EFFECT OF GRAZING *Cratylia argentea* ASSOCIATED WITH *Brachiaria brizantha*-Toledo ON QUALITY PASTURE AND WEIGHT GAIN IN HOLSTEIN × ZEBU HEIFERS

[EFECTO DEL PASTOREO DE *Cratylia argentea* ASOCIADA CON *Brachiaria brizantha*-Toledo SOBRE LA CALIDAD DE LA PASTURA Y GANANCIA DE PESO EN NOVILLONAS HOLSTEIN × CEBÚ]

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SUMMARY

The relationship between grazing a high quality shrub legume, blood serum urea (BSU) and daily weight gain (DWG) in F_1 Holstein x Zebu heifers was evaluated. Two pastures were compared: 1) high crude protein diet (HCP): *Cratylia argentea* + *Brachiaria brizantha* Toledo grass, and 2) low crude protein diet (LCP): *Brachiaria brizantha* Toledo grass alone. Grazing of each treatment lasted 164 days. Dry matter yield (DMY), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (LIG) were evaluated in both pastures. Before grazing, DMY at HCP and LCP was 1922 ± 405 and 770 ± 405 kg ha^{-1}, respectively, and CP was 8.3 ± 0.85 and 8.7 ± 0.85 %, respectively. The NDF, ADF and LIG of Toledo grass at HCP and LCP were similar, averaging 73.1 ± 0.92, 42.7 ± 1.2 and 13.5 ± 0.7 %, respectively, while in *C. argentea* averages at HCP and LCP were 51.6 ± 0.58 % (NDF), 32.5 ± 0.85 % (ADF) and 16.7 ± 1.3 % (LIG). The BSU was 11.01 ± 0.35 (HCP) and 7.87 ± 0.35 (LCP) mg dL^{-1}. Average DWG in HCP and LCP was 839 ± 258 and 580 ± 278 g day^{-1}, respectively. In conclusion, in F_1 Holstein x Zebu heifers DWG can reach over 800 g day^{-1} when grazing a high CP diet.

Key words: *Cratylia argentea*; *Brachiaria brizantha* Toledo grass; blood serum urea; crude protein.

RESUMEN

Se evaluó la relación entre el pastoreo de una leguminosa arbustiva de alta calidad, la concentración de urea en suero sanguíneo (USS) y la ganancia diaria de peso (GDP) en novillonas F_1 Holstein x cebú. Se compararon dos pasturas: 1) dieta alta en proteína cruda (APC): *Cratylia argentea* + *Brachiaria brizantha* Toledo, y 2) dieta baja en proteína cruda (BPC): *Brachiaria brizantha* Toledo solo. En cada tratamiento el pastoreo duró 164 días. En ambas pasturas se evaluó el rendimiento de materia seca (RMS), proteína cruda (PC), fibra detergente neutro (FDN), fibra detergente ácido (FDA) y lignina (LIG). Antes del pastoreo, el RMS en APC y BPC fue 1922 ± 405 y 770 ± 405 kg ha^{-1}, respectivamente, y la PC fue 8.3 ± 0.85 y 8.7 ± 0.85 %, respectivamente. La FDN, FDA y LIG del pasto Toledo en APC y BPC fueron similares, promediando 73.1 ± 0.92, 42.7 ± 1.2 y 13.5 ± 0.7 %, respectivamente, mientras que en *C. argentea* los promedios en APC y BPC fueron 51.6 ± 0.58 % (FDN), 32.5 ± 0.85 % (FDA) y 16.7 ± 1.3 % (LIG). La USS fue 11.01 ± 0.35 (APC) y 7.87 ± 0.35 (BPC) mg dL^{-1}. La GDP en APC y BPC promedió 839 ± 258 y 580 ± 278 g día^{-1}, respectivamente. En conclusión, la GDP en novillonas F_1 Holstein x cebú puede exceder 800 g día^{-1} cuando pastorean en pasturas altas en PC.

Palabras clave: *Cratylia argentea*; pasto *Brachiaria brizantha* Toledo; urea en suero; proteína cruda.

INTRODUCTION

In tropical and subtropical conditions, cattle graze mainly on native pastures, which are poor in quality and have marked seasonality in their growth. The major constrains in cattle production systems are the scarcity and the poor quality of feed, in terms of low crude protein (CP) level and digestibility, mainly during the dry season. This poor quality of the feed results in low live weight and/or milk production, poor body condition and unsatisfactory reproductive performance. To enhance ruminant productivity during critical seasons, it is common to supply expensive commercial concentrates. However, the current world food crisis is making people to reconsider the use of alternative feeds for animal production. Makkar (2003) stated that because fodder trees and shrubs are not an important source of food for humans, they can be a significant source of nutrients for ruminants in biodiverse environments.

