Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v43i1.52805

Ewe performance in the post-weaning phase and structural characteristics of *Brachiaria brizantha* cultivars in the dry season

Alex Álvares da Silva[1], Gelson dos Santos Difante[2], João Virgínio Emerenciano Neto[3], Antonio Leandro Chaves Gurgel[2*], Leonardo Santana Fernandes[4], Nathalia Rafaela Fidelis Campos[2], Roldão Teixeira de Carvalho Netto[5] and Juliana Caroline Santos Santana[2]

[1]Departamento de Fitotecnia, Universidade Federal Rural do Semi-Árido de Mossoró, Mossoró, Rio Grande do Norte, Brazil. [2]Faculdade de Medicina Veterinária e Zootecnia, Universidade Federal do Mato Grosso do Sul, Av. Costa e Silva, s/nº, 79070-900, Campo Grande, Mato Grosso do Sul, Brazil. [3]Universidade Federal do Vale do São Francisco, Campus Ciências Agrárias, Petrolina, Pernambuco, Brazil. [4]Centro de Ciências Agrárias, Universidade Federal da Paraíba, Areia, Paraiba, Brazil. [5]Unidade Acadêmica Especializada em Ciências Agrárias, Universidade Federal do Rio Grande do Norte, Macaíba, Rio Grande do Norte, Brazil. *Author for correspondence. E-mail: antonioleandro09@gmail.com

ABSTRACT. The objective of this study was to examine the performance of ewes in the post-weaning phase and the structural characteristics of *Brachiaria brizantha* cultivars in the dry season. The treatments were represented by four *Brachiaria brizantha* cultivars (Piatã, Marandu, Paiaguás, and Xaraés), which were evaluated in a randomized-block design with two replicates for the forage variables and eight replicates for the animal performance variables. Canopy height, masses of forage and morphological components and chemical composition of morphological components were evaluated. Thirty-two ½ Santa Inês and ½ Dorper sheep with an initial body weight (BW) of 22.7 ± 1.2 kg were used. Average daily gain (ADG – kg animal^{-1} day^{-1}), stocking rate (in animal units [AU] = 30 kg of body weight) and weight gain per area (kg ha^{-1} day^{-1}) were measured. There was no cultivar effect ($p > 0.05$) on the structural characteristics of the pasture. The highest crude protein content in the leaf blade (11.8%) were found in cultivar Marandu. Average daily gain was higher in the animals that grazed on cultivar Marandu (0.08 kg animal^{-1} day^{-1}) as compared with cultivars Xaraés (0.05 kg animal^{-1} day^{-1}) and Piatã (0.04 kg animal^{-1} day^{-1}), whereas the ewes that grazed on cultivar Paiaguás showed intermediate ADG values (0.06 kg animal^{-1} day^{-1}). There was no difference between the cultivars for stocking rate (9.2 AU). Weight gain per area was highest in cultivar Marandu (0.33 kg ha^{-1} day^{-1}) and lowest in cv. Piatã (0.16 kg ha^{-1} day^{-1}). *Brachiaria brizantha* cultivars Piatã, Marandu, Paiaguás and Xaraés proved to be forage options for the post-weaning phase of ewes supplemented with concentrate in the dry season.

Keywords: agronomic traits; Marandu; Paiaguás; Piatã; sheep farming; Xaraés.

Received on March 26, 2020.
Accepted on May 11, 2020.

Introduction

The major feed source for ruminants in Brazil are pastures, which constitute one of the largest and most important ecosystems in the country (Euclides et al., 2019). They are characterized by varying levels of complexity, ranging from low-productivity native fields (Oliveira, Macêdo, & Santos, 2019) to cultivated areas with high production potential (Euclides et al., 2017; Emerenciano Neto et al., 2018). In the northeast region of Brazil, the main roughage source for animals is native pasture with practically no management actions. In this scenario, sheep farming stands out as a livestock activity with potential for expansion (Emerenciano Neto, Bezerra, França, Assis, & Difante, 2011).

In the rainy season, there is a greater accumulation of forage (Euclides et al., 2019), which promotes quantitative and qualitative benefits for the animal diet. In the dry season, however, forage supply declines in response to the direct effect of abiotic factors that limit plant development (Euclides, Montagner, Barbosa, Valle, & Nantes, 2016). For this reason, the production performance of animals reared on pasture is seasonal (Emerenciano Neto et al., 2018). It is, therefore, essential to seek forage cultivars able to maintain forage availability—even if low-quality-, since the use of supplementation can partly correct these deficiencies, in addition to improving the use of these pastures in the dry period of the year (Gurgel et al., 2020; Fernandes et al., 2020a).

