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In situ Digestibility of Neutral Detergent Fiber of Introduced *Cenchrus ciliaris* and Six Native Mexican Grasses Consumed by Small Ruminants

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Abstract

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Native grasses from northeastern Mexico such as ***Aristida longiseta (Steud), Bouteloua gracilis (Thurb), Cenchrus incertus (M.A. Curtis), Hilaria berlangeri (Steud, Nash), Panicum hallii (Varsey) and Setaria macrostachya (H.B.K.)*** *and introduced* ***Cenchrus ciliaris (L),*** *a cultivated grass, that are consumed by range small ruminants were evaluated to estimate seasonally, their neutral detergent fiber (NDF) content and the rate and extent of NDF digestion.* ***Panicum hallii*** *was lower (72, 34, 26%, respectively) in NDF, cellulose and hemicellulose content and* ***A. longiseta*** *was higher (87, 37, 37%).* ***Cenchrus incertus*** *(42%, annual mean) was higher in EDNDF and* ***A. longiseta*** *(25%) was lower. With exception of* ***C. incertus,*** *all native grasses had lower EDNDF than* ***C. ciliaris*** *(40%). Because of their low NDF digestion most native grasses could be considered poor food resources for range small ruminants.*

Keywords: Grasses: *Aristida longiseta, Bouteloua gracilis, Cenchrus ciliaris, Cenchrus incertus, Hilaria berlangeri, Panicum hallii, Setaria macrostachya,* effective degradability, neutral detergent fiber.

Introduction

Neutral Detergent Fiber (NDF) contains cellulose, hemicellulose, silica, some protein (heat damaged) and lignin (Van Soest *et al.*, 1991). The NDF have low digestibility and are entirely dependent on the microorganisms of the digestive tract and is closely related to feed intake (Jung and Allen, 1995).

Research has demonstrated that ruminants will eat more dry matter (DM) when fed forages that have higher NDF digestibility (Van Soest *et al.*, 1991). Moreover, the major factor lowering digestibility of forages as they mature is the higher fiber and lower cell-soluble concentrations of mature grasses (Reid *et al.*, 1988). Grass leaves develop a lignified midrib to provide mechanical support, which contributes to the high fiber concentration of grass leaf blades. However, provision of adequate fiber is important for ruminants (Mertens and Sauvant, 1995).

The *in situ* technique is a very good method to estimate NDF digestibility of

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forages and is often used in research and other forage evaluation programs (Ramirez, 1999). The objectives of this study were to estimate and compare the degree and extent of NDF digestion of seven grasses growing in northeastern Mexico.

Materials and Methods

The study was carried out in a shrubland of approximately 20 ha at the Agricultural Experimental Station of Facultad de Agronomía Autónoma de Nuevo León at Marín, County, N.L., Mexico. Marín is located at 25°43' north latitude and 100°02' west longitude. The average elevation is 393 m. The climate of the region is considered semiarid with an annual mean temperature of 22C and about 500 mm of rainfall. Rainfall is bimodal, with peaks occurring in spring and fall. During the study, in winter precipitated 61.6 mm, in spring 140.2 mm, in summer 73.0 mm and in autumn 144.1 mm. Most soils of the region are rocky type of Upper Cretaceous calcite and dolomite. Dominants are deep, dark gray, lime-clay vertisols which are the result of alluvial and colluvial processes. They are characterized by high clay and calcium carbonate contents (pH: 7.5 - 8.785) and low organic matter content (Foroughbakhch, 1992).

Grasses such as *Cenchrus ciliaris* (L), *Aristida* spp., *Bouteloua gracilis* (Thurb), *Cenchrus incertus* (M.A. Curtis), *Hilaria berlangeri* (Steud. Nash), *Panicum hallii* (Varsey) and *Setaria macrostachya* (H.B.K.) that are consumed by range Spanish goats (Ramirez *et al.*, 1993), white tailed deer (Ramirez *et al.*, 1997) and range sheep (Ramirez *et al.*, 1995) were collected for nutritional studies. As encountered in the range, grasses were hand harvested until adequate amounts of material were obtained and compositing by species in each of the four seasons of the year (spring, winter, autumn and summer). Samples were stored in paper bags in the field and transported to laboratory. The sites of collection were ungrazed by livestock. Dry matter was determined subjecting samples to oven at 55C during 72 h, then were ground in a Wiley mill (1 mm) and stored in plastic containers for further analyses.

Samples were analyzed for organic matter, neutral detergent fiber (NDF), cellulose and hemicellulose (Van Soest *et al.*, 1991). The rate and extent of NDF loss was estimated using the nylon bag technique. Nonlinear digestibility parameters and effective degradability of NDF (EDNDF) of grasses were described by Ramirez *et al.* (2003). Data were statistically analyzed using an experimental design of two ways of classification (being grasses and seasons the study factors), with interaction between seasons and grasses. Partial correlation coefficients were performed between chemical composition, seasonal rainfall and EDNDF (Steel and Torrie, 1980).