Tropical trees and shrubs are important sources of protein for ruminants (Alonso-Díaz *et al*., 2010), but their high levels of secondary metabolites and/or their high fiber contents and/or their high level of CP are often considered as factors that might limit their use as ruminant food (Buttler, 1998; Ben Salem *et al*., 2005; Sandoval-Castro *et al*., 2005). *Cratylia argentea* is a shrub legume native to Latin America, which has high CP level, low to moderate concentration of tannins, is drought-tolerant, and in tropical regions is used as foliage to feed cattle (Lascano *et al*., 2002). Andersson *et al*. (2006) have reported CP content from 184 to 237 g kg^{-1} in this legume, which reveals its high quality.

Studies using a cut and carry system have reported that inclusion of *C. argentea* in animal diets improves their productivity (Ibrahim *et al*., 2001; Lascano and Plazas, 2003; Sánchez and Ledin, 2006). However, there is a lack of information about the use of this legume through direct grazing/browsing by heifers during the dry season. This information might be important in those regions where the workforce is expensive. Indeed, it has been widely demonstrated that the use of forage legumes associated with grasses improves the productivity of ruminants (Pereira *et al*., 2009; Manríquez-Mendoza *et al*., 2011; Paciullo *et al*., 2011), because of an increased forage quality (Deinum *et al*., 1996; Yamamoto *et al*., 2007) and soil fertility (Power *et al*., 2003).

When a high CP pasture is consumed by ruminants, the efficiency of nitrogen use is a concern. It has been shown that high concentrations of serum urea nitrogen may affect reproductive function and cause decreased pregnancy rates (Chapa *et al*., 2001). According to Butler (1998), the excess of ruminally degradable protein or ruminally undegradable protein can contribute to reduced fertility in lactating cows. Dietary protein utilization and its associated effects on ovarian or uterine physiology have been monitored with urea nitrogen in plasma or milk. To this respect, Butler (1998) indicated that concentrations of urea nitrogen in plasma above 19 mg dL^{-1} have been associated with reduced fertility in dairy cows. These considerations are important, because raising of heifers is often the second or third largest expense in dairy systems.

We hypothesized that heifers grazing a high quality pasture will achieve greater weight gain, and that their blood serum urea concentrations will not reach toxic levels that could risk their future reproductive performance. Therefore, the objective of this study was to evaluate the effect of the content of CP in the diet in heifers grazing a grass-legume association (*Brachiaria brizantha* Toledo – *C. argentea*; high CP diet) or a single grass (*B. brizantha* Toledo; low CP diet) pasture, on blood serum urea levels and daily weight gain, in tropical conditions.

MATERIALS AND METHODS

Experimental site

The study was conducted in Atzalan, Veracruz, Mexico, located at Lat. 20°02'N, Long. 97°06'W, at 114 m above sea level, in a wet-dry tropical climate. The study had a duration of 164 days (12/19/2010 to 05/31/2011), time that corresponded to the dry season. The period of habituation to pastures was 20 days. Sixteen F_1 Holstein x Zebu heifers, 11 month-old, with average initial body weight of 237 ± 37 kg, were divided in two groups of eight heifers each, and assigned to one of two grazing treatments: 1) an associated grass-legume (*B. brizantha* Toledo – *C. argentea*) pasture or high CP (HCP; grass 8.3 %, legume 22.0 %) level; and 2) grass (*B. brizantha* Toledo) alone pasture or low CP (LCP, 8.7 %) level. *Cratylia argentea* had a density of 570 shrubs ha^{-1}, and *B. brizantha* Toledo (associated or alone) was planted using 8 kg of seeds ha^{-1}. The legume was planted within rows every 2.5 m, with a distance between rows of 3 m, and the grass was sown between each row. The age of the legume and grass at the beginning of the experiment was 14 and 6 months, respectively. The grazing area for each treatment was 2.21 ha, divided in six paddocks of 3863 m^2 each. Because there are no previous experiences with grazing of *C. argentea*, we determined the stocking rate below the carrying capacity of *B. brizantha* Toledo grass, that is usually 2.0 AU ha^{-1} (AU = animal unit = one animal weighing 450 kg) in the dry season (Euclides *et al*., 2001). Therefore, the initial stocking rate in both groups of heifers was 1.9 AU ha^{-1}. Each group grazed the corresponding treatment in an intensive rotational system, in a fixed cycle of 4 (grazing) and 20 (rest) days.

Quantitative and qualitative forage analysis

Throughout the experimental period, three (fixed) paddocks from the six of each treatment were sampled before and after grazing, in order to estimate dry matter yield (kg ha^{-1}) and daily growth rate (kg ha^{-1} day^{-1}), using the comparative yield method (Haydock and Shaw, 1975), with a set of 100 reference quadrats (50 x 50 cm) for each component corresponding to the specific pasture. These components were leaves and stems for *B. brizantha* Toledo, and only leaves for *C. argentea*. Samples from these evaluations were used to determine the nitrogen concentration, expressed as CP (N % x 6.25; AOAC, 1990), neutral detergent fiber (%), acid detergent fiber (%) (Goering and Van Soest, 1970), and lignin (%) (Robertson and Van Soest, 1981), using the Ankom filter bags technique.

