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Different Nutritional Systems at Suckling and Finishing Phases of Lambs Grazing on Tropical Pasture

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ABSTRACT

The objective of the study was to evaluate the lambs' performance in the suckling and finishing phases in different nutritional systems. The study was carried out in two phases: suckling (from birth to weaning) and finishing (from weaning to slaughter). Each phase was evaluated in two experimental periods (characterized by year). The suckling phase used 76 lambs divided into two groups: control (without supplementation) and creep feeding (with creep feeder supplementation of 20 g/kg of body weight). The lambs were distributed in the treatments according to sex and type of delivery (single or twin). The finishing phase was characterized from weaning to slaughter. Sixty-two lambs were used, 28 females and 34 males, average age of 85 days and an average weight of 19 kg, and the animals were distributed in treatments according to weight and sex. Five treatments were evaluated, animals in *Brachiaria* spp. receiving increasing levels of supplementation (0%, 0.8%, 1.6%, and 2.4% of BW) and confinement as a positive performance control. The creep feeding treatment presented superior performance with an average daily gain of 64.85 g more than the control treatment, which anticipated the shorter age at weaning with higher weaning weight (weaning in 64 days for supplemented lambs and 77 days for animals without supplementation). In the finishing phases, the lambs of the treatments 1.6%BW and 2.4%BW presented average daily gain similar to the confined animals and higher ($p<0.05$) than the treatments 0.8%BW and 0%BW. We recommend that ad libitum supplementation of creep feeding during the suckling phase is a nutritional strategy to wean heavier lambs and consequently reduce time in the finishing phase. For fattening the lambs, we recommend the inclusion of protein-energy supplementation of 1.6% BW for lambs produced in the tropical pasture.

Keywords: Brachiaria grass; creep feeding; performance; small ruminants

INTRODUCTION

Several lamb-production systems have been proposed; however, few studies evaluate different feeding systems in tropical pastures, especially when considering the complete production cycle, from birth to finishing lambs. The growing interest in products of animal origin that are ecologically sustainable and that meet animal welfare are of interest to the end consumer, and the production of lambs on tropical pastures becomes a viable alternative to meet this demand (Jacques *et al.*, 2011). Lambs have a high ability to use forage and transform it into a product (Emerenciano Neto *et al.*, 2019). Thus, the use of forage as a basis for nutritional management is an interesting strategy that can meet the needs of the animal and consumer.

Because they are adapted to the soil and climatic conditions and have low demands on soil fertility (Oliveira *et al.*, 2019), grasses of the *Brachiaria* genus are widely used and enable livestock farming in tropical regions. However, as the only source of food, these forages alone are not sufficient to meet the nutritional requirements of lambs in the growing phase (Melo *et al.*, 2019; Oliveira *et al.*, 2019). This condition leads most producers to finish (weaning to slaughter) in confinement. However, the low weight at weaning increases the finishing time, making the use of not feasible. On the other hand, finishing exclusively on pasture compromises the carcass quality (Gallo *et al.*, 2019; Silva *et al.*, 2020).

The use of supplementation in the creep feeding system in the suckling phase and at different levels in the finishing phase of the lambs are used to supply the nutritional deficiencies of the pastures and appear as sustainable alternatives when compared to the exclusive use of the feedlot (Melo *et al.*, 2019; Oliveira *et al.*, 2019). In addition, concentrated supplementation allows the confinement of carcasses of similar quality (Silva *et al.*, 2020). Our research group has been developing technologies and management practices to produce a system for breeding and ending lambs in tropical pasture.

Therefore, our hypothesis in this study is that supplementation in the suckling period improves the performance of lambs. In the finishing phase, high levels of supplementation are able to maintain performance similar to that of animals finished in confinement. In this regard, this experiment aimed to evaluate lambs' performance in the suckling and finishing phases, with ad libitum supplementation in creep feeder in the suckling phase receiving different levels of supplementation maintained in tropical pastures.

