J. Range Manage.
47:405-409 September 1994

Observation: Cattle diets on excellent and good condition Chihuahuan desert rangelands

GRETCHEN SMITH, JERRY L. HOLECHEK, AND MANUAL CARDENAS

Authors are graduate research assistant and professor, Department of Animal and Range Sciences; and professor, Department of Exp. Sta., New Mexico State University, Las Cruces 88003.

Abstract

Information is limited on the influence of range condition on cattle diets in the Chihuahuan desert. Botanical composition of cattle diets on Chihuahuan desert ranges in excellent and good condition was studied by microhistological analysis. Cattle feces were analyzed seasonally from fall 1991 through fall 1992. Excellent condition and good condition ranges supported 86% and 72% of the climax vegetation, respectively. Key species in cattle diets on the excellent condition range were black grama (*Bouteloua eriopoda* Torr.) and threeawns (*Aristida* spp.). On the good condition range the key species were dropseeds (*Sporobolus* spp.), threeawns and black grama. Total grass and black grama content of cattle diets were greater on the excellent condition range. Seasonal trends occurred in cattle diets on good condition but not on excellent condition range. Low availability of forbs and shrubs explained the high diets similarities among seasons on the excellent condition range. Cattle on good condition range readily used forbs and shrubs when green grass was unavailable. Nitrogen and phosphorus analyses of fecal samples indicated diets were nutritionally superior on the good compared to the excellent condition range. Our research and other studies show consumption of forbs and shrubs permits cattle to maximize their nutritional welfare when grasses are dormant. The excellent condition range in our study had a different($P<0.05$) mean grass standing crop (999 kg/ha) across periods compared to on the good condition range (659 kg/ha). Based on our research and other studies excellent condition Chihuahuan desert range maximizes forage quantity for cattle but good condition range appears better from a nutritional standpoint in the spring and early summer. Our research and other studies indicate Chihuahuan desert ranges dominated by black grama are most effectively used in winter while ranges with a high dropseed component are best suited for use in summer and early fall.

Key words: rangeland, grazing, livestock, arid lands, food habits, cattle nutrition.

Information is limited on range ecological condition influences on cattle diets and productivity in the Chihuahuan desert. Generally, as the condition of the range deteriorates under heavy grazing, plant composition shifts toward an increase in forbs and shrubs and a decrease in perennial grasses (Paulsen and Ares 1962). Daniel et al (1993) found that cattle on Chihuahuan desert ranges in good and fair condition consumed similar amounts of grass. Browse consumption was greatest on fair condition range, whereas more forbs were consumed on the range in good condition. The good condition range in their study gave superior cattle productivity and economic returns compared to surrounding ranges in lower condition (Holechek 1991). Limited research indicates that cattle maximizing forb consumption in the Chihuahuan desert are more productive than those consuming high levels of grass (Winder et al. 1993). In the past range managers have considered Chihuahuan desert rangeland supporting near climax vegetation (excellent condition) as the most desirable for cattle production (Paulsen and Ares 1962). However, research has not compared cattle diet botanical composition and quality on excellent compared to good condition range. This type of information would help managers better decide which ecological condition classes to emphasize and when these condition classes could best be used to optimize livestock production. The objective of our study was to estimate vegetation composition and standing crop and botanical composition of cattle diets on Chihuahuan desert ranges in good and excellent ecological condition.

This research was supported by the New Mexico Agr. Exp. Sta., Las Cruces, New Mexico and was part of project 1-5-27417.
Manuscript accepted 22 Feb. 1994.

Materials and Methods

Study Area Description

Two study sites with similar soils, terrain, and precipitation were selected based on their ecological condition classification. A study site in excellent condition was located on the Bureau of Land Management, Goodsight Allotment 24 km northeast of Deming, New Mexico. The condition classification was assessed using Dyksterhuis's (1949) quantitative climax guidelines and data collected by Smith (1993). The excellent condition range supports about 86% of the climate vegetation. The good condition study site is located on the New Mexico State University College Ranch 37 km north of Las Cruces, New Mexico, and supports 72% of the climax vegetation.

Soils at both sites consist mostly of sandy loams classified as paleorthids, haplargids or calciorthids. The excellent condition study site has a sandy clay loam component. Both study sites have an undulating restrictive caliche layer. However, the caliche layer on the good condition site is generally deeper than on the excellent condition site. The topography at both sites is relatively flat with all slopes under 5%.

