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Diurnal ingestive behaviour of steers grazing Alexander grass with various levels of nitrogen and feed supplements

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Abstract

Given the increasing availability of new cultivars with high yield potential, the use of annual tropical forages to improve cattle production systems is increasing and therefore warrants more research. The objective of this study was to quantify the influence of feed supplementation and nitrogen fertilization on the diurnal ingestive behaviour of crossbred steers (zebu x taurine), maintained on a pasture of Alexander grass *(Urochloa plantaginea).* The treatments included the application of nitrogen fertilizer at 100 kg/ha; at 100 kg/ha + supplemented feed of wheat bran (0.5% of bodyweight); and at 200 kg/ha. The study used a completely randomized design with three replications. The paddock size was 0.7 ha. Data were analysed by fitting mixed models. The times spent resting, ruminating and consuming water were not different among treatments. However, time spent grazing significantly differed. On average, steers given supplemented feed spent less time grazing (297 min/day) than steers without the supplemented feed (345 min/day). Steers in the pasture with supplementation showed a significantly greater number of daytime bites (2029 bites) than steers in the 200 kg nitrogen treatment (1715 bites). Supplementation reduced grazing time without altering other behaviour variables. The number of daily bites was lower on the pasture with the higher nitrogen level.

Keywords: Feeding time, grazing, idle, nitrogen fertilization, rumination
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Introduction

The increased availability of new cultivars with high forage-mass production potential has led to the widely promoted use of annual tropical grasses. Benefits include reduction of production costs and of length of production cycle in growing and finishing cattle. Millet *(Pennisetum americanum)* and Alexander grass *(Urochloa plantaginea)* present satisfactory results in the finishing of beef cattle in Mexico when used as forage and are no longer considered invasive plants (Sánchez-Ken, 2011). These authors reclassified Alexander grass in the genus *Urochloa.*

Among the factors that influence animal performance, ingestive behaviour has been used as an important tool for understanding variations in the productivity of animals. Behavioural changes are due to environmental, genetic and dietary factors and are dynamic and sensitive to variations in processes in the physical environment and in social stimuli (Snell-Rood, 2013).

Animals' grazing behaviour is influenced by pasture characteristics such as structure, forage, leaf to stem ratio and bromatological characteristics. Variations in the food structure can have positive or negative effects on food consumption by influencing the size of the bite and bite rate and, consequently, the time spent grazing (Glienke *et al*., 2016). Grazing activity typically ranges from 4 to 12 hours per day on low-energy diets (Burger *et al*., 2000) and resting time, without rumination, lasts approximately 10 hours a day.

High-roughage diets tend to increase rumination, resulting in reduced particle size and greater surface area of particles (Campos *et al*., 2006). This allows for greater exposure to the rumen bacteria involved in digestion and eventually a greater total digestibility of the feedstuff. Thus, increased fibre intake amplifies rumination time (Weckerly, 2013), whereas food consumption without concentrated supplementation tends to

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reduce it (Van Soest, 1994). Consequently, increasing the level of concentrate in the diet changes the food intake. However, the level of supplemental feed consumption needed to maintain energy is not known. Furthermore, the quality of grass in fertilized pastures is higher than that in non-fertilized pastures, thus offering increased nutrition to meet the demands of the animals and contributing to reduced food intake (Burger *et al*., 2000).

Evaluating behaviour is an important tool in nutritional rating because it provides an understanding of the relationships that determine animal performance and suggests strategies for improving productivity. Thus, the aim of the study was to evaluate the influence of energy supplementation and nitrogen fertilization (N) on the ingestive behaviour of crossbred steers (zebu x taurine), kept on a pasture of Alexander grass.

Materials and Methods

The study was conducted at the Teaching and Research Unit of Beef Cattle, Federal Technological University of Paraná (UTFPR), Campus Dois Vizinhos, from January to March 2013. The experimental area is located at 25°42′52″ S and 53º03′94″ W, and 519 m above sea level. The soil of the region is characterized as typic alfisol distroferric (Brazilian Agricultural Research Corporation, 2006), with an average slope of 5%. The climate in the area is classified as mesothermal humid subtropical, according to the Köppen classification. The average temperatures during the days of the behavioural evaluation, recorded in the meteorological station of Dois Vizinhos-Paraná, Brazil, varied between 20 ºC and 25 °C. The minimum and maximum temperatures of the experimental period were 14 ºC and 32.8 ºC, respectively. The relative humidity of the air ranged from 58% to 93.6%. The historical rainfall of the period (January to March) for the region is 526 mm (Possenti et al., 2007). However, during the experiment the rainfall was 796 mm, with the highest intensity in March (358 mm).