MATERIALS AND METHODS

Location and Ethics Committee

This study was approved by the Ethics Committee for Use of Animals in Experiments (CEUA-UFMS) under protocol no. 481/2012. The experiment was conducted at the Faculty of Veterinary Medicine and Animal Science (FAMEZ) of the Federal University of Mato Grosso do Sul (UFMS) -Brazil.

Suckling Phase

The suckling phase was performed in two trials (two consecutive years). The suckling phase (from birth to weaning) characterized the experimental period. This phase used 76 lambs, control treatment with 21 males and 17 females, and creep feeding treatment with 20 males and 18 females.

The lambs were distributed in 6 paddocks in 4.77 ha, three animals per treatment, formed by *Brachiaria brizantha* and *B. decumbens*. To adjust the stocking, regulating animals were used, depending on the dry matter supply of the leaves, allowing an offer of 10% of body weight. For the exclusive supplementation of lambs, wooden structures with screens (creep feeders) were used, opening 20 cm wide and 30 cm high and a total area of 2.6 m², allowing only access by the lamb.

The concentrated supplement (Table 1) was provided ad libitum in the morning (8:00 am) from the first week of birth, with lambs having free access throughout the day. To calculate the average daily consumption in the creep feeder, the concentrate offered and leftovers were quantified daily.

To meet the nutritional requirements of lactating females, 350 g/day of the protein-energy supplement was offered, meeting 30% of the requirement for maintenance and lactation according to National Research Council (2007). The mineral supplementation offered *ad libitum*.

All animals will remain in *brachiaria* grass with mineral supplementation ad libitum. The experimental lambs were divided into two treatments: (1) without protein-energy supplementation as a control, and (2) with protein-energy supplementation in creep feeding.

Finishing Phase

After weaning, the finishing phase began. Sixty-two lambs were used and distributed according to weight and sex, being 28 females and 34 males, average initial weight of 19.45 kg, crossed with Ile de France or White Dorper. During the suckling phase, two trials were carried out to increase the number of animals evaluated and decrease the environmental effects.

The animals were distributed in 5 different finishing systems according to supplementation level (0%BW, 0.8%BW, 1.6%BW, or 2.4%BW) or feedlot. All lambs of supplementation treatment were kept in a *Brachiaria* grass pasture on continuous grazing.

The 0% treatment consisted of mineral supplementation only; lambs on 0.8%BW, 1.6%BW, and 2.4%BW treatments received mineral-energy-protein supplementation. The feedlot treatment was characterized by feeding with a diet supplied at a 400:600 ratio of roughage (Tifton hay) to concentrate, and it was considered as a positive control. The offer of the concentrate was made in the morning (8:00 am). The concentrate was available for the animals to consume (Table 1). The concentrate was available for consumption in collective troughs with free access for all lambs in the respective treatments.

The same concentrate was used for animals finishing in the feedlot, and Tifton-grass hay (*Cynodon dactylon*) composed 400 g/kg of the daily diet offered (Table 1). The diet was supplied daily at 8:00 am, and leftovers were collected and quantified to determine daily consumption (offered – leftovers). To allow for *ad libitum* consumption, the food was calculated daily to guarantee

Table 1. Chemical composition of feed (roughage and concentrate) provided to animals in the experimental period

Feed types	Chemical composition (g/kg)					
	Dry matter	Organic matter	Crude protein	Ether extract	Neutral detergent fiber	Total digestible nutrients[d]
Concentrate creep feeding[a]	897.9	932.0	225.5	30.7	216.6	851.4
Concentrate of ewes[b]	900.1	904.0	163.9	27.7	170.5	836.8
Concentrate finishing[c]	856.4	919.5	220.1	34.9	290.1	851.4
Tifton hay	875.4	942.2	60.7	28.5	766.4	522.4