Although species of the genus *Brachiaria* are highly representative in cultivated pastures in Brazil, there is a need to define strategies for their use, given the different soil-climatic conditions as well as different management and intensities of use in the Brazilian territory (Portela, Pedreira, & Braga, 2011). In this respect, researchers (Emerenciano Neto et al., 2014; Souza et al., 2019; Gurgel et al., 2020; Fernandes et al., 2020b) have evaluated *Brachiaria* cultivars as forage alternatives for sheep farming in semi-arid regions and obtained promising results.

However, in view of the release of cultivars with potential for use during the dry season (Valle et al., 2013; Euclides et al., 2016), further studies are warranted to discover forage solutions for livestock production in semi-arid regions (Portela et al., 2011). On this basis, the present study was developed to examine the performance of ewes in the post-weaning phase and the structural characteristics of *Brachiaria brizantha* cultivars in the dry season.

Material and methods

The experiment was conducted in the experimental area of the Forage Research Group (GEFOR) at the Federal University of Rio Grande do Norte (UFRN), at the Macaíba Campus, Brazil (5°53'34'' S, 35°21'50'' W, 160 m of altitude). The experimental period was from October to December 2015, which is considered to be the period of lowest rainfall in the region.

According to the Köppen classification, the climate of the region is a BSh'W type, with water surplus from May to August. Average annual precipitation is 1,048 mm and cumulative average annual potential evapotranspiration is 1,472 mm, according to the National Institute of Meteorology (INMET). Temperature data were obtained from the INMET database, whereas precipitation data (Figure 1) were obtained using a stainless-steel *Ville de Paris* rain gauge installed at the experiment site.

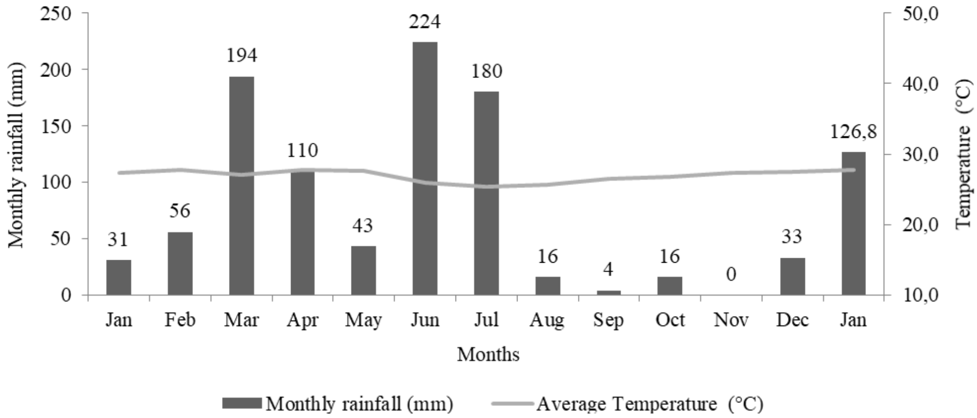

Figure 1. Precipitation and average temperature from January 2015 to January 2016.

The soil in the experimental area is classified as an Arenosol (Psamment) (Food and Agriculture Organization [FAO], 2015). Chemical analyses of the soil were carried out at the depths of 0-20 cm and 20-40 cm. In the 0-20 cm layer, the soil had low levels of phosphorus, calcium, and magnesium (Table 1). Based on these results, 500 kg ha^{-1} dolomitic limestone were applied and topdressing was performed using 70 kg ha^{-1} P_2O_5 (single superphosphate) and 100 kg ha^{-1} N in the form of ammonium sulfate. The N dose was split into two applications, in May and August 2015.

Table 1. Chemical characteristics of soil samples from the experimental area, in the 0-20 and 20-40 cm layers.

Layer (cm)	P	K	Na	pH	Ca	Mg	Al	H + Al	BS (%)
	mg dm^{-3}				cmol$_c$ dm^{-3}				
0-20	2.0	41.0	9.0	6.6	1.1	0.2	0.0	1.1	56.6
20-40	1.0	22.0	9.0	6.3	0.5	0.1	0.0	0.6	53.4

BS - base saturation.

