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Grazing behavior and spatial distribution of feces of Young bulls in silvopastoral systems and Marandu monoculture in the Pre-Amazon region

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ABSTRACT. The objective was to evaluate the grazing behavior and the spatial distribution of feces of F1 young bulls from the cross between Nellore and Guzera on pastures of *Urochloa brizantha* cv. Marandu in silvopastoral systems composed of babassu palm (*Attalea speciosa*) and Marandu monoculture in the Pre-Amazon region of the state of Maranhão. Animals were evaluated in four systems consisting of 0, 80, 131, 160 palms ha^{-1}, characterizing monoculture (mono), low density of palm trees (LD), medium density of palm trees (MD) and high density of palm trees (HD) during the rainy (RE) and dry (DE) periods. Five animals (repetitions) were used in each system, with 231-303 days of age and 180±15 kg body weight. Determinations of behavioral patterns were made by instant sampling, at 10 min intervals. In each system, we demarcated 50 squares of 100 m^2, which served as useful area to evaluate the dispersion of feces. The grazing behavior was influenced by the sward structure, which, in turn, was influenced by densities of palm trees, due to shading. The distribution of feces was affected by both the presence of babassu plantations and periods. The silvopastoral systems made the environment more pleasant to animals, since activities considered more stressful and avoided during the daytime were performed by animals of these environments, unlike animals in the monoculture system.

Keywords: babassu, sward structure, dispersal, idle, palm trees, rumination.

Comportamento de pastejo e distribuição espacial de fezes de tourinhos em sistemas silvipastoris e monocultura de capim-Marandu na região pré-amazônica

RESUMO. Objetivou-se avaliar o comportamento de pastejo e a distribuição espacial de fezes de tourinhos F1 do cruzamento de Nelore com Guzerá em pastagens de *Urochloa brizantha* cv. Marandu em sistemas silvipastoris compostos por palmeiras de babaçu (*Attalea speciosa*) e em monocultivo de capim-Marandu na região pré-amazônica maranhense. Os animais foram avaliados em quatro sistemas, sendo 0, 80, 131, 160 palmeiras ha^{-1}, caracterizando monocultura (mono), baixa densidade de palmeiras (BDP), média densidade de palmeiras (MDP) e alta densidade de palmeiras (ADP), respectivamente, durante os períodos chuvoso (PC) e seco (PS). Foram utilizados cinco animais (repetições) em cada sistema, os animais tinham entre 231 e 303 dias de vida e peso vivo de 180±15 kg. As medidas dos padrões comportamentais foram realizadas por colheita instantânea, a intervalos de 10 min. Em cada sistema foram demarcados 50 quadrados de 100 m^2, que serviram como área útil para avaliar a dispersão das fezes. Observou-se que o comportamento de pastejo foi influenciado pela estrutura do pasto, que por sua vez foi influenciado pelas densidades de palmeiras pelo sombreamento e a distribuição das fezes foi influenciada tanto pela presença dos babaçuais quanto pelos períodos avaliados. Os sistemas silvipastoris tornaram o ambiente mais agradável aos animais, visto que as atividades consideradas mais estressantes e que são evitadas durante o dia foram realizadas pelos animais desses ambientes, ao contrário dos animais do sistema de monocultivo.

Palavras-chave: babaçu, estrutura do pasto, dispersão, ócio, palmeiras, ruminação.

Introduction

When conducting the grazing of cattle, it is expected a maximum utilization of the forage available. The recommendation is to keep a homogenous distribution of animals in the area and ensure regular intake of forage, with minimal trampling and activity of recognition by the animals.

Most of the forage intake by cattle occurs in the daytime: the two most important grazing periods are observed at dawn and at dusk (Kilgour, Uetake, Ishiwata, & Melville, 2012); between these well marked periods there usually are short periods of consumption. In general, the grazing is influenced by the demands of the animal, the quantity and quality of pasture, and by the spatial distribution and morphology of the plants; all these factors affect the consumption and consequently livestock production.

The act of excretion differs both temporally and spatially from grazing. It can be observed large concentration of feces in restricted and isolated areas, which favors the translocation of nutrients available in forage for areas with little or no importance for production, and this has a great relevance in the process of nutrient recycling in pasture ecosystems.