Note: [a]Ingredients (g/kg): 517.0 corn; 472.0 soybean meal; 10 of premix mineral (artificial aroma of milk, sodium bicarbonate, calcium carbonate, choline chloride, sodium chloride, sulfur, dicalcium phosphate, potassium iodate, sodium selenite, aluminum silicate, cobalt sulphate, copper sulphate, manganese sulphate, and zinc sulphate).
[b]Ingredients (g/kg): 761.1 corn; 198.9 soybean meal; 40 of calcium carbonate.
[c]Ingredients (g /kg): 517.0 corn; 473.0 soybean meal; 10 of premix mineral (sodium bicarbonate, calcium carbonate, choline chloride, sodium chloride, sulfur, dicalcium phosphate, potassium iodate, sodium selenite, aluminum silicate, cobalt sulphate, copper sulphate, manganese sulphate, and zinc sulphate).
[d]Estimated value by the equation of Cappelle *et al.* (2001): TDN= 91.0246-0.571588 * NDF.

10% of the leftovers. All treatments had access to water and mineral supplements at will.

Pasture

The animals produced in pastures remained in paddocks formed by *Brachiaria* spp. during the entire experimental period in continuous grazing with variable stocking rate, using lambs as regulators, which allowed a forage supply of 10% of the leaf blade to be fixed. The adjustment of the animal load was performed every 28 days. Biomass was determined according to the methodology described by McMeniman (1997). The determination of biomass is shown in Tables 2 and 3.

The chemical composition of the leaf was determined, which was pre-dried in a forced air oven at 55 °C for 96 h, ground with 1 mm sieves to determine the dry matter (DM), crude protein (CP) and ether extract content (EE), according to the Association of Official Analytical Chemists (AOAC) methods 930.15, 976.05 and 920.39 (2000), respectively. Neutral detergent fiber (NDF) was determined according to Mertens (2002), using thermostable amylase, without sodium sulfite, and expressed as residual ash (Tables 4 and 5).

Parasitological Evolution (Eggs per Gram of Feces)

For parasitological control, feces were collected directly from the rectum of each animal every 14 days. The analysis of quantifying the number of eggs per gram of feces (fecal egg counts, FECs) was performed according to the methodology described by Gordon and Whitlock (1939). When FECs were ≥1000, the experimental animals were dewormed with monepantel or nitroxinil.

Productive Performance

The first weight collected was at birth, and weighing was continued every 14 days until weaning. The body weight of 18 kg was the criterion adopted for weaning, where to determine the weight at weaning, the animals were subjected to 16-hour solids fasting. Due to the extension of the birth period, it was necessary to wean the lambs in stages.

After weaning, the animals were in an adaptation period for seven days, and the finishing phase began. The lambs were weighed every 14 days to adjust the protein-energy supplement. At the beginning and end of the experimental period, the animals were fasted for 16 hours before weighing. The end of the finishing period was determined as the time at which the animals in the groups with the greatest nutritional support (feedlot and 2.4%BW) reached at least 32 kg of average body weight. To determine the performance of the animals, the total gain (final weight minus initial weight), average daily gain (total gain divided by the experimental period), the differential gain was calculated using the 0% treatment as a reference.

Table 2. Forage biomass (kg DM/ha), leaf blade (kg DM/ha) and stem + sheath (kg DM/ha) from deferred pasture of *Brachiaria* spp. during the rearing phase

Months	Forage biomass		Leaf blade		Stem + sheath	
	Control	Creep feeding	Control	Creep feeding	Control	Creep feeding
Year 1						
June	5828	4239	1951	1516	2774	2034
July	3350	3564	1125	1192	1566	1535
August	2765	3197	907	1016	1188	1319
September	3373	3069	1028	936	1619	1280
Year 2						
April	5045	4502	1887	1593	2710	1634
May	4402	5125	1525	1971	1867	2293
June	6019	5440	1328	1232	3624	2045

Table 3. Forage biomass (kg DM/ha), leaf blade (kg DM/ha) and stem + sheath (kg DM/ha) from deferred pasture of *Brachiaria* spp. during the finishing phase