The pastures were implemented in 2011 and since then grazed by sheep. The experimental area was 2.88 ha, which was divided into two blocks, each consisting of four 0.36-ha paddocks. A fixed stocking rate was adopted, with four animals per paddock. Because the stocking rate varied according to changes in animal weight throughout the experimental period, the continuous grazing method with variable stocking rate was adopted. The experiment was laid out in a randomized block design with four treatments and two replicates for the pasture evaluations and eight replicates for the animal performance evaluations. The treatments were represented by four *Brachiaria brizantha* cultivars, namely, Marandu, Piatã, Xaraés, and Paiaguás.

All structural characteristics of the pastures were evaluated every 28 days. Canopy height was measured using a 1-m ruler graduated in centimeters, at 40 random points per paddock. The canopy height at each point corresponded to the average height of the curvature of the upper leaves around the ruler.

Forage mass was estimated by cutting the forage contained within a 0.5-m² frame near the soil surface, at six points in each paddock. Approximately 50% of each sample was packed in paper bags and dried in a forced-air oven at 55°C for 72h. Subsequently, they were weighed again to determine the dry weight. The other 50% of the sample was grouped into two composite samples. To evaluate the morphological components, the composite samples were manually separated into leaf blade, stem (stem + sheath) and dead material and the masses of the respective components were determined. Leaf:stem ratio was calculated by dividing leaf mass by stem mass.

Samples of morphological components were ground through a Willey mill with a 20-mm mesh sieve and subsequently analyzed for the contents of crude protein (CP), according to the methodology described by Association Official Analytical Chemist [AOAC] (2005); and neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) by the methodologies described by Mertens (2002).

Thirty-two ½ Santa Inês and ½ Dorper ewes at approximately seven months of age, with an initial body weight (BW) of 22.7 ± 1.2 kg, were used. The animals were identified with numbered plastic earrings and collars with different colors for each treatment. All paddocks were equipped with salt and water troughs which were freely available.

The animals were kept in the pasture during the day (from 07:00 to 16:00) and housed in a shed with collective stalls at night, where they received a protein-energy concentrate supplement for an average intake of 0.8% BW, calculated based on National Research Council [NRC] (2007) recommendations to provide a daily gain of 150 g. The concentrate consisted of 72% ground corn, 22% soybean meal, 3% mineral supplement and 3% livestock urea, with a chemical composition of 22% CP, 20.4% NDF, and 6.8% ADF (DM basis).

The animals were weighed every 14 days. Average daily gain was calculated as the difference between the final and initial weights of the animal divided by the number of days in the experiment, and expressed in kg animal^{-1} day^{-1}. Weight gain per hectare was obtained by multiplying ADG by the number of animals kept per hectare in each treatment, also expressed in kg ha^{-1} day^{-1}. Stocking rate (number of animals with 30 kg BW ha^{-1}) was calculated by multiplying the average animal weight of each treatment by the number of animals kept in the area corresponding to one hectare and dividing the result by 30, to express it in animal units.

All variables were subjected to the Shapiro-Wilker test to check for normality assumptions. The data were subjected to analysis of variance considering a randomized-block design with repeated measures over time, where the main treatment were the cultivars (Marandu, Piatã, Xaraés, and Paiaguás) and the repeated measures were the months of evaluation. When significant by the F test, the effects of cultivar, month of collection or their interaction were analyzed by Tukey's test, both at 5% significance.

Results and discussion

The interaction effect between cultivars and periods was not significant ($p > 0.05$) for any of the evaluated variables. The isolated effect of cultivar was not significant ($p > 0.05$) for canopy height (43.5 ± 15.2 cm), forage mass (2,185.9 ± 222.8 kg ha^{-1} DM), leaf mass (277.2 ± 51.6 kg ha^{-1} DM), stem mass (370.0 ± 51.1 kg ha^{-1} DM), dead material mass (1,537.5 ± 214.2 kg ha^{-1} DM) or leaf:stem ratio (0.7 ± 0.1). These results were probably a reflection of the low forage accumulation in the dry season (Euclides et al., 2016). Effects caused by environmental interference (Figure 1) on forage accumulation are immediate (Nantes et al., 2013; Euclides et al., 2019), which compromises the productive potential of cultivars.