The distribution of cattle on pastures and the selection of sites for grazing, resting, or ruminating are determined by complex interactions between biotic and abiotic factors (Hirata, Yamamoto, & Tobisa, 2010). Among them, stand out the climate, soil characteristics, topography, availability of water, botanical composition, quantity and quality of forage, shading, and factors related to animal behavior and human activity.

The presence of trees in pastures affects the distribution of animals in paddocks; an important factor in this respect is the microclimate provided by trees (Souza et al., 2010), changes in the sward structure (Rodrigues et al., 2016) and the improvement of the nutritional value under shade (Araújo et al., 2016b). All these factors influence the behavior of grazing, which highlights its importance in research with animals on pasture, in view of the effect of the behavior on consumption and consequently on animal performance.

Given the above and considering the adaptation of cattle in relation to shading in silvopastoral systems, the goal of this study was to evaluate the influence of different densities of babassu palm trees in agroforestry systems on the grazing behavior and the spatial distribution of cattle feces in pastures of *Urochloa brizantha* cv. Marandu in silvipastoral systems composed of babassu (*Attalea speciosa*) trees and in monoculture in the Pre-Amazon region of the state of Maranhão.

Material and methods

The experiment was conducted at Água-Viva Farm, in the municipality of Matinha-Baixada Maranhense region, at the geographical coordinates 45° 00´ 40.9´´ W longitude and 03° 06´ 55.5´´ S latitude. Forage species used was *Urochloa brizantha* CV. Marandu and the tree species was babassu palm *Attalea speciosa* Martius, which was already established on the property. Animals were evaluated in four systems: Marandu grass monoculture and three densities of babassu palm trees plus Marandu grass (SSP), corresponding to 0, 80, 131, and 160 trees ha^{-1}, respectively. These systems characterize monoculture (MC), low density (LD), medium density (MD) and high density of palm trees (HD). Animals were assigned to experimental units in a completely randomized design (CRD) with subdivided plots, with densities of palm trees in the plots and the seasons in the subplots. Data were grouped in two periods: rainy season (April to June/July 2013) and dry season (June/July to October 2013).

Figure 1 illustrates the average rainfall calculated from a 30-year series and during the experimental period. During the study period, the rainfall averaged 2,000 mm per year, with higher concentration from April to June. Maximum and minimum temperatures ranged between 32 and 23°C, respectively.

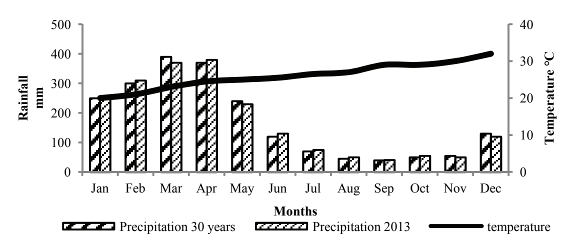

Figure 1. Average temperature during the study period and average monthly rainfall calculated from a 30-year series and from the experimental period.

Before the experiment, soil samples were taken at the 0-20 cm layer for soil fertility analysis. As shown in Table 1, all experimental units had medium soil fertility, and, regardless of treatment, soil acidity was corrected through the increase of base saturation.

The experimental units were fertilized with nitrogen (N) as urea at 150 kg ha^{-1}, phosphorus (P_2O_5) as simple superphosphate at 150 kg ha^{-1}, and potassium chloride (KCl) at 60 kg ha^{-1}. Finally, depending on the silvopastoral system, dolomitic lime was added at 550, 135, 775 and 630 kg ha^{-1} to the palisadegrass monoculture and the three increasing palm-tree densities (80, 131 and 160 trees ha^{-1}), respectively.

Table 1. Soil chemical composition prior to the beginning of experiments in the four pasture systems evaluated.

