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Spatio-Temporal Variations in Nutritive Quality and Mineral Contents of Diets by Grazing Steers in Native Range

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Abstract: The objective of this study was to determine and compare seasonally the nutritive quality and mineral contents of diets by grazing steers during 2 consecutive years. For the statistical analysis a repeated measure design was used. There was not year x season interaction for Organic Matter (OM), Crude Protein (CP), Neutral Detergent Fiber (NDF), *In vitro* DM Digestibility (IVDMD) and Metabolizable Energy (ME) ($p>0.05$). Researchers found differences in CP content, IVDMD and ME between years ($p<0.05$). The higher values in these variables were registered in 2004. CP content was 20% higher in 2004. However, NDF content was 8% higher in 2005 that in 2004. There was not year x season interaction for the minerals evaluated ($p>0.05$). Nevertheless, the values of Calcium (Ca), Phosphorus (P), Sodium (Na), Potassium (K), Magnesium (Mg), Zinc (Zn), Selenium (Se), Manganese (Mn) and Copper (Cu) were different between years ($p<0.05$) and seasons ($p<0.01$). With the exception of P, the diet consumed for cattle throughout of the years and seasons had appropriate amounts of Ca, Na, K, Mg, Zn, Se, Mn and Co to meet requirements of beef cattle grazing native rangelands. The information generated in this study can be used for the formulation of protein, energy and mineral supplements according to the season of year.

Key words: Steers, grazing, nutritive quality, minerals, diets, rangelands

INTRODUCTION

Some studies report that as a result of drastic climate change, the animals in the region of north of Mexico have periods of 90-100 days of favorable grazing conditions and if the number of days is reduced, the survival of these animals may be in jeopardy. Under long-term drought conditions, the evaluation of nutritive quality of the diet selected by grazing cattle across seasons is essential to establishing strategic programs of dietary supplementation (Klopfenstein *et al*., 2001). However, the grazing beef cattle also require a number of mineral for optimal growth and reproduction. According to McDowell (1992) the most critical mineral for grazing cattle are: Ca, P, Na, Co, Cu, Se and Zn. During disease states mineral requirements of cattle may be affected by immune system response. High concentrations of Zinc have been shown to be beneficial to the ruminant´s health during disease and Zn, Cu, Se and Iron (Fe) seem to be necessary for inmunocompetence (NRC, 2000). The knowledge of mineral content of diet selected by grazing cattle is necessary to design supplementation strategies under range conditions. During the dry season the inadequate intake of forage by grazing cattle that result from the low protein and high fiber content, may decrease the total mineral intake while in the wet season, high forage availability with higher concentration of protein and energy may improve growth of cattle but mineral requirements are increased and deficiencies may be more drastic if cattle are not supplemented (McDowell, 1985). The objective of this study was to determine and compare, seasonally, across two consecutive years the nutritive quality and mineral contents of diets by grazing steers.

MATERIALS AND METHODS

Study area: The study was carried during 2 consecutive years (2004 and 2005) in a medium-sized shrub-grassland east of the city of Durango, Mexico (24°22'N, 104° 32'W

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at an altitude of about 1938 m above sea level) which has a dry temperate (BS_1k) climate with average annual temperature and rainfall of 17.5°C and 450 mm, respectively. Rainfall in 2004 was above average at 547.5 mm and 2005 was drier that normal at 238.0 mm. The study area covers 2,000 ha (6 ha/AU) with an average of forage biomass of 1,796 kg of DM/ha. During the 2 years of the study, we estimated vegetation cover using minimum area sampling with nested points (Franco *et al*., 1985). Dominant grass species included *Melinis repens* Willd (rose natal grass), *Chloris virgata* (feather fingergrass), *Bouteloua gracilis* (blue grama), *Aristida adscensionis* (6 weeks threeawn) and *Andropogon barbinodis* (cane bluestem); bushes: *Acacia tortuosa* (poponax), *Prosopis juliflora* (mezquite), *Opuntia* sp. (prickly pears and chollas), *Mimosa biuncifera* (mimosa); plus a wide variety of annual herbs.

Animals and collection of diet samples: We used four steers fistulated in the esophagus with a live weight of 350±3 kg. Surgery was performed on the steers according to procedures approved by the University of Durango Laboratory Care Advisory Committee. We collected diet samples with the steers fistulated of esophagus during four consecutive days at 07:00 h for 45 min periods (Karn, 2000), 8 times annually: Jan 2-5, Feb 4-7, Apr 13-16, May 15-18, Jul 20-23, Aug 11-14, Oct 12-15 and Nov 20-23. The first two collection periods were considered to be in winter; 3 and 4, spring; 5 and 6, summer and 7 and 8, fall. Collection periods were conducted at these times to reflect phenological changes in the rangelands.