This response may also be associated with the relationship between canopy height and structural characteristics of the pasture found in *Brachiaria brizantha* cultivars Marandu (Calvano et al., 2011; Euclides et al., 2019), Xaraés (Carloto et al., 2011), and Piatã (Nantes et al., 2013). Silva et al. (2016) evaluated *Panicum* and *Brachiaria* pastures in the dry season and found values close to those presented in this study for the forage mass of cultivars Marandu and Piatã (2,047 and 2,790 kg ha^{-1} DM, respectively). In their study, lower canopy heights were observed for these two cultivars (32.4 and 28.5 cm, respectively), which may be a consequence of the higher stocking rate used.

The low proportion of leaf blades over stem and dead material may reflect the high canopy height (43.5 cm), which is close to 45.0 cm, considered the maximum limit for the management of these cultivars under continuous grazing (Calvano et al., 2011; Carloto et al., 2011; Nantes et al., 2013; Euclides et al., 2019). As canopy height increases, there is a decrease in the proportion of green leaf blades and an increase in the proportions of stalk and dead material (Gimenes et al., 2011; Nantes et al., 2013). This compensatory mechanism promoted a low leaf:stem ratio.

In general, a high percentage of dead material in the forage mass (40 to 60%) has been observed for cultivars Marandu, Xaraés and Piatã under continuous stocking in the dry season (Euclides, Macedo, Valle, Barbosa, & Gonçalves, 2008; Carloto et al., 2011). The current results show that cultivar Paiaguás exhibits a similar behavior. One way to avoid the greater participation of stalk and dead material in the forage mass is by increasing grazing intensity (Carloto et al., 2011; Nantes et al., 2013).

When the periods evaluated during the dry season were compared, no difference was detected for canopy height, forage mass or dead material mass (Table 2). However, leaf and stem masses and leaf:stem ratio decreased (Table 2). The studied cultivars show management flexibility under continuous grazing and can be managed at heights between 30 and 45 cm (Calvano et al., 2011; Carloto et al., 2011; Nantes et al., 2013; Euclides et al., 2019). Therefore, the average height obtained during the experimental period is within the recommended range for the management of the cultivars.

Table 2. Structural characteristics of *Brachiaria brizantha* pastures according to the evaluation period.

Variable	October	November	December	SEM	P-value
Canopy height (cm)	44.2[a]	43.8[a]	42.5[a]	3.1	0.9174
Forage mass (kg ha^{-1} DM)	2348.7[a]	2245.8[a]	1963.2[a]	193.0	0.3763
Leaf mass (kg ha^{-1} DM)	581.8[a]	176.2[b]	73.6[b]	44.7	0.0001
Stem mass (kg ha^{-1} DM)	567.5[a]	225.1[b]	317.3[b]	43.4	0.0005
Dead material mass (kg ha^{-1} DM)	1190.2[a]	1844.4[a]	1578.0[a]	185.5	0.0831
Leaf:stem ratio	1.1[a]	0.7[b]	0.4[b]	0.1	0.0010

Means followed by common letters do not differ by Tukey's test, at 5% probability.

The average forage mass was 2,185.9 kg ha^{-1} DM, which was constituted by a large proportion of dead material (over 50%). High amounts of dead material in the pasture impair the ability of animals to capture the forage, affect voluntary intake and may compromise efficiency in the use of the produced forage (Difante et al., 2010).

However, dead material represents an important source of fiber required by the animal in the dry season. This is especially true in semi-arid regions (Gurgel et al., 2017; Fernandes et al., 2020b), where forage accumulation is practically zero. Carloto et al. (2011) evaluated Xaraés grass pastures managed under continuous grazing with different grazing intensities (15, 30, and 45 cm) and observed that pastures managed under lower intensities (30 and 45 cm) showed a greater proportion of dead material. However, the animals also exhibited a higher dry matter intake. The authors suggested that the forage and leaf supplies are more decisive in promoting changes in intake.

There was a decrease in the masses of leaf and stem from the start to the end of the experimental period (Table 2). The reduction in leaf percentage is directly linked to their consumption by the animals coupled with the non-appearance of new leaves due to water stress (Figure 1). Pezzopane et al. (2015) evaluated water stress in four *Brachiaria brizantha* cultivars (Piatã, Marandú, Xaraés, and Paiaguás) and observed a reduction of 45.0 to 49.0% in leaf mass in response to water stress.