Silvopastoral systems[1]	pH ($CaCl_2$)	OM (g DM^{-3})	P (g DM^{-3})	K (g DM^{-3})	Ca (g DM^{-3})	Mg (g DM^{-3})	H+Al (g DM^{-3})	Al (g DM^{-3})	B (g DM^{-3})	CTC (g DM^{-3})
MC	4.8	23	21	32	17	6	42	2	19	68
LD	5.2	23	9	40	21	9	27	1	20	61
MD	5.0	22	23	26	22	10	42	2	20	77
HD	4.8	23	11	37	20	7	44	1	28	75

Silvopastoral systems	V (%)	S (mg dm^{-3})	Cu (mg dm^{-3})	Fe (mg dm^{-3})	Zn (mg dm^{-3})	Mn (mg dm^{-3})	B (mg dm^{-3})
MC	38	5	0.4	104	4.4	47.3	0.19
LD	56	7	0.4	149	4.2	33.6	0.20
MD	45	6	0.4	61	4.6	54	0.20
HD	41	10	0.4	105	4.1	44	0.28

[1]Babassu palm tree density: MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

The total experimental area had eight hectares, subdivided into four two-hectare plots, managed under continuous grazing, with five mixed Nelore x Guzerá animals, with initial age between 231 and 303 days and body weight of 180±15 kg, in each unit. Animals were introduced or removed from the units as required to keep the pasture at the pre-determined height. When not in the experimental units, animals were kept in a reserved six-hectare area.

During the days for data collection, one day in each period, we observed the behavior of 'tester' animals on grazing, starting at 5:00 pm and ending at 5:00 pm the next day, totaling 24 hours of observation, there was no adaptation of observers to animals, since the daily management was carried out by the same. Determinations of behavioral patterns were conducted by instant assessments or a scan-sampling method, at 10 min intervals, by three trained observers in each system, who took turns and made notes in spreadsheets. On the occasion of these observations, it has been identified, for each animal, one of the following behaviors: grazing, rumination, idle, displacement and intake of water and mineral salt.

For analysis of the distribution of feces, each paddock was subdivided into 50 quadrants of 10 x 10 m, resulting in a net area of 5000 m^2 in each system. From the records of the distributions of feces in each quadrant, we calculated the mean and the variance, based on the record of each count during seven days of evaluation in each period, which enabled the calculation of the index of dispersion defined. To test statistically the Index of dispersion, the chi-square test was used in such a way that: $X^2obs = ID (n-1)$, where X^2obs: observed value of chi-square; ID: Index of dispersion; n: Number of quadrants counted (50).

During each test, the feces were marked with lime, so that each plate was recorded only once. To facilitate the counting of fecal plates and prevent the wrong record, i.e., plates of different quadrants, we used a GPS (Global Positioning System) to correctly demarcate the area of the quadrant before starting the count.

Through the Morisita index of dispersion (Id), Uniformity Index, and the Aggregation index, and subsequent evaluation of their values, we obtained the specific formula for calculation of the standardized Morisita index of dispersion, which ranges from -1.0 to 1.0+, with confidence limit of 95% to +0.5 and -0.5. The random model is characterized by Id equal to zero, the aggregate model, above zero and the uniform model, below zero.

Data were initially tested for normality (Crame-Von Misses) and homoscedasticity (Levene) and, when assumptions were met, data were subjected to analysis of variance with the F-test. In the case of significant differences, mean values were compared by Duncan's test at 5% probability. Statistical analyses were run using the software SAS 9.0® (Statistical Analysis System [SAS], 2002).

Results and discussion

The animals grazed more during the day in all systems (Table 2). During the rainy season, the presence of babassu plantations did not influence the diurnal grazing time ($p > 0.05$). In the monoculture, the animals spent less time grazing, on average 3.86 hours. During the day, in the dry season, the animals spent more time grazing in LD and HD, with 6.16 and 6.18 hours day^{-1}, respectively. In the monoculture system, it was observed that the animals grazed less, both during the day (3.51 hours day^{-1}) and at night (1.68 hours ay^{-1}).

The lowest grazing time in the system without palm trees was caused by changes in the structural characteristics of pasture, because the leaf: stem ratio was critical during the dry season, the production of stems was about 8.20% higher than the leaf fraction (Figure 2).