After a period of grazing on the oat/ryegrass/vetch pasture in the area, and a rest period in October and November 2012, fertilizer and pasture residue were incorporated into the soil by harrowing. The Alexander grass (*Brachiaria plantaginea*, synonym *Urochloa plantaginea*) was established by natural reseeding from the previous year's seed bank.

The experimental area consisted of nine 0.7 ha paddocks, totalizing 6.3 ha. There were three treatments in a completely randomized design experiment with three replications. The treatments were N100 (low N; 100 kg N/ha), N100S (low N plus wheat bran supplemental feed; 0.5 kg/100 kg of bodyweight), and N200 (high N; 200 kg/N/ha). On 5 October 2012, 250 kg/ha of 5-20-10 (N-P-K) were applied to all pastures. Urea (45% N) to meet the N treatment application level was applied in four split applications at the start of each trial period (every 21 days).

Twenty-seven tester animals were used, three in each repetition, with a variable number of regulators, through the put-and-take technique (Mott & Lucas, 1952), with an herbage allowance of 10 kg dry matter (DM) of forage for every 100 kg BW for all treatments. There were three 10-month-old non-castrated crossbred Nellore (zebu) x Braford (taurine), weighing an average of 276 ± 41 kg, in each paddock. The animals were used in accordance with the Animal Utilization Protocol approved by the UTFPR, based on guidelines set by Olfert *et al.* (1993) in the Canadian Council on Animal Care. The standard housing procedure on the pasture was applied, as in standard meat production, so the bioethical commission agreement was not needed.

Animals were placed on the experimental paddocks on 13 December 2012. After a 23-day adaptation period, data were collected for four 21-day periods. The forage mass was determined at the beginning of both the adaptation period and the first period, and at the end of each period, at 21-day intervals, using the double-sampling technique developed by Wilm *et al.* (1944). A subsample of the double sampling was used to determine DM. The determination of the accumulation rate of DM was performed according to the methodology described by Klingman *et al.* (1943). Herbage had a mean mass of 3007 kg of DM/ha, the daily herbage allowance was 9.87 kg DM/100 kg of body weight (BW) and the leaf : stem ratio was 0.46, without significant differences between the treatments. Further details of the results of treatments on grazing and animal performance are presented in Venturini *et al.* (2017).

Chemical composition analysis (Table 1) was performed at the Laboratory of Bromatology UTFPR-DV, based on their botanical separation. Samples were collected to determine their total DM, ash, and crude protein (CP) by the micro Kjeldahl method (AOAC, 1990). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were calculated according to the method in Van Soest *et al.* (1991) and *in vitro* digestibility of organic matter was calculated according to Tilley & Terry (1963), as modified by Goering & Van Soest (1970).

Two evaluations per trial were performed, and each evaluation included eight 12-hour (07:00 until 19:00) direct behavioural assessments of the animals. In 2013, observations of grazing time, the number of cud and chewing, and the number of bites and feeding stations were made on 17 and 23 January (first period), 7 and 13 February (second period), 28 February and 6 March (third period), and 21 and 25 March (fourth period). The dates were chosen at random as long as typical climatic conditions (excess rain or wind) did not occur.

Table 1 Mean nutritive values (%) during experimental period for Alexander grass (*Urochloa plantaginea*) grown with additional nitrogen or supplementation

	N100S[1]	N200[2]	N100[3]
Leaf			
Crude protein	17.2	18.7	17.3
Ash	10.9	9.8	10.5
Neutral detergent fibre	60.9	60.4	61.0
Acid detergent fibre	21.0	20.1	21.3
In vitro dry matter digestibility	42.1	42.3	41.6
Total plant material			
Crude protein	13.3	14.8	13.3
Ash	9.2	8.7	9.2
Neutral detergent fibre	66.2	64.6	66.1
Acid detergent fibre	26.9	26.5	27.2
In vitro dry matter digestibility	39.5	40.8	39.7

[1]100 kg/ha of N + 0.5 kg/100 kg BW from wheat bran
[2] 200 kg/ha of N
[3] 100 kg/ha of N