There was no difference between the cultivars for the NDF and ADL levels in the leaf blade (Table 3). However, cultivar Marandu showed higher CP levels than Paiaguás, which, in turn, was superior to the other two cultivars for this variable. Acid detergent fiber was higher in cultivar Paiaguás and lower in cultivars Marandu and Xaraés. Euclides et al. (2009) reported that the leaf blade of cultivar Marandu showed better nutritional value than those of cultivars Xaraés and Piatã. Euclides et al. (2016), on the other hand, observed that cultivar Paiaguás maintained higher CP levels in the leaf blade than cultivar Piatã in the dry season.

The leaf is the morphological component most preferred by animals and contains higher levels of CP and lower structural fractions. Therefore, in the dry season, when there is an increase in structural fractions and a reduction in CP levels (Euclides et al., 2016), supplementation is necessary to maintain the expected performance levels, especially for the Piatã and Xaraés cultivars, which showed low CP levels.

Table 3. Chemical composition of morphological components of *Brachiaria brizantha* cultivars managed under continuous grazing in the dry season.

Variable (%)	Marandu	Piatã	Paiaguás	Xaraés	SEM	P-value
			----------------Leaf----------------			
Crude protein	11.8^{a}	6.5^{c}	9.0^{b}	6.3^{c}	0.4	0.0013
Neutral detergent fiber	57.5^{a}	61.4^{a}	59.2^{a}	55.3^{a}	2.1	0.3529
Acid detergent fiber	28.4^{b}	29.9^{ab}	32.2^{a}	29.0^{b}	0.5	0.0171
Acid detergent lignin	1.5^{a}	2.2^{a}	2.0^{a}	1.5^{a}	0.3	0.4271
			----------------Stem----------------			
Crude protein	2.2^{a}	2.4^{a}	2.6^{a}	2.2^{a}	0.2	0.4148
Neutral detergent fiber	63.6^{a}	68.9^{a}	68.2^{a}	62.4^{a}	1.3	0.0560
Acid detergent fiber	40.8^{b}	45.7^{ab}	46.1^{a}	42.1^{ab}	0.9	0.0307
Acid detergent lignin	5.2^{a}	6.1^{a}	7.3^{a}	7.1^{a}	0.8	0.3180
			----------------Dead material----------------			
Crude protein	1.7^{a}	1.9^{a}	1.9^{a}	1.2^{a}	0.2	0.1017
Neutral detergent fiber	64.5^{b}	70.0^{a}	68.1^{ab}	69.8^{a}	0.7	0.0117
Acid detergent fiber	41.4^{b}	46.9^{a}	46.5^{a}	47.1^{a}	0.6	0.0075
Acid detergent lignin	4.5^{c}	5.7^{b}	6.8^{a}	5.8^{b}	0.7	0.0013

Means followed by equal letters do not differ by Tukey's test, at 5% probability.

There was no cultivar effect ($p > 0.05$) for the CP, NDF, or ADL contents of the stem (Table 3). However, cultivar Paiaguás showed higher levels of ADF in this plant component than cultivar Marandu, with no statistical difference detected for the other cultivars. In the dead material fraction, the CP and ADL levels were similar between the cultivars. These few alterations in the chemical composition of dead material and stem are likely related to the similar canopy heights between the cultivars. Changes in the chemical composition of these components are often attributed to excessive stem elongation resulting from increased structural components and reduced cell content (Caroloto et al., 2011; Nantes et al., 2013; Gurgel et al., 2017).

Average daily gain was higher for the animals that grazed on the pastures of cultivar Marandu as compared with cultivars Xaraés and Piatã. Intermediate ADG values were shown by the ewes that grazed on cultivar Paiaguás (Table 4). Since there was no difference for the structural characteristics of the pasture, the results for ADG are a reflection of the chemical composition of the leaf blades, the component most consumed by the animals. Cultivar Marandu showed the highest protein levels in this morphological component (Table 3). The ADG observed in this study was lower than the 0.138 kg day^{-1} per lamb reported by Fernandes et al. (2020b) in Marandu grass pastures in the dry season in Northeastern Brazil, which is explained by the use of a higher supplementation level (1.4% of live weight).

There was no difference between the cultivars for stocking rate. Weight gain per area was greater in cultivar Marandu than Piatã, whereas the other cultivars showed intermediate values (Table 4). Because stocking rate was not changed, the increase in weight gain per area was the result of the higher ADG. Greater individual gains allow an earlier sale of animals (Difante et al., 2010), while greater gains per area allow farming more animals per area (Euclides et al., 2015), which represents an alternative for the rearing of future dams, since the objective is not to reach slaughter weight, but to maintain body score.