Table 2. Grazing time of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Silvopastoral systems	Diurnal grazing (hours day^{-1}) Season Rainy	Dry	CV %
MC	4.51 Ba	3.51 Cb	10.02
LD	5.73 Aa	6.16 Aa	
MD	5.63 Aa	5.11 Ba	
HD	5.96 Aa	6.18 Aa	
Silvopastoral systems	Night grazing (hours day^{-1})		CV %
MC	3.21 Ba	1.68 Cb	12.72
LD	3.01 Ba	3.08 Bb	
MD	4.03 Aa	4.43 Aa	
HD	2.33 Ca	2.56 Ba	

Means followed by different uppercase/lowercase letters in the same column/row, respectively, are significantly different, according to Duncan's test ($p < 0.05$). MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

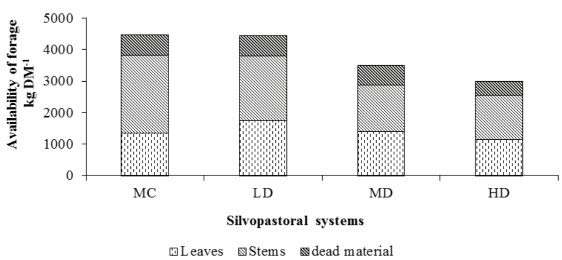

Figure 2. Forage availability in relation to the amount of leaves and stems in silvopastoral systems and monoculture during the dry season. MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

According to Cecato et al. (2000), the animals select the more palatable fractions of grasses, in general the green leaves, and thus pasture starts to have increasing proportion of material not preferred or rejected, as stem and dead/ senescent material, throughout the period of occupation, making it increasingly difficult the selection and intake of forage.

Therefore, during the dry season, animals on monoculture spent less time grazing due to the low amount of leaves, the expected would be the animals spend more time grazing, because the selectivity would be greater. However, the lack of shade and the higher temperature cause the animals to graze less in this environment, thus avoiding greater expenditure of energy.

The grazing time by cattle decreases when the ambient temperature exceeds 26°C, and values above this were common during the experiment, even in the rainy season. This hypothesis is even more consistent when observing the grazing during the night, because in the rainy season, the animals spent less grazing time in HD, indicating that the large amount of palm trees provided a favorable environment during the day, thereby decreasing the demand for forage during the night, as most of the daily grazing had already occurred in the previous shift, because, during the day, the shading on the system with 160 trees ha^{-1} favored the diurnal grazing.

In general, the animals remained longer grazing during the day in silvopastoral systems, because the presence of babassu trees, regardless of density, created a microclimate more favorable, causing the animals to increase the grazing time during the hottest hours, i.e., in the morning and afternoon.

Even with the structural changes in the pasture, described previously, it was observed that the animals had good amount of forage in a low total grazing time, because, according to Gimenes et al. (2011), animals on grazing with forage supply that has a sward structure with high percentage of stems or senescent leaves, have greater difficulty of taking and eat grass, and may spend more than 12 hours per day grazing, but the normal is eight hours per day and in none of the evaluated systems, the animals remained more than this time.

The time the animals remained ruminating was similar to all of the silvopastoral systems when comparing the periods ($p > 0.05$) in both shifts (Table 3).

Table 3. Rumination time of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Silvopastoral systems	Diurnal rumination (hours day^{-1}) Season Rainy	Dry	CV%
MC	3.28 Ab	6.86 Aa	17.32
LD	2.06 Ba	2.56 Ba	
MD	3.38 Ba	2.90 Ba	
HD	2.03 Ba	2.75 Ba	
Silvopastoral systems	Night rumination (hours day^{-1})		CV %
MC	4.73 Bb	6.26 Ba	14.00
LD	6.38 Aa	6.91 Aa	
MD	0.98 Da	1.00 Da	
HD	3.96 Ca	4.36 Ca	

Means followed by different uppercase/lowercase letters in the same column/row, respectively, are significantly different, according to Duncan's test ($p < 0.05$). MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

The time spent in rumination was influenced by periods only for stem kept in the monoculture system ($p < 0.05$). During the dry season, the animals of this system spent more time ruminating, on average 6.53 hours during the day and 6.26 hours during the night.

