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Animal Science/ Original Article

Weaned lambs from different litter size submitted to contrasting feeding systems on tropical pastures

Abstract – The objective of this work was to evaluate the performance and ingestive behavior of singleton and twin lambs after weaning under different feeding systems on tropical pasture. Studies were carried out over three years with castrated and weaned males of Texel x Corriedale lambs. In the first year, the treatments were: grass; grass and supplementation with concentrate (1.5% or 2.5% of live weight); grass and controlled legume grazing. In the second and third years, the treatments were: either grass or legume; mixed, this is, contiguous area of both grass and legume. On tropical pasture system, twin lambs fed with high levels of concentrate can gain more live weight than singletons, showing a compensatory growth and reaching the singletons live weight. Sheep litter size does not affect weaned lambs' grazing behaviour under different feeding systems on tropical grassland. The use of concentrate supplementation changes lambs' ingestive behavior by reducing grazing time and increasing idling time. Pigeon pea, as a monoculture or associated with grass, can be an important source of nutrients for lambs; however, it is not sufficient to ensure the same performance of twin and singleton lambs.

Index terms: *Cajanus cajan, Megathyrsus maximus*, prolificacy, supplementation, tropical pastures.

Cordeiros desmamados de diferentes tamanhos de ninhada submetidos a sistemas de alimentação contrastantes em pastagens tropicais

Resumo – O objetivo deste trabalho foi avaliar o desempenho e o comportamento ingestivo de cordeiros de partos simples e gemelar após o desmame em diferentes sistemas alimentares em pastagem tropical. Os estudos foram realizados com machos castrados e desmamados de cordeiros Texel x Corriedale ao longo de três anos. No primeiro ano, os tratamentos foram: capim; capim e suplementação com concentrado (1,5% ou 2,5% do peso vivo); capim e pastejo controlado de leguminosa. Nos segundo e terceiro anos, os tratamentos foram: ou gramínea ou leguminosa; misto, ou seja, área contígua de gramínea e leguminosa. Em sistema de pastagem tropical, cordeiros gêmeos alimentados com altos níveis de concentrado podem ganhar mais peso vivo que cordeiros de parto simples, apresentando crescimento compensatório e atingindo o peso vivo dos de parto simples. O tamanho da ninhada de ovinos não afeta o comportamento de pastejo dos cordeiros desmamados nos diferentes sistemas de alimentação em pastagens tropicais. O uso de suplementação concentrada altera o comportamento ingestivo dos cordeiros, reduzindo o tempo de pastejo e aumentando o tempo de ócio. O feijão-guandu, em monocultura ou associado ao capim, pode ser uma importante fonte de nutrientes para cordeiros; entretanto, não é suficiente para garantir o mesmo desempenho de cordeiros gêmeos e cordeiros de parto único.

Termos para indexação: *Cajanus cajan*, *Megathyrsus maximus*, prolificidade, suplementação, pastagens tropicais

Introduction

The productive performance of sheep flocks is measured in kilograms of lamb weaned per ewe and is determined both by the number of lambs weaned and individual lamb performance (Murphy et al., 2020). Thus, if prolificacy is increased significantly, productivity boosts, demanding more intensive management. Additionally, ewes carrying twins have higher nutritional needs during late gestation and lactation, and twin lambs are lighter and have less energy reserves, requiring additional care, since they receive less milk compared to singletons (Kenyon et al., 2019). Although pre-weaning performance has been enhanced by nutritional and genetic improvements, post-weaning performance of twins under tropical grazing systems remains little explored.

According to Kenyon et al. (2019), ewes rearing multiple lambs produce less milk per lamb, which limits pre-weaning weight gain, so, to alleviate this restriction, the creep-feeding system is used, in which lambs access supplemental feed alongside grazing. Twin lambs typically have lower birth and weaning weights than singletons, however, they may achieve compensatory growth post-weaning, narrowing the differences (Fernandes et al., 2001). Consequently, the feed efficiency of post-weaning singleton and twin lambs may vary, depending on the feeding system used.

In tropical and subtropical regions, the use of tropical cultivated pasture is an important alternative herbage system for sheep production (Poli et al., 2020); however, to improve animal performance on these herbages, tropical legumes or concentrate supplementation must be included (Castro-Montoya & Dickhoefer, 2020), since they contribute substantially to pastures in warm seasons (Muir et al., 2014). Among the tropical legume options, pigeon pea (*Cajanus cajan*) shows high production in tropical and subtropical regions (Hampel et al., 2021). It is hypothesized that the use of concentrate supplementation or pigeon pea legume in combination with tropical guinea grass (*Megathyrsus maximus*, cv. IZ-5) could enhance post-weaning live weight gain in twin lambs, resulting in a final weight comparable to that of singleton lambs.