Urea nitrogen determination

Throughout the experimental period, blood samples were obtained every seven days from eight heifers (four per treatment). Heifers were taken from the pasture at 0700 h and blood samples were collected via coccygeal venipuncture as aliquots of 3.5 mL, which were centrifuged at 1500 rpm/15 min and stored at -10 ºC until analysis. Serum urea nitrogen was determined using an IDEXX Dry-Slide technology (VetTest® Chemistry Analyzer). Heifers were returned to their respective pasture following each blood sample collection.

Daily weight gain was recorded every 28 days, after a 12 h-fast. A trace mineral salt block (12 % P) was available in both groups of heifers for *ad libitum* consumption. Sanitary measures such as vaccination and deworming were applied as rutine procedures for all animals.

Statistical analysis

A completely randomized design was applied, using the animals as experimental units for daily weight gain and serum urea levels. Statistical significances were obtained with the F test, without the need of multiple range tests, having only two treatments. Also, repeated measurements data procedure was made using Proc Mixed (SAS/STAT,1995). An analysis of structures of covariance was performed in order to detect tendencies of correlation between serum urea - CP pasture variables.

RESULTS AND DISCUSSION

Dry matter yield and daily growth rate

Results of dry matter yield (DMY, kg ha^{-1}; averages ± SE) before grazing in HCP and LCP, during the period January-May 2011, were 1922 ± 405 and 770 ± 405 kg ha^{-1}, respectively, whereas after grazing they were 734 ± 242 and 413 ± 242, respectively (Figure 1). No statistical differences were found between treatments, neither before or after grazing. A tendency of decrease in forage allowance was observed troughout the experimental period as a result of transition from winter to the dry period, as well as by effect of an increasing stocking rate, from 1.9 to 2.3 AU ha^{-1}.

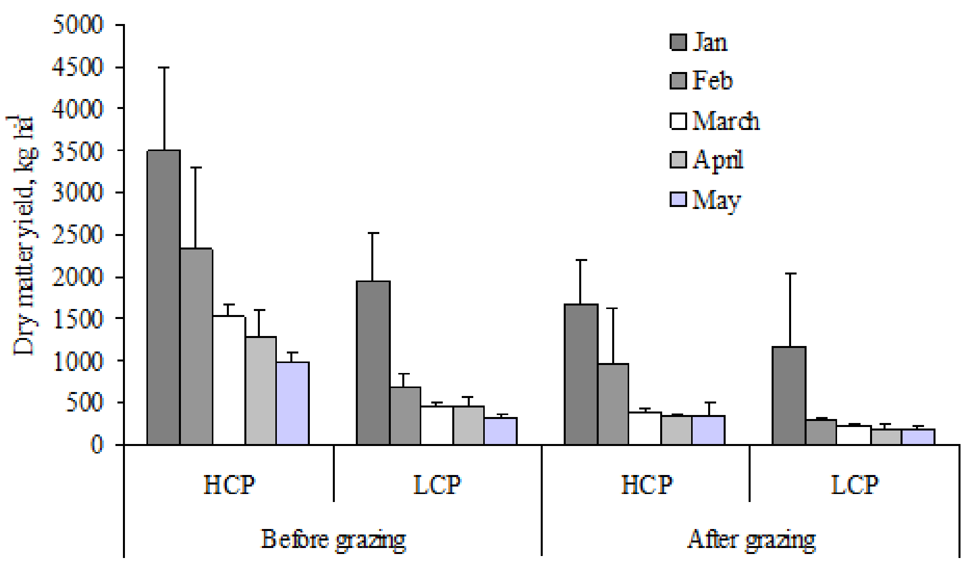

Figure 1. Dry matter yield (DMY, kg ha^{-1}) of high (*Brachiaria brizantha* Toledo - *Cratylia argentea*) and low (*B. brizantha*) crude protein pastures, before and after grazing (January-May, 2011) by Holstein x Zebu heifers.

Literature on grazing of *C. argentea* showed no effect in the subject, therefore, the discussion is focused in experiments with different species and or management of this association. In Colombia, Aparicio *et al*. (2002) reported values from an experiment using six cows/treatment (average weight 425 kg) with *B. decumbens* alone, or including restricted grazing (2 h d) of *C. argentea*. In the association, leaves of *B. decumbens* and *C. argentea* yielded 2153 and 7036 kg DM ha^{-1}, respectively. These values are higher than those reported here, but it should be noted that, in the Colombian experiment, the forage legume was used in restricted grazing; therefore, in the case of *Cratylia*, the use by the animals was less intense. Dry matter yield from the associated grass was 55 % higher than the grass alone. This agrees with reports of other authors (Alpizar, 1987; Kass, 1994), who have found that grasses associated with a N_2-fixing legume yield more forage than the same grass growing alone.

