vachellia farnesiana</i> var. <i>farnesiana</i>) 1,2	2.0	2.3	<1	3.1
Catclaw acacia (<i>Stengalia greggii</i>) 1,2	<1			
Whitebrush (<i>Aloisia gratissima</i> var. <i>gratissima</i>) 1	<1			
Burr ragweed (<i>Ambrosia cordifolia</i>) 1	<1	<1		<1
Burrobush (<i>Ambrosia dumosa</i>)				<1
Aster (<i>Symphotrichum subulatum</i> var. <i>ligulatum</i>) 1,2	<1	<1	2.1	2.2
Vomitbush (<i>Atamisquea emarginata</i>) 1,2		2.5		1.1
Fourwing saltbush (<i>Atriplex canescens</i>)	<1	3.7		<1
Mule's fat (<i>Baccharis salicifolia</i>) 1	<1			
Chuparosa (<i>Justicia californica</i>) 1,2		5.9	2.4	7.5
Bursera (<i>Bursera laxiflora</i>) 1,2	3.2			
Elephant tree (<i>Bursera microphylla</i>) 1,2				2.6
Bird-of-paradise (<i>Caesalpinia pumila</i>) 1,2	3.4	7.9	11.9	2.1
Fairy duster (<i>Calliandra eriophylla</i>)		11.3	2.8	7.0
Spiny hackberry (<i>Celtis pallida</i>) 1,2	1.2		<1	
Blue paloverde (<i>Parkinsonia florida</i>)	1.4	<1	6.3	8.1
Paloverde (<i>Parkinsonia microphylla</i>)	10.0			
Rosary baby bonnets (<i>Coursetia glandulosa</i>) 1,2		2.8	3.0	3.9
Sonoran croton (<i>Croton sonorae</i>) 1,2	<1		1.2	
Coville's bundleflower (<i>Desmanthus covillei</i>) 1,2			<1	<1
Bundleflower (<i>Desmanthus palmeri</i>) 1,2	<1			
Brittle bush (<i>Encelia farinosa</i>)	4.2	2.2	<1	<1
Tahitian kidneywood (<i>Eysenhardtia orthocarpa</i>) 1,2	<1	<1	6.8	
Palo Adan (<i>Fouquieria macdougalii</i>) 1,2		<1	1.1	1.0
Ocotillo (<i>Fouquieria splendens</i>)	2.9			1.9
Guayacan (<i>Guajacum angustifolium</i>) 1,2	3.3	2.6	5.6	
Arizona rosemallow (<i>Hibiscus biseptus</i>)		1.4	1.3	3.9
<i>Ipomoea wolcottiana</i> 1	<1	<1		
Sangre de Cristo (<i>Jatropha cardiophylla</i>) 1,2	<1			5.4
White ratany (<i>Krameria grayi</i>)	<1	2.0	1.9	
Little leaf ratany (<i>Krameria erecta</i>)				6.3
Indian shrub verbena (<i>Lantana horrida</i>) 1,2	<1	4.7	3.5	<1
Water jacket (<i>Lycium andersoni</i>)	<1			
<i>Lycium californicum</i> 1			<1	
Catclaw mimosa (<i>Mimosa distachya</i> var. <i>laxiflora</i>) 1,2	<1	6.7	5.1	1.4
Ironwood (<i>Olneya tesota</i>)	15.0	8.1	6.2	4.8
Retama (<i>Parkinsonia aculeata</i>) 1,2	3.3	<1		
Mesquite mistletoe (<i>Phoradendron californicum</i>)	<1	<1	<1	
Mesquite (<i>Prosopis juliflora</i>)	24.0	13.8	11.0	3.6
Salvia (<i>Salvia humilis</i>) 1,2	<1	2.5	<1	4.1
Sage (<i>Salvia</i> sp.) 1,2			1.7	
Jojoba (<i>Simmondsia chinensis</i>)				13.4
TOTAL	76.6	83.0	76.8	87.9
No. species	30	26	25	26
Forbs (33 species)				
Careless weed (<i>Amaranthus palmeri</i>) 1,2	<1	<1	<1	<1
Crested anoda (<i>Anoda cristata</i>) 1			<1	
Melon loco (<i>Apodanthera undulata</i>) 1	<1			
Milkweed (<i>Asclepias</i> sp.) 1,2				2.4
Rush milkweed (<i>Asclepias subulata</i>) 1	<1			