Nutritive quality: Esophageal samples were dried at 60°C for 48 h and ground through a 2 mm screen in a Wiley mill and were determined Dry Matter (DM), CP, OM (AOAC, 1999), NDF (Van Soest *et al*., 1991) and IVDMD (Daisy II ANKOM Technology, Macedon NY USA). We estimated ME content with the formulas used by Waterman *et al*. (2007): Digestible Energy (DE; Mcal kg^{-1}) = [0.039×(OMD g%)]-0.10; ME (Mcal (kg) = DE (Mcal kg^{-1})×0.82. Where OMD is the organic matter degradability obtained after 48 h incubation in the rumen. The Mcal of ME obtained was transformed to Mega Joule (MJ) from of 4.184 constant.

Minerals contents: Esophageal samples were incinerated in a muffle oven a 600°C during 5 h. The ashes obtained were digested in a solution HCl-HNO_3 (Cherney, 2000). Concentrations of Ca, Mg, K, Na, Cu Mn, Z and Se were determined by atomic absorption spectrophotometry while P content was determined by a colorimetric procedure (Fink *et al*., 1979).

Statistical analysis: Data over month were analyzed as a repeated measure (split-split plot) design using the MIXED procedure by SAS (2003). The model included fixed effects for years, season and years x season interaction. The repeated effects was month and steers within years×season was used as the error term for the split-split plot. Autoregressive Order 1 was used as the covariance structure because it was better fitting structure based on comparison of covariance structures with Akaike and Bayesian information criterions (Littell *et al*., 1998). The comparison of means between years and season was performed using the LSMEANS (least squares means) statement of MIXED procedure.

RESULTS AND DISCUSSION

Nutritive quality: There was not year×season interaction for OM, PC, NDF, IVDDM and ME (p>0.05; Table 1). Neither, we find significant differences in OM content in the diet within years and seasons of this study (p>0.05) but we found differences in CP content, IVDDM and ME between years (p<0.05). The higher values for these variables were registered in 2004. However, NDF content was 8% higher in 2005 that in 2004 while CP content was 20% higher in 2004. These differences may be result of registered rainfall during the experimental period (Cline *et al*., 2009). CP, IVDDM and ME content were higher in summer and fall (p<0.05). Grings *et al*. (2004) and Olson *et al*. (2002) reported similar results across seasons. Also, Chavez and Gonzalez, mention that nutritive quality of the diet of grazing cattle in northern Mexico is higher in summer and fall versus winter and spring they attribute these differences to the phenology of rangelands. Consequently, these variables were also higher in the months of summer (July and August) and fall (October and November) that in the months of spring (April and May) and winter (January and February) (p<0.05).

Table 1: Least squares means for nutritive quality in the diet of grazing steers

	OM	CP	NDF	IVDMD	ME
Parameters	----------------(g/100 g DM)			------------------	(MJ kg^{-1})
Years (Y)					
2004	88.2	11.70[a]	69.9[b]	64.20[a]	11.70[a]
2005	87.2	9.60[b]	75.6[a]	60.10[b]	5.40[b]
SEM	2.2	2.10	1.1	1.30	1.60
Season (S)					
Spring	87.9	6.20[b]	74.0[b]	57.10[b]	8.70[b]
Summer	88.3	11.90[a]	67.5[a]	65.50[a]	10.00[a]
Fall	88.8	11.20[a]	68.5[a]	64.20[a]	10.00[a]
Winter	89.0	5.90[b]	73.7[b]	57.30[b]	8.30[b]
SEM	1.2	0.99	1.1	0.98	0.87
Effects	p<	p<	p<	p<	p<
Y	NS	*	*	*	*
S	NS	*	*	*	*
Y×S	NS	NS	NS	NS	NS

[ab]Means with different superscripts, within column are significantly different (p<0.05); SEM: Standard Error of Mean. n = 4; NS: Not Significant (p>0.05); *(p<0.05)