Months	Forage biomass				Leaf blade				Stem + sheath			
	0%	0.80%	1.60%	2.40%	0%	0.80%	1.60%	2.40%	0%	0.80%	1.60%	2.40%
Year 1												
August	6918	7270	8083	7388	1331	1517	1581	1393	1524	1827	1961	1556
September	7229	6793	7887	6143	943	930	1180	947	1306	1152	1451	1167
October	5859	6974	5727	5435	817	844	754	768	986	1113	924	934
November	7166	7626	6727	8278	1192	1247	1086	1456	1341	1366	1271	1621
Year 2												
July	5519	4684	4467	5464	1351	1218	1274	1277	1547	1489	1555	1330
August	4235	4675	4110	3822	911	1040	768	926	2161	1644	1900	2131
September	6619	6065	5495	5047	1748	1363	1161	1244	3115	1933	2192	1805

Table 4. Chemical composition of forage botanical components during the rearing phase

Months	Leaf blade			Stem + sheath		
	Dry matter	Crude protein	Neutral detergent fiber	Dry matter	Crude protein	Neutral detergent fiber
Year 1						
June	374.0	84.3	764.5	324.0	35.3	721.5
July	498.8	57.9	692.9	435.0	21.4	794.1
August	572.9	57.7	742.4	633.1	22.7	837.9
September	560.7	86.2	771.5	710.7	23.7	911.7
Year 2						
April	260.5	133.2	381.8	294.2	78.9	536.8
May	308.4	129.5	428.7	322.2	54.2	600.5
June	330.5	126.7	522.7	331.6	50.4	705.8

Table 5. Chemical composition of forage during finishing phase

Months	Leaf blade			Stem + sheath		
	Dry matter	Crude protein	Neutral detergent fiber	Dry matter	Crude protein	Neutral detergent fiber
Year 1						
June	428.8	48.8	811.3	387.8	29.8	799.4
July	470.0	58.8	793.9	394.0	35.8	800.3
August	381.0	62.0	804.5	340.2	27.6	783.0
September	390.6	63.3	798.9	327.7	36.8	815.5
Year 2						
April	333.6	63.1	712.2	344.2	23.0	792.1
May	389.7	58.1	695.4	386.9	23.6	796.6
June	432.5	61.4	683.1	422.5	22.4	814.6

Ingestive Behavior

For the ingestive behavior, sampling of stantaneous scanning was used (Altmann, 1974). With behavioral data collection every 10 minutes, from sunrise to sunset, totaling 12 hours of observations. Ingestive behavior was classified as feeding, ruminating, resting, and walking being carried out every 14 days.

Statistical Analysis

The study comprised two experimental periods (suckling period and finishing period) that were evaluated separately. Each experimental period comprised two trials, repeated in two consecutive years.

The experimental design in the suckling period was in randomized blocks according to the year, and factorial scheme (2x2), according to the sex of the lambs in the treatments (control or creep feeding), and analyzed according to the statistical model: Yijk= m + Ai + Bj + ABij + Ck + eijk, where Yijk is the observation value of animal k, referring to treatment, i.e., sex j, within block k; m is the general constant; Ai is the treatment effect (i = 1,2); Bj is the effect of sex (j = 1,2); Bij is the effect of the treatment x sex interaction; Ck is the effect of the block, which corresponds to the year of evaluation (k = 1.2); eijk is the random error associated with each observation. The data were evaluated using analysis of variance and considered different by the F test at the 0.05 level of significance.

On finishing period, the experimental design comprised randomized blocks according to the year of evaluation and sex, and the lambs were distributed among five treatments (without concentrated supplementation, 0.8%, 1.6%, 2.4% of the BW as a concentrated supplement, or feedlot), according to the statistical model: Yijk= m + Ai + Bj + ABij + Ck + eijk, where Yijk is the observation value of animal k, referring to the treatment, that is, sex j, within the k block; m is a general constant; Ai is the treatment effect (i = 1,2); Bj is the effect of sex (j = 1,2); Bij is the effect of the treatment x sex interaction; ck is the effect of the block, which corresponds to the year of evaluation (k =1.2); eijk is the random error associated with each observation, used for data analysis. The behavior data were analyzed using analysis of variance and by the F test at the 0.05 level of significance. The Dunnett test ($p<0.05$) was used to compare means with the feedlot group as a control. Also, the comparisons of mean values of lambs finished in the feedlot and groups finished on pasture were performed using the Tukey test ($p<0.05$).