When ADG was evaluated as a function of the experimental period, the highest values ($P = 0.0001$) were observed in the month of October (0.09 g animal^{-1} day^{-1}), as compared with November (0.03 g animal^{-1} day^{-1}) and December (0.03 g animal^{-1} day^{-1}). This can be explained by the reduction in leaf mass from the beginning to the end of the experimental period (Table 2), since leaf supply is positively correlated with dry matter intake (Carloto et al., 2011) and intake is the parameter that most influences animal performance (Montagner, Euclides, Genro, & Nantes, 2013; Euclides et al., 2015).

Table 4. Mean values for average daily gain, final weight, stocking rate and weight gain per area of ewes managed under continuous grazing on *Brachiaria brizantha* cultivars in the dry season.

Variable	Marandu	Piatã	Xaraés	Paiaguás	SEM	P-value
ADG (kg animal^{-1} day^{-1})	0.08^{a}	0.04^{b}	0.05^{b}	0.06^{ab}	0.1	0.0096
Final weight (kg)	27.4^{a}	25.2^{a}	25.4^{a}	27.0^{a}	1.4	0.6060
Stocking rate (AU ha^{-1})	9.5^{a}	9.0^{a}	9.0^{a}	9.4^{a}	0.8	0.9675
Gain per area (kg ha^{-1} day^{-1})	0.32^{a}	0.16^{b}	0.20^{ab}	0.24^{ab}	0.1	0.0062

ADG: average daily gain. Means followed by equal letters do not differ by Tukey's test, at 5% probability. AU, animal unit of 30 kg live weight.

It is worth stressing the importance of maintaining the forage mass from the rainy season to be used during the dry season, since forage accumulation is practically zero at this time of the year. Accordingly, the studied cultivars were able to keep the forage mass constant during the period of water scarcity (Table 2). Moreover, when associated with supplementation, they provided gains for the ewes during the post-weaning phase, enabling them to reproduce at the end of the dry season.

Conclusion

The *Brachiaria brizantha* cultivars Piatã, Marandu, Paiaguás, and Xaraés proved to be forage options for the post-weaning phase of ewes supplemented with energy-protein concentrate at an intake rate of 0.8% of body weight during the dry season, as these cultivars were able to maintain forage supply even under low water availability, providing satisfactory gains per individual and per area. Therefore, the four evaluated cultivars are recommended.

Acknowledgements

The authors thank the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) for the financial support - Finance Code 001. The support from the Federal University of Mato Grosso do Sul, CNPq, and the Federal University of Rio Grande do Norte is also acknowledged.

References

Association Official Analytical Chemist [AOAC]. (2005). *Official Methods of Analysis* (18th ed.). Gaitherburg, MD: AOAC International.

Calvano, M. P. C. A., Euclides, V. P. B., Montagner, D. B., Lempp, B., Difante, G. S., Flores, R. S., & Galbeiro, S. (2011). Tillering and forage accumulation in Marandu grass under different grazing intensities. *Revista Ceres*, *58*(6), 781-789. DOI: https://doi.org/10.1590/S0034-737X2011000600015

Carloto, M. N., Euclides, V. P. B., Montagner, D. B., Lempp, B., Difante, G. S., & Paula, C. C. L. (2011). Desempenho animal e características de pasto de capim-xaraés sob diferentes intensidades de pastejo, durante o período das águas. *Pesquisa Agropecuária Brasileira*, *46*(1), 97-104. DOI: https://doi.org/10.1590/S0100-204X2011000100013

Difante, G. S., Euclides, V. P. B., Nascimento Júnior, D., Silva, S. C., Barbosa, R. A., & Torres Junior, R. A. A. (2010). Desempenho e conversão alimentar de novilhos de corte em capim-tanzânia submetido a duas intensidades de pastejo sob lotação rotativa. *Revista Brasileira de Zootecnia*, *39*(1), 33-41. DOI: https://doi.org/10.1590/S1516-35982010000100005

Emerenciano Neto, J. V., Bezerra, M. G. S., França, A. F., Assis, L. C. S. L. C., & Difante, G. S. (2011). A agricultura familiar na cadeia produtiva de carne ovina e caprina no semi-árido. *Revista Brasileira de Agropecuária Sustentável*, *1*(2), 10-16. DOI: https://doi.org/10.21206/rbas.v1i2.32

Emerenciano Neto, J. V., Difante, G. S., Aguiar, E. M., Fernandes, L. S., Oliveira, H. C. B., & Silva, M. G. T. (2014). Performance of meat sheep, chemical composition and structure of tropical pasture grasses managed under intermittent capacity. *Bioscience Journal*, *30*(3), 834-842.