Results and Discussion

The organic matter (OM) content in all grasses was significantly different among seasons and among grasses within seasons. *Aristida longiseta* was higher and *C. incertus* was lower. Moreover, NDF content in all grasses was significantly different among seasons and among grasses within seasons. *Aristida longiseta* was higher and *P. hallii* was lower. With exception of *P. hallii* all grasses had higher NDF content (annual mean basis) than *C. ciliaris* (Table 1). It seems that NDF content, in all grasses, was influenced by the climatic conditions; in those seasons when rainfall was higher (spring and autumn), invariably NDF content was lower. Conversely, NDF content, in most grasses, increased during the dryer seasons (winter and summer). Cellulose and hemicellulose content (Table 1) followed the same pattern as NDF.

The portion of NDF solubilized at the beginning of incubation (a), the portion of NDF that is slowly degraded in the rumen (b) and the rate constant of disappearance of

Table 1
Seasonal trends and annual means of organic matter, neutral detergent fiber (NDF), cellulose, hemicellulose of cultivated grass *Cenchrus ciliaris* and six Mexican native grasses

Grasses	Organic matter[1]							NDF[1]						
	Seasons[2]					SEM	Sig	Seasons[2]					SEM	Sig
	w	sp	su	f	M			w	sp	su	f	M		
A. longiseta	92	92	93	93	92	0.5	*	87	85	87	88	97	0.3	**
B. gracilis	87	89	87	84	87	0.6	**	90	81	82	77	82	0.2	***
C. ciliaris	93	86	91	87	89	0.6	***	78	74	76	74	76	0.5	**
C. incertus	86	84	88	83	85	0.5	**	80	74	80	75	77	0.1	***
H. berlangeri	89	86	88	82	86	0.6	***	83	75	82	75	79	0.4	***
P. hallii	89	83	89	87	87	1.1	***	76	69	73	68	72	0.2	***
S. macrostachya	90	90	90	82	90	0.4	*	80	79	86	74	80	0.2	***
Mean	89	88	87	89	88	0.8	NS	77	79	80	79	79	1.3	NS
SEM	0.5	0.3	0.6	0.4	1.0			0.2	0.2	0.4	0.3	1.8		
Sig	***	***	***	***	***			***	***	***	***	***		
	Cellulose[1]							Hemicellulose[1]						
A. longiseta	37	37	37	37	37	0.2	NS	37	33	37	37	37	0.2	***
B. gracilis	33	38	32	33	34	0.3	**	43	30	32	29	34	0.2	***
C. ciliaris	36	35	35	34	35	0.2	***	32	30	31	33	32	0.2	***
C. incertus	34	30	35	31	32	0.2	***	36	26	34	33	32	0.3	***
H. berlangeri	39	28	38	32	32	0.4	***	32	31	31	30	31	0.2	**
P. hallii	32	30	29	31	31	0.6	NS	31	29	32	26	29	0.7	**
S. macrostachya	37	35	42	33	36	1.0	**	32	35	35	31	33	0.4	**
Mean	33	35	34	33	34	1.0	NS	32	32	33	34	33	1.0	NS
SEM	0.4	0.2	0.8	0.3	1.3			0.3	0.2	0.3	0.6	1.4		
Sig	***	***	***	***	***			***	***	***	***	***		

[1]Percent of DM; [2]w=winter; sp=spring; su=summer; f=fall; M=annual mean, SEM=standard error of the mean; Sig=significant level; *(P<0.05); **(P<0.01); ***P<0.001); NS=not significant.

fraction b (c) were significantly different among seasons and among grasses within seasons (Table 2). In addition, EDNDF was significantly different among seasons and among grasses within seasons. *Cenchrus incertus* had higher annual mean and *A. longiseta* was lower. In general, during spring and autumn seasons EDDM was higher (P<0.001) than other seasons. With exception of *C. incertus* all grasses had lower EDNDF values than *C. ciliaris* (Table 2). It seems that NDF (r=-0.31; P<0.05) and cellulose (r=-0.45; P<0.01) content in grasses negatively influenced the rumen digestion of NADF because when NDF or cellulose increased EDNDF decreased. Seasonal rainfall, however, positively influenced (r=0.31; P<0.05) EDNDF. This correlation coefficient may be explained because of the seasonal patterns visually approximated those

Table 2
Seasonal variation and annual means of the parameters of the *in situ* digestibility and effective degradability of neutral detergent fiber of cultivated grass *Cenchrus ciliaris* and six Mexican native grasses

