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Annual and Seasonal Changes in Ruminal Degradability of Diets by Grazing Steers in Native Range

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Abstract: The objective of this study was to evaluate the annual and seasonal changes on *in situ* degradability of dry matter, crude protein and neutral detergent fiber in the diet of grazing steers. For the statistical analysis a fixed effects model was used. Significant effects of years were observed in soluble fractions a, degradable b, degradation rate c of the Dry Matter (DM) and Crude Protein (CP) ($p<0.05$). Also was observed effects between years in the Potential Degradability of Dry Matter (PDDM), Potential Degradability of the Crude Protein (PDCP) and Potential Degradability of the Neutral Detergent Fiber (PDNDF) as well as in the Effective Degradability of Dry Matter (EDDM), Effective Degradability of Crude Protein (EDCP) and Effective Degradability of Neutral Detergent Fiber (EDNDF) ($p<0.05$). The values of a, b, c of DM and CP as well as the PDDM, PDCP, EDDM and EDCP of the diet in summer and in fall were higher than those observed in winter and spring ($p<0.05$). Soluble fraction A and degradable B as well as values of c of the Neutral Detergent neutral (NDF) in summer and fall were equal but different from those observed in winter and spring ($p<0.05$) while the PDNDF and EDNDF were different between seasons ($p<0.05$). We conclude that annual and seasonal weather changes affected *in situ* degradability of DM, NDF and CP in the diet selected by grazing steers.

Key words: Steers, grazing, nutritive quality, ruminal degradability, detergent fiber, seasonal change

INTRODUCTION

In Northern Mexico as in other regions with similar agro-ecological characteristics, the extreme drought and overgrazing have contributed to grasslands degradation and as a consequence, the undernourishment of grazing livestock. Some studies report that as a result of drastic climate change, animals in these regions have a period 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 nutritional quality of the diet selected by free-grazing bovines across seasons is essential to establishing strategic programs of dietary supplementation.

Moreover, these studies must be complemented by analyses of ruminal degradability of dietary nutrients in order to more precisely establish dietary supplementation needs. Ruminal degradability has been used often to estimate nutritive quality of cultivated forage (Huntington and Burns, 2008) and of irrigated prairies (Madero, 2000) in different cuts and states of maturity. Nonetheless, there is little information about ruminal degradability of the principal nutritional fractions of the diet consumed by grazing steers in native rangelands. Consequently, the aim of this study was to examined annual and seasonal changes on *in situ* degradability of DM, CP and NDF of the diet selected by grazing steers.

MATERIALS AND METHODS

Study area: The study was carried during two consecutive years (2004 and 2005) in a medium-sized shrub-grassland East of the city of Durango, Mexico (24° 22' N, 104°32' W 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 than 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^{-1}. During the 2 years of the study, we estimated

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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) and plus a wide variety of annual herbs.

Animals and collection of diet samples: We used four steers with fistulated in the esophagus and three heifers cannulated of the rumen both with a live weight of 350±3 kg. Surgery was performed on the steers and heifers according to procedures approved by the University of Durango Laboratory Care Advisory Committee. We collected diet samples with the steers fistulated of esophagus on four consecutive days at 07:00 during a 45 min period (Karn, 2000), eight times annually: January 2-5, February 4-7, April 13-16, May 15-18, July 20-23, August 11-14, October 12-15 and Novemeber 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 plant community.

***In situ* degradability and rate of passage (Kp):** We determined *in situ* degradability of the DM, NDF and CP in the heifers during grazing by incubating 10×20 cm bags with a pore size of 27×47 μm that contained 10 g of sample ground to 2 mm in the rumen, repeated twice for each time and animal at intervals of 3, 6, 9, 15, 24, 36, 48, 72, 96 and 0 h. After incubation, bags were removed from the rumen and rinsed with cold tap water, until the rinse water remained clear. Then, they were dried at 60°C for 48 h and then weighed. We determined degradability of DM at time 0 h by immersing the bags containing 10 g of sample in the rumen for 1 min and then washing them as described above (Ellis *et al.*, 2005). We corrected degradability of CP by subtracting CP linked to acid detergent fiber (N-ADF× 6.25) from (Klopfenstein *et al.*, 2001).

