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Diets of desert mule deer

PAUL R. KRAUSMAN, AMY J. KUENZI, RICHARD C. ETCHBERGER, KURT R. RAUTENSTRAUCH, LEONARD L. ORDWAY, AND JOHN J. HERVERT

Authors are professor, Wildlife and Fisheries Science Program, University of Arizona, Tucson, Ariz.; graduate research assistant, Wildlife and Fisheries Science Program, University of Arizona, Tucson, Ariz.; assistant professor, Fisheries and Wildlife Department, Uintah Basin Branch Campus of Utah State University, Vernal, Ut.; research scientist, EEG consultants, Las Vegas, Nev.; field supervisor, Arizona Game and Fish Department, Mesa, Ariz.; and wildlife program manager, Arizona Game and Fish Department, Yuma, Ariz. At the time the research was conducted, Kuenzi, Etchberger, Rautenstrauch, Ordway, and Hervert, were graduate research assistants, Wildlife and Fisheries Program, University of Arizona, Tucson, Ariz.

Abstract

We studied the diets of desert mule deer (*Odocoileus hemionus crooki* Mearns) at 3 sites in Arizona and collated this information with that of previous diet studies of desert mule deer across their range in the United States. We documented 96 browse, 69 forb, 14 succulent, and 6 grass species that each constituted ≥ 1% of the diet during ≥ 1 season. The occurrence of individual plant species varied spatially and temporally. Changes in nutrient levels and climatic influence on relative availability and phenology of plant species likely influenced diet. Desert mule deer rely heavily on browse and forbes, which make up the majority of their diet (> 90%). Grasses and succulents were generally < 5% of the diet. Rangeland managers should strive to keep desert rangelands productive with a diversity of forage so animals have opportunities to exercise free choice of diet.

Key Words: Arizona, desert mule deer, diet, *Odocoileus hemionus crooki*

Resúmen

Estudiamos la dieta del venado bura del desierto (*Odocoileus hemionus crooki* Mearns) en tres sitios del estado de Arizona y cotejamos esta información con los estudios previos de dieta sobre esta especie, a lo largo de su rango de distribucion en los Estados Unidos. Nosotros registramos 96 plantas arbustivas, 69 especies de hierbas, 14 suculentas y 6 especies de pastos en donde cada una de estas categorías constituyó el 1% o más de la dieta durante una o más de las estaciones. La presencia de estas especies de plantas varió espacial y temporalmente. Los cambios en los niveles de nutrientes así como la influencia climática sobre la disponibilidad relativa y fenología de las plantas, pudieron haber influenciado la composición de la dieta. El venado bura depende grandemente de arbustos y hierbas, los cuales constituyen una gran parte de su dieta (> 90%). Los pastos y suculentas constituyeron menos del 5% de la dieta. Los manejadores de pastizales de ambientes desérticos deben de esforzarse por mantener las áreas de forrajeo en forma productiva y con una diversidad tal de forraje, que permita a los animales tener una dieta de elección libre.

Desert mule deer (*Odocoileus hemionus crooki* Mearns) are endemic to desert shrub and chaparral areas of the southwestern United States and northern Mexico (Wallmo 1981). In the United States their range extends from south of the Gila River, Arizona eastward into central New Mexico and the Texas Panhandle (Hoffmeister 1962). The abundance and distribution of a species within its range is influenced by environmental components necessary for existence including food (Litvaitis et al. 1994). We reviewed the diet studies of desert mule deer that have been conducted; most were confined to small areas and few plant species were found in the diet when compared to the number of plant species eaten throughout their range.

The objectives of our study were to provide new information on desert mule deer diets obtained from 3 sites in Arizona and to collate this information with existing information to obtain a comprehensive list of plant species eaten by desert mule deer in the United States. It is important to understand desert mule deer diets to enhance management practices.

Materials and Methods

We conducted diet studies in 3 areas of Arizona: King Valley, which lies within the boundaries of the Kofa National Wildlife Refuge, Yuma County; the Belmont Mountains, western Maricopa County; and the Picacho Mountains, Pinal County. Elevations in King Valley ranged from 1,000 to 1,500 m. Elevations in the Belmont Mountains ranged from 415 m in the lowlands to 1,042 m at Sugarloaf Mountain. Elevations in the Picacho Mountains ranged from 485 m in the surrounding flats to 1,374 m at Newman Peak. Annual precipitation is similar in the Belmont and Picacho mountains, averaging 20 and 22 cm, respectively, with much of the rain occurring during the July–September monsoon season and during winter (Sellers and Hill 1974). King Valley, on the northwest edge of desert mule deer range, is one of the hottest and driest regions inhabited by

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mule deer. The average annual precipitation is 11–17 cm (Sellers and Hill 1974).

The Belmont and Picacho mountain study areas are vegetated with plant species characteristic of Sonoran Desert scrub. Creosotebush (*Larrea tridentata* [D.C.]Coville) and triangle bursage (*Ambrosia deltoidea* Torr.) dominate large areas between dry washes. Dominant species within dry washes include blue palo verde (*Cercidium floridum* Benth.), ironwood (*Olneya testota* Gray), white brittle bush (*Encelia farinosa* Gray), wolfberry (*Lycium* spp.), and jojoba (*Simmondsia chinensis* [Link] Schneid). Most flora in the southern half of King Valley are restricted to washes. The uplands between washes are usually covered with desert pavement (i.e., a tightly packed layer of wind and water eroded pebbles) and only support sparse stands of creosotebush, white brittle bush, and white bursage (*Ambrosia dumosa* Gray). Larger washes have an overstory of ironwood and blue palo verde. The common understory species are cresotebush, wolfberry, globe mallow (*Sphaeralcea* spp.), and brittle bush (*Rautenstrauch* et al. 1988).