During the observation, every 10 min. the animal was classified into the following activities: grazing, ruminating, taking in water, taking in supplement and idling. The activities of each animal were recorded in an exclusive and unique way by evaluators with experience in these evaluations. Each evaluator observed three paddocks. The animal testers had been previously identified with numbering in the thoracic region, according to the methodology described by (Thurow *et al*., 2009). Grazing time was recorded as the time spent selecting and seizing forage, including the time spent moving around for diet selection. The rumination time was identified as the end of grazing and the onset of mastication and rumination. The period in which the animal came to the water cooler or to the troughs with supplement (treatment N100S) was classified as consumption of water and/or supplement. An idle period was when the animal remained at rest (Forbes, 1988). The activities were expressed as total time in min/day.

The time spent for the animal to perform 20 bites was evaluated to calculate the rate of bites minute-1 (Hodgson, 1982). The intake behaviour was measured six times per day: three times each in the morning and afternoon. Observed variables were time spent to complete 10 food stations and the number of footsteps between stations. A feeding station was regarded as the space corresponding to grazing without moving the front legs (Laca *et al*., 1992). A footstep was defined as every movement of the front legs. Displacement rate (footsteps minute-1) and daytime number of feeding stations were estimated from these data. The number of bites per station was calculated by dividing the number of daytime bites by the feeding station's daytime number. The number of stations per minute was calculated by dividing the number of daytime stations by grazing time.

A completely randomized design was employed with three treatments (N100, N100S and N200) and three replications (paddocks). Data were tested for normality using the Shapiro-Wilk test, and compared by the PROC MIXED procedure, with fixed effects for the treatments and the random residual error. Analysis was performed with the MIXED procedure of SAS 8.2 (SAS Institute Inc., Cary, NC, USA, 2000). The data for day grazing time from the observation days (Day 1 and Day 2) were included in the model as a fixed effect, significance was declared at $P \leq 0.05$.

Results

The steers spent a mean of 5 hours and 29 min grazing, 4 hours and 34 min in idleness, 1 hour and 49 min ruminating, 52 min chewing the bolus, 1 hours and 27 min taking 20 bites and 13 min ingesting water (Table 2). Supplemented animals spent an average of 23 min at the trough. Grazing activity was lower in the supplemented animals than for cattle in the other treatments. This difference was caused by the amount of time the animals spent feeding on the concentrate. Therefore, the mass and forage allowance did not vary among treatments. Idle time did not differ among treatments (P >0.05). Similarly, offering a low amount of supplement did not negatively influence idle time.

Table 2 Mean values of diurnal ingestive behaviour variables for cattle given energy supplementation and grazed on Alexander grass (*Urochloa plantaginea*) with nitrogen addition

	N100S[1]	N200[2]	N100[3]	SEM	*P*
Grazing (min/day)	297.3[b]	336.7[a]	352.3[a]	14.59	0.0029
Resting (min/day)	299.4	276.7	247.0	23.13	0.0964
Ruminating (min/day)	99.3	108.8	116.8	12.79	0.4055
Chewing (min/day)	134.3	118.6	131.8	14.09	0.4983
Daytime chewing time per bolus (min/day)	52.5	50.3	51.6	1.49	0.3680
Time of 20 bites (s)	83.0	86.4	91.0	5.8	0.4021
Sup. consumption (m/day)	22.6	-	-	-	-
Water intake (min/day)	12.4	10.2	15.5	2.1	0.0563

[a, b] Row means with different superscripts differ significantly at P ≤0.05
SEM: standard error of the mean
[1]100 kg/ha of N + 0.5 kg/100 kg BW from wheat bran; [2] 200 kg/ha of N; [3] 100 kg/ha of N
N: nitrogen

The number of chews per bolus and time for daylight rumination, idleness, chewing and taking 20 bites were similar (P >0.05) among treatments (Table 3). Times for chewing and for taking 20 bites were not negatively influenced by the treatments because forage availability and supply were similar in the homogenous pastures. Bites per station, bites per minute, stations per minute and steps per minute were similar (P >0.05) among treatments, with average values of 6.9, 15.4, 2.3 and 6.3, respectively. The number of bites was greater (P ≤0.05) for the supplementation treatment and for the pasture-only treatment than it was for the treatment with N fertilization (2029.9, 1863.6 and 1715.7, respectively).