APPENDIX I—CONTINUED

Species ^a	Areas and periods of study			
	1991-1992		2002-2004	
	San Luis Carbo	La Jubaivena Carbo	La Pintada Hermosillo	El Americano Pitiquito
<i>Asteraceae</i>		<1	<1	<1
Spiderling (<i>Boerhavia rosei</i>) 1	<1			
Paux persil (<i>Cardiospermum corindum</i>) 1	<1			
Coves' cassia (<i>Senna covesii</i>) 1		<1		<1
Goosefoot (<i>Chenopodium</i> sp.)				1.3
Whitemouth dayflower (<i>Commelina erecta</i>) 1,2	<1			
Low rattlebox (<i>Crotalaria pumila</i>) 1	<1			
Panamint cryptantha (<i>Cryptantha angustifolia</i>) 1,2		<1	<1	1.0
Flatsedge (<i>Cyperus</i> sp.) 1,2	<1			
Arizona foldwing (<i>Dicliptera resupinata</i>) 1,2	<1		1.2	
Desert silverbush (<i>Ditaxis claryana</i>) 1	<1			
False daisy (<i>Eclipta prostrata</i>) 1	<1			
California poppy (<i>Eschscholzia californica</i> ssp. <i>mexicana</i>) 1	<1			
Prostrate sandmat (<i>Euphorbia prostrata</i>) 1,2		<1	2.8	2.7
Perennial sandmat (<i>Euphorbia perennans</i>) 1,2				1.8
Wild dwarf morning-glory (<i>Evolvulus arizonicus</i>)	1.6			
Indigo (<i>Indigofera trita</i>)	<1			
Arizona poppy (<i>Kallstroemia grandiflora</i>)	<1			
Texas toadflax (<i>Nuttallanthus texanus</i>) 1	<1			
Annual monsterwort (<i>Parthenice mollis</i>) 1	<1			
Violet dock (<i>Rumex violascens</i>) 1,2	<1			
Spreading fanpetals (<i>Sida abutilifolia</i>) 1		<1		<1
London rocket (<i>Sisymbrium irio</i>)	<1		<1	
Coulter's globemallow (<i>Sphaeralcea coulteri</i>) 1	<1			
Woolly tidestromia (<i>Tidestromia lanuginosa</i>)	<1			
Moradia (<i>Verbena delticola</i>) 1,2		5.7	3.1	
Hillside vervain (<i>Glandularia delticola</i>) 1,2	<1			
Unidentified forb	<1		<1	
TOTAL	4.9	7.6	8.9	9.8
No. species	23	7	9	9
Grasses (12 species)				
Sixweeks threeawn (<i>Aristida adscensionis</i>) 1	<1		<1	<1
Spidergrass (<i>Aristida ternipes</i>) 1	<1		<1	<1
Niddle grama (<i>Bouteloua aristidoides</i>) 1,2	1.2		<1	
False sideoats (<i>Bouteloua reflexa</i>) 1,2	1.8			
Slender grama (<i>Bouteloua repens</i>) 1,2	1.1			
Rothrock's grama (<i>Bouteloua barbata</i> var. <i>rothrockii</i>) 1,2	<1	<1	<1	<1
False grama (<i>Bouteloua erecta</i>) 1,2	<1	<1	<1	<1
Buffelgrass (<i>Cenchrus ciliaris</i>) 1,2	<1	<1	<1	
Feather fingergrass (<i>Chloris virgata</i>) 1,2	1.0			
Jungle rice (<i>Echinochloa colona</i>) 1,2	1.2			
Mexican panicgrass (<i>Panicum capillare</i>) 1	<1			
Unidentified grass	<1			
TOTAL	8.9	0.17	1.90	0.2
No. species	12	3	6	4
Succulents (6 species)				
Barrel cactus (<i>Ferocactus cylindraceus</i> var. <i>cylindraceus</i>) 1		<1		<1
Organpipe cactus (<i>Lemaireocereus thurberi</i>) 1		<1	<1	<1
Chainfruit cholla (<i>Opuntia fulgida</i>)	9.6	5.6	9.2	1.7
Christmas cactus (<i>Opuntia leptocaulis</i>) 1,2		1.7		
Pricklypear (<i>Opuntia</i> sp.)			3.0	<1
Walkingstick cactus (<i>Opuntia spinosior</i>)		1.8		
TOTAL	9.6	9.2	12.4	2.1
No. species	1	5	3	4
Grand Total	100.0	100.0	100.0	100.0
Plants contributing ≥1%	19	20	22	25
Total No. species	66	40	43	43