The esophageal samples as well as the residues obtained from each incubation time,were dried at 60°C for 48 h and by standard procedures was analized for DM, CP (AOAC, 1999) and NDF (Van Soest *et al.*, 1991). Using the model proposed by Orskov and Shand (1997), we estimated parameters a (soluble fraction of the DM, CP and NDF), b (degradable fraction of the DM, CP and NDF), c (constant degradation rate of b) and the PDDM, PDNDF and PDCP. Using parameters obtained from these calculations, we estimated the fractions A and B of NDF. Fraction A represents particles of the diet that were lost as a result of washing bags (time 0) and B is the insoluble yet fermentable fraction defined as B = (a+b)–A (Khazaal *et al.*, 1995). Upon concluding periods of incubation of bags in the rumen and before initiating grazing, we removed all ruminal content in each heifer and placed them in black polyethylene bags, weighed them, took 0.5 kg samples and immediately reintroduced the contents into the rumen of the heifer from which it came. We determined Acid-Insoluble Ash (AIA) in samples the diet as well as in samples of ruminal contents according to Van Soest *et al.* (1991). We determined Kp dividing AIA content in the diet consumed by the steers by total AIA in the ruminal content (Ogden *et al.*, 2005). At once, inserted the Kp into the model (a+b*c)/(c+Kp) proposed by the AFRC (Agricultural and Food Research Council), 1993 for estimation of EDDM, EDNDF and EDCP.

Statistical analysis: For the statistical analysis a fixed effects model was used. We used the options LSMEANS, STDERR and adjust = SCHEFFE, in GLM of SAS (2003) to calculate least squares means, their standard errors and to predict differences between means.

RESULTS AND DISCUSSION

***In situ* ruminal degradability of DM:** Values of a, b, c, of the DM and PDDM and EDDM were greater in 2004 versus 2005 ($p<0.05$; Table 1). We cite weather conditions as the cause of these differences given that temperature and rainfall have a direct effect on degradability of dry matter in grasslands of northern Mexico (Ramirez *et al.*, 2004). We did not find differences in values of a-c of the DM and PDDM and EDDM between summer and fall ($p>0.05$) but values for these seasons were different from

Table 1: Least squares means (±standard error) for parameters of *in situ* degradability and effective degradability of dry matter in the diet of grazing steers

Factors	a (%)	b (%)	c (% h^{-1})	PDDM (%)	EDDM (%)
Year					
2004	20.7±0.7^{a}	62.5±0.5^{a}	4.3±0.2^{a}	83.2±0,6^{a}	60.2±0.9^{a}
2005	18.2±0.7^{b}	59.5±0.5^{b}	3.1±0.2^{b}	79.1±0,6^{b}	56.8±0.9^{b}
Season					
Spring	18.9±0.4^{b}	58.1±1.2^{b}	1.8±0.6^{b}	77.0±1.3^{b}	51.5±0.4^{b}
Summer	22.0±1.1^{a}	63.4±0.8^{a}	4.6±0.2^{a}	84.3±1.1^{a}	60.9±0.9^{a}
Fall	21.2±0.4^{a}	62.4±0.8^{a}	3.9±0.9^{a}	83.4±1.1^{a}	58.8±1.0^{a}
Winter	18.6±0.9^{b}	57.6±0.9^{b}	1.8±0.5^{b}	76.2±0.8^{b}	49.7±0.7^{b}
Month					
January	17.7±1.2^{d}	56.2±1.6^{d}	1.6±0.7^{d}	73.9±1.5^{f}	48.7±1,2^{e}
February	19.6±1.3^{c}	59.1±1.6^{c}	2.0±0.6^{c}	78.7±1.5^{d}	50.7±0,9^{d}
April	19.1±1.1^{c}	58.2±1.3^{c}	1.9±0.9^{c}	77.3±1.1^{de}	52.6±0,6^{c}
May	18.8±1.1^{c}	58.0±1.6^{c}	1.8±1.1^{cd}	76.8±1.7^{e}	50.4±0,2^{d}
July	21.2±0.9^{b}	63.0±1.2^{a}	4.4±1.0^{a}	84.2±1.7^{b}	60.4±1,1^{a}
August	22.8±1.4^{a}	63.8±0.9^{a}	4.9±0.6^{a}	86.6±1.1^{a}	61.5±0,9^{a}
October	22.3±0.9^{a}	63.2±1.0^{a}	4.6±0.3^{a}	85.5±1.0^{ab}	60.8±0,8^{a}
November	20.2±1.0^{b}	61.7±1.4^{b}	3.2±0,4^{b}	81.9±1.0^{c}	56.7±1,2^{b}