Table 3 Mean values of daytime behaviours for cattle given energy supplementation and grazed on Alexander grass *(Urochloa plantaginea)* with added nitrogen

	N100S[1]	N200[2]	N100[3]	SEM	*P*
Number of chews by bolus	50.3	50.2	49.9	1.25	0.9556
Number of chews per minute	48.9	51.3	49.4	1.55	0.2762
Total number of chews	5709.4	6503.2	6767.5	766.9	0.3718
Number of chewed food cakes	116.3	131.5	138.5	16.67	0.4098
Number of bites per minute	15.9	15.4	14.9	1.18	0.5303
Number of bites	2029.2[a]	1715.7[b]	1863.6[ab]	108.12	0.0272
Number of stations per minute	2.3	2.2	2.4	0.11	0.2634
Total number of stations	310.1	260.6	309.8	46.02	0.4749
Steps per minute	6.2	6.1	6.6	0.24	0.1789
Number of bites per season	7.1	7.2	6.4	0.76	0.5161

[a,b] Row means with different superscripts differ significantly at P ≤0.05
SEM: standard error of mean
[1]100 kg/ha of N + 0.5 kg/100 kg BW from wheat bran; [2] 200 kg/ha of N; [3] 100 kg/ha of N
N: nitrogen

The number of chews per bolus, number of chews per min/day, number of chewed bolus/day, and the number of stations/day were not influenced by the treatments (P >0.05).

Discussion

The daytime grazing behaviour showed that these results were within the range observed in experiments with tropical forage species (Brâncio *et al*., 2003; Sbrissia *et al*., 2004; Palhano *et al*., 2006). Grazing activity was lower in the supplemented animals than in the other treatments. This difference was caused by the amount of time the animals spent feeding on the concentrate. Therefore, the mass and forage allowance did not vary among treatments. The supplement was a filler that caused rumen satiety and contributed to the energy demands of the animals, thereby reducing grazing activity. Sheahan *et al.* (2011), in New Zealand, concluded that cows reduced grazing time by 12 min for every 1 kg DM of concentrate supplement consumed. According to Carvalho *et al.* (2007), the time taken for grazing daily (24-hour evaluation) ranges from 6 to 12 hours and is rarely above or below these values. In the current daytime study, the total time spent grazing averaged 5 hours and 29 min. This value can be considered high because it belonged only to daytime data. However, the average temperature during the experimental period was moderate and did not cause extreme heat stress. Therefore, animals were able to graze rather than seek shaded areas. In addition, the crossbred animals used in this study are more heat tolerant than European breeds.

Idle time did not differ among treatments. In general, supplemented animals spend less time ruminating after reduced forage intake, and consequently their intake of neutral detergent fibre decreases. Van Soest *et al.* (1991) reported that ruminating time was influenced by the type of diet and the bulky cell wall content and was thereby directly proportional to increased supplement amounts. However, in the present work, this activity showed no difference, probably because of the low level of energy supplement ingested by the animals. Similarly, the idle time was not influenced negatively by this low amount of supplement, but more studies should be conducted to determine the level that will bring changes, as idle time usually increases with an increase in the amount of dietary concentrate (Valente *et al*., 2013).

The amount of time spent in rumination, idleness and chewing, chews per bolus and the time required for 20 bites were similar among treatments. The timing of the evaluation period for grazing behaviour in the middle period may have been one of the factors that resulted in no significant differences between the pasture-only treatment and the pasture and supplementation treatment because rumination occurs mainly at night, and idleness is a daytime activity (Bremm *et al*., 2005). Non-assessment during the 24 hours of the day may have been a limitation of the current study.

The number of chews per bolus and the times for chewing, bolus formation, and taking 20 bites were not influenced by the treatments because forage availability and supply were similar in the homogenous pastures. According to Gregorini *et al.* (2013), the number of bites per feeding station, the total number of bites, the number of feeding stations and the rate of displacement per minute are considered functional responses of grazing animals to the forage supply.

The lowest bite rate was observed in N200, and may be because of the greater accumulation rate (Venturini *et al*., 2017), mainly from the emergence of new leaves at the top of the plant, which could be consumed more easily. According to Teixeira *et al.* (2011), in pastures where there is a greater availability of forage, the bite rate is reduced because the animal can increase the depth and volume of the bite, thereby resulting in a lower bite rate.