When compared only the systems within each period, during the day, as well as in the comparison between periods, only in the system without trees, there was an influence on the rumination time ($p < 0.05$), since during the night, the presence of babassu trees influenced the rumination time in all environments ($p > 0.05$), in both periods. In general, the animals kept in the LD showed a greater rumination time (7 hours day^{-1}) and those at the HD, shorter times (0.99 hours day^{-1}).

This behavior demonstrates again the influence of trees on animal behavior, because during the hottest hours of the day, i.e, during the morning and afternoon, the animals avoid physical effort to reduce energy expenditure and minimize losses.

In agreement with Leme, Pires, Verneque, Alvim, and Aroeira (2005), the animals spend the hot hours of the day resting and ruminating. Around noon, most of the activities are interrupted and grazing is left to be held during the night. The time spent in rumination is longer at night, but is also influenced by the food.

According to Phillips and Rind (2001), the rumination activity in adult animals takes about eight hours per day with variations between 4 and 9 hours day^{-1}. In this study, with rearing animals, a time longer than that can be observed only in the monoculture during the dry season (12.79 hours day^{-1}). These values show that the food, in this case the forage was influenced by the environment without shade and consequently the time of rumination, which, according to Araújo et al. (2016a), affects animal performance in silvipastoral systems formed by babassu palm trees.

Table 4 lists the time at which the animals remained in idle; when considering the influence of periods, only animals kept in the HD were not affected during the day, but at night, the periods did not influence the time in idle of animals in LD and HD ($p > 0.05$).

Table 4. Idle time of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Silvopastoral systems	Diurnal idle (hours day^{-1}) Season Rainy	Dry	CV%
MC	3.60 Aa	1.00 Bb	10.53
LD	3.41 Aa	2.46 Ab	
MD	2.56 Ba	1.81 Ab	
HD	2.15 Ba	1.85 Aa	
Silvopastoral systems	Night idle (hours day^{-1})		CV %
MC	2.65 Ca	0.86 Db	8.67
LD	1.61 Da	1.58 Ca	
MD	5.78 Aa	6.21 Aa	
HD	4.61 Ba	3.43 Bb	

Means followed by different uppercase/lowercase letters in the same column/row, respectively, are significantly different, according to Duncan's test ($p < 0.05$). MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

The presence of trees caused the animals of the MD and HD to remain less time in idle during the day, in the rainy season. In the dry season, the steers spend more time in idle in silvopastoral systems when compared to the monoculture ($p < 0.05$). There was an influence of palm trees in all systems during the night, and in the rainy season, the animals spent less time in idle in the LD and in dry season in the monoculture ($p < 0.05$).

The displacement time of animals is shown in Table 5. Considering only the dry season, the animals kept in the MD showed less displacement, mainly due to the good availability of forage with reasonable quantities of leaves in tillers (Figure 2), in this way, the animals have decreased the grazing sites and did not need to move over large areas in search of forage, since the displacement is directly related to grazing.

Table 5. Displacement time of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Silvopastoral systems	Diurnal displacement (hours day^{-1}) Season Rainy	Dry	CV%
MC	0.33 Bb	1.62 Aa	25.03
LD	0.51 Ba	0.57 Ba	
MD	0.25 Bb	1.41 Aa	
HD	1.06 Ab	1.31 Aa	
Silvopastoral systems	Night displacement (hours day^{-1})		CV %
MC	1.00 Aa	1.30 Aa	28.28
LD	0.35 Ba	0.48 Ca	
MD	0.98 Aa	0.73 Ba	
HD	1.03 Aa	0.75 Ba	

Means followed by different uppercase/lowercase letters in the same column/row, respectively, are significantly different, according to Duncan's test ($p < 0.05$). MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

During the day, only animals of LD were not influenced by the periods ($p > 0.05$). In the other systems, the animals moved more during the dry season, unlike the night assessment, when there was no influence of periods.

The grazing time affects the displacement time of animals, and according to Difante et al. (2009), the pastures maintained lower result in lower bite mass, forage intake and, consequently, lower animal performance, thereby increasing the displacement in the pasture. Despite the attempt of animals to compensate for this reduction by increasing the number of bites per unit of time and increasing the time spent grazing.