Table 2: Least squares means for mineral content in the diet of grazing steers

Parameters	Ca	P	Mg	K	Na	Zn	Se	Mn	Cu
	----------g kg^{-1} DM----------					----------mg kg^{-1} DM----------			
Years (Y)									
2004	5.80^{a}	1.60^{a}	3.30^{a}	14.60^{a}	1.500^{a}	35.7^{a}	0.93^{a}	44.30^{a}	14.00^{a}
2005	4.70^{b}	1.20^{b}	2.60^{b}	9.20^{b}	1.300^{b}	32.2^{b}	0.82^{b}	41.50^{b}	12.00^{b}
SEM	0.22	0.16	0.80	1.10	0.920	1.20	0.09	1.40	1.60
Season (S)									
Spring	4.30^{b}	1.20^{c}	2.40^{b}	8.40^{d}	1.100^{c}	31.2^{c}	0.64^{c}	41.00^{c}	11.00^{b}
Summer	6.20^{a}	1.80^{a}	3.80^{a}	16.80^{a}	1.900^{a}	38.4^{a}	1.00^{a}	47.00^{a}	15.00^{a}
Fall	5.50^{a}	1.60^{ab}	3.50^{a}	11.00^{b}	1.600^{b}	34.5^{b}	0.95^{a}	45.00^{b}	14.00^{a}
Winter	4.50^{b}	1.40^{bc}	2.50^{b}	8.80^{c}	1.200^{c}	31.4^{c}	0.83^{b}	42.00^{c}	12.00^{b}
SEM	0.70	0.52	0.41	0.16	0.100	0.84	0.10	0.13	0.17
Effects	p<	p<	p<	p<	p<	p<	p<	p<	p<
Y	*	*	*	*	*	*	*	*	*
S	**	**	**	**	**	**	**	**	**
Y×S	NS	NS	NS	NS	NS	NS	NS	NS	NS

$^{a\text{-}d}$Means with different superscripts, within column are significantly different (p<0.05). SEM: Standard Error of Mean. n = 4; NS: Not Significant (p>0.05); *(p<0.05); **(p<0.01)

Mineral content: There was not year×season interaction for the mineral evaluated (p>0.05; Table 2). However, the values of Ca, P. Na, K, Mg, Zn, Se Mn and Cu were greater in 2004 versus 2005 (p<0.05). The Ca content of diet selected was higher in summer and fall (p<0.01). In this study, the diet consumed for cattle throughout of the seasons had appropriate amounts of Ca to meet requirements of growing beef cattle (4.0 g kg^{-1} DM), beef gestating cows (1.6 g kg^{-1} DM) and early lactation (2.8 g kg^{-1} DM) (NRC, 2000). Due to its low mobility, Ca concentration is lower in mature forage (Minson, 1990). This probably results from Mg availability being linked to soil Ca and pH; increased Ca in acid soils favors Mg uptake by roots. Low Al, Mn and Fe contents in acidic pH increases Cu and Zn uptake without affecting plant Ca concentration (Pope, 1971). The P concentration in the diet consumed for cattle was higher in 2004 versus 2005 (p<0.05) as well as was greater in summer as compared to winter and spring (p<0.01). However, in this research the P concentration was not sufficient for to meet requirements of beef cattle (2.2, 1.7 and 2.2 g of P kg^{-1} of DM for growing beef cattle, beef pregnant cows and beef cows early lactation, respectively) (NRC, 2000). Greene, (2000) reported that due to slow growth and increased temperature, P decreases from 1.8-1.2 g kg^{-1} DM during the dry season. The Mg content of diet selected was higher in summer and fall versus winter and spring (p<0.01). The Mg present in the diet consumed for cattle during seasons was sufficient to meet requirements of beef cattle (1, 1.2 and 2 g of mg kg^{-1} of DM for growing beef cattle, beef gestating cows and beef cows early lactation, respectively) (NRC, 2000). The K content was affected by season of the year (p<0.01). Diet K content in all seasons was similar to required levels (6, 6 and 7 g kg^{-1} of DM for growing beef cattle, beef gestating cows and early lactation, respectively) (NRC, 2000). Grazing cattle normally receive sufficient K because forage contains high K levels (McDowell and Valle, 2000). The Na content of diet selected for cattle was different between seasons and years (p<0.01). The changes in Na content may be caused by atmospheric Na and geochemical factors (Minson, 1990). In this research, the Na content was sufficient for to meet requirements of beef cattle (0.6, 0.6 and 1 g of Na kg^{-1} of DM for growing beef cattle, beef cows gestating and early lactation, respectively) (NRC, 2000).