Diet Studies

We estimated diets of desert mule deer in each study area by micro-histological identification of plant epidermal fragments in fecal material (Sparks and Malechek 1968, Vavra and Holechek 1980). We collected a fresh composite fecal sample (≥ 10 pellets from ≥ 5 pellet groups) in the middle of the 4 seasons: winter (Jan.–Mar.); spring (Apr.–Jun.); summer (Jul.–Sep.); and autumn (Oct.–Dec.). Pellets were collected in the Belmont Mountains during January 1980 through December 1981, in the Picacho Mountains during January 1981 through September 1982, and in King Valley during September 1983 through June 1984. Pellet groups were stored in 70% ethyl alcohol until analyses were performed at the University of Arizona Forage Analysis Laboratory.

After the pellet groups were composited, 5 slides per composite were examined through a compound microscope set at 100X. We randomly selected 20 microscopic fields per slide that contained ≥ 7–10 identifiable particles. We computed frequencies for each plant species and converted them to particle density (Fracker and Brischle 1944). We obtained relative density by the equation of Sparks and Malechek (1968). The technician responsible for micro-histological identification of plant epidermal fragments in fecal material was experienced and tested to ensure reliability (Krausman et al. 1989). We classified plant species as browse (i.e., perennial shrubs), forb (i.e., annual, herbaceous plants), grass, or succulent (i.e., *Agave* spp., cactuses, or *Yucca* spp.). Plant names follow Lehr (1978) and Scott and Wasser (1980).

Literature Review

We reviewed the literature for quantitave studies of desert mule deer diets in the United States. We excluded references that contained statements of what desert mule deer eat based on general knowledge or casual observations. We included plant species in our summary if ≥ 1 study reported their contribution to the diet as ≥ 1% during ≥ 1 season. Because diet studies differ in a variety of ways including method of data collection, availability of plant species, and number of animals within the study area, we could not compare results in terms of direct numbers. Instead we categorized the quantities recorded into 3 groups: low (1–5% of the diet), medium (> 5–15% of the diet), and high use (> 15% of the diet).

Results

Diet Studies

Desert mule deer at the 3 study sites ate a variety of plants (Tables 1–3). In the Belmont Mountains, 29 plant species contributed ≥ 1% to the diet, followed by the Picacho Mountains (n = 23), and King Valley (n = 14). Many plant species in the diet made up ≤ 1% of the total diet: 29 species at Picacho Mountain, 24 at Belmont Mountain, and 14 at King Valley.

Overall, browse comprised the highest percent of the diet at all study sites (Tables 1–3). Important browse species included desert ironwood (King Valley and Belmont Mountains), jojoba (Picacho and Belmont mountains), janusia (*Janusia gracilis* Gray), wild buckwheat (*Eriogonum* spp.) (Picacho Mountains), and smoketree (*Dalea spinosa* Gray) (King Valley).

Diets varied seasonally at all study sites. Forb consumption increased and browse consumption decreased during winter and spring when forb production was high as a result of winter precipitation. Forb species during these seasons included lupine (*Lupinus* spp.) and paperflower (*Psilotrophe* spp.) at Picacho Mountain, filaree (*Erodium cicutarium* [L.]L'Her.) at King Valley, and pursh plantain (*Plantago purshii* R. & S.) in the Belmont Mountains. Combined succulent species comprised < 5% of the diet at all study sites. Grass also comprised a low percent of the diet at each site. However, Mediterranean grass (*Schismus barbatus* [L.] Thell.) and Bigelow's bluegrass (*Poa bigelovii* Vasey & Scribn.) comprised 5.7% of the diet in the Belmont Mountains during winter 1980 (Table 1).

Literature Review

Fourteen studies of desert mule deer diets were found that met our review criteria (Table 4). The methods of data collection for these studies fell into 3 categories: rumen analysis, fecal analysis, and feeding observations of wild deer. Most of the studies provided diet information on a seasonal basis. Because of the variety of ways in which seasons were defined (Table 4), we did not standardize seasons in our summary tables.

Ninety-two browse and 14 succulent plant species constituted ≥ 1% of the diet of desert mule deer throughout their range in the United States during ≥ 1 season (Table 5). The majority of these species (79%) were found in ≤ 2 studies. Range ratany (*Krameria parvifolia* Benth.) occurred in 7 studies and use levels varied seasonally from low to high. Jojoba and honey mesquite (*Prosopis glandulosa* Torr.) both were found in 6 studies. Catclaw (*Acacia greggii* Gray) occurred in 5 studies conducted in Arizona with levels of use ranging from low during winter and spring to low through high levels during summer and fall. Catclaw also was documented in an additional Arizona study at trace levels (< 1%). Another common browse species in Arizona is fairy duster (*Calliandra eriophylla* Benth.), which occurred at low to high levels in 4 studies and in trace amounts in 1 study. Use levels of fairy duster were high during summer and autumn. Other species that occurred in > 3 studies included true mountain mahogany (*Cercocarpus montanus* Raf.), wild buckwheat (*Eriogonum* spp.), Wright's buckwheat (*E. Wrightii* Torr.), janusia, juniper (*Juniperus* spp.), shrub live oak (*Quercus turbinella* Greene), and squaw bush (*Rhus trilobata* Nutt.)

Prickly pear cactus (*Opuntia* spp.) was the most common succulent, occurring in 7 studies. Use of this plant by deer was low

Table 1. Percent relative density of plant species in seasonal diets of desert mule deer in the Belmont Mountains, Arizona as determined by fecal composition analysis, 1980–82.

Species	Winter (Jan.-Mar.)			Spring (Apr.-Jun.)		Summer (Jul.-Sep.)		Autumn (Oct.-Dec.)	
	1980	1981	1982	1980	1981	1980	1981	1980	1981
	(%)								
Forb									
Astragalus spp.	0.5	0.8	1.0		0.5				0.1
Boraginaceae spp.	6.9	0.8	9.0	1.5	0.7			1.7	0.1
Chorizanthe rigida		0.2							
Eriastrum spp.	4.7			0.5					
Eriodum spp.	5.7	2.4	0.2	8.2	0.7	3.2	0.6	0.4	0.1
Eriogonum deflex				0.9					
Lesquerella gordoni		3.4	0.2						
Lotus spp.	0.2			1.2					
Lupinus spp.	0.6	4.8	0.2	6.6		35.9		0.4	
Menodora spp.						0.3			
Perityle emory	0.3			1.3					
Plantago insular					0.2				
Plantago purs	11.7	11.4	9.1	2.2					
Salazaria mexica		0.2							
Tidestromia languginosa							10.8		
Trixis californica	0.7	0.3							
Vicia spp.									0.1
Forb Total	31.3	24.3	19.7	22.4	2.1	39.4	13.1	2.5	0.4
Grass									
Bouteloua spp.							0.3		0.1
Bromus spp.		0.3							
Bromus rubens		0.4			0.2				
Festuca octoflora				0.3					
Poa bigelovii	1.0								
Schismus barbatus	4.7	0.6	0.8	2.0					
Grass Total	5.7	1.3	0.8	2.3	0.2		0.3		0.1
Browse									
Abutilon spp.									1.2
Acacia constricta	0.4								
Acacia gregii		13.7							
Ambrosia spp.	0.3			0.8		0.6			8.8
Ambrosia dumosa	0.3								
Argythamnia spp.	0.7			1.1	0.7	2.1	1.2	1.2	0.2
Atriplex spp.			0.3					0.4	
Cercidium floridum	3.3	1.9		0.5	1.5	3.3	4.5	7.6	
Cercidium microphyllum		0.3							
Cowania mexicana									0.1
Encelia farinosa	0.7		0.8						1.7
Ephedra spp.		0.1					0.3		
Eriogonum spp.		12.3	3.9						8.9
Eriogonum trichopes	0.4	0.3	0.3	0.5					
Eriogonum wrightii		2.7	0.7				0.6	0.4	0.9
Eurotia lanata								0.1	
Hibiscus denudatus	5.4	2.6		0.2		0.8			
Hyptis emoryi	1.5	4.2				6.1		0.3	9.5
Janusia gracilis			0.2		4.2	8.0	15.0	2.0	2.2
Krameria spp.			0.6		7.2		7.3		0.6
Krameria grayi		0.2		23		5.4		0.6	
Larrea tridentata	0.3		0.1						
Lycium spp. (desertthorn)									0.2
Lycium spp. (wolfberry)							0.3		
Olneya tesota	37.3	12.5	24.2	15.1	78.3	31.7	25.1	52.9	46.4
Prosopis glandulosa	0.2		0.3			1.5			0.3
Simmondsia chinesis	7.0	19.8	40.3	33.1	5.8	0.5	29.0	22.9	19.5
Sphaeralcea spp.			6.2				0.3		1.7
Viguiera parishii			0.4						0.4
Browse total	57.8	70.6	78.3	74.3	97.7	59.5	85.1	97.2	93.8
Succulents									
Opuntia spp.	1.2		0.4	0.8		0.9	0.9	0.3	4.8
Unknowns	4.0	4.2	0.4	0.2	0.0	0.2	0.6	0.0	0.9
Grand total	100.0	100.4	99.6	100.0	100.0	100.0	100.0	100.0	100.0
No. species	25	23	22	19	11	14	16	15	21

Table 2. Percent relative density of plant species in seasonal diets of desert mule deer in the Picacho Mountains, Arizona as determined by fecal composition analysis, 1981–82.

Species	Winter (Jan.-Mar.)		Spring (Apr.-Jun.)		Summer (Jul.-Sep.)		Autumn (Oct.-Dec.)
	1981	1982	1981	1982	1981	1982	1981
	(%)						
Forbs							
Acamptopappus sphaerocephalus				3.7			
Arabis spp.		0.1					
Astragalus spp.	2.7	1.0	2.0	6.4		0.3	
Baileya multiradiata			0.1				0.1
Boraginaceae spp.	5.2	15.2	0.3	11.9	0.5	0.4	0.1
Descurainia pinnata	0.4	0.3					
Erodium spp.	2.7	1.0	2.0	6.4		0.3	
Lupinus spp.	13.0	15.7	3.3	4.5		0.4	
Menodora spp.		0.2					
Plantago insularis				0.1			
Plantago purshii		0.7	1.3				
Psilotrophe spp.		18.6		0.1	0.3		0.1
Salazaria mexicana			0.1				
Tidestromia lanuginosa					0.4		
Vicia spp.			0.7				
Forb total	24.0	52.8	9.8	33.1	1.2	1.4	0.3
Grass							
Bouteloua spp.							
Bromus rubens	0.2	0.1	0.1	0.1			
Schismus barbatus			0.9	0.1			
Grass total	0.2	0.1	1.0	0.2			
Browse							
Abutilon spp.		0.1					0.7
Ambrosia dumosa			0.1	0.2	0.2		0.1
Argythamnia spp.	0.2	5.6	5.0	0.7	3.7	6.3	1.7
Artemisia spp.	0.6			0.4	0.8		1.4
Atriplex spp.	0.2						0.1
Calliandra eriophylla						0.3	0.3
Ceanothus spp.					1.2		0.3
Cercidium floridum				7.5			0.2
Encelia farinosa		0.1	0.3	1.8			0.5
Encelia frutescens		0.3		0.1			
Ephedra spp.					0.1	0.1	
Eriogonum spp.	10.9	11.1	16.9	14.8	1.7	2.3	5.0
Eriogonum inflatum		0.1					
Eriogonum wrightii	10.3	0.4	1.1		0.3	0.7	1.8
Erigeron spp.	0.2						
Hyptis emoryi	0.9	0.5			2.3		3.0
Janusia gracilis	1.1	3.5	35.4	5.0	71.1	52.0	26.6
Juniperus monosperma				0.4			
Krameria spp.		0.7	1.3	4.6	5.5	4.6	0.8
Krameria grayi			4.6				
Larrea tridentata			0.4				
Lycium spp. (desertthorn)				0.1			
Lycium spp. (wolfberry)							0.3
Olneya tesota		0.2		0.1			
Pellaea spp.							0.1
Prosopis glandulosa			0.6	0.2	1.3	3.1	5.5
Quercus spp.					0.1		
Rhus trilobata			0.1				
Simmondsia chinensis	34.4	15.1	23.3	28.3	8.0	28.5	28.3
Sphaeralcea spp.	17.0	8.2	0.5	0.1	0.5		20.3
Browse total	75.8	45.9	90.1	64.3	96.8	97.9	94.7
Succulents							
Cereus giganteus				0.1			
Mammillaria spp.				1.4		0.1	0.2
Opuntia spp.		0.4	0.5	0.9	1.9	0.6	2.8
Yucca spp.					0.1		
Succulent total		0.4	0.5	2.4	2.0	0.7	3.0
Unknowns	0.0	0.8	0.0	0.0	0.0	0.0	2.0
Grand total	100.0	100.0	101.4	100.0	100.0	100.0	100.0
No. species	16	25	23	27	19	15	23

Table 3. Percent relative density of plant species in seasonal diets of desert mule deer in King Valley, Arizona as determined by fecal composition analysis, September 1983–June 1984.

Species	Winter (Jan.–Mar.)	Spring (Apr.–Jun.)	Summer (Jul.–Sept.)	Autumn (Oct.–Dec.)
	(%)			
Forbs				
Astragalus spp.				0.2
Boraginaceae spp.	0.6	0.1	3.0	1.2
Erodium cicutarium	9.7	31.1	1.5	7.7
Euphorbia spp.	0.1			0.2
Lotus spp.	0.2			
Plantago insularis	23.2	1.9	1.5	4.3
Polygala macradenia				0.1
Salazaria mexicana	0.1			
Sphaeralcea spp.	0.5	0.3		0.4
Tidestromia lanuginosa	0.4			0.1
Unknown forb		0.1		
Forb total	34.8	33.5	6.0	14.2
Grass				
Bouteloua spp.		0.1		
Muhlenbergia spp.			1.5	
Schismus barbatus	0.1	0.2	1.5	0.4
Unknown grass		0.1		
Grass total	0.1	0.4	3.0	0.4
Browse				
Ambrosia dumosa	1.2	0.6		0.6
Cercidium spp.	0.1	4.5	8.0	2.6
Dalea spinosa	18.9	3.2	14.0	31.5
Encelia farinosa	0.1			0.1
Ephedra spp.	0.1			
Eriogonum spp.	1.1			
Hyptis emoryi		0.3		0.2
Janusia gracilis				0.1
Krameria parvifolia	1.6	19.4	4.5	0.4
Olneya tesota	40.8	35.9	49.0	44.1
Prosopis juliflora	0.4	1.6	8.5	1.2
Simmondsia chinensis	0.3	0.6	3.0	3.4
Browse total	64.6	66.1	87.0	84.2
Succulents				
Opuntia spp.	0.3		3.0	0.9
Unknowns	0.2	0.0	1.0	0.3
Grand total	100.0	100.0	100.0	100.0
No. Species	20	16	12	20

for most seasons, but use was documented at high and medium levels during spring and summer for ≥ 1 study. Other succulent species eaten by deer in ≥ 2 studies were Engelmann's prickly pear (*O. phaeacantha* Engelm.) (n = 5 studies) and lecheguilla agave (*Agave lecheguilla* Torr.), which was found in 3 of the 4 studies conducted in Texas.

Six grass and 69 forb species constituted ≥ 1% of the diet of desert mule deer during ≥ 1 season (Table 6). All of the grass species and 91% of the forb species occurred in ≤ 2 studies. Forb species documented in ≥ 2 studies included spurge (*Euphorbia.* spp.), lupine, fleabane (*Eriastrum* spp.), menodora (*Menodora* spp.), filaree, and borage (*Boraginaceae* spp.). In general, use of these species were higher during winter and spring.

Most species that comprised ≤ 1% of the diet for all seasons and studies (Table 7) may be of little importance in management considerations; however, they may contain important micronutrients. The role of micronutrients in the diet of desert mule deer needs further study.

Table 4. Summary of the location and type of data collected for desert mule deer diet studies.

State	Reference	Type of data[a]	Seasonal data	Seasons defined[b]
Arizona	Anthony (1976)	F	No	
Arizona	Anthony and Smith (1977)	F	4 seasons	1
Arizona	Krausman et al. (1989)	F	4 seasons	2
Arizona	Urness (1981:353)	R	Winter, spring	2
Arizona	McCulloch (1973)	R	4 seasons	2
Arizona	Short (1977)	R	4 seasons	3
Arizona	Truett (1971)	O	4 seasons	4
New Mexico	Boeker et al. (1972)	R	4 seasons	5
New Mexico	Anderson et al. (1965)	R	4 seasons	2
New Mexico	Snyder (1961)	R	No	
Texas	Krausman (1978)	R	4 seasons	1
Texas	Leopold and Krausman (1987)	F	4 seasons	1
Texas	Keller (1975)	R	4 seasons	6
Texas	Uzzell (1958)	R	Winter	5

[a]F = fecal pellet composition, R = rumen contents O = feeding observations.
[b]1 = winter (Nov.–Jan.), spring (Feb.–Apr.), summer (May–Jul.), late summer/autumn (Aug.–Oct.), 2 = winter (Jan.–Mar.), spring (Apr.–Jun.), summer (Jul.–Sep.), autumn (Oct.–Dec.), 3 = winter (Dec.–Feb.), spring (Apr.–May), summer (Aug.–Sep.), autumn (Oct.–Nov.), 4 = 1 Feb. –30 Apr., 1 May–15 Jul., 16 Jul.–15 Oct. 16 Oct.–31 Jan., 5 = timing of seasons undefined, 6 = winter (Dec.–Feb.), spring (Mar.–May), summer (Jun.–Aug.), autumn (Sep.–Nov.).

Discussion and Conclusions

Diets of desert mule deer varied among the 3 Arizona study sites, seasonally within years, and from year to year. Such variation is not uncommon; other desert mule deer diet studies have found similar patterns (Short 1977, Krausman 1978, Leopold and Krausman 1987). Diet composition likely varies as a result of climatic influence on relative availability and phenology of plant species (Hansen and McCulloch 1955). Anthony (1976) found that drought had an effect on desert mule deer diets in south-central Arizona and Anderson et al. (1965) reported that forbs were the dominant item in diets during wet years with browse dominant during dry years. Our study indicated that browse was the dominant forage consumed by desert mule deer throughout their range in the United States.

Changes in diet composition are likely influenced by changes in nutrient levels. Swank (1956) found that crude protein and phosphorous contents of most browse species in Arizona chaparral varied seasonally, increasing during seasons of active growth. Urness et al. (1971) analyzed seasonal diets of desert mule deer in central Arizona to estimate nutrient intake. They found that although diets varied seasonally, protein and phosphorous intake was constant year round. Browse was found not to supply protein in proportion to its consumption in mid winter and early spring but was equal to or exceeded consumption during the other seasons. Payton and Garner (1980) reported that nutrient levels of forages of desert mule deer in southwest Texas were highest following seasonal rains. This was also the case for forage in the Picacho Mountains and in King Valley. Krausman et al. (1990) and Rautenstrauch et al. (1988) found higher levels of protein in 12 of 19 plants sampled in the Picacho Mountains and 8 of 16 plants sampled in King Valley, during summer monsoons from July to October.

Table 5. Browse and succulents reported as food of desert mule deer.

Species	Winter	Spring	Summer	Autumn	Total	Reference[a]
Browse						
Acacia spp.		H[b]	L–M	L–M	L	5, 6, 1[c]
Acacia constricta	L		L	L	L	11, 13, 15[c]
Acacia greggii	L	L	L–H	L–M	L–M	2, 3, 9, 11, 13, 7[c]
Anisacanthus thurberi				L	L (Jan.–Jul.)	11, 13
Aplopappus laricifolius				L		9
Arctostaphylos pungens	H					10
Argythamnia spp.	M	L	L–M	L		15, 16
Artemisia spp.	L,H	L		L		10,16
Artemisia ludoviciana		M	L, M		L	1, 7, 13[c]
Berberis haematocarpa			L			1
Brickellia spp.				L		9
Brickellia multifolora					L (Jul.–Oct.)	13
Calliandra eriophylla	L, H	L–H	H	H	L, H	2, 3, 11, 13, 4[c]
Ceanothus spp.			L			16
Ceanothus greggii	L	L–H	M	M		7, 9, 10, 1[c]
Celtis reticulata	L	M	L	L	L–M	2, 3, 9[c]
Cercidium spp.		L	M	L		17, 7[c]
Cercidium floridum	L	L–M	L	M		9, 15, 16
Cercidium microphyllum					L (Feb.–Jul.)	13, 9[c], 15[c]
Cerococarpus betuloides	H	M–H	L	L–M		9, 10
Cercocarpus montanus	L–H	M		H	M–H	1, 4, 12, 13
Chilopsis linearis		L				11
Condalia lycioides					L (Jan.–Jul.)	13
Dalea spp.	L–M	M	M	M–H	L, H	5, 6
Dalea formosa		L	M		L (Jan.–Jul.)	5, 13, 1[c]
Dalea spinosa	H	L	M	H		17
Dasylirion leiophyllum	M					14
Ditaxis lanceolata	L			L		7
Dyssodia spp.				L		6
Encelia farinosa					L (Feb.–Apr.)	13, 16[c], 17[c]
Erigonum spp.	L–H	L–H	L	L–M		9, 10, 11, 15, 16, 17, 4[c]
Eriogonum trichopes			L			15
Eriogonum wrightii	M	L	L	L	L	2, 3, 7, 13, 15, 16
Eysenhardtia polystachya	H	M	H	L, H		2, 3, 11
Fallugia paradoxa	L	L				1, 12
Fendlera rupicola		M	L	L	L–M	2, 3
Fouquieria splendens		L			L–M	11, 13
Garrya spp.	M					1
Garrya wrightii	M	L			L	4, 10
Gaura spp.	L–M	L	L–M	L–M		8
Gutierrezia spp.	L			L		1, 7[c]
Gutierrezia sarothrae	M					5, 9[c]
Haplopappus laricifolius					L (Oct.–Jan.)	13
Hibiscus denudatus	L–M					15
Hyptis emoryi	L					7
Janusia gracilis	L	L	L–H	L–H	L–M (May–Jan.)	7, 8, 9, 13, 15, 16,17
Juglans spp.			L		L	1
Juniperus spp.	L, H	L–H		M	M	1, 4, 5, 10, 6[c]
Juniperus ashei	M–H					14
Juniperus deppeana	L, H			H		12
Juniperus monosperma					L–M	2, 13[c]
Krameria spp.		L–M	L–M			15, 16
Krameria grayi		L–H	M			15, 16
Krameria parvifolia	M	L–H	L–M	L, H	M–H	2, 3, 7, 8, 9, 13, 17
Leucophyllum spp.	L, H	H	M–H	M		8, 6[c]
Lotus rigidus	M				L (Feb.–Jul.)	9, 13
Lycium andersonii					L (Jul.–Oct.)	13
Mimosa biuncifera					L (Jan.–Jul.)	13, 9[c]
Mortonia scabralla					M (Jan.–Jul.)	13
Nolina spp.	L	L	L–M		L–M	1, 2, 3
Nolina erumpens			L			6
Nolina microcarpa					L (Jan.–Jul.)	13, 7[c]
Olneya tesota	H	H	M–H	M–H		7, 17, 13[c], 15[c], 16[c]
Ostrya knowltonii		L				1
Parthenium incanum	L–M	L–M	L–M	M–H		8
Phoradendron spp.					L	4, 1[c], 6[c]
Phoradendron californicum				L		9
Phoradendron villosum				L		9

Table 5. (Continued)

Species	Winter	Spring	Summer	Autumn	Total	Reference[a]
Pinus cembroides	L					14
Pinus edulis	L					1
Polygala macradencia	L	L	L	L		8, 17[c]
Porlieria angustifoli	L			M	L	6
Porophyllum gracile				L		9, 13
Prosopis glandulosa			L, H	L	L–M	5, 6, 15, 16
Prosopis juliflora	L, H	L	L, H	L	L–M	2, 3, 9, 11, 13, 17, 7[c]
Quercus emoryi	M	M	L	M	M	5
Quercus spp.					H	4, 16[c]
Quercus oblongifolia					L	2
Quercus turbinella	L, H	L	M–H	L	M (Jan.–Jul.)	7, 9, 10, 13
Quercus undulata	L	H	H	H	H	1, 12
Q. undulata and *pungens*	H					14
Rhamnus crocea	L	H	L	L–M		9, 10
Rhus microphylla			M	L–M	L–M	5, 6, 13
Rhus ovata	L	M	L	L–M		9
Rhus trilobata	L	L, H	M	M	L	1, 4, 7, 10, 9[c]
Rhus virens	M	M			L	6
Simmondsia chinensis	M–H	L–H	L–H	L–H		7, 9, 13, 15, 16, 17
Sphaeralcea spp.	L–H	M	M	L, H		7, 9, 15, 16[c]
Sphaeralcea coccinea					L (Feb.–Apr.)	13
Vauquelinia californica		L			H (Jan.–Jul.)	11, 13
Viguiera spp.		L	M	L	L	5, 6[c]
Viguiera deltoidea	L					7
Succulents						
Agave lecheguilla	L–H	L, H	L	L, H	H	8, 6, 14
Agave palmeri					M (Jan.–Jul.)	13
Agave schotti					L	13
Cereus gigantea			L			9, 13[c], 16[c]
Ferocactus wislizenii	H	M	L	H	H (Jan.–Jul.)	11, 13, 7[c]
Mammillaria spp.		L				16
Opuntia spp.	L	L–H	L–M	L	L	1, 4, 7, 8, 15, 16, 17
Opuntia fulgida	L	H		M	L	11, 13
Opuntia phaeacantha	M–H	L, H	L–H	M	L–M	6, 9, 11, 13, 14
Opuntia spinosior	L–M	L	L	L		11, 14
Opuntia versicolor					L (Jul.–Oct.)	13
Yucca spp.	H	H	L	L	M	1, 4[c], 16[c]
Yucca baccata	L					14
Yucca elata					H (Mar.)	12

[a] 1 = Anderson et al. 1995, 2 = Anthony (1976), 3 = Anthony and Smith (1977), 4 = Boeker et al. (1972), 5 = Keller (1975), 6 = Krausman (1978), 7 = Krausman et al. (1989), 8 = Leopold and Krausman (1987), 9 = McCulloch (1973), 10 = Urness (1981), 11 = Short (1977), 12 = Snyder (1961), 13 = Truett (1971), 14 = Uzzell (1958), 15 = Belmont Mts., 16 = Picacho Mts., 17 = King Valley

[b] L = 1–5% of the diet, M = > 5–15% of the diet, H = > 15% of the diet.

[c] = plant species make up < 1% of diet.

Table 6. Forbs and grass reported as food for the desert mule deer.

Species	Winter	Spring	Summer	Autumn	Total	ReferenceForbs
Forbs						
Abutilon spp.	M[b]	L	L	L–M		8, 9
Acamptpappus sphaerocephalus		L				16
Acanthaceae		L				1
Allium spp.		L				5
Ambrosia confertiflora	L			L		9,13[c]
Anemone tuberosa	L					9
Anisacanthus thurberi					L–M	2
Apodanthera undulata			L			11
Arabis perennans	L					9, 7[c]
Astragalus spp.	L	L–M				15, 16,17[c], 4[c], 7[c]
Baileya multiradiata		L			M (Jan.–Jul.)	11, 13, 7[c], 16[c]
Boraginaceae	M	M	L	L		15, 16, 17
Calochortus kennedyi		L				9
Carlowrightia arizonica					L (Jul.–Jan.)	13
Commelina dianthifolia					L	4
Compositae	L			L		9
Coreopsis tinctoria	L					1

(Continued on page 520)

Table 6. (Continued)

Species	Winter	Spring	Summer	Autumn	Total	R
Cucurbita foetidissima					L	4
Cuscuta spp.		L				9, 13
Dalea spp.					L	4
Dalea neomexicana	L, H	L, H	H	M, H		8
Descurainia obtusa					L	4
Descurainia pinnata		L			L	4, 11, 13[c], 16[c]
Desmanthus cooleyi					L	4
Dichelostemma pulchellum	M					9
Draba cuneifolia	M				L	5
Dudleya collomiae	L			L		9
Dyssodia papposa			M	L		1
Eriastrum spp.	L	M				10, 11, 15
Erigeron divergens	L					6
Eriogonum fasciculatum	H	H	M	M	H (Oct.–Jul.)	7, 13
Erodium spp.	M	M	L			15, 16
Erodium cicutarium	L–M	L, H	L–H	L		7, 9, 17, 4[c]
Euphorbia spp.	L–H	L–H	L–H	H	L–M	1, 5, 8, 9, 11, 15[c], 16[c]
Euphorbia incisa			L	L		9
Euphorbia serrula	M	L	H	H	H	6
Galium spp.	L					7
Hedyotis spp.			L			6
Hibiscus coulteri					L (Oct.–Jan.)	13
Houstonia spp.	M	M				5
Lesquerella spp.	L–H	L	L–M	L	L	5, 8
Lesquerella gordoni	L				L (Feb.–Apr.)	13, 15
Linum spp.	L			M	L	1
Lotus spp.	M	L				9, 15, 7[c], 17[c]
Lupinus spp.	L–M	L–H	H	L		7, 9, 15, 16
Lupinus succulentus		L				9
Lygodesmia spp.	L	L				9
Marah gilensis		L				9
Melampodium leucanthum		L	L	L	L	1
Menodora spp.	M				L	6, 15, 16
Menodora scabra					L (Feb.–Apr.)	13
Menodora scoparia		L				9
Nerisyrenia camporum	H	H		M		8
Notholaena spp.	L					5
Pellaea longimucronata	L					9
Peritule emoryii		L				15
Plantago insularis	L, H	L	L	L		7, 17, 15[c], 16[c]
Planatago purshii	M	L				15, 16
Polypodiaceae				L		9, 4[c]
Psilotrophe spp.	H	L				8, 16[c]
Psoralea spp.		M				9
Sphaeralcea spp.			L	L		1, 8, 17[c]
Stephanomeria pauciflora		L	M		L–M	2, 3, 13[c]
Tidestromia lanuginosa			M			15, 16[c], 17[c]
Tidestromia oblongifolia			L	M		7
Tradescantia occidentalis				L		9
Verbena spp.		L				11
Vicia exigua	L					7
Zinnia acerosa					L (Jan.–Jul.)	13, 7[c]
Grasses						
Bouteloua chondrosioides					L	2
Bouteloua curtipendula					L	2, 13[c]
Bromus rubens	L–M					9, 7[c], 15[c], 16[c]
Muhlenbergia spp.			L			17
Poa bigelovii	L					15
Schismus barbatus	L	L	L			15, 17, 7[c], 16[c]
Unidentified grass (graminae)	L–M	L–M	L–M	L	L	1, 3, 4, 6, 9, 10, 11
Other						
Lichen	L			L	L	1, 17

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[b]L = 1–5% of the diet, M = > 5–15% of the diet, H = > 15% of the diet.

[c] = plant species make up < 1% of diet.

Table 7. Plant species reported as foods of desert mule deer in trace amounts (< 1%).

Species	References[a]
Browse	
Ambrosia deltoidea	7
Ambrosia dumosa	7, 15, 16, 17
Amborsia spp.	15
Amelanchier spp.	1
Arbutus texana	1
Artemesia carruthii	1
Atriplex spp.	7, 15, 16
Atriplex canescens	1
Cowania mexicana	15
Clematis spp.	1
Diospyros texana	6
Dyssodia porophylloides	13
Ephedra spp.	7, 15, 16, 17
Erigeron spp.	13, 16
Eriogonum inflatum	7, 16
Eurotia lanata	15
Forestiera angustifolia	6
Haplopappus gracilis	13
Hoffmanseggia spp.	6
Larrea tridentata	15, 16
Lycium spp. (wolfberry)	15, 16
Lycium spp. (desert thorn)	15, 16
Lycium exsertum	9
Mimosa dysocarpa	2
Pellaea spp.	16
Phoradendron juniperinum	1
Prosopis spp.	1
Prosopis havardii	6
Ptelea trifoliata	1
Rhus choriophylla	13
Solanum xanti	9
Symphoricarpos spp.	1
Viguiera parishii	15
Xanthocephalum spp.	6
Succulents	
Agave spp.	1, 7
Echinocereus spp.	13
Forbs	
Amaranthus fimbriatus	13
Amsinkia spp.	13
Arabis spp.	16
Argemone platyceras	2
Bahia spp.	6
Boerhaavia intermedia	13
Chenopodiem spp.	1
Chenopodium album	4
Chorizanthe spp.	1
Chorizanthe rigida	7, 15
Crassulaceae (spp.)	1
Cruciferae (spp.)	1
Eriogonum deflexum	15
Eriogonum harardii	1
Euphorbia polycarpa	13
Evolvulus arizonicus	13
Gilia spp.	4
Hedeoma costata	1
Kallstroemia grandiflora	13
Lepidium spp.	13
Lesquerella fendleri	1
Liliaceae (spp.)	1
Margaranthus solanaceus	9
Melilotus albus	4
Mirabilis spp.	7
Mirabilis bigelovii	7, 13
Mirabilis multiflora	4
Physalis fendleri	4
Plantago spp.	9
Pseudocymopterus montanus	9
Psilotrophe cooperi	7
Salazaria mexicana	7, 15, 16, 17
Salsola kali	1
Sisymbrium irio	13
Stenandrium barbatum	1
Teucrium spp.	1
Thlaspi spp.	1
Trifolium spp.	1
Trixis californica	7, 15
Verbena wrightii	1
Vicia spp.	15, 16
Viguiera spp.	1
Grass	
Bouteloua spp.	9
Bouteloua eriopoda	13
Bouteloua filiformis	13
Bromus spp.	15
Festuca octoflora	15
Hilaria belangeri	9
Hilaria rigida	7
Muhlenbergia porteri	7
Poa spp.	9
Tridens pulchellus	7

[a]1 = Anderson et al.(1995), 2 = Anthony (1976), 3 = Anthony and Smith (1977), 4 = Boeker et al. (1972) 5 = Keller (1975), 6 = Krausman (1978), 7 = Krausman et al. (1989), 8 = Leopold and Krausman (1987), 9 = McCulloch (1973), 10 = Urness (1981), 11 = Short (1977), 12 = Snyder (1961), 13 = Truett (1971), 14 = Uzzell (1958), 15 = Belmont Mts., 16 = Picacho Mts., 17 = King Valley.

Desert mule deer eat a wide variety of plant species across their range. Browse (range = 45.9–97.9%) is consumed more than the other forage classes and when combined with forbs makes up > 93% of the overall diet of desert mule deer. Grasses and succulents make up < 1% of the diet in 50% of the seasons sampled and never exceeded 7% of the diet in the other seasons (range = 1.2–6.9%). It is difficult to generalize about the importance of individual plant species within their diet, because diet composition varies spatially and temporally.

Management Implications

Because rainfall is not predictable in deserts, the ability of desert mule deer to consume a wide variety of browse (126 species) and forbs (111 species) (Tables 5, 7) allows them to take advantage of plant availability and those with higher nutritive value. Overall, the vegetation diversity provides ample choices for mule deer to be highly opportunistic feeders. Variability in available forage is a result of unpredictable rains, drought, and other climatic factors (Peek and Krausman 1996). Succulents may play an important role during drought and may be under represented in the studies presented here. They have high (> 90%) moisture content and may not be adequately represented in micro-histological or rumen analysis. The range manager cannot anticipate the weather. However, the implications are obviously to keep desert rangelands productive with a diversity of forage so animals have opportunities to exercise free choice of diet.

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