^{abcdef}Means with different letters in columns for year, season and month are statistically different ($p<0.05$)

those found in winter and spring ($p<0.05$). Under conditions similar to those of the study, Reyes *et al.* (2006) found differences between seasons in values of a-c, of the DM and PDDM. Seasonal differences in parameters of *in situ* degradability of DM may be attributed to protein, fiber and lignin contents of the diet selected by study animals (Baumont *et al*., 2000).

The highest values of a-c, of the DM, PDDM and EDDM appeared in August and the lowest in January ($p<0.05$). Average values of a (20.9%), b (33.3%), c (3.9% h^{-1}) and EDDM (40.1%) reported by Ramirez *et al.* (2004) in nine grasslands in northeastern Mexico are lower than those we obtained for the month of August.

Also, Obeidat *et al*. (2002) report lower values of b for the months of February (48.2%) and May (39.8%) than the findings. These discrepancies between studies are most likely a result of the different plant communities and climate zones in which the investigations took place.

***In situ* ruminal degradability of CP:** Values of a-c of the CP, PDCP and EDCP were greater in 2004 versus 2005 ($p<0.05$) (Table 2). Fractions a and b and the rate of degradation of protein c were greater in summer and fall as compared to winter and spring ($p<0.05$). Numerous studies report similar results and attribute differences between years and seasons to the level of lignification in the grazing area which impedes access of microbial proteases to protein soluble in the diet (Hirschfeld *et al*., 1996; Foster *et al*., 2007).

The PDCP and EDCP were affected by season of the year ($p<0.05$) with the highest values of PDCP in summer (82.2%) and the lowest in winter (73.8%) while the highest EDCP occurred in fall (63.2%) and the lowest in spring (58.2%) ($p<0.05$). Such differences may be a result of potentially degradable and soluble protein content in the diet selected in the two studies (Atkinson *et al*., 2010). The values of a, b, c of the CP, PDCP and EDCP for August were higher than those observed in other months of the year ($p<0.05$).

Values of a (40.4%), b (37.4%) and PDCP (77.7%) reported by Caton *et al.* (1993) for the month of August were higher than the values, although their rate of protein degradation (5.4% h^{-1}) agrees with the finding for the month of August (5.3% h^{-1}). Johnson *et al.* (1998) suggest that differences between parameters of ruminal CP degradation may be a result of differences in methods of estimation of soluble protein a in the diet.

***In situ* ruminal degradability of NDF:** Losses of NDF due to washing (fraction a), degradable fraction b, rate of degradation c, as well as PDNDF and EDNDF were different between years ($p<0.05$) (Table 3). Small portions of NDF that were partitioned in fraction A could be associated, in part with losses of small particles of the diet through pores in the bags more so than with solubilization of components of the cell wall (Ogden *et al*., 2005). Consequently, differences observed between years in fraction a, PDNDF and EDNDF may be a result of different lignin content in the diet consumed by study animals (Juarez *et al*., 2004).

Values of a, b and c in summer and fall differed from those for winter and spring ($p<0.05$) while PDNDF and EDNDF varied between seasons ($p<0.05$) with the highest values in summer (PDNDF: 56.9%, EDNDF: 35.5%) and the lowest in winter (PDNDF: 39.5%, EDNDF: 24.3%). Under conditions similar to those of the study, Fredrickson *et al.*

Table 2: Least squares means (± standard error) for parameters of *in situ* degradability and effective degradability of crude protein in the diet of grazing steers