Annual precipitation at both locations is typical of the Chihuahuan desert. The precipitation is bimodal with a peak in the summer and another peak in the winter. The summer peak in late August provides 20-25% and the winter peak in January provides 13-15% of the annual precipitation (Pieper and Herbel 1992). The mean annual precipitation for the excellent and good condition study sites is near 250 mm. Temperature in June reaches a mean maximum of 36° C and during January drops to a mean maximum of 13° C (Pieper and Herbel 1982).

The climax vegetation for both study sites is considered to be black grama (*Bouteloua eriopoda* Torr.) grasslands with a scattering of soaptree yucca (*Yucca elata* Engelm.) (Buffington and Herbel 1965). The present vegetation on the excellent condition range is dominated by black grama (Table 1). Scattered yucca plants are present, and creosotebrush (*Larrea tridentata* Lar.) occupies limited area on the periphery.

Primary grass species on the good condition range include black grama, mesa dropseed (*Spoorobolus flexuosus* Thrub. Rybd.) and

spike dropseed (*Sporobolus contractus* A. Hitch.) (Table 1). Honey mesquite (*Prosopis glandulosa* Torr.) dominates the overstory and has increased over the past 50 years (Pieper and Herbel 1982). In degraded areas near watering points, broom snakeweed (*Gutierrezia sarothrae* Pursh.) is dominant. Important forbs include leatherweed croton (*Croton pottsii* Lam.), nightshades (*Solanum* spp.), and globemallow (*Sphaeralcea* spp.). More detailed descriptions of the study areas are provided by Smith (1993).

Grazing Histories

The excellent condition study area was contained within 1 pasture. Historically, this pasture was conservatively stocked (30-35% use of key forages). The grazing strategy has incorporated periodic rest during the growing season (1 May—1 October). During the period of study, however, the pasture was continuously grazed. The annual stocking rate averaged 20 ha/animal unit.

The good condition study area contained 4 pastures. One was continuously grazed while the others were grazed in a seasonal suitability strategy. For the past 25 years these pastures have been conservatively stocked with utilization of key forage species (black grama and mesa dropseed) averaging about 30%. McNeely (1983) and Beck and Kiesling (1991) found that the seasonal suitability pastures had similar vegetation to the continuous grazed pasture. Therefore, transects were placed across the 2 grazing strategies without concern of confounding. The annual stocking rate averaged 48 ha/animal unit (Beck and Kiesling 1991).

Vegetation Analyses

Four transects 6.4 km in length were established on the good condition study site along the road that boarders the west side of the pastures. Two transects 3.2 km in length and four 1.6 km in length were established on the excellent condition range. Cover data were collected along these transects in spring 1992 and fall 1992. The line-intercept method (Canfield 1941) as modified by Holechek and Stephenson (1983) was used to determine percent cover. A meter stick was used instead of a line. A total of 80 sampling points were taken for each study area during 1 sampling period. Spacing between sampling points varied with the length of the transect. Sampling was at 320 m intervals on 6.4 km transects, and at 160 m intervals on 3.2 km transects. The meter stick was placed perpendicular to the transect and the intercept of the plants were measured (Bonham 1989). Plants were identified according to Allred (1988).

Standing crop for herbage was also determined along these transects in October 1991, April 1992, and October 1992. The data was collected by clipping the standing crop at ground level in quadrats 0.5 m^2. A total of 40 quadrats (10 per transect) were clipped in each study area during each sampling period.

Fresh cattle feces samples were obtained for 5 consecutive seasons beginning fall 1991 and ending fall 1992. A total of 10 patties were selected at random during each sampling period in each pasture. The patties were placed into plastic containers and put into forced air ovens at 60° C. The feces remained in the ovens for an average of 72 hours or until thoroughly dried, and then ground in a micro-Wiley mill with 1-mm mesh screen.

Diet Botanical Composition Analyses

Slide preparation followed a modification (Holechek 1982) of the Sparks and Malechek (1968) procedure. A training procedure (Holechek and Gross 1982) was used to gain experience in the microhistological technique. A Nikon binocular microscope at 200X magnification was used for microhistological analyses. Twenty fields were systematically observed for each slide, resulting in a total of 100 fields per sample. Relative botanical composition by weight was calculated using the frequency addition procedure (Holechek and Gross 1982).

Nutritive Evaluation of Fecal Samples

Fecal samples (10 patties/pasture/period) were analyzed for dry matter, ash and phosphorus concentrations (AOAC 1984). The Kjeldahl method (AOAC 1984) was used to determine fecal nitrogen concentrations.