Grasses	a[1]							b[1]						
	Seasons[2]					SEM	Sig	Seasons[2]					SEM	Sig
	w	sp	su	f	M			w	sp	su	f	M		
A. longiseta	11	12	9	12	11	0.2	***	21	27	23	28	25	1.7	NS
B. gracilis	13	17	9	21	18	0.7	***	23	28	24	31	27	1.0	**
C. ciliaris	12	16	15	17	15	0.6	**	35	47	43	50	44	1.6	**
C. incertus	14	18	14	22	17	0.3	***	43	44	44	40	43	1.0	NS
H. berlangeri	11	14	11	15	13	0.5	**	26	25	29	35	29	0.7	***
P. hallii	12	16	12	17	14	0.3	***	35	40	34	42	38	0.9	***
S. macrostachya	10	12	10	14	11	0.4	**	34	29	29	31	31	1.6	*
Mean	12	11	14	14	13	1.1	***	30	33	34	34	33	1.4	**
SEM	0.5	0.4	0.5	0.4	1.5			0.9	1.7	1.4	0.8	1.9		
Sig	***	***	***	***	***			***	***	***	***	***		
	c[1]							EDNDF[1]						
A. longiseta	4	4	4	4	4	0.6	NS	22	28	21	28	25	0.8	**
B. gracilis	5	6	5	6	6	0.3	NS	27	37	29	40	33	0.7	***
C. ciliaris	5	7	5	8	7	0.2	*	36	42	38	44	40	0.4	***
C. incertus	6	7	6	7	7	0.3	NS	39	43	40	46	42	0.4	***
H. berlangeri	5	6	5	8	6	0.03	*	25	34	28	37	31	0.6	***
P. hallii	6	7	6	7	7	0.4	NS	33	39	34	42	39	0.4	**
S. macrostachya	5	6	5	7	6	0.4	*	29	31	29	33	30	0.7	**
Mean	6	6	6	6	6	0.2	NS	29	30	34	38	33	1.3	***
SEM	0.4	0.4	0.2	0.5	0.3			0.5	0.8	0.4	0.5	1.7		
Sig	*	**	**	*	***			***	***	***	***	***		

[1]Percent of DM; [2]w=winter; sp=spring; su=summer; f=fall; M=annual mean, SEM=standard error of the mean; Sig=significant level; *(P<0.05); **(P<0.01); ***P<0.001); NS=not significant.
a = intercept representing the portion of NDF solubilized at the beginning of incubation (time 0).
b = portion of NDF that is slowly degraded in the rumen.
c = rate constant of disappearance of fraction b.
EDNDF=effective degradability of NDF calculated with a rumen outflow rate of 2.0%/h^{-1}

obtained with NDF concentrations and rainfall. These effects have also been reported in introduced grasses to northeastern Mexico such as common buffelgrass *(C. ciliaris*; Ramirez *et al.*, 2001a), nueces buffelgrass (Ramirez *et al.*, 2001b), bermudagrass (Ramirez *et al.*, 2003) and *Dichanthium annulatum* (Ramirez *et al.*, 2005). According to Johnson and de Oliveira (1989) the NDF content is a useful negative indicator of the nutritive value of feeds. Moreover, they indicated that a range of 45 to 55% NDF will permit a modest performance of ruminants. In this study, a higher range (72-87%; Table

1) was obtained, thus ruminants consuming these grasses might have a poor performance.

Seasonal rainfall and plant maturity influenced the NDF composition of all evaluated grasses. During spring and fall, when rainfall was higher NDF content was lower and EDNDF was higher. Conversely, in winter and summer when NDF was higher and rainfall was lower EDNDF was lower. The cultivated grass *C. ciliaris* is considered to be more digestible than native grasses, however, with good management, native grasses will have good productivity levels and are generally more persistent. Selection of superior native grasses may increase their value further.

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आर.जी. रामिरेज। छुद्र रोमांथियों द्वारा भक्षित स्थापित सेन्क्रस सीजिएरिस और छः देसी मेक्सिकनी घासों की स्वस्थाने पाच्यता।

उत्तर-पूर्वी मेक्सिको से देसी घासें जैसे एरीस्टिदा लांगीसेटा (स्टचूड), बौटेलौवा ग्रेसिलिस (थर्ब), सेन्क्रस इन्सर्टस (एम.ए. कर्टिस), हिलेरिया बर्लेन्गेरी (स्टचूड नथ), पैनिकम हैल्लाई (वार्से) और सिटेरिया मैक्रोस्टेचिया (एच.बी.के.) और उगाई जाने वाली स्थापित सेन्क्रस सीलिएरिस (एल.) घासों का मूल्यांकन मौसमी उदासीन अपक्षारक रेशा (उअरे) और उसकी पाच्यता की दर और सीमा मापने के लिए किया गया। पैनिकम हैल्लाई में उअरे, सेलुलोज और हैमी सेलुलोज की मात्राएं क्रमशः 72%, 34%, और 26% न्यूनतम, और एरिस्टिडा लांगीसेटा में उसी क्रम में 87%, 37% और 37% सर्वाधिक थी। सेन्क्रस इन्सर्टस की 42% प्रभावी उअरे पाच्यता ए. लांगीसेटा के 25% से अधिक थी। सेन्क्रस सीजिएरिस के 40% की तुलना में सेन्क्रस इन्सर्टस को छोड़कार सभी देसी घासों की प्रभावी उअरे पाच्यता कम थी। इसलिए उअरे की पाच्यता कम होने के कारण चारागाह पर चरने वाले छुद्र रोमांथियों के लिए देसी घासें निम्न कोटि की मानी जाती हैं।