Factors	a (%)	b (%)	c (% h^{-1})	PDCP (%)	EDCP (%)
Year					
2004	34.9±0.8^{a}	47.2±0.2^{a}	4.2±0.7^{a}	82.1±1.1^{a}	62.5±1.6^{a}
2005	28.8±0.8^{b}	41.4±0.2^{b}	3.1±0.7^{b}	70.2±1.1^{b}	57.0±1.6^{b}
Season					
Spring	30.3±0.4^{b}	44.7±1.2^{c}	2.9±0.4^{c}	75.0±1.2^{c}	58.2±0.4^{d}
Summer	34.2±0.8^{a}	48.0±1.1^{a}	4.7±0.2^{a}	82.2±1.4^{a}	60.2±0.8^{c}
Fall	33.0±0.5^{a}	46.9±0.9^{b}	4.1±0.4^{b}	80.0±1.1^{b}	63.6±0.6^{a}
Winter	30.7±0.2^{b}	43.1±1.2^{c}	2.9±0.6^{c}	73.8±0.9^{d}	62.2±0.4^{b}
Month					
January	29.6±1.2^{b}	40.7±1.1^{e}	2.3±0.8^{e}	70.3±1.2^{f}	55.6±1.2^{e}
February	31.9±0.9^{b}	45.5±0.9^{d}	3.6±0.4^{d}	77.4±1.7^{d}	62.2±1.1^{bc}
April	30.9±1.1^{b}	45.3±0.7^{d}	3.2±0.2^{d}	76.2±1.3^{d}	62.4±1.1^{bc}
May	29.7±0.7^{b}	44.1±1.3^{d}	2.7±0.4^{de}	73.8±1.4^{e}	58.0±1.3^{d}
July	33.8±0.3^{a}	47.2±1.6^{bc}	4.2±0.9^{bc}	81.0±1.1^{b}	62.9±1.1^{b}
August	34.6±1.1^{a}	48.8±1.1^{a}	5.3±0.3^{a}	83.4±1.5^{a}	64.3±1.3^{a}
October	33.9±1.4^{a}	47.7±1.2^{ab}	4.4±0.3^{ab}	81.6±1.1^{b}	63.0±1.2^{ab}
November	32.2±1.1^{a}	46.2±1.8^{c}	3.8±0.6^{c}	78.4±1.1^{c}	61.4±0.9^{c}

^{abcdef}Means with different letters in columns for year, season and month are statistically different ($p<0.05$)

Table 3: Least squares means (± standard error) for fractions of *in situ* degradability and effective degradability of neutral detergent fiber in the diet of grazing steers

Factors	a (%)	b (%)	c (% h^{-1})	PDNDF (%)	EDNDF (%)
Year					
2004	7.9±0.6^{a}	42.4±0.8^{a}	2.7±0.2^{a}	50.3±1.3^{a}	33.4±0.9^{a}
2005	4.1±0.6^{b}	38.6±0.8^{b}	2.3±0.2^{b}	42.7±1.4^{b}	26.6±0.9^{b}
Season					
Spring	3.2±0.9^{c}	37.8±0.8^{b}	2.2±0.3^{c}	41.0±1.1^{c}	26.1±0.9^{c}
Summer	9.6±0.2^{a}	47.3±0.3^{a}	3.6±0.2^{a}	56.9±1.4^{a}	35.5±1.2^{a}
Fall	7.7±0.8^{b}	46.9±0.4^{a}	3.1±0.9^{b}	54.6±0.8^{b}	33.7±1.4^{b}
Winter	3.0±0.6^{c}	36.5±0.9^{b}	2.2±0.7^{c}	39.5±1.2^{d}	24.3±0.7^{d}
Month					
January	2.5±1.1^{f}	33.2±1.4^{e}	1.7±1.1^{e}	35.7±1.3^{c}	21.3±1.2^{e}
February	3.5±1.1^{d}	39.8±1.2^{d}	2.7±1.2^{c}	43.3±1.1^{d}	27.3±0.9^{c}
April	3.4±1.1^{d}	37.4±1.1^{d}	2.4±0.9^{d}	40.8±0.9^{e}	27.0±1.1^{c}
May	3.1±1.3^{f}	38.2±0.8^{de}	2.1±0.5^{de}	41.3±1.4^{e}	25.3±0.8^{d}
July	8.7±0.9^{b}	43.8±0.9^{c}	3.6±1.2^{a}	52.5±0.8^{b}	34.1±1.2^{b}
August	10.5±0.8^{a}	50.8±1.2^{a}	3.7±1.4^{a}	61.3±1.1^{a}	36.9±0.5^{a}
October	7.8±1.1^{c}	47.1±1.4^{b}	3.2±1.1^{b}	54.9±1.3^{b}	32.9±1.1^{b}
November	7.6±1.3^{c}	46.8±1.1^{b}	3.0±0.8^{bc}	54.4±0.8^{b}	34.6±1.6^{b}