^a1 = Species not previously reported as forage for desert mule deer.

2 = Occurred in the diet >1%, in >1 season, and in >1 area of our study.

APPENDIX II: PERCENT RELATIVE DENSITIES OF PLANT SPECIES IN SEASONAL DIETS OF DESERT MULE DEER AND CATTLE IN THE RANCHO SAN LUIS, CARBO, CENTRAL SONORA, MÉXICO, 1991-1992.

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	Mule deer	Cattle	Mule deer	Cattle	Mule deer	Cattle	Mule deer	Cattle
Browse (30 species)								
Indian mallow					0.2			
Sweet acacia	0.4				2.2	1.9	5.4	
Catclaw acacia		0.6	1.2	0.6	0.2		0.8	
Whitebrush					0.2			0.4
Burr ragweed					0.2			
Aster			0.2					
Fourwing saltbush			0.4					
Mule's fat			0.2					
Bursera	3.0	0.6	3.3	0.3	5.1	0.6	1.5	1.1
Bird-of-paradise	1.4	1.5	4.8	4.6	3.4		4.1	2.8
Spiny hackberry	4.5			3.3		3.4	0.4	0.2
Blue paloverde	1.1		1.0		1.5		1.9	
Paloverde	14.4	0.9	10.0	1.3	4.0	1.1	11.5	0.3
Sonoran croton					0.4			
Bundleflower	0.1	3.5				0.6		
Brittle bush	4.8	1.8	7.3	1.7	3.8	0.5	0.9	2.3
Tahitian kidneywood	0.3	0.3	0.3	0.9			0.6	
Ocotillo	5.7		1.7		2.4		1.7	0.2
Guayacan	2.1		1.9		1.6	1.2	7.4	0.8
<i>Ipomoea wolcattiana</i>			0.3	0.6		0.6		
Sangre de Cristo	0.4	0.6	2.2					
White ratany		0.3			0.2			
Indian shrub verbena		0.6	0.3			1.2		1.0
Water jacket			0.3	0.4			0.2	
Catclaw mimosa	0.1				1.0		0.4	
Ironwood	21.1	6.7	14.5	17.1	9.4	8.8	14.9	8.7
Retama	2.6		1.5		0.2		8.9	
Mesquite mistletoe	19.1	4.1	28.9	14.0	19.4	7.3	28.7	6.5
Mesquite					0.2	0.6		1.2
Salvia					0.2			
Total	81.1	21.4	80.1	44.8	55.7	27.6	89.5	25.6
No. species	16	12	19	11	20	12	16	12
Forbs (31 species)								
Careless weed		0.3			0.2	0.4		
Melon loco				4.7	0.4	1.9		0.6
Rush milkweed				0.3	0.2	0.2		
Spiderling	0.3							0.3
Paux persil			0.3					
Whitemouth dayflower	1.0				0.2			
Low rattlebox				0.7	0.2			
Flatsedge		0.6	1.0	2.2	1.5	5.5		0.5
Arizona foldwing			0.4					0.6
Desert silverbush			0.3					
<i>Cyperaceae</i>		0.9				0.5		1.7
False daisy			0.4		0.2			
California poppy					0.3			
Wild dwarf morning-glory		1.5	4.5	0.6	2.0	1.4		2.1
Goldenweed								
Slender goldenweed (<i>Xanthisma gracile</i>)						0.2		
Indigo			0.3		0.2			
Arizona poppy			0.3					
Texas toadflax	0.5			0.6	0.5			
Desert evening-primrose								
Desert evening primrose (<i>Oenothera primiveris</i>)				0.3				
Lineleaf whitepuff (<i>Oligomeris linifolia</i>)				0.3				0.6
Annual monsterwort			0.4			0.3		
Rockdaisy						0.4		