RESULTS

The lambs from the creep feeding treatment had an average dry matter (DM) intake of the supplement of 243 g/day. The performance of lambs submitted to the creep feeding treatment was superior to those not supplemented (Table 6). The lambs' birth weight (3.82 kg) can be considered medium to high, and the variation in birth weight between treatments was small, giving homogeneity between flocks.

The criterion for weaning the lambs was weight, thus the weaning weight was similar between treatments. However, weaned lambs that received supplementation in creep feeding had higher ADG than lambs that did not receive supplementation, i.e., 257.79 g/day and 192.94 g/day, respectively (Table 6). Thus, the creep feeding treatment lambs were younger at weaning (64 days) than those of the control treatment (77 days).

An average daily gain of 64.8 g/day was observed for lambs with access to creep feeding, which resulted in an average gain difference of 4.15 kg with weaning at 64 days. The animals of the creep feeding treatment had 19.17 kg of body weight at weaning, while the animals of the control treatment had an average of 15.24 kg of BW in the same period (64 days on suckling).

During the finishing phase, there was a positive effect ($p<0.05$) of the concentrate inclusion in the diet on the performance of the lambs (Table 7). Feedlot finishing, as well as the supply of supplements at 1.6% and 2.4% of body weight (1.6%BW and 2.4%BW) on pasture, allowed lambs to perform better compared to the 0% (without concentrated supplementation) and 0.8%BW (0.8% of body weight as a supplement) groups.

Animals finished in the feedlot demonstrated superior performance than lambs finished on pasture (Table 7). Animals in the 1.6%BW and 2.4%BW and feedlot groups on average reached the expected slaughter weight within the target age previously established. In contrast, the animals in the 0%BW and 0.8%BW groups did not reach the requirements of an animal ready for slaughter, mainly due to low body weight. When comparing the systems in which the animals were finished

Table 6. Performance of suckling lambs supplemented (creep feeding) or not (control) during the rearing phase

Variables	Lamb gender	Rearing phase system		P			CV (%)
		Control	Creep feeding	Gender	Treatment	G*T	
Birth weight (kg)	Male	3.94	4.04	0.15	0.61	0.34	25.58
	Female	3.83	3.51				
	Mean	3.89	3.77				
Weaning weight (kg)	Male	18.44	19.37	0.44	0.17	0.76	18.15
	Female	17.5	18.97				
	Mean	17.97	19.17				
Weaning age (days)	Male	75	64	0.77	<0.01	0.44	20.05
	Female	79	63				
	Mean	77[a]	64[b]				
ADG (g/day)	Male	200.47	252.56	0.90	<0.01	0.49	31.75
	Female	185.41	263.02				
	Mean	192.94[b]	257.79[a]				

Note: CV= coefficient of variation (%); G*T= interaction effect of Gender×Treatment; ADG= average daily gain. [a-b] Different lowercase letters on the same line indicate significant difference by the Tukey test ($p<0.05$).