In Mexico, Valles *et al*. (2010) found that a mixture of native (*Paspalum* and *Axonopus* species, mainly) and introduced (*Cynodon nlemfuensis*, *Brachiaria arrecta*) pastures grazed by cows in a rotational system of leaders (48 cows) and followers (120 cows), in a grazing cycle of 1 to 3 days of use and 36 to 60 days of rest, yielded during dry season an average of 1977 ± 72 and 1468 ± 78 kg DM ha^{-1} before and after grazing. These values are higher than those reported here for LCP pasture, where the rest period was shorter.

Daily growth rate values were 22.8 ± 3.1 and 10.3 ± 3.1 kg DM ha^{-1} d^{-1}, for HCP and LCP, respectively ($P \leq 0.05$) (Figure 2), representing the last value a daily contribution of only 45 % with respect to HCP. In both cases, this variable decreased as the experimental period progressed, and this fact could be attributed to the gradually increased grazing pressure over the pastures as the animals gained weight. The value of LCP was similar to that reported by Ramírez (1974), of daily growth rate for *Cynodon plectostachyus* of 10.4 kg DM d^{-1}, with occupation period of four days.

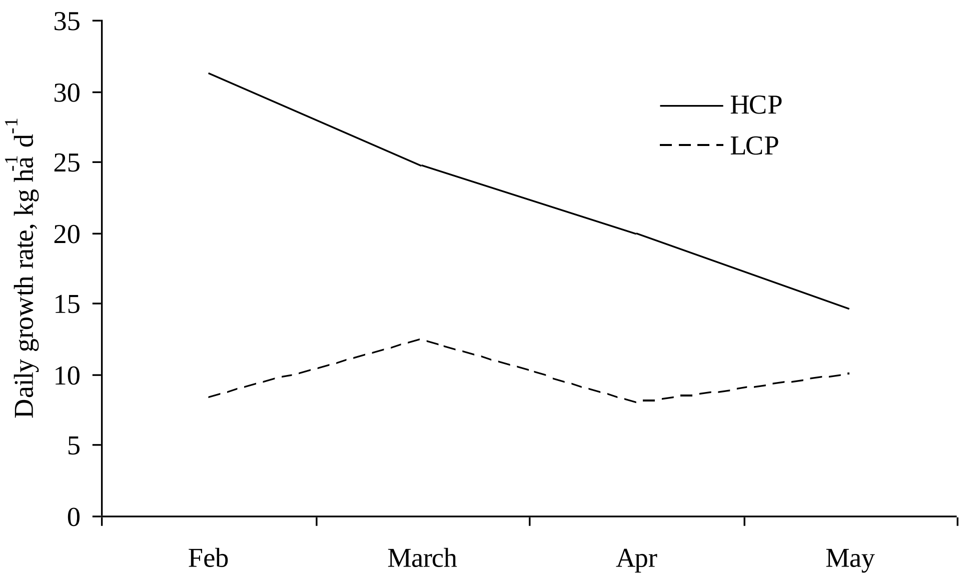

Figure 2. Daily growth rate (kg ha^{-1} d^{-1}) of high (HCP, *Brachiaria brizantha* Toledo - *Cratylia argentea*, range: 15.1 to 13.7 %) and low (LCP, *B. brizantha*, range: 8.7 to 7.4 %) crude protein pastures (February-May, 2011).

Quality variables in pasture botanical components

Crude protein

Results of CP (%) in the botanical components of the pastures are shown in Table 1. Crude protein values for *B. brizantha* Toledo grass alone and associated with *C. argentea* were similar before and after grazing ($P \geq 0.05$), although a little decrease was observed in CP values after grazing. In the case of *C. argentea*, CP values were higher than in *B. brizantha* Toledo before and after grazing. Crude protein values for *B. brizantha* Toledo associated or alone were slightly higher than those reported by Paciullo *et al*. (2011) in Brazil, who evaluated the characteristics of the pasture and performance of dairy heifers in a silvopastoral system established with *B. decumbens* grass in combination with four tree species (*Acacia mangium*, *A. angustissima*, *Mimosa artesiana* and *Eucalyptus grandis*; 105 trees ha^{-1}) and in a monoculture system of *B. decumbens*. They found CP concentrations of 7.2 to 7.5 % in a pre-grazing sampling, with pasture management of 7 days in grazing and 45 days of rest, during the dry season. It is likely that these differences in favor of the *B. brizantha* Toledo - *C. argentea* pasture were given because the rest period for this pasture was shorter (20 days) than for *B. decumbens*, and the heifers consumed younger leaves and stems, and therefore better quality in terms of CP.