APPENDIX II—CONTINUED

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	Mule deer	Cattle	Mule deer	Cattle	Mule deer	Cattle	Mule deer	Cattle
<i>Ruellia intermedia</i>						0.4		
Violet dock	0.3	0.3		0.9	1.0			0.6
Spreading fanpetals						0.8		
London rocket	0.3			0.9				
Coulter's globemallow	0.3			0.6	0.2			
Woolly tidestromia					0.4			
<i>Tithonia</i> sp.						0.8		0.8
Hillside vervain			0.2		1.2			
Unidentified					0.2			
Total	2.6	3.5	8.1	12.3	8.8	12.6	0.0	7.8
No. species	6	5	10	11	16	12	0	9
Grasses (15 species)								
Sixweeks threeawn	0.3	6.5		2.1	0.7	0.3		1.0
Spidergrass	0.1	2.1	0.3		0.4	2.4		1.8
Niddle grama		1.7		3.9	4.8	2.1	0.2	0.8
False sideoats		11.2		4.0	3.9	3.3	0.1	6.8
Slender grama		8.8		2.1	7.0	4.8		5.4
Rothrock's grama	1.2	9.4		2.2	3.1	2.6		5.7
False grama		3.3		6.3	1.6	8.3		7.7
Buffelgrass	1.0	19.9		14.0	3.1	23.2		26.1
Feather fingergrass	0.3	3.0		0.4	2.2	1.1		3.1
Jungle rice		1.2		1.2	5.0	0.5		0.4
Canyon cupgrass								
southwest cupgrass (<i>Eriochloa lemmonii</i>)		0.3		0.2		0.3		1.0
mucronate sprangeltop		1.2				1.4		0.4
(<i>Leptochloa panicea</i> ssp. <i>brachiata</i>)								
Mexican panicgrass		0.9		1.9	0.2	1.4		0.7
Bristlegrass (<i>Setaria macrostachya</i>)		2.7				2.7		0.8
Unidentified grass	0.4							
Total	3.3	72.1	0.3	38.2	31.9	54.4	0.3	61.7
No. species	6	14	1	11	11	14	2	14
Succulents (1 species)								
Chainfruit cholla	13.0	2.9	11.6	4.6	3.6	5.4	10.3	5.0
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. species total	29	32	31	34	48	39	19	36

APPENDIX III: PERCENT RELATIVE DENSITIES OF PLANT SPECIES IN SEASONAL DIETS OF DESERT MULE DEER IN THE RANCHO LA JUBAIVENA, CARBO, CENTRAL SONORA, MEXICO, 2002-2004.