Supplementation did not affect chewing time, probably because of the low fibre content in the supplements and the type of supplement, which had low starch content. Valente *et al.* (2013), in Brazil, found a reduction in chewing activity in young bulls finished in a feedlot that were fed various levels of concentrate. However, the amount of supplementation was greater than that provided in this study, supporting the idea that the level used here was not sufficient to cause a change in this behaviour.

It is important to highlight the use the Alexander grass as a pasture grass because, in addition to having spontaneous summer reseeding (especially in areas used for crop-livestock integration), it has high forage potential for animal production. Future research should address higher supplementation levels and doses of N in grasslands. These increased levels may result in greater productivity gains in the pasture and the animals, contribute to behaviour all changes in the animals, and indicate the economic viability of the system better.

Energy supplementation proved to be an important pasture management tool, since it was able to alter the grazing behaviour of the animals, reducing grazing time and increasing the number of bites. Result not found with increase in nitrogen level.

Conclusions

Supplementation of cattle grazing on grass pasture was lower than grazing time. N fertilization was lower than the number of daily bites.

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Authors' Contributions

TV, LFGM and WP contributed to the project design and drafting of the paper, JLN, LR S and FLMP contributed to the conduct of the experiment and revision of paper, AMOD and EFCOL contributed to the collection of data

Conflict of Interest Declaration

None

References

Association of Official Analytical Chemists (AOAC) 1990. Official methods of analysis. 15th edition. Arlington, Virginia: 1117 p.

Brâncio, P.A., Nascimento Junior, D., Euclides, V.P.B., Fonseca, D.M., Almeida, R.G., Macedo, M.C.M. & Barbosa, R.A., 2003. Evaluation of three varieties of Panicum maximum Jacq. under grazing: diet composition, dry matter intake and animal weight gain. Rev. Bras. Zoot. 32, 1045-1053.

Brazilian Agricultural Research Rio de Janeiro Corporation (EMBRAPA) 2006. Brazilian system of soil classification. 2nd edition. Embrapa Solos, 306 p.

Bremm, C., Rocha, M.G., Restle, J., Pilau, A. Montagner, D.B., Freitas, F.K. Macari, S., Elejalde, D.A.G., Roso, D., Roman, J., Guterres, E.P., Costa, V.G. & Neves, F.P., 2005. Ingestive behavior of beef heifers grazing oat (*Avena strigosa* Schreb) and ryegrass (*Lolium multiflorum* Lam) pasture under supplementation levels. Rev. Bras. Zoot. 34, 319-329.

Burger, P.J., Pereira, J.C., Queiroz, A.C., Silva, J.F.C., Valadares Filho, S.C., Cecon, P.R. & Casali, A.D.P., 2000. Ingestive behavior in Holstein calves fed diets with different concentrate levels. Rev. Bras. Zoot. 29, 236-242.

Campos, P.R.S.S., Valadares Filho, S.C., Cecon, P.R., Detmann, E., Leão, M.I., Souza, S.M., Lucchi, B.B. & Valadares, R.F.D., 2006. Comparative study of ruminal degradation kinetics of tropical forages in cattle and sheep. Arq. Bras. Med. Vet. Zoot. 58, 1181-1191.

Carvalho, P.C.F., Carvalho, P.C.F., Kozloski, G.V., Ribeiro Filho, H.M.N., Reffatti, M.V., Genro, T.C.M. & Euclides, V.P.B., 2007. Advances in methods for determining animal intake on pasture. Rev. Bras. Zoot. 36, 151-170 (supl. especial).

Forbes, T.D.A., 1988. Researching the plant-animal interface: The investigation of ingestive behavior in grazing animals. J. Anim. Sci. 66, 2369-2379.

Glienke, C.L., Rocha, M.G., Potter, L., Roso, D., Montagner, D.B. & Oliveira Neto, R.A., 2016. Canopy structure, ingestive behavior and displacement patterns of beef heifers grazing warm-season pastures. Arq. Bras. Med. Vet. Zoot. 68, 457-465.

Goering, H.K. & Van Soest, P.J., 1970. Forage fiber analysis (apparatus, reagents, procedures and some application). Agricultural Handbook No. 379, Agricultural Research Service, US Department of Agriculture.

Gregorini, P., Beukes, P.C., Romera, A.J., Levy, G., Mark, D. & Hanigan, M.D., 2013. A model of diurnal grazing patterns and herbage intake of a dairy cow, MINDY: Model description. Ecological Modelling 270, 11-29.