Table 7. Performance of lambs in different finishing systems

Variables	Lamb gender	Treatments					P			CV (%)
		0%	0.8%BW	1.6%BW	2.4%BW	Feedlot	Gender	Treatment	G*T	
Slaughtering age (days)	Male	178	158	168	161	157	0.78	0.85	0.48	11.03
	Female	159	165	163	167	162				
	Mean	168	162	165	164	160				
Initial weight (kg)	Male	20.89	18.82	19.96	19.34	19.88	0.52	0.94	0.33	21.16
	Female	16.36	20.99	19.23	20.21	18.65				
	Mean	18.62	19.91	19.59	19.77	19.27				
Final weight (kg)	Male	28.74	25.6	31.1	31.48	36.69	0.11	<0.01	0.35	18.84
	Female	21.49	26.84	27.35	32.64	32.77				
	Mean	*25.12[b]	*26.21[ab]	29.22[ba]	32.06[a]	34.73				
ADG (g/day)	Male	62.81	87.28	143.29	164.88	240.05	0.13	<0.01	0.42	28.44
	Female	78.23	75.25	108.65	160.59	195.78				
	Mean	*70.52[c]	*81.26[c]	*125.97[b]	*162.73[a]	217.91				
Total gain (kg)	Male	4.81	6.81	11.33	12.36	16.78	0.20	<0.01	0.52	31.17
	Female	5.91	5.84	8.17	12.43	14.16				
	Mean	*5.36[b]	*6.33[b]	*9.75[a]	12.40[a]	15.47				
DifG (g/day)	Male	0.00	15.59	71.59	93.18	168.35	0.13	<0.01	0.42	60.4
	Female	0.00	3.55	36.95	88.89	124.09				
	Mean	*0.00[c]	*9.57[c]	*54.27[b]	*91.04[a]	146.22				

Note: [a-b]Different lowercase letters on the same line indicate significant difference by the Tukey test ($p<0.05$). *Averages differ from Dunnett test ($p<0.05$) feedlot group. CV= coefficient of variation (%); G*T = interaction effect of Gender×Treatment; BW= body weight, ADG= average daily gain; DifG= differential gain of the treatment 0% of supplementation.

on pasture, the 2.4%BW group had the highest average daily gain and differential gain ($p<0.05$), and the animals in the 1.6%BW group showed intermediate values, both being superior to the gains observed in the 0.8%BW and 0%BW groups (Table 7).

The FEC of lambs in the rearing phase indicates that the egg count values per gram of feces of the lambs of the control treatment showed greater dispersion and amplitude when compared to the values of the lambs of the creep feeding treatment. In the finishing phase, the FEC of lambs supplemented on pasture indicated that the higher the level of supplementation in relation to body weight, the smaller the amplitude and dispersion of the data. In the feedlot treatment, although the mean FEC was lower than the other treatments, the egg count per gram of feces indicated that these values showed greater amplitude and dispersion when compared to supplementation levels of 1.6 and 2.4% of BW (Figure 1).

The evaluated treatments also showed differences ($p<0.05$) in the ingestive behavior of the lambs (Table 8), with an average expenditure of 9.59 hours feeding by the animals in the 0%BW and 0.8%BW groups, which was more than in the other groups. The greater time spent in feeding resulted in less time spent resting.

DISCUSSION

The performance of lambs for the creep feeding treatment was superior compared to those not supplemented with creep feeding (Table 6). Only breast milk and pasture are not efficient to accelerate the growth of lambs in the calving stage (Melo *et al.*, 2019) with the consequence of weaning lighter lambs and increasing the finishing time, which reflects in the carcass quality

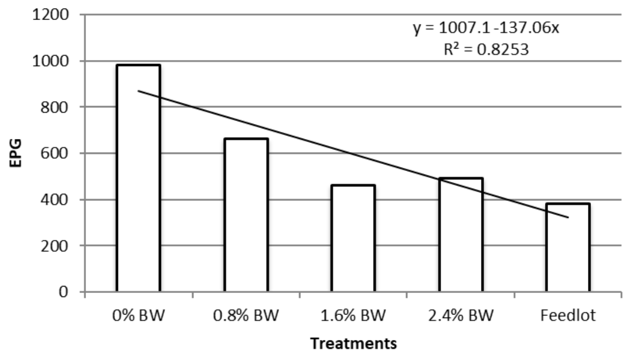

Figure 1. Egg count per gram of feces (EPG) in lambs submitted in different fattening systems (EPG= 10007.1 – 137.06x; R^2= 0.8253).

and economy of the production system. The introduction of solid foods in the early stages of ruminant life accelerates rumen development (National Research Council, 1985). Lambs fed only on pasture and milk possibly did not have the same ruminal conditions, as reflected in the lower performance of these animals.