^{abcdef}Means with different letters in columns for year, season and month are statistically different ($p<0.05$)

(1993) reported higher NDF degradability parameters in summer compared to winter. Constant NDF degradation rates were faster in summer (3.6% h^{-1}) and fall (3.1% h^{-1}) compared to winter (2.2% h^{-1}) and spring (2.2% h^{-1}) but all were lower than rates reported by (Funk *et al*., 1987) (4.2% h^{-1}). However, values for rate of degradation of NDF c obtained by Caton *et al*. (1988) (3.1% h^{-1}) and Barton *et al*. (1992) (2.2% h^{-1}) are similar to the findings for spring, fall and winter. Values of a, b, c, PDNDF and EDNDF were greater in August vs January ($p<0.05$).

Gelvin *et al*. (2004) report lower values than we found for NDF degradation rate in August and October (1.9 and 1.1% h^{-1}, respectively). The observed differences between seasons and months with respect to NDF degradability parameters may be associated with an increase in indigestible fractions in the diet selected by study animals (Steg *et al*., 1994).

CONCLUSION

The study provides new knowledge of the NDF fraction in the diet of grazing steers that is lost of particulates due to bag washing (fraction a). This fraction is associated with high contents of lignocellulosic matter which makes it a good indicator of nutritive quality of the diet selected by free-grazing ruminants across seasons of the year.

Although, the values of the soluble fraction of protein a across years, seasons and months were within acceptable ranges for the assimilation of ammoniacal nitrogen resulting from the fermentation of soluble protein by ruminal microorganisms, Effective Degradability of Crude Protein (EDCP) in the diet, indicates low quantities of bypass protein. Bypass protein supplementation is essential to covering metabolizable protein needs of free-grazing cattle. The results allow us to conclude that *in situ* degradability of DM, NDF and CP in the diet selected by free-grazing steerss were affected by annual and seasonal weather changes.

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REFERENCES

AFRC. (Agricultural and Food Research Council), 1993. Energy and Protein Requirements of Ruminants: AFRC Technical Committee on Responses to Nutrients. CAB International, Wallingford, UK.

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

Atkinson, R.L., C.D. Toone and P.A. Ludden, 2010. Effects of ruminal protein degradability and frequency of supplementation on site and extent of digestion and ruminal fermentation characteristics in lambs fed low-quality forage. J. Anim. Sci., 88: 718-726.

Barton, P.K., L.J. Krysl, M.B. Judkins, D.W. Holcombe, J.T. Broesder, S.A. Gunter and S.W. Beam, 1992. Time of daily supplementation for steers grazing dormant intermediate wheatgrass pasture. J. Anim. Sci., 70: 547-558.

Baumont, R., S. Prache, M. Meuret and P. Morand-Fehr, 2000. Forage characteristic influence behavior and intake in small ruminants. A review. Livest. Prod. Sci., 64: 15-28.

Caton, J.S., A.S. Freeman and M.L. Galyean, 1988. Influence of protein supplementation on forage intake, *in situ* forage disappearance, ruminal fermentation and digesta passage rates in steers grazing dormant blue grama rangeland. J. Anim. Sci., 66: 2262-2271.

Caton, J.S., D.O. Erickson, D.A. Carey and D.L. Ulmer, 1993. Influence of *Aspergillus oryzae* fermentation extract on forage intake, site of digestion, *in situ* degradability and duodenal amino acid flow in steers grazing cool-season pasture. J. Anim. Sci., 71: 779-787.

Ellis, W.C., M. Mahlooji and J.H. Matis, 2005. Models for estimating parameters of neutral detergent fiber digestion by ruminal microorganisms. J. Anim. Sci., 83: 1591-1601.

Foster, J.J., J.P. Muir, B.D. Lambert and D. Pawelek, 2007. *In situ* and *in vitro* degradation of native Texas warm-season legumes and alfalfa in goats and steers fed a sorghum-sudan basal diet. Anim. Feed Sci. Technol., 133: 228-239.