Hodgson, J., 1982. Ingestive Behaviour. In: J.D. Leaver (ed.) Herbage Intake Handbook. British Grassland Society, Hurley. p. 113.

Klingman, D.L., Miles, S.R. & Mott, G.O., 1943. The cage method for determining consumption and yield of pasture herbage. J. Am. Soc. Agron. 35, 739-746.

Laca, E.A., Ungar, E.D., Seligman, N. & Demment, M.W., 1992. Effects of sward height and bulk density on bite dimensions of cattle grazing homogeneous swards. Grass For. Sci. 47, 91-102.

Mott, G.O. & Lucas, H.L., 1952. The design conduct and interpretation of grazing trials on cultivated and improved pastures. In: International Grassland Congress Proceedings. State College Press Pensylvania. 1380-1395.

Olfert, E.D., Cross, B.M. & McWilliam, A.A., 1993. Guide to the care and use of experimental animals. Working Party Report. Volume 1. Canadian Council on Animal Care, Ontario, Canada.

Palhano, A.L., Carvalho, P.C.F., Dittrich, J.R., Moraes, A., Silva, S.C. & Monteiro, A.L.G. 2006. Displacement and forage searching patterns of Holstein heifers in Mombaça grass pasture. Rev. Bras. Zoot. 35, 2253-2259.

Possenti, J.C., Gouveia, A., Martin, T.N. & Cadore, D., 2007. Distribuição pluvial em Dois Vizinhos, Paraná, Brasil. In: Sistemas De Produção Agropecuária, Dois Vizinhos, PR. Anais. Dois Vizinhos.

Sánchez-Ken, J.G., 2011. Two new species of Urochloa (Paniceae; Panicoideae; Poaceae) from Western Mexico and the updated checklist with a key to species of the genus in Mexico. Systematic Botany 36, 621-630.

SAS Institute 2000. SAS/Insight User's Guide. versão 8.2, versão para Windows, Cary, NC, USA.

Sbrissia, A.F., Silva, S.C. & Sarmento, D.O.L., 2004. A simple method for measuring tiller volume of grasses. Grass For. Sci. 59, 406-410.

Sheahan, A.J., Kolver, E.S. & Roche, J.R., 2011. Genetic strain and diet effects on grazing behavior, pasture intake, and milk production. J. Dairy Sci. 94, 3583-3591.

Snell-Rood, E.C., 2013. An overview of the evolutionary causes and consequences of behaviour plasticity. Anim. Behav. 85, 1004-1011.

Teixeira, F.A., Bonomo, P., Pires, A.J.V., Silva, F.F., Marques, J.A. & Santana Júnior, H.A., 2011. Displacement and permanency patterns of grazing cattle on *Brachiaria decumbens* deferred under four fertilization strategies. Rev. Bras. Zoot. 40, 1489-1496.

Thurow, J.M., Nabinger, C. & Castilhos, Z.M.S., 2009. Vegetation structure and ingestive behavior of steers in natural pasture in the state of Rio Grande do Sul Ver. Bras. Zoot. 38, 818-826.

Tilley, J.M.A. & Terry, R.A., 1963. A two-stage technique for the *in vitro* digestion of forage crop. J. Brit. Grassl. Soc. 18, 104-111.

Valente, E.E, Valente, E.E., Paulino, M.F., Detmann E., Valadares Filho, S.C., Barros, L.V., Paula, N.F., Lopes, S.A., Almeida, D.M. & Martins, L.S., 2013. Effect of calves supplementation on performance, nutritional and behavioral characteristics of their dams. Trop. Anim. Health Prod. 45, 487-495.

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. 2.ed. Ithaca: Cornell University Press, 476p.

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

Venturini, T., Menezes, L.F.G., Montagner, M.M., Paris, W., Schmitz, G.R. & Molinete, M.L., 2017. Influences of nitrogen fertilization and energy supplementation for growth perfomance of beef cattle on Alexander grass. Trop. Anim. Health Prod. 49, 1-6.

Weckerly, F.W., 2013. Conspecific body weight, food intake, and rumination time affect food processing and forage behavior. J. Mammalogy 94, 120-126.

Wilm, H.G., Costello, D.F. & Klipple, G.E., 1944. Estimating forage yield by the double-sampling methods. J. Am. Soc. Agron. 36, 194-203.