Table 1. Crude protein (mean ± SE) in *Brachiaria brizantha* Toledo grass alone or associated with *Cratylia argentea*, and *Cratylia argentea*, before and after grazing.

Comparisons between pasture components	Crude protein %	
	Before grazing	After grazing
B. brizantha Toledo grass associated with *C. argentea*	8.3 ± 0.85[NS]	7.6 ± 0.84[NS]
B. brizantha Toledo grass alone	8.7 ± 0.85	7.4 ± 0.63
B. brizantha Toledo grass associated with *C. argentea*	8.3 ± 0.76[b1]	7.6 ± 0.84[b]
vs.		
C. argentea associated with *B. brizantha* Toledo grass	22.0 ± 0.76[a]	19.9 ± 1.53[a]

NS = Not significant.
[1]Within each column, different literals are statistically different at $P \leq 0.05$.

Neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin

Statistical comparisons between plant components in LCP and HCP before grazing were made. The comparisons between *B. brizantha* Toledo grass (alone or associated) showed similar values ($P \geq 0.05$) for these quality variables (Table 2), contrary to what was observed in the HCP plant components where, in all cases, statistical differences were found ($P \leq 0.05$). Table 2 also shows the values after grazing, but for this case no statistical procedures were conducted; however, as with the values obtained before grazing, similar tendencies were observed between plant components.

Table 2. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (mean ± SE) in *Brachiaria brizantha* Toledo grass as low crude protein (LCP) pasture, or associated with *Cratylia argentea* as high crude protein (HCP) pasture, before and after grazing by Holstein x Zebu heifers.

Grazing	Plant comparisons	NDF	ADF	Lignin
		%	%	%
Before	*B. brizantha* Toledo (HCP)	73.2 ± 0.93	42.8 ± 1.26	13.3 ± 0.71
	vs.	NS	NS	NS
	B. brizantha Toledo (LCP)	73.1 ± 0.91	42.6 ± 1.23	13.8 ± 0.69
	B. brizantha Toledo (HCP)	73.3 ± 0.60[a]	42.9 ± 0.88[a]	13.4 ± 1.27[b]
	vs.			
	Cratylia argentea (HCP)	51.6 ± 0.58[b]	32.5 ± 0.85[b]	16.7 ± 1.30[a]
After[1]	*B. brizantha* Toledo (LCP)	74.89 ± 2.8	45.01 ± 2.5	14.21 ± 3.5
	B. brizantha Toledo (HCP)	74.6 ± 6.3	46.0 ± 4.2	14.3 ± 3.6
	Cratylia (HCP)	52.2 ± 4.0	33.5 ± 2.7	16.7 ± 5.3

NS= Not significant.
[a,b]Different letters within each column/comparison are statistically different ($P \leq 0.05$).
[1]No statistical comparisons were made.

In Veracruz, Mexico, Manríquez-Mendoza *et al*. (2011) assessed nutricional quality in a silvopastoral system with *Guazuma ulmifolia* trees mixed with *B. brizantha* (Insurgente grass) and *Digitaria eriantha* during the winter, dry and rainy seasons. They reported, for the dry season, values of 73.6 %, 40.6 % and 6.6 % for NDF, ADF and lignin, respectively, which were similar for NDF, slightly lower for ADF and lower for lignin in comparison with the ones reported in this study. The values of *B. brizantha* obtained in the present study were lower than those indicated by Costa *et al*. (2009) in Brazil, after cutting every 30 days three cultivars (Marandú, Xaraes and MG-4) with no fertilization, with values for NDF and

ADF of 68.8 to 70.6 % and 37.2 to 37.9 %, respectively. In the present study, in *C. argentea* the values for NDF and ADF were slightly lower than those reported by Franco (1997), who evaluated NDF and ADF in this legume at 2, 3 and 4 month-old, and obtained values of 55.6 to 57.2 % and 33.8 to 36.1 % for NDF and ADF, respectively. This difference was probably because in this study, *C. argentea* was sampled at an earlier age, it is 28 (before grazing) to 32 (after grazing) days. However, in the case of lignin, the differences were greater, since they reported values in a range of 8.7 to 10.9 %, which are much smaller than those obtained in this study. In Nicaragua, Sánchez and Ledin (2006) offered 3 month-old *C. argentea* to Criollo Reyna cows, and values for NDF and ADF were 60 % and 32.5 %, respectively, which were higher than those from the present study.