Statistical Analyses

Standard t-test were used to compare total standing crop of grasses, cattle diets, and fecal chemical composition between pastures within seasons (Steel and Torrie 1980). Transects were used as replicates for total grass standing crop evaluations. Fecal collections (10 patties/pasture/period) were used as replicates for both diet and chemical evaluations.

Results and Discussion

Vegetation Cover and Standing Crop

Differences ($P<0.05$) occurred in total grass standing crop in each period. Total grass standing crops on the excellent condition range were 971, 982, and 1,044 kg/ha for October 1991, April 1992, respectively. On the good condition range these values were 554, 581, and 842 kg/ha, respectively. The large increase on the good condition range in October 1992 is attributed to above average rainfall during the previous summer.

Black grama was the primary forage plant found on both excellent and good condition study areas based on canopy cover and standing crop (Table 1). In contrast threeawn and dropseeds were higher on the good than excellent condition range. Canopy cover showed shrubs were more prevalent on the good condition range.

Plant species found on the excellent and good condition ranges numbered 21 and 31, respectively (Smith 1993). With the Shannon-Weiner index (Barbour et al. 1987), diversity values were 2.72 and 3.38 on the excellent and good condition ranges (Smith 1993, The Shannon-Weaver diversity index reflects the number of species and their proportional distribution within the sample.

Our data indicate Chihuahuan desert ranges in high ecological condition produce more forage than those in an earlier successional stage. Paulsen and Ares (1962) and Tembo (1990) in New Mexico, and Frost and Smith (1991) in Arizona also found forage production increased as ecological condition increased on desert ranges. Cattle grazing capacity might be 30 to 40% higher on excellent compared to good condition range.

Botanical Composition of Cattle Diets

Black grama was a key species in cattle diets on both excellent and good condition ranges when samples were pooled across seasons (Tables 1 and 2). It comprised 50% and 15% of the overall diet on excellent and good condition ranges, respectively. Other important plants in the diets on both ranges were dropseeds, threeawns, leatherweed croton, and globemallow. Key forage species for cattle in our study were consistent with Hakkila et al. (1987). Their study was conducted on good condition sandy loam rangeland in southcentral New Mexico.

Total grass in the cattle diet was greater ($P<0.05$) on the excellent condition range than the good condition range in April 1992 and October 1992 (Table 2). The predominance of grass in cattle diets on excellent condition range is consistent with Galt et al. (1969). They found cattle diets contained 82% grass on a southern Arizona study area comprised of 97% grass by weight. Cattle on good condition range consumed more dropseeds than black grama in every period except April 1992 even though black grama and dropseeds were similar in availability. Rosiere et al.(1975) reported cattle had higher preference for dropseeds than black grama on good condition Chihuahuan desert range.

Forbs were most available on the good condition range during

Table 1. Available forage and botanical composition of cattle diets on excellent (EC) and good condition (GC) ranges in the Chihuahuan desert for data pooled across seasons.

Species	Available forage: Standing Crop[1] EC	GC	Cover[2] GC	EC	Relative Cover[2] EC	GC	Percent in Diet[3] EG	GC
	(kg/ha)		(%)		(%)		(%)	
Grasses:								
Bouteloua eriopoda	669	240	20	10	53	26	50	15
Sporobolus spp.	3	213	t	8	t	21	7	19
Aristida spp.	48	175	2	4	5	10	16	15
Other grasses	279	31	14	1	37	2	16	31
Total grasses	999	659	36	23	95	59	89	80
Palatable Forbs[4]:								
Croton pottsii	23	10	t	t	t	t	4	8
Sphaeralcea spp.	15	3	t	t	t	t	3	2
Other Forbs	9	8	2	t	5	2	1	2
Total forbs	47	21	2	1	5	2	8	12
Shrubs:								
Gutierrezia sarothrae	0	246	t	6	t	15	0	0
Prospopis glandulosa	NS	NS	t	7	t	18	1	6
Yucca elata	NS	NS	t	2	t	5	1	1
Other Shrubs	NS	NS	t	t	t	t	t	1
Total shrub	NS	NS	1	15	1	38	2	8

[1]Data pooled across fall 1991, spring 1992, and fall 1992.
[2]Data pooled across spring 1992 and fall 1992.
[3]Data pooled across fall 1991, winter 1992, spring 1992, summer 1992, and fall 1992.
NS = Not sampled.
t = trace
[4]Forbs readily consumed by cattle that are low in toxicity.

spring 1992 (Smith 1993). Cattle consumption of forbs was highest in this period which is consistent with other research (Hakkila et al. 1987, Rosiere et al. 1975).

Diet similarities between the excellent and good condition pastures ranged from a high of 58% in winter of 1992 to a low of 41% in fall 1991. Cattle on both ranges made considerable use of black grama in the winter period. Because black grama stems stay green in winter it is one of the most palatable and nutritious of the desert grasses in this period (Nelson et al. 1970). Cattle on the good condition range made considerable use of honey mesquite (*Prosopis glandulosa* Torr.) in July 1992. Consumption of mesquite in summer by cattle was also reported by Rosiere et al. (1975).

Seasonal similarities on the excellent condition range varied from 70% to 81%. Cattle diets on the good condition range were more variable ranging from 41% to 76% in similarity. Greater plant diversity and periodicity on the good compared to the excellent condition range explain these differences.

Fecal Indicators of Nutritional Status

Fecal nitrogen concentration has been positively correlated to protein concentration in cattle diets (Moir 1960, Holechek et al. 1982, Hakkila et al. 1988) and to cattle weight changes (Holechek et al. 1982, Squires and Siebert 1983). In the Chihuahuan desert, Hakkila et al. (1988) found it to be a useful indicator of trends in cattle nutritional

Table 2. Botanical composition (% dry weight) of cattle diets on excellent and goood condition ranges in the Chihuahuan Desert for 5 seasons.

Species	October 1991 EC[1]	GC	January 1992 EC	GC	April 1992 EC	GC	July 1992 EC	GC	October 1992 EC	GC
Grasses:										
Bouteloua eriopoda	43[a]	11[b]	54[a]	19[b]	57[a]	16[b]	51[a]	13[b]	46[a]	15[b]
Sporobolus spp.	8[a]	63[b]	19[a]	32[b]	8[a]	13[b]	10[a]	50[b]	5[a]	27[b]
Artistida spp.	27[a]	13[b]	10[a]	11[a]	20[a]	38[b]	6	2	14	13
Other grass	14	6	14	32	8	7	13	10	22	10
Total grass	92[a]	93[a]	97[a]	93[a]	93[a]	74[b]	80[a]	75[a]	87[a]	65[b]
Forbs:										
Croton pottsii	1	5	t	t	2[a]	18[b]	6	8	8	12
Sphaeralcea spp.	1	1	t	t	1	7	8	1	2	2
Other forbs	3	0	t	t	3	t	4	3	2	2
Total forbs	5	6	1	1	6a	25b	18a	12b	12a	16[a]
Shrubs:										
Prosopis glandulosa	0	1	0	1	0	0	2[a]	12[b]	1[a]	17[b]
Other Shrubs	1	1	1	5	1	0	0	2	0	0
Total shrubs	1	2	1[a]	6[b]	1	1	2[a]	14b	1a	17b

[1]EC = Excellent condition range; GC = Good Condition Range.
Row means with different letters differ ($P<0.05$) between ranges for each sampling period using standare t-test.
t = trace

status. Fecal nitrogen concentration in our study were higher ($P<0.05$) on good compared to excellent condition ranges in most periods (Table 3). Differences occurred in spring, summer and fall of 1992. We attributed this to the higher forb and shrub content of cattle diets on the good condition range. Forbs and shrubs generally have level of crude protein than grasses in the Chihuahuan desert (Nelson et al. 1970).

Fecal nitrogen concentrations below 1.20% indicate that dietary nitrogen is inadequate for weight maintenance by cattle (Hakkila et al. 1988). In our study this occurred on both ranges in winter. Diet samples from cattle have shown low crude protein levels in winter in Chihuahuan desert studies with fistulated animals (Hakkila et al. 1987, King et al. 1993) because of dormant grasses and a lack of forbs.

Cattle diet and fecal phosphorus concentrations have been positively correlated (Moir 1960, Holechek et al. 1985). Hakkila et al. (1988) found fecal phosphorus to be one of the best single indicators of crude protein concentration in cattle diets in the Chihuahuan desert. Fecal phosphorus concentrations showed the same trends and differences as did fecal nitrogen concentration with the exception of October 1992 (Table 3). In this period fecal nitrogen was higher on the good condition range but fecal phosphorus showed no difference between the 2 ranges. We explain this by the high level of mesquite in cattle diets on the good condition range (Table 2). Mesquite has high condensed tannin concentration which can cause elevated fecal nitrogen values compared to dietary N (Holechek et al. 1990).

Table 3. Seasonal fecal nitrogen and phosphorus concentrations on excellent and good condition ranges in the Chihuahuan desert.

Condition	Fecal Nitrogen (omb)[1]	Fecal Phosphorus (omb)[1]
	(%)	(%)
October 1991:		
Excellent	1.71[a]	0.48[a]
Good	1.95[b]	0.62[b]
January 1992:		
Excellent	1.00[a]	0.31[a]
Good	0.97[a]	0.22[a]
April 1992:		
Excellent	2.22[a]	0.50[a]
Good	2.66[b]	0.52[a]
July 1992:		
Excellent	1.25[a]	0.44[a]
Good	1.85[b]	0.47[a]
October 1992:		
Excellent	1.32[a]	0.28[a]
Good	1.56[b]	0.23[a]
Mean		
Excellent	1.50[a]	0.40[a]
Good	1.80[b]	0.41[a]

Means within columns and seasons with different letters are different ($P<0.05$) using standard t-test.
[1]OMB = organic matter basis.

Management Implications

Our data show black grama is the most important forage plant for cattle on Chihuahuan desert ranges in high ecological condition. Dropseeds and threeawns were the other 2 key cattle forages. Forbs were seasonally important in cattle diets. They provide cattle with needed protein in spring when grasses are dormant.

Excellent condition Chihuahuan desert ranges produce more forage for cattle than those in lower condition based on our research and other studies. Good condition ranges, however, appear to have nutritional advantages over excellent condition ranges during the spring and early summer because of a higher component of forbs, dropseeds, and threeawns. Forbs and threeawns initiate growth earlier in the spring than black grama, and are heavily used by cattle in later winter through early summer.

Most ranchers in the Chihuahuan desert have limited amounts of excellent and good condition range but large amounts of range in fair condition. Our study supports integrating Chihuahuan desert ranges in different ecological condition classes into the seasonal suitability grazing scheme discussed by Holechek and Herbel (1982). This involves using poor and fair condition ranges with a high forb and threeawn component in spring and early summer, using good condition ranges dominated by dropseeds in mid-summer through early fall, and saving excellent condition ranges dominated by black grama for winter use. Plant requirements and cattle nutritional welfare are optimized using this strategy. Research has shown that black grama has low resistance to summer grazing but withstands winter grazing fairly well (Paulsen and Ares 1962), and has a higher protein concentration than other desert grasses in the winter (Nelson et al. 1970). In contrast, mesa dropseed is well adapted to summer grazing (Miller and Donart 1979) when it is most palatable and superior to other grasses in nutritional quality (Nelson et al. 1970).

Literature Cited

AOAC. 1984. Official mehtods of analysis (14th ed.). Assoc. of Official Anal. Chem. Washington, D.C.

Allred, K. 1988. A guide to the flora of the Jornada plain. Agr. Exp. Sta. Bull. 739.

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publishing Company, Inc., Menlo Park, Calif.

Beck, R.F., and H.E. Kiesling. 1991. Improving range and cattle production on semidesert rangeland. Livestock Research Briefs and Cattle Growers Short Course. N. Mex. Agr. Exp. Sta., Coop. Ext. Ser., and New Mexico Cattle Growers Assoc., Las Cruces., N.M.

Bonham, C.D. 1989. Measurements for Terrestrial Vegetation. John Wiley and Sons, New York., N.Y.

Buffington, L.C., and C.H. Herbel. 1965. Vegetation changes on semidesert grassland range from 1958-1963. Eco Monogr. 35:139-164.

Canfield, R.H. 1941. Application of the line intercept method in sampling range vegetation. J. Forest. 39:188-394.

Daniel, A., J.L. Holechek, R. Valdez, A. Tembo, L. Saiwana, M. Fusco, and M. Cardenas. 1993. Range condition influences on Chihuahuan desert cattle and jackrabbit diets. J. Range Manage. 46:296-301.

Dyksterhuis, E.J. 1946. Condition and management of rangelands based on quantitative ecology. J. Range Manage. 2:104-115.

Frost, W.B., and E.L. Smith. 1991. Biomass productivity and range condition on range sites in southern Arizona. J. Range Manage. 44:64-68.

Galt, H.D., B. Theurer, J. H. Ehrenreich, W.H. Hale, and S.C. Martin. 1969. Botanical composition of diet of steers grazing a desert grassland range. J. Range Manage. 22:14-19.

Hakkila, M., J.L. Holechek, J. D. Wallace, D.M. Anderson, and M. Cardenas. 1988. Fecal indicators of cattle protein status in desert grassland range. Nutr. Rept. Int. 37:137-147.