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Browse (26 species)								
Pringle's abutilon				0.4				
Whitehorns acacia		0.5			0.3			
Sweet acacia	1.6	0.9	2.4	4.7	1.4	4.7	2.0	0.3
Burr ragweed		0.3	1.8	0.8	1.2			
Aster							0.2	
Vomitbush	0.7	0.4			0.1	5.1	6.9	6.9
Fourwing saltbush		7.4	6.7	9.0	5.9	0.7		
Chuparosa	5.9	5.6	5.3	5.6	2.6	3.7	4.6	14.3
Bird-of-paradise	15.0	12.5	7.6	7.3	8.3	5.6	3.3	4.0
Fairy duster	14.5	11.6	11.2	8.6	11.6	8.1	10.2	14.5
Blue paloverde	0.4	0.4	0.3	0.5	0.7	0.6	0.9	0.3
Rosary baby bonnets	1.9	0.8	2.9	0.5	3.8	4.5	2.8	4.9
Brittle bush	0.5	0.6	0.8	0.9	0.7	1.6	1.4	10.7
Tahitian kidneywood	1.3		0.7	0.3	0.4	0.3	0.6	
Palo Adan	1.1	1.2	0.8	0.3	0.5	0.6	0.8	1.9
Guayacan	3.4	1.0	1.2	6.7	0.6	1.0	0.5	6.5
Arizona rosemallow	0.3	1.9	0.9	1.0	1.4	3.9	1.2	0.3
<i>Ipomoea wolcattiana</i>			0.9					
White ratany	1.6	1.5	3.9	1.9	2.0	4.2	0.8	
Indian shrub verbena	1.1	6.4	6.1	2.9	6.2	6.0	7.4	1.4
Catclaw mimosa	10.0	4.8	4.6	7.1	7.8	8.0	7.0	4.4
Ironwood		12.2	9.7	10.8	14.0	8.0	8.7	1.0
Retama	0.1			0.1				
Mesquite mistletoe						0.2	0.6	
Mesquite	15.0	9.8	12.8	14.6	11.2	15.0	20.3	11.7
Salvia	1.0	3.4	3.6	3.2	2.9	1.3	0.1	4.2
Total	75.5	83.1	84.0	87.2	83.5	83.1	80.4	87.4
No. species	18	20	20	21	21	20	20	16
Forbs (7 species)								
Careless weed	0.8	1.5	1.1	0.9	2.8	0.6		
Coves' cassia								0.2
Panamint cryptantha		0.4	0.5	0.3		2.6		
Prostrate sandmat	0.7	0.3		1.1	0.2	0.2		0.5
<i>Asteraceae</i>						0.2	0.6	0.1
Spreading fanpetals							0.1	
Moradia	0.7	4.0	7.4	4.9	9.0	7.9	6.8	4.5

APPENDIX III—CONTINUED

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Total	2.1	6.2	9.0	7.1	12.1	11.5	7.5	5.3
No. species	3	4	3	4	3	5	3	4
Grasses (3 species)								
Rothrock's grama		0.1	0.3	0.1	0.1	0.2		0.1
False grama				0.1	0.1			
Buffelgrass		0.1						
Total	0.0	0.3	0.3	0.2	0.2	0.2	0.0	0.1
No. species	0	2	1	2	2	1	0	1
Succulents (5 species)								
Barrel cactus				0.1				
Organpipe cactus				0.1				
Chainfruit cholla	16.0		5.7		3.9	3.8	10.4	4.7
Christmas cactus	6.3	0.4	1.0	0.4	0.3	1.4	1.7	2.5
Pricklypear		10.0		4.7				
Total	22.3	10.4	6.7	5.4	4.1	5.2	12.1	7.2
No. species	2	2	2	4	2	2	2	2
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. species total	23	28	26	31	28	28	25	23

APPENDIX IV: PERCENT RELATIVE DENSITIES OF PLANT SPECIES IN SEASONAL DIETS OF DESERT MULE DEER IN THE RANCHO LA PINTADA, CARBO, CENTRAL SONORA, MEXICO, 2002-2004.