This was found in this study, during the rainy season, because the canopy structure was higher in the MD system (Figure 3). The highest height in this system, approximately 40.44 cm, was mainly due to etiolation, which meant that the animals spent more time grazing (9.73 hours) to compensate for the bite mass.

In turn, in the dry season, the monoculture system showed the highest height (50.75 cm), but the animals spent less time grazing, which is not common, but the displacement time was one of the highest caused mainly by tiller population density (Figure 4). In this environment, there was a smaller amount of units of Marandu grass per square meter, which probably caused the animals to graze for more time to meet the requirements, increasing the search of forage and consequently the displacement.

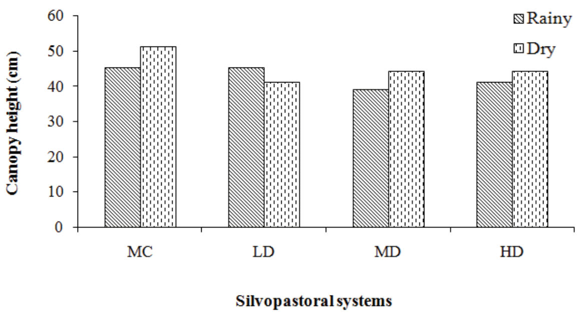

Figure 3. Average sward height in silvopastoral systems and in monoculture during the experimental period of 2013. MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

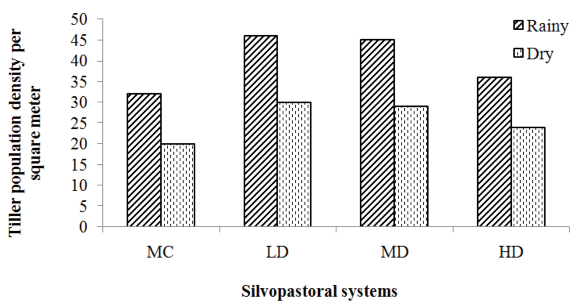

Figure 4. Tiller population density in silvopastoral systems and in monoculture during the experimental period of 2013. MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

In the monoculture, the tiller population density during the dry season was the lowest, then the animals needed to move more to increase the bite rates, because, in this environment, besides the lowest density, the leaf: stem ratio was critical.

The supply of mineral salt and water to animals was constant throughout the experiment, but during the day, in the rainy season, there was greater demand for salt and water troughs in the HD. At night, in the monoculture and MD, what most attracts attention is the behavior during the dry season, because the animals in the system without palm trees visited more the water and salt troughs (0.66 hours day^{-1}) during the day, demonstrating once again that the absence of shade imposes a more stressful environment for cattle, and at night, when the temperature decreases, the demand for water and salt reduced by around 37% It is also evident that in LD, demand for such food was low during the night. Comparing the periods, only in the monoculture and MD, the execution of these activities was different, being higher in dry and rainy season, respectively (Table 6).

Table 6. Time spent drinking water and mineral salt of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Diurnal ingestion of water and salt (hours day^{-1})			
Silvopastoral systems	Season		CV%
	Rainy	Dry	
MC	0.33 Bb	0.66 Aa	32.85
LD	0.11 Ba	0.20 Ca	
MD	0.18 Ba	0.36 Ba	
HD	0.64 Aa	0.35 Ba	
Silvopastoral systems	Night intake of water and salt (hours day^{-1})		CV %
MC	0.36 Aa	0.25 Aa	40.48
LD	0.00 Ca	0.00 Ba	
MD	0.23 ABa	0.04 Ba	
HD	0.21 Ba	0.29 Aa	

Means followed by different uppercase/lowercase letters in the same column/row, respectively, are significantly different, according to Duncan's test ($p < 0.05$). MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

During the rainy season, the distribution of plates of feces in the paddocks was aggregated, ranging from 0.504 to 0.105 except for HD that occurred in a uniform way, getting around to -0.030 (Table 7).

Table 7. Index of dispersion of plates of feces of young bulls reared in silvopastoral systems with different palm tree densities and in monoculture in rainy and dry seasons.