Emerenciano Neto, J. V., Difante, G. S., Lana, Â. M. Q., Medeiros, H. R., Aguiar, E. M., Montagner, D. B., & Souza, J. S. (2018). Forage quality and performance of sheep in Massai grass pastures managed at pre-grazing canopy heights. *South African Journal of Animal Science*, *48*(6), 1073-1081. DOI: http://dx.doi.org/10.4314/sajas.v48i6.10

Euclides, V. B. P., Carpejani, G. C., Montagner, D. B., Nascimento Junior, D., Barbosa, R. A., & Difante, G. S. (2017). Maintaining post-grazing sward height of *Panicum maximum* (cv. Mombaça) at 50 cm led to higher animal performance compared with postgrazing height of 30 cm. *Grass and Forage Science*, *73*(6), 174-182. DOI: https://doi.org/10.1111/gfs.12292

Euclides, V. P. B., Lopes, F. C., Nascimento Junior, D., Silva, S., Difante, G. S., & Barbosa, R. A. (2015). Steer performance on *Panicum maximum* (cv. Mombaça) pastures under two grazing intensities. *Animal Production Science*, *56*(11), 1849-1856. DOI: http://dx.doi.org/10.1071/AN14721

Euclides, V. P. B., Macedo, M. C. M., Valle, C. B., Barbosa, R. A., & Gonçalves, W. V. (2008). Produção de forragem e características da estrutura do dossel de cultivares de *Brachiaria brizantha* sob pastejo. *Pesquisa Agropecuária Brasileira*, *43*(12), 1805-1812. https://doi.org/10.1590/S0100-204X2008001200023

Euclides, V. P. B., Macedo, M. C. M., Valle, C. B., Difante, G. S., Barbosa, R. A., & Cacere, E. R. (2009). Valor nutritivo da forragem e produção animal em pastagens de *Brachiaria brizantha*. *Pesquisa Agropecuária Brasileira*, *44*(1), 98-106. DOI: https://doi.org/10.1590/S0100-204X2009000100014

Euclides, V. P. B., Montagner, D. B., Barbosa, R. A., Valle, C. B., & Nantes, N. N. (2016). Animal performance and sward characteristics of two cultivars of *Brachiaria brizantha* (BRS Paiaguás and BRS Piatã). *Revista Brasileira de Zootecnia*, 45(3), 85-92. DOI: https://doi.org/10.1590/S1806-92902016000300001

Euclides, V. P. B., Montagner, D. B., Macedo, M. C. M., Araújo, A. R., Difante, G. S., &Barbosa, R. A. (2019). Grazing intensity affects forage accumulation and persistence of Marandu palisadegrass in the Brazilian savannah. *Grass and Forage Science*, *75*(1), 1-13. DOI: https://doi.org/10.1111/gfs.12422

Fernandes, L. S., Difante, G. S., Emerenciano Neto, J. V., Araújo, I. M. M., Veras, E. L. L., & Costa, M. G. (2020a). Performance of sheep grazing *Panicum maximum* cv. Massai and supplemented with protein sources during the dry season. *South African Journal of Animal Science*, *50*(1), 1-8. DOI: http://dx.doi.org/10.4314/sajas.v50i1.1

Fernandes, L. S., Difante, G. S., Costa, M. G., Emerenciano Neto, J. V., Araújo, I. M. M., Dantas, J. L. S., & Gurgel, A. L. C. (2020b). Pasture structure and sheep performance supplemented on different tropical grasses in the dry season. *Revista Mexicana de Ciências Pecuárias*, *11*(1), 89-101. DOI: https://doi.org/10.22319/rmcp.v11i1.5083

Food and Agriculture Organization [FAO]. (2015). *International Soil Classification System for Naming Soils and Creating Legends for Soil Maps* (Update 2015; World Soil Resources Report 106). Rome, IT: FAO.