The better performance of lambs supplemented on creep feeding than non-supplemented is related to the accelerated development of the gastrointestinal system, especially due to the higher intake of energy and protein in the diet (Melo *et al.*, 2019). Intake of solid foods encourages early rumen development (Yang *et al.*, 2015; Mc Coard *et al.*, 2020). In lambs with functional rumen, after the transition from pre-ruminant to ruminant, the effect of supplementation is related to the fermentation profile, where there is a greater production of propionate, which is absorbed by the rumen wall and becomes a glycogenic metabolite for the animal. The greater supply of propionate avoids the need to use other less efficient energy sources, such as amino acids, for gluconeogenesis and maintenance of serum glucose levels (Kozloski, 2011). Thus, the more efficient glucose anabolism allows a better energy balance, which translates into greater tissue deposition and positively reflects performance.

The similarity in the performance of females and males may be related to the low production of the male hormone testosterone in males, mainly due to the age of the animals, which did not have time to present sexual dimorphism (Koritiaki *et al.*, 2012). Results of this study are similar to the study by Pires *et al.* (2011), which does not bring the significant difference between sexes in the performance of lambs obtained up to 42 days of age.

However, weaned lambs that received supplementation in creep feeding had higher ADG than lambs that did not receive supplementation, 257.79 g/day and 192.94 g/day, respectively. This increase in BW is attributed to supplementation, corresponding to a feed conversion of 3.75:1, that is ingestion of 243 g/day of supplement (54 g of CP and 189 g of TDN) increased ADG 64.8 g/day (Table 6).

The results indicate that the use of supplementation, due to the composition of the forage produced, the leaf presented CP variation from 55.7 (August of year 1) to 133.2 g/kg DM (April of year 2). Therefore, it was considered that the leaf was insufficient to meet the nutritional requirement of lambs in the control treatment. Other studies using creep feeding demonstrate favorable results with weaning weight of 20.3 kg for simple delivery and 18.9 kg for twin birth with weaning at 60 days of age; while in the same study at weaning

Table 8. Ingestive behavior in hours of lambs in different finishing systems

Variables	Treatments					CV	P
	0%BW	0.8%BW	1.6%BW	2.4%BW	Feedlot		
Feeding	*9.55^{a}	*9.63^{a}	*7.88^{b}	*5.96^{c}	3.01	5.34	<0.01
Ruminating	*2.29^{a}	*1.74^{b}	*1.80^{ab}	*2.02^{a}	2.83	14.21	<0.01
Resting	*0.77^{c}	*0.94^{c}	*2.36^{b}	*4.25^{a}	5.45	25.48	<0.01
Walking	*0.24^{c}	*0.52^{b}	*0.80^{a}	*0.60^{b}	1.54	21.87	<0.01

Note: Different letters on the same line indicate a significant difference ($p<0.01$) by the Tukey test, for groups fattened on pasture. *Asterisk averages differ from Dunnett test ($p<0.05$) feedlot group. CV= coefficient of variation. BW= body weight.

age of 90 days, the authors verified weight at weaning 27 kg for simple delivery (Heimbach *et al.,* 2019). The research by Melo et al. (2019) found that animals produced exclusively on *Brachiaria brizantha* pasture did not reach the ideal weight for weaning at 60 days of age, being weaned at 20 kg at 80 days of age. In contrast, lambs supplemented in creep feeding were weaned at 58 days with 20 kg, suggesting creep feeding as an important tool to increase weight at weaning and decrease termination time. The greater nutrient supply provided to animals in the feedlot, 2.4%BW and 1.6%BW groups, can be identified as the main factor responsible for the better performance of these animals. In feedlot animals with an average daily consumption of 1.056 kg DM, 174 g CP, and 0.69 kg TDN, the average expected daily gain was within the expected range for lambs according to the National Research Council (2007).

The finishing phase started after one week of weaning with a similar weight average between treatments. The evaluations ended when the animals were on average 163 days old but continued evaluations until 6 months of age. It is unlikely that the animals in the 0%BW and 0.8%BW groups would have achieved the minimum body weight required for a lamb ready for slaughter due to the low average daily gains (ADG) in weight observed in these groups (Table 7).