Index	Rainy season			
	MC	LD	MD	HD
Morisita (Id)	1.494	1.210	1.009	0.756
Uniformity (Un)	0.976	0.981	0.984	0.984
Grouping (Gr)	1.010	1.008	1.007	1.007
Standardized Morisita (Is)	0.504	0.500	0.105	-0.030
Index	Dry season			
	MC	LD	MD	HD
Morisita (Id)	1.324	1.109	1.221	1.321
Uniformity (Un)	0.643	0.731	0.876	0.866
Grouping (Gr)	0.765	1.218	1.100	1.110
Standardized Morisita (Is)	0.051	0.410	-0.218	-0.276

MC = Grass monoculture (no tree); LD = Low density (80 trees ha^{-1}); MD = Medium density (131 trees ha^{-1}); HD = High density (160 trees ha^{-1}).

The spatial distribution of animals in the pasture is related to the use of space, the dispersion does not occur at random, and is related to the physical and biological structure of the environment, climate and behavior. Therefore, the structural changes described above in the silvopastoral systems caused the animals to move over larger areas, thus selecting more nutritious forage. This is justified by observing the distribution of feces in the dry season, in which the MD and HD showed a uniform distribution between -0.218 and -0.276, respectively.

The quadrants that received above 10 deposition of feces during the days of assessment were highlighted. In the monoculture, after seven days of observations in the dry season, the quadrants that received greater deposition of feces (>10) were located near the areas of water and salt troughs. The animals remained in these locations during a long period of time, leaving to graze and drink water throughout the day. There was also a concentration of feces next to the gates for access to the paddock. This was not common in the silvopastoral systems.

According to Braz et al. (2003), in continuous grazing systems, animals travel the pasture homogeneously and intensely for collection of food. However, the act of excretion differs both temporally and spatially from the act of grazing.

The mean frequency of defecation in the rainy season was 6.81; 7.32; 7.86 and 8.31 plates animal^{-1} day^{-1} for MC, LD, MD and HD, respectively. As for the dry season, values were 6.31; 6.78; 7.22 and 7.76 31 plates animal^{-1} day^{-1} in the same order. Considering the surface covered by a plate of feces as 0.0474 m^2, it can be estimated that the surface covered by plates of feces from each animal on a daily basis was 0.32; 0.34; 0.37 and 0.39 m^2, respectively, in the rainy season, and 0.29; 0.32; 0.34 and 0.36, in the dry season.

Regarding the time of assessment for each period, in each paddock of 20000 m^2, during this time, the surface of the pastures of each paddock covered by plates were about 0.96; 1.04; 1.11 and 1.18% of the total area. In the dry season, the surfaces of pastures covered were 0.67; 0.72; 0.77 and 0.82% for MC, LD, MD and HD, respectively.

These results are close to the expected, as Marsh and Campling (1970) compiled data from various authors and estimated that the surface covered by feces of an animal per day can vary between 0.45 and 1.1 m^2, concluding that the area covered during 180 days of grazing with one cattle per hectare, represented approximately 0.8 to 2.0% of the pasture area.

With increasing density of palm trees, the area covered by plates is larger, thus demonstrating a greater return of nutrients to the soil of these systems, in addition, the number of fecal plates in the rainy season was higher than in the dry season. According to Rodrigues et al. (2015), in silvopastoral systems formed by Marandu grass with different densities of palm trees, the silvopastoral systems favor the soil microbial biomass and activity, because they reported that the microbial C, microbial N, microbial biomass: organic carbon ratio showed higher values in soils at high density of babassu palm trees, which favors the soil mineralization, increasing the fertility.

Conclusion

The grazing behavior is influenced by the presence of palm trees in the pasture. The silvopastoral system provides a more favorable structural environment to animals on pasture when compared to the monoculture. With increasing densities of palm trees, the surface covered by feces grows.

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References

Araújo, R. A., Rodrigues, R. C., Costa, C. S., Lana, R. P., Santos, F. N. S., Lima, A. J. T., & Rodrigues, M. M. (2016a). Forage intake and performance of cattle in silvopastoral systems and monoculture of Marandu in Pre-Amazon region. *African Journal of Agricultural Research, 11*(20), 1849-1857.