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.

Fredrickson, E.L., M.L. Galyean, M.E. Branine, B. Sowell and J.D. Wallace, 1993. Influence of ruminally dispensed monensin and forage maturity on intake and digestion. J. Range Manage., 46: 214-220.

Funk, M.A., M.L. Galyean, M.E. Branine and L.J. Krysl, 1987. Steers grazing blue grama rangeland and throughout the growing season. I. Dietary composition, intake, digesta kinetic and ruminal fermentation. J. Anim. Sci., 65: 1342-1353.

Gelvin, A.A., G.P. Lardy, S.A. Soto-Navarro, D.G. Landblom and J.S. Caton, 2004. Effect of field pea-based creep feed on intake, digestibility, ruminal fermentation and performance by nursing calves grazing native range in western North Dakota. J. Anim. Sci., 82: 3589-3599.

Hirschfeld, D.J., D.R. Kirby, J.S. Caton, S.S. Silcox and K.C. Olson, 1996. Influence of grazing management on intake and composition of cattle diets. J. Range Manage., 49: 257-263.

Huntington, G.B. and J.C. Burns, 2008. The interaction of harvesting time of day of switchgrass hay and ruminal degradability of supplemental protein offered to beef steers. J. Anim. Sci., 86: 159-166.

Johnson, J.A., J.S. Caton, W. Poland, D.R. Kirby and D.V. Dhuyvetter, 1998. Influence of season on dietary composition, intake and digestion by beef steers grazing mixed-grass prairie in the Northern great plains. J. Anim. Sci., 76: 1682-1690.

Juarez, R.A.S., E.R. Montoya, C.G. Nevarez, S.M.A. Cerrillo and F.L. Mould, 2004. *In situ* degradability of dry matter and neutral detergent fiber of thorn scrubland forage consumed by goats in the semi-arid region of Northern Mexico. Anim. Sci., 79: 505-511.

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

Khazaal, K., M.T. Dentinho, J.M. Ribeiro and E.R. Orskov, 1995. Prediction of apparent digestibility and voluntary intake of hay fed to sheep: Comparison between characteristics of gas production or nylon bag degradation. Anim. Sci., 61: 527-538.

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.

Madero, G.S., 2000. Degradabilidad ruminal de la hierba en praderas aprovechadas bajo pastoreo rotacional en la zona costera de Cantabria. Invest. Agra Prod. San. Anim., 15: 125-136.

Obeidat, B.S., M.G. Thomas, D.M. Hallford, D.H. Keisler and M.K. Petersen *et al*., 2002. Metabolic characteristics of multiparous Angus and Brahman cows grazing in the Chihuahua Desert. J. Anim. Sci., 80: 2223-2233.

Ogden, R.K., W.K. Coblentz, K.P. Coffey, J.E. Turner, D.A. Scarbrough, J.A. Jennings and M.D. Richardson, 2005. Ruminal *in situ* disappearance kinetics of dry matter and fiber in growing steers for common crabgrass forages sampled on seven dates in Northern Arkansas. J. Anim. Sci., 83: 1142-1152.

Orskov, E.R. and W.J. Shand, 1997. Use of the nylon bag technique for protein and energy evaluation and for rumen environment studies in ruminants. Livestock Res. Rural Dev., 9: 1-10.

Ramirez, R.G., G.F.W. Haenlein, C.G. Garcia-Castillo and M.A. Nunez-Gonzalez, 2004. Protein, lignin and mineral contents and in situ dry matter digestibility of native Mexican grasses consumed by range goats. Small Rumin. Res., 52: 261-269.

Reyes, E.O., O.M. Murillo, T.E, Herrera, C.M.Guerrero and C.G. Nevarez *et al*., 2006. *In situ* dry matter degradation kinetics of the diet selected by grazing cattle in a grassland of Northern Mexico. Joint Annu. Meeting. ADSA-ASAS. Minneapolis (Minnesota-USA). July 9-13. pp: 7 -484.

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

Steg, A.W.M., V.A. van Straalen, W.A. Hindle Wensik, F.M.H. Dooper and R.L.M. Schils, 1994. Rumen degradation and intestinal digestion of grass and clover at two maturity levels during the season in dairy cows. Grass Forage Sci., 49: 378-390.

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