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Browse (25 species)								
Pringle's abutilon							0.1	
Sweet acacia	0.1				2.0			
Aster	5.3	2.2		2.0	4.1		0.1	3.0
Chuparosa	4.6	4.1	0.2	0.2	3.8		1.3	4.8
Bird-of-paradise	8.7	5.1	12.8	14.8	10.1	9.4	16.8	17.5
Fairy duster	3.0	2.6	0.7		4.3	7.5	0.1	4.2
Spiny hackberry		4.9		0.7		1.8		
Blue paloverde	5.1	8.6	7.4	6.8	2.1	10.3	8.5	1.7
Rosary baby bonnets	2.6	1.2	4.0	5.1	3.4	1.8	4.0	1.6
Sonoran croton	1.4	2.8			0.4		3.0	1.9
Coville's bundleflower					2.4	0.7		
Brittle bush	1.7	1.5	1.1	0.2	0.5		0.7	0.1
Tahitian kidneywood	6.0	4.9	8.4	9.9	6.5	4.6	9.4	5.0
Palo Adan	1.4		1.9	1.7	1.7	0.9	1.3	0.3
Guayacan	7.5	4.9	2.5	6.0	8.0	5.7	7.9	2.5
Arizona rosemallow	3.5	0.6	1.1		0.7	0.2	0.8	3.7
White ratany	2.0	2.4	0.5		3.2	0.4	1.7	4.8
Indian shrub verbena	2.1	8.6	0.9	4.1	2.6	0.9	2.9	6.0
<i>Lycium californicum</i>							0.4	
Catclaw mimosa	5.3	4.1	0.5	5.5	7.6	8.5	3.8	5.5
Ironwood	9.2	10.0	7.2	1.7	5.4	3.6	8.5	3.7
Mesquite mistletoe	0.6	0.3					0.5	1.0
Mesquite	5.4	9.1	11.7	15.7	7.3	18.0	11.5	9.0
Salvia	0.5			0.4	1.1		0.5	0.3
Sage	0.3	4.7	0.7	2.9	3.6	0.9	0.3	0.1
Total	76.4	82.3	61.7	77.7	80.9	75.3	84.1	76.3
No. species	21	19	16	16	21	16	22	20
Forbs (9 species)								
Careless weed	1.6	0.3			1.8	0.9		0.1
Crested anoda				0.5				0.1
<i>Asteraceae</i>					0.1			
Panamint cryptantha	5.3						1.5	
Arizona foldwing					4.7	4.6		
Prostrate sandmat	2.6	0.5	9.4	0.4	3.4	4.6	1.5	0.3
London rocket	0.1							

APPENDIX IV—CONTINUED

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Moradia	4.6	4.4			6.5	5.5	3.7	
<i>Unidentified</i>	1.6				0.3			
Total	15.7	5.1	9.4	0.9	16.8	15.6	6.8	0.5
No. species	6	3	1	2	6	4	3	3
Grasses (6 species)								
Sixweeks threeawn	0.9	0.1			0.1			
Spidergrass						0.7	0.4	
Niddle grama	1.0	0.3	0.4	1.9	0.5			
Rothrock's grama						4.4	0.1	0.3
False grama			0.2			0.2	0.1	
Buffelgrass	2.7	0.3			0.1	0.2		0.3
Total	4.6	0.7	0.5	1.9	0.8	5.5	0.7	0.5
No. species	3	3	2	1	3	4	3	2
Succulents (3 species)								
Organpipe cactus			0.5	0.9				
Chainfruit cholla	1.4	11.8	26.3	12.9	0.6	3.6	8.0	9.0
Pricklypear	1.8		1.5	5.8	0.9		0.4	13.6
Total	3.3	11.8	28.3	19.6	1.6	3.6	8.4	22.6
No. species	2	1	3	3	2	1	2	2
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
No. species total	32	26	22	22	32	25	30	27

APPENDIX V: PERCENT RELATIVE DENSITIES OF PLANT SPECIES IN SEASONAL DIETS OF DESERT MULE DEER IN THE RANCHO EL AMERICANO, PITIQUITO, WESTERN SONORA, MEXICO, 2002-2004.