Gimenes, F. M. A., Da Silva, S. C., Fialho, C. A., Gomes, M. B., Berndt, A., Luciana Gerdes, L., & Colozza, M. T. (2011). Ganho de peso e produtividade animal em capim-marandu sob pastejo rotativo e adubação nitrogenada. *Pesquisa Agropecuária Brasileira*, *46*(7), 751-759. DOI: https://doi.org/10.1590/S0100-204X2011000700011

Gurgel, A. L. C., Difante, G. S., Emerenciano Neto, J. V., Roberto, F. F. S., Zaros, L. G., Costa, M. G., Ítavo, L. C. V., & Ítavo, C. C. B. F. (2020). Impact of supplementation with different protein sources on the parasitological profile of ovine matrices and development of lambs. *Bioscience Journal, 36*(2), 496-506. DOI: https://doi.org/10.14393/BJ-v36n2a2020-39823

Gurgel, A. L. C., Difante, G. S., Emerenciano Neto, J. V., Souza, J. S., Veras, E. L. L., Costa, A. B. G., Carvalho Netto, R. T., Fernandes, L. S., Cunha, J. C., & Roberto, F. F. S. (2017). Estrutura do pasto e desempenho de ovinos em capim-massai na época seca em resposta ao manejo do período das águas. *Boletim de Industria Animal*, *74*(2), 86-95. DOI: https://doi.org/10.17523/bia.v74n2p86

Mertens, D. R. (2002). Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beaker or crucibles: collaborative study. *Journal of AOAC International*, *85*(6), 1217-1240.

Montagner, D. B., Euclides, V. P. B., Genro, T. C. M., & Nantes, N. N. (2013). Dry matter intake by beef steers on Piatã palisadegrass (*Brachiaria brizantha* cv. BRS Piatã) pasture. *Tropical Grasslands – Forrajes Tropicales*, *1*(1), 106–108. DOI: https://doi.org/10.17138/tgft(1)106-108

Nantes, N. N., Euclides, V. P. B., Montagner, D. B., Lempp, B., Barbosa, R. A., & Gois, P. O. (2013). Animal performance and sward characteristics of piatã palisade grass pastures subjected to different grazing intensities. *Pesquisa Agropecuária Brasileira*, *48*(1), 114-121. DOI: https://doi.org/10.1590/S0100-204X2013000100015

National Research Council [NRC]. (2007). *Nutrient Requirements of Small ruminants* (2th ed.). Washington, DC: National Academy Press.

Oliveira, L. B., Macêdo, A. J. S., & Santos, E. M. (2019). Interação entre espécies forrageiras nativas e cultivadas em condições de semiárido: revisão. *Arquivo de Ciências Veterinária e Zoologia*, *22*(4), 127-138. DOI: https://doi.org/10.25110/arqvet.v22i4.6949

Pezzopane, C. G., Santos, P. M., Cruz, P. G., Altoé, J.; Ribeiro, F. A., & Valle, C.B. (2015). Estresse por deficiência hídrica em genótipos de *Brachiaria brizantha. Ciência Rural*, *45*(5), 871-876. DOI: https://doi.org/10.1590/0103-8478cr20130915

Portela, J. N., Pedreira, C. G. S., & Braga, G. J. (2011). Demografia e densidade de perfilhos de capim braquiária sob pastejo em lotação intermitente. *Pesquisa Agropecuária Brasileira*, *46*(3), 315-322. DOI: https://doi.org/10.1590/S0100-204X2011000300013

Silva, L.F. N., Difante, G. S., Fernande, L. S., Araujo, I.M. M., Emerenciano Neto, J. V., Costa, M. G., & Felisberto, N. (2016). Ingestive behavior of sheep in *Panicum* and *Brachiaria* pastures in dry season. *Bioscience Journal*, *32*(4), 1018-1024. DOI: https://doi.org/10.14393/BJ-v32n4a2016-32945

Souza, J. S., Difante, G. S., Emerenciano Neto, J. V., Lana, A. M. Q., Roberto, F. F. S., & Ribeiro, P. H. C. (2019). Biometric measurements of Santa Inês meat sheep reared on *Brachiaria brizantha* pastures in Northeast Brazil. *PloS One*, *30*(1), 1-16. DOI: https://doi.org/10.1371/journal.pone.0219343

Valle, C.B., Euclides, V. P. B., Montagner, D. B., Valério, J. R., Fernandes, C. D., Macedo, M. C. M., & Machado, L. A. Z. (2013). Paiaguás: A new Brachiaria (*Urochloa*) cultivar for tropical pastures in Brazil. *Tropical Grasslands – Forrajes Tropicales*, *1*(1), 121-122. DOI: https://doi.org/10.17138/tgft(1)121-122