Although adjustments were made to ensure the availability of 10% of the leaf blade CP to grazing animals, the low quality of the forage (Table 3) did not allow adequate growth of lambs in the 0% group or the 0.8% group. The addition of 40 g of CP and 0.13 kg of TDN via concentrated supplement was not sufficient to counteract the nutritional deficit. On the other hand, supplementation via concentrate at 1.6% of body weight for lambs on pasture was sufficient to meet nutritional needs for gain, and animals in the 1.6%BW and 2.4%BW groups achieved satisfactory and similar development to those finished in the feedlot.

The greater supply of nutrients favored the better immune response, reflecting the lower parasitic burden (Figure 1). It is observed that the animals that received higher levels of supplementation had a lower egg count per gram of feces (EPG), which also reflected in the better performance of these animals. Melo *et al*. (2017) also found positive effects of supplementation on the parasitic load, reflecting on the performance improvement.

The supply of 88 g of CP and 0.29 kg of TDN (1.6%BW) can be pointed out as a critical nutritional level. The supplementation level of 1.6% of BW should be considered the minimum for finishing lambs grazing on pastures of Brachiaria grass.

The main factor limiting the performance of lambs in the 0% and 0.8% BW groups may be the low CP content of the pasture, as this results in a low concentration of ammonia-nitrogen in the rumen, a reduction in microbial growth, and as a consequence, a reduction in the rate of fiber degradation and food consumption. Protein supplementation on low-quality pasture tends to increase the consumption of forage, and consequently, nutritional intake in ruminants (Carvalho *et al.,* 2019), which allows the production of carcasses with a quality similar to lamb carcasses finished in feedlots (Silva *et al.,* 2020). Similar results to this work were found in the other studies with feedlot lambs (Heimbach *et al.,* 2019, Ítavo *et al.,* 2016).

The use of 1.6% supplementation of animals during finishing allows a high differential of average daily gain compared to non-supplemented animals, but increasing the level of supplementation to 2.4% did not improve the average gain any further (Silva *et al.,* 2017). These results suggest that the use of adequate levels of protein-energy supplementation can be economically viable (Silva *et al.,* 2017) and sustainable, meeting current consumer demand (Jacques *et al.,* 2011).

The feedlot animals needed less time to feed to spend more time in leisure. The observed ingestive behavior is one of the factors that contributed to the greater weight gain in the confined animals, since they expended less energy on feeding, increasing their chances of storing energy reserves by spending more time in leisure; similar results were reported by Silva *et al.* (2017).

The higher the cell wall content of the food, the longer the time spent with rumination will be, so increasing the NDF level of the diets would increase the time spent on rumination (Van Soest, 1994). However, in the current study, there were no significant differences in rumination time between groups. The confined animals, which received only 40% of the roughage diet, showed similar rumination times to those in the 0% group, with a 100% roughage diet. This similarity in the time spent on rumination may be related to the high fiber content of the roughage used (Table 1).

For animals that received medium and high supplementation, there was a significant difference in the time spent on feeding, with the time spent on feeding inversely proportional to the level of supplementation and differing significantly ($p<0.05$) from lambs belonging to the 0%BW and 0.8%BW groups. A reduction in feeding time ($p<0.05$) was also observed by Melo *et al.* (2019) in lambs supplemented in a creep feeder.

CONCLUSION

The use of creep feeding for growing lambs is effective for animal production in tropical pastures of *Brachiaria brizantha* due to the increase in average daily gain and reduction in age at weaning lambs, coupled with the termination of lambs on pasture is an alternative feedlot for finishing lambs. We recommend that ad libitum supplementation of creep feeding during the suckling phase is a nutritional strategy to wean heavier lambs and consequently reduce time in the finishing phase. For fattening the lambs, we recommend the inclusion of protein-energy supplementation of 1.6% BW for lambs produced in the tropical pasture.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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