The objective of this work was to evaluate the performance and ingestive behavior of singleton and twin lambs after weaning under different feeding systems on tropical pasture.

Materials and Methods

The present study was undertaken over three years, with all experimental procedures approved by the Animal Ethics and Experimentation Committee of the Universidade Federal do Rio Grande do Sul (Protocol no. 21121 for 2014 and 2015; and Protocol no. 27830 for 2016).

In all years, lambs and their dams were monitored from birth to weaning at Embrapa Pecuária Sul, in the municipality of Bagé, n the state of Rio Grande do Sul, Brazil (31°19'50"S; 53°59'30"W). Lambing occurred from August to September of each year, and lambs were weaned when they were between three and four months of age. All lambs used were Texel x Corriedale breed castrated males. During lactation, lambs were raised in similar conditions: a natural grassland with a stocking rate of five sheep per hectare. The stocking adopted met the nutritional requirements related to periods of rest, mating, pregnancy, and lactation, according to the monthly availability of dry matter in the paddocks. In the upper extract of the pasture, annoni grass (*Eragrostis plana* Ness) was present, not being considered in the diet of the sheep, as they do not consume it. The lower extract was mainly composed of carpetgrass (*Axonopus affinis*), bahiagrass (*Paspalum notatum*), and lowgrass (*Paspalum pumilum*) (Moraes et al., 2020). The lambs were separated by treatments only after weaning in each year of evaluation.

After weaning, in year 1, the experiment was conducted at the Viamão Unit of the Federação Estadual de Pesquisa Agropecuária (FEPAGRO), in the state of Rio Grande do Sul, Brazil (30°02'09"S, 51°01'18.16"W). The climate of the region is of the Cfa type, humid subtropical with a hot summer, with well distributed rains, and an annual average precipitation of 1,300 mm (Köppen, 1900). The experiment was carried out between February and May 2014. During the experimental period, the average rainfall was 107.5 mm per month and the maximum and minimum temperatures were 27.3ºC and 17.4ºC, respectively.

In years 2 and 3, the experiments were conducted at the Experimental Agronomic Station of the Universidade Federal do Rio Grande do Sul (UFRGS), in Rio Grande do Sul state, Brazil (29°13'26"S, 53°40'45"W). The region climate is humid subtropical, classified as Cfa type (Köppen, 1900), with an annual average precipitation of 1,440 mm. In year 2, the experiment was conducted from February to April

2015, with average temperature of 29ºC, and with an average monthly precipitation of 79.5 mm. In year 3, the experiment was conducted from January to April 2016, with an average rainfall of 145 mm per month, and the maximum and minimum temperatures were 28.3ºC and 19.9ºC, respectively.

The experiments were set out in a split plot design with the effects of block and feeding system as whole plots, using three blocks per year, and the effect of litter size as split plot. The litter size for singletons and twins was uniformly distributed in all feeding system treatments and blocks.

In year 1, the experimental area was 1.5 ha, divided into 12 paddocks of approximately 0.1 ha. Four feeding systems were used: grass, pasture of guinea grass (GG) (*Megathyrsus maximus* cv. IZ-5); GG+1.5S, guinea grass and supplementation at 1.5% of lamb live weight; GG+2.5S, guinea grass and supplementation at 2.5% lamb live weight; GG+PP, guinea grass and supplementation with controlled grazing in 0.1 ha of pigeon pea (PP) (*Cajanus cajan* cv. Anão) for three hours a day. Forty-four weaned castrated male lambs, 21 singletons and 23 twins, were used in the study. The supplement was a concentrate feed formulated with ground corn (74.0%), soybean meal (22.0%), urea (1.5%), calcite limestone (1.0%) and mineral premix (1.5%), and was offered daily at 12h. The ration was balanced according to NRC (2007). Water and mineral supplementation were offered ad libitum.

In years 2 and 3, the experimental area was 1.8 ha, with nine paddocks of 0.2 ha. Three feeding systems were used: grass, only guinea grass; cajanus, pasture of pigeon pea; grass/cajanus, half of the paddock with guinea grass and the other half with pigeon pea. In year 2, 22 singletons and 18 twins were assessed, whereas in year 3, nine singletons and 23 twins.

In year 1, all animals received 10 mg kg^{-1} BW of 20% disophenol (Ibasa, Porto Alegre, RS, Brazil) anthelmintic treatment ten days before the experiment began, regardless of the parasitic contamination, so that the experiment started with a low parasite load, not influencing the animals' performance. During the experimental period, the animals were treated with the same anthelmintic only if they reached above 1,000 eggs per gram of feces. In year 2 and 3 the animals received anthelmintic treatment with 2.5 mg kg^{-1} BW of Zolvix monepantel (Novartis, Basel, Switzerland) when