The Zn content was higher in summer and lower in spring (p<0.01). The diet consumed for cattle throughout of the seasons and years had appropriate amounts of Zn to meet requirements of beef cattle (30, 30 and 30 mg of Zn kg^{-1} of DM for growing beef cattle, beef gestating cows and early lactation, respectively) (NRC, 2000). Similarly, Moya *et al*. (2002) reported variations seasonal in Zn content of eight species shrubs occur in North Mexico. The Se content was affected by season of the year (p<0.01) with highest values in summer and lower in spring (p<0.01). This coincides with Jumba *et al*. (1996) who reported that rainfall influenced on forage Se content. In this study, Se content was higher that the minimal requirements recommended for cattle throughout of the seasons and years (growing beef cattle 10 mg kg^{-1} DM, beef cows gestating 10 mg kg^{-1} DM and early lactation 10 mg kg^{-1} DM) (NRC, 2000). Likewise, the Mn content of diets was higher in summer and lower in spring (p<0.01) and had adequate amounts to meet requirements of beef cattle (20, 40 and 40 mg of Mn kg^{-1} of DM for growing beef cattle, beef gestating cows and early lactation, respectively) (NRC, 2000). Nonetheless, McDowell (2003) has been reported in USA and other countries Mn scarcity for ruminants under grazing conditions. Similarly, the Cu content of diets was higher in summer and lower in spring (p<0.01). During dry season might have also reduced availability of Cu (Spears, 1994).

The diet consumed for cattle throughout of the seasons and years had adequate amounts of Cu to meet requirements of growing beef cattle (10 mg kg^{-1} DM), beef cows gestating (10 mg kg^{-1} DM) and early lactation (10 mg kg^{-1} DM) grazing native rangelands (NRC, 2000). Under conditions similar to those of the study, Mayland and Lesperance (1977), Kalmbacher *et al.* (1984) and Arthington and Swenson (2004) found differences between seasons in contents of Ca, P. Na, K, Mg, Zn, Mn and Cu. According to McDowell (2003) and Haenlein and Ramirez (2007) these differences in the mineral contents of diets may be attributed to the interaction of a number factor including soil, plant species, yield, pasture management, climate (temperature and rainfall) and stages of maturity. The fiber content increases with the rangelands maturity (Murillo *et al*., 2006). A sizable amount on the total Ca, Cu and Zn was associated with the Neutral Detergent Fiber (NDF) fraction (Van Soest, 1994). The association of certain minerals with fiber or other insoluble plant components could decrease the rate and extent of mineral release from forages in the ruminant gastrointestinal tract (Spears, 1994). In addition, all factors that determine the mineral contents of the vegetative parts of plants, basically influence the mineral intakes of range livestock grazing system (McDowell, 1996). Nonetheless, the mineral content of diet grazing cattle obtained from esophageal samples should be viewed with some caution because leaching by saliva might overestimate mineral concentrations mainly of Na, K, Mn and Fe (Hoehne *et al*., 1967).

CONCLUSION

The results indicate that drought induced by spring and winter results in decreased diet quality nutritive because to the decreased of CP and increase of NDF. The protein supplementation and energy might be beneficial for cattle grazing during spring and winter. Further, optimal type and level of protein and energy supplementation under spring drought condition have yet to be determined.

During wet season, the mineral content was higher compared to dry season. Ca, Mg, Na, Zn, Se, Mn and Cu supplied by the diet, meet the requirements of grazing native rangelands cattle while P content was deficient in both years and seasons. The study provides new knowledge can be used to make more precise the formulation of supplements that grazing cattle need to improve their health, immunity, lactation, growth and reproduction.

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REFERENCES

AOAC, 1999. Official Methods of Analysis of the Association of Official Agricultural Chemists. 16th Edn., AOAC International, Gaithersburg, MD, USA.

Arthington, J.D. and C.K. Swenson, 2004. Effects of trace mineral source and feeding method on the productivity of grazing Braford cows. Prof. Anim. Sci., 20: 155-161.

Cherney, D.J.R., 2000. Characterization of Forages by Chemical Analysis. In: Forage Evaluation in Ruminant Nutrition, Givens, D.I., E. Owen, R.F.E. Axford and H.M. Omed (Eds.). CAB International, Wallingford, UK., pp: 275-300.

Cline, H.J., B.W. Neville, G.P. Lardy and J.S. Caton, 2009. Influence of advancing season on dietary composition, intake, site of digestion and microbial efficiency in beef steers grazing a native range in Western North Dakota. J. Anim. Sci., 87: 375-383.

Fink, K.R., L.R. McDowell, P.H. Miles, N.S. Wilkinson, J.D. Funk and J.H. Conrad, 1979. Methods of Mineral Analysis for Plant and Animal Tissues. 2nd Edn., University of Florida, Gainsville.

Franco, L.J., A.G. De-la-Cruz, G.A. Cruz, R.A. Rocha and S.N. Navarrete *et al*., 1985. Manual de Ecologia. Editorial Trillas, Mexico.