Araújo, R. A., Rodrigues, R. C., Costa, C. S., Santos, F. N. S., Costa, F. O., Lima, A. J. T., ... Rodrigues, M. M. (2016b). Composição químico-bromatológica e degradabilidade *in situ* de capim- Marandu em sistemas silvipastoris formados por babaçu e em monocultivo. *Revista Brasileira de Saúde Produção Animal, 17*(3), 401-412.

Braz, S. P., Nascimento Junior, D. N., Cantarutti, R. B., Regazzi, A. J., Martins, C. E., Fonseca, D. M., & Barbosa, R. A. (2003). Caracterização da distribuição espacial das fezes por bovinos em uma pastagem de *Brachiaria decumbens*. *Revista Brasileira de Zootecnia, 32*(4), 787-794.

Cecato, U., Machado, A. O., Martins, E. N., Pereira, L. A. F., Barbosa, M. A. A. F., & Santos, G. T. (2000). Avaliação da produção e de algumas características da rebrota de cultivares e acessos de *Panicum maximum* Jacq. sob duas alturas de corte. *Revista Brasileira de Zootecnia, 29*(3), 660-668.

Difante, G. S., Euclides, V. P. B., Nascimento Jr., D., Silva, S. C., Torres Jr., R. A. A., & Sarmento, D. O. L. (2009). Ingestive behaviour, herbage intake and grazing efficiency of beef cattle steers on tanzânia guinea grass subjected to rotational stocking managements. *Revista Brasileira de Zootecnia, 38*(6), 1001-1008.

Gimenes, F. M. A., Silva, S. C., Fialho, C. A., Gomes, M. B., Berndt, A., 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.

Hirata, M., Yamamoto, K., & Tobisa, M. (2010). Selection of feeding areas by cattle in a spatially heterogeneous environment: selection between two tropical grasses differing in accessibility and abiotic environment. *Journal of Ethology, 28*(1), 95-103.

Kilgour, R. J., Uetake, K., Ishiwata, T., & Melville, G. J. (2012). The behaviour of beef cattle at pasture. *Applied Animal Behaviour Science, 138*(1), 12-17.

Leme, T. M. S. P., Pires, M. F. A., Verneque, R. S., Alvim, M. J., & Aroeira, L. J. M. (2005). Comportamento de vacas mestiças Holandês x Zebu, em pastagem de *Brachiaria decumbens* em sistema silvipastoril. *Ciência e Agrotecnologia, 29*(3), 668-675.

Marsh, R., & Campling, R. C. (1970). Fouling of pastures by dung. *Herbage Abstracts, 40*(2), 123-130.

Phillips, C. J., & Rind, M. I. (2001). The effects of social dominance on the production and behavior of grazing dairy cows offered forage supplements. *Journal of Dairy Science, 85*(1) 51-59.

Rodrigues, R. C., Araújo, R. A., Costa, C. S., Lima, J. T., Oliveira, M. E., Santos, F. N. S., ... Araújo, A. S. F. (2015). Soil microbial biomass in agroforestry system of Northeast Brazil. *Tropical grasslands, 3*(1) 41-48.

Rodrigues, R. C., Lima, A. J. T., Araújo, R. A., Jesus, A. P. R., Costa, C. S., Santos, F. N. S., ... Azevêdo, D. M. M. R. (2016). Características agronômicas, morfogênicas e estruturais do capim-Marandu em sistemas silvipastoris formados por palmeiras de babaçu e em monocultura. *Semina: Ciências Agrárias, 37*(4) 2331-2342.

Souza, W., Barbosa, O. R., Marques, J. A., Costa, M. A. T., Gasparino, E., & Limberger, E. (2010). Microclima em sistemas silvipastoris com eucalipto em renques com diferentes alturas. *Revista Brasileira de Zootecnia, 39*(3), 685-694.

Statistical Analysis System [SAS]. (2002). *SAS/STAT User guide, Version 9.0*. Cary, NC: SAS Institute Inc.

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