Blood serum urea levels

Blood serum urea nitrogen was significantly higher ($P \leq 0.05$) in heifers grazing the HCP pasture (11.01 ± 0.35 mg dL^{-1}) with respect to heifers grazing the LCP pasture (7.87 ± 0.35 mg dL^{-1}). The concentration of serum urea in all but the first sampling was higher in HCP (Figure 3). In the fourth sampling date, both treatments showed similar serum urea nitrogen concentrations. In other samples, the HCP treatment exceeded ($P \leq 0.05$) to LCP at different rates. Also, the interaction treatment x sampling was statistically significant ($P \leq 0.05$). Urea levels in blood serum had ups and downs throughout the study, but the heifers in HCP always showed higher values for this variable (11.3 ± 21 mg dL^{-1}) compared to heifers in LCP (8.4 ± 3.4 mg dL^{-1}).

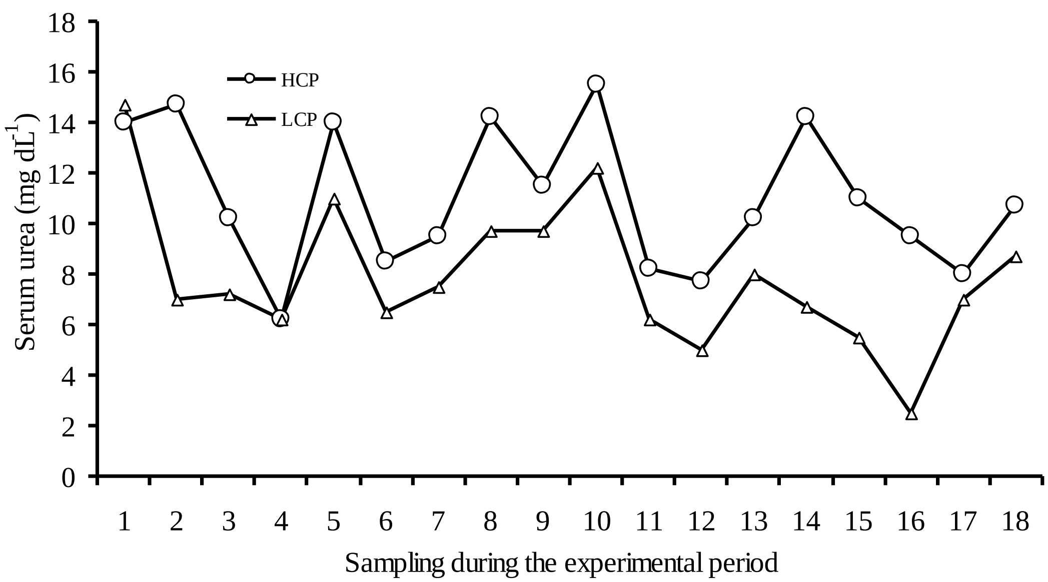

Figure 3. Blood serum urea concentration in Holstein x Zebu heifers grazing pastures with a high (HCP, *Brachiaria brizantha* Toledo - *Cratylia argentea*) or low (LCP, *Brachiaria brizantha* Toledo) crude protein levels, sampled every seven days.

Because no information was found on grazing systems using *C. argentea*, the discussion is based on pastures and/or similar diets. Carroll *et al*. (1988) compared the effect of 13 and 20 % CP rations (50 % grass-legume silage: 50 % corn silage; and 60 % concentrate [DM basis]) on the reproductive performance of early lactating dairy cows. They observed that plasma urea nitrogen increased rapidly in cows on the 20 % CP diet, maintaining a 10 mg dL^{-1} superiority over the other group fed 13 % CP, after the fourth week (of 14) of the experiment. However, these authors concluded that no relationship was found between reproduction and CP level in the ration. Previously, similar results were obtained by Barton *et al*. (1996) in a study conducted to determine the impact of dietary CP (13 % vs. 20 %), parity (first vs. second lactation or later), and breed (Holstein vs. Jersey) on the reproductive efficiency of dairy cows. Plasma urea nitrogen concentrations were influenced by diet (8.6 vs. 21 mg dL^{-1}, 13 and 20 % CP, respectively), parity and breed. Ferguson *et al*. (1993) mentioned values of urea in blood serum of cattle ranging from 10 to > 20 mg dL^{-1}, and established a negative relationship when these concentrations exceed 20 mg dL^{-1}, resulting in lower conception rates. Concentrations found here are lower than those reported by Butler (1998) in Holstein cows fed 50:50 % forage-commercial concentrate (18.9 ± 0.3 mg dL^{-1}), and by Aparicio *et al*. (2002) in cows grazing *Brachiaria decumbens* grass with restricted access (2 h day^{-1}) to *C. argentea* with 18.2 mg dL^{-1}.