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Browse (26 species)								
Pringle's abutilon		0.3	1.0	1.8	0.2	1.1	1.1	1.0
Sweet acacia	0.9	5.0	5.2	2.0	5.2	3.3	1.8	1.0
Burr ragweed	1.5	0.1	0.2	1.0	0.7	0.4	1.7	0.7
Burrobush	2.0	1.7	4.9	8.0	5.4	1.0	7.2	0.8
Aster	3.2	3.9	1.1	1.6	1.2	1.9	2.0	2.6
Vomitbush	0.8	1.2	0.3	2.3	0.4	1.5	2.0	0.6
Fourwing saltbush		0.3	1.0	0.8	0.1	0.4	0.4	0.2
Chuparosa	6.7	7.1	5.8	5.6	6.8	11.0	5.8	10.9
Elephant tree	4.2	3.1		8.4	0.1	0.2	2.3	2.7
Bird-of-paradise		0.6	9.5		5.6	0.2	0.7	
Fairy duster	13.6	7.5	10.0	8.0	0.9	10.0	2.9	3.4
Blue paloverde	8.0	5.0	10.0	8.0	11.7	4.3	7.0	11.0
Rosary baby bonnets	8.0	5.0				10.0	0.2	7.9
Coville's bundleflower			0.8	1.2	1.5	0.5	0.9	
Brittle bush	3.2	0.8	0.3	0.2		0.3	1.0	0.3
Palo Adan	1.5		0.8	1.0	0.4	1.2	1.4	1.7
Ocotillo	0.3	0.8	0.6			5.0		8.1
Arizona rosemallow					5.9			
Sangre de Cristo	6.5	6.0	5.0	6.3	2.3	4.5	7.0	5.9
Little leaf ratany	7.3	9.2	10.0	2.3	8.0	3.0	6.8	4.0
Indian shrub verbena			0.6		2.6			
Catclaw mimosa	2.0	1.9	2.3	1.2	1.2	1.1	1.1	0.5
Ironwood	0.5	1.6	3.0	8.0	14.3	2.3	2.0	6.5
Mesquite	2.0	6.0	5.0	2.3	3.1	4.8	1.1	4.8
Salvia	0.9	1.5	3.3	3.5	5.2	9.9	6.2	2.5
Jojoba	16.7	15.3	7.2	15.7	8.0	17.8	14.5	11.9
Total	89.8	84.0	87.8	89.0	90.7	95.5	77.1	89.2
No. species	20	22	23	21	22	24	23	22
Forbs (9 species)								
Careless weed	0.0				0.0	0.0		
Milkweed	7.1	1.8	1.3	1.4	0.4	2.7	1.0	3.7
<i>Asteraceae</i>			0.2				1.1	
Coves' cassia	0.1	0.1	0.2	0.8	0.7		0.6	
Goosefoot				0.4		0.1	10.0	
Panamint cryptantha		0.5		1.4			6.0	0.2
Prostrate sandmat	0.7	1.1	9.1	0.8	1.1	1.3	0.3	0.3

APPENDIX V—CONTINUED

Species	Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sep)		Autumn (Oct-Dec)	
	2003	2004	2002	2003	2002	2003	2002	2003
Perennial sandmat	1.2	12.4	0.2	2.7	0.1		2.3	2.9
Spreading fanpetals					0.3			
Total	9.0	15.9	10.9	7.4	2.6	4.1	21.3	7.1
No. species	5	5	5	6	6	4	7	4
Grasses (4 species)								
Sixweeks threeawn	0.3						0.2	
Spidergrass	0.2							
Rothrock's grama								0.2
False grama				0.2	0.4		0.4	0.1
Total	0.5	0.0	0.0	0.2	0.4	0.0	0.5	0.3
No. species	2	0	0	1	1	0	2	2
Succulents (4 species)								
Barrel cactus				0.2	0.2	0.1		
Organpipe cactus		0.1			0.3	0.3		0.4
Chainfruit cholla	0.7		0.3	2.3	5.9		1.1	3.0
Pricklypear			1.0	1.0				
Total	0.7	0.1	1.3	3.5	6.4	0.4	1.1	3.4
No. species	1	1	2	3	3	2	1	2
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. species total	28	28	30	31	32	30	33	30