Greene, L.W., 2000. Designing mineral supplementation of forage programs for beef cattle. J. Anim. Sci., 77: 1-9.

Grings, E.E., M.R. Shorth, M.R. Haferkamp and R.K. Heitschmidt, 2004. Late summer protein supplementation for yearling cattle. J. Range. Manage., 57: 358-364.

Haenlein, G.J.W. and R.G. Ramirez, 2007. Potential mineral deficiencies on arid rangelands for small ruminants with special reference to Mexico. Small Rum. Res., 68: 35-41.

Hoehne, O.E., D.C. Clanton and C.L. Streeter, 1967. Chemical changes in esophageal fistula samples caused by salivary contamination and preparation. J. Anim. Sci., 26: 628-631.

Jumba, I.O., N.F. Suttle, E.A. Hunter and S.O. Wandiga, 1996. Effects of Botanical Composition, Soil Organic and Composition on Mineral Concentrations in Dry Season Pastures in Weatern Kenya. In: Environment Geochemistry and Health, Appleton, J.D., R. Fuge and G.J.H. MarCall (Eds.). Geolical Society Special Publicaction, London, UK., pp: 39-45.

Kalmbacher, R.S., K.R. Long and F.G. Martin, 1984. Seasonal mineral concentration in diets of esophageally fistulated steers on three range areas. J. Range. Manage., 37: 36-38.

Karn, J.F., 2000. Supplementation of yearling steers grazing northern Great Plains rangelands. J. Range Manage., 53: 170-175.

Klopfenstein, T.J., R.A. Mass, K.W. Creighten and H.H. Patterson, 2001. Estimating forage protein degradation in the rumen. J. Anim. Sci., 79: 217-217.

Littell, R.C., P.R. Henry and C.B. Ammerman, 1998. Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci., 76: 1216-1231.

Mayland, H.F. and A.L. Lesperance, 1977. Mineral composition of rumen fistula samples compared to diets. J. Range. Manage., 39: 338-390.

McDowell, L.R. and G. Valle, 2000. Major Minerals in Forages. In: Forage Evaluation in Ruminant Nutrition, Givens, D.I., E. Owens and H.M. Omed (Eds.). CABI Publishing, Oxon, UK., pp: 373-397.

McDowell, L.R., 1985. Nutrition of Grazing Ruminants in Warm Climates. Academic Press, New York.

McDowell, L.R., 1992. Mineral in Animal and Human. Academic Prees Inc., USA., pp: 387.

McDowell, L.R., 1996. Feeding mineral to cattle on pasture. Anim. Feed Tech., 60: 247-271.

McDowell, L.R., 2003. Mineral in Animal and Human. 2nd Edn., Elsevier, The Netherlands, pp: 256-315.

Minson, D.J., 1990. Forages in Ruminants Nutrition. Academic Press, California, USA.

Moya, R.J.G., R.G. Ramirez, R. Foroughbackhch, L.A. Hauad and R.H. Gonzalez, 2002. Variacion estacional de minerales en las hojas de ocho especies arbustivas. Ciencia UANL, 5: 59-65.

Murillo, O.M., O. Reyes, E. Herrera, M. Guerrero and G. Nevarez *et al.*, 2006. Chemical composition, intake and *in vitro* gas production of forage selected by cattle in a grassland of Northern Mexico. J. Anim. Sci., 84: 23-23.

NRC, 2000. Nutrient Requirements of Domestic Animals, Nutrient Requirements of Beef Cattle. 7th Edn., NRC, Washington, DC, USA.

Olson, K.C., J.R. Jaeger, J.R. Brethour and T.B. Avery, 2002. Steer nutritional response to intensive-early stocking on short-grass rangeland. J. Range Manage., 55: 222-228.

Pope, A.L., 1971. A review of recent mineral research with sheep. J. Anim. Sci., 33: 1332-1338.

SAS, 2003. SAS User's Guide (Release 9.1). SAS Inst. Inc., Cary, NC.

Spears, J.W., 1994. Minerals in Forages. In: Forage Quality, Evaluation and Utilization, Fahey, G.C., M. Collins and D.R. Mertens (Eds.). American Society of Agronomy, Madison, WI., pp: 281-317.

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. 2nd Edn., Cornell University Press, Ithaca, New York, pp: 373.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polisacharides in relation to animal nutrition. J. Dairy. Sci., 74: 3583-3597.

Waterman, R.C., E.E. Grings, T.W. Geary, A.J. Roberts, L.J. Alexander and M.D. MacNeil, 2007. Influence of seasonal forage quality on glucose kinetics of young beef cows. J. Anim. Sci., 85: 2582-2595.