The records of blood serum urea for each of the four heifers that were sampled by treatment throughout the experimental period are shown in Figure 4. In average, heifers grazing the grass-legume treatment had serum urea nitrogen concentration 33.3 % higher (10.8 ± 0.6 mg dL^{-1}) than heifers grazing the *B. brizantha* Toledo grass alone (7.2 ± 0.2 mg dL^{-1}), showing in all cases a consistent difference between treatments. Blood serum urea concentration was above 20 mg dL^{-1} in both treatment groups, although the HCP group reflected the effect of the diet with higher CP content in the pasture. These values in both treatments were lower than those found by Hammon *et al*. (2005), feeding Holstein dairy cows with a diet containing alfalfa hay, alfalfa silage, and corn silage, and 50 % concentrate formulated to provide at least 20 % CP. They recorded blood urea nitrogen in a range of 17.0 ± 0.34 to 22.36 ± 0.44 mg dL^{-1}.

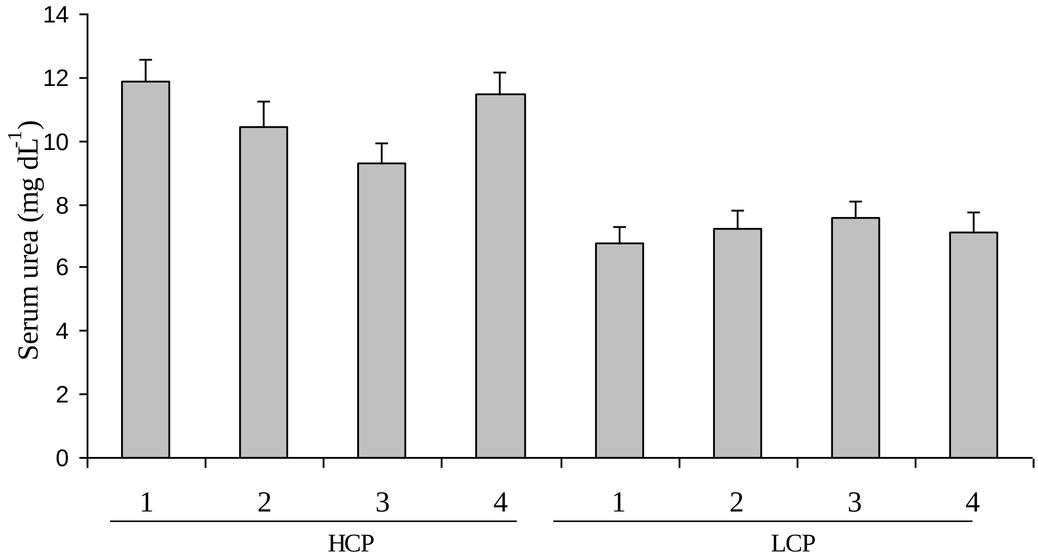

Figure 4. Serum urea concentration (mg dL^{-1}) in each of the four heifers sampled (1 to 4), grazing in pastures with high (*Brachiaria brizantha* Toledo - *Cratylia argentea*) and low (*B. brizantha* Toledo) crude protein levels. Lines upon bars are standard error of means.

Looking for a model consistent with data of relationship serum urea - CP in pastures, an analysis of structures of covariance was performed in order to detect tendencies of correlation between these variables (Table 3). The analisys showed that the first order autoregresive (AR) model produced the best results, considering the statisticals of fitting.

Table 3. Covariance structures for repeated measures analysis of serum urea nitrogen in heifers grazing *Brachiaria brizantha* Toledo grass alone or the association *B. brizantha* Toledo - *Cratylia argentea*.

Fit Statistics[1]	Covariance structure						
	CS	CSH [2]	UN [2,3]	AR(1)	ARH(1)	ARMA(1,1)	HF[4]
-2 RLL	470.7	------	------	468.1	438.7	467.2	------
AIC	476.7	------	------	474.1	478.7	475.2	------
AICC	477.0	------	------	474.3	488.4	475.6	------
BIC	477.0	------	------	474.3	480.3	475.5	------

[1] “Smaller is better.”
[2] “Stopped because of infinite likelihood.”
[3] “Unable to make hessian positive definite.”
[4] “Did not converge.”

Weight gain by heifers

Heifers that grazed the HCP pasture averaged a daily weight gain of 839 ± 258 g, while for the LCP pasture weight gain was 580 ± 278 g ($P \leq 0.05$; Table 4). The weight change for the period 02/02/2011 to 05/25/2011 in HCP was from 235 ± 39 kg to 327 ± 53 kg, compared to LCP from 231 ± 36 kg to 293 ± 47 kg. These changes accounted for a cumulative weight gain during the experimental period, of 92 and 62 kg by animal, respectively (Figure 5).

Table 4. Daily weight gain (g day^{-1}) of heifers grazing in pastures with high (HCP, *Brachiaria brizantha* Toledo - *Cratylia argentea*) and low (LCP, *B. brizantha* Toledo) crude protein diet during the 2011 dry season (February-May) in Atzalan, Veracruz, Mexico.