Hakkila, M.D., J.L. Holechek, J.D. Wallace, D.M. Anderson, and M. Cardenas. 1987. Diet and forage intake of cattle on desert grassland range. J. Range Manage. 40:339-342.

Holechek, J.L. 1982. Sample preparation technique for microhistological analysis. J. Range Manage 35:267-268.

Holechek, J. L. 1991. Chihuahuan desert rangeland, livestock grazing and sustainability. Rangelands. 13:115-120.

Holechek, J.L., M.L. Galyean, J.D. Wallace, and H. Wofford. 1985. Evaluation of fecal indices for predicting phosphorus status of cattle. Grass and Forage Sci. 40:489-492.

Holechek, J.L., and B.D. Gross. 1982. Training needed for quantifying simulated diets from fragmented range plants. J. Range. Manage. 35:644-647.

Holechek, J.L., and C.H. Herbel. 1982. Seasonal suitability grazing in the western United States. Rangelands. 4:252-255.

Holechek, J.L., and T. Stephenson. 1983. Comparison of big sagebrush in

northcentral New Mexico under moderately grazed and grazing excluded conditions. J. Range Manage. 36:455-456.

Holechek, J.L., A.V. Munshikpu, L. Saiwana, G. Nunez-Hernandez, R. Valdez, J.D. Wallace, and M. Cardenas. 1990. Influences of six shurb diets varying in phenol content on intake and nitrogen retention by goats. Tropical Grass. 24:93-98.

Holechek, J.L., M. Vavra, and D. Arthun. 1982. Relationships between performance intake, diet nutritive quality and fecal nutritive quality of cattle on mountain range. J. Range Manage. 35:741-744.

King, D.W., J.L. Holechek, J.D. Wallace, R.D. Pieper, C.A. Ferrando, M. Aged, and L. Murray. 1993. Seasonal diet quality and intake of steers grazing semidesert rangeland. Proc. West. Sec. Amer. Soc. Anim. Sci. 44:134-139.

McNeely, R.P. 1983. Influence of mesquite on vegetational chenges under two grazing strategies in southern New Mexico. M.S. Thesis, New Mexico State Univ., Las Cruces. N.M.

Miller, R.F., and G.B. Donart. 1979. Response of *Bouteloua eriopoda* and *Sporobolus flexuousus* to season of defoliation. J. Range. Manage. 32:63-67.

Moir, K.W. 1960. Nurtition of grazing cattle. III. Estimation of protein, phosphorus and calcium in pasture selected by grazing cattle. Queensland J. Agr. Sci. 17:358-389.

Nelson, A.B., C.H. Herbel, adn H.M. Jackson. 1970. Chemical composition of forage species grazed by cattle on arid New Mexico range. New Mexico Agr. Exp. Bull. 561. Las Cruces N.M.

Paulsen, H.A., Jr. and F.N. Ares. 1962. Grazing values and management of black grama and tobosa grassland and associated shrub ranges of the Southwest. USDA Forest Serv. Tech. Bull. 1270., Washington, D.C.

Pieper, R.D., and C.H. Herbel. 1982. Herbage dynamics and primary productivity of a desert grassland ecosystem New Mexico Agr. Exp. Sta. Bull. 685., Las Cruces, N.M.

Rosiere, R.E., R.F. Beck, and J.D. Wallace. 1975. Cattle diets on semidesert grassland: Botanical composition J. Range Manage. 28:89-93.

SAS. 1985. User's guide; Statistics. Cary, N.C.

Smith, G.T. 1993. Influence of excellent and good condition Chihuahuan Desert range on vegetation, cattle diets and wildlife populations. M.S. Thesis, New Mexico State Univ., Las Cruces., N.M.

Sparks, D.R., and J.C. Malechek. 1968. Estimating percentage dry weight in diets using a microscope technique. J. Range Manage. 21:274-265.

Squires, V.R., and B.D. Siebert. 1983. Botanical and chemical components of the diet and liveweight changes in cattle on semi-sesert rangeland in central Australia. Australian Rangel. J. 6:28-34.

Steel, R.G. and J. H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill Book Co., New York., N.Y.

Winder. J.A., C.A. Ferrando, A. Mohammed, R.M. Kattnig, and R.D. Pieper. 1993. Effect of the proportion of cattle diets make up of grasses, forbs and shrubs on performance. *In*: Livestock Research Briefs and Cattle Growers' Shortcourse. New Mexico State Univ., Las Cruces., N.M.