Weighing	HCP diet		LCP diet		Diff	Pr>|t|	
	DWG[1]	SE[2]	DWG	SE			
Feb	592	0.080	328	0.088	0.263	0.0866	NS
March	993	0.065	690	0.092	0.303	0.0302	*
Apr	781	0.051	754	0.059	0.027	0.7326	NS
May	951	0.085	522	0.077	0.429	0.0026	**

[1]Daily weight gain.
[2]Standard error.
NS= Not significant. * = P < 0.05; ** = P < 0.01.

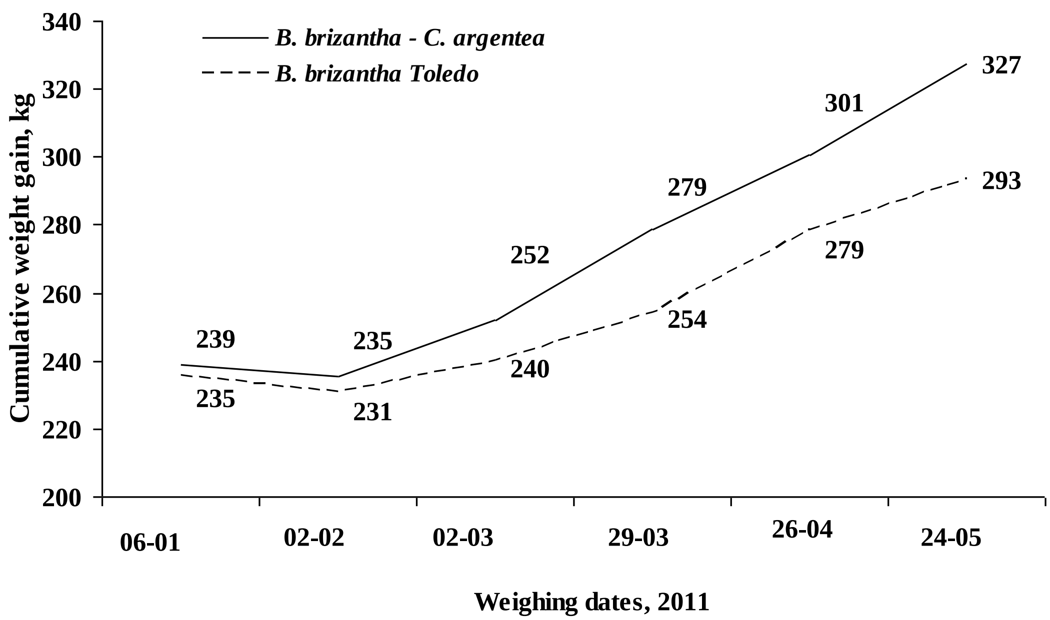

Figure 5. Cumulative weight gain (kg) in Holstein x Zebu heifers grazing in pastures with high (*Brachiaria brizantha* Toledo - *Cratylia argentea*) and low (*B. brizantha* Toledo) crude protein levels.

The daily weight gains reported here were higher than those obtained by Aranda *et al*. (2001) in a 153-day grazing experiment with heifers (six heads ha^{-1}), in the humid tropic of Tabasco, Mexico. They evaluated the grazing of African stargrass (*Cynodon plechtostachyus*) alone (CP 8.9 %), supplemented with sugarcane (CP 10.3 %), sugarcane without urea 1 % (CP 4.2%), or sugarcane with urea plus a protein supplement (CP 23.4 %). Heifers receiving the protein supplement had the highest daily gain (528 g d^{-1}) compared to the other treatments (control group 0.320 kg day^{-1}; sugarcane without urea 0.327 kg day^{-1};

sugarcane plus urea 0.366 kg day^{-1}). The experiment of Paciullo *et al*. (2011) that evaluated a silvopastoral system (*B. decumbens* associated with four species of trees) and a monoculture (*B. decumbens*), during three years, reported that the lowest body weight gains were observed during the dry season of the three years, averaging 355 (silvopastoral system) and 338 (monoculture) g day^{-1}, which can be attributed to the lower CP (7.3 % as average) content of the pasture, as a consequence of the decreased rainfall and increased air temperature.

Our results suggest that grazing *C. argentea* associated with *B. brizantha* Toledo promoted weight gain higher than expected in the dry season, attributing these results to the high quality of the mixed pasture.

Coefficients of simple correlation (R^2) between blood serum urea levels and daily weight gain were, comparing HCP, LCP and HCP+LCP vs. daily weight gains: 0.20, 0.29 and 0.01, respectively, indicating a poor relationship between these variables.

CONCLUSION

Considering the greater forage yields, the higher quality of the components of the association especially in terms of CP, the fact that blood serum urea concentrations never reached the toxic levels reported in the literature (> 20 mg dL^{-1}), and the best performance in terms of daily weight gain by heifers grazing a high CP pasture, the association *B. brizantha* Toledo - *C. argentea* can be a desirable alternative to improve tropical animal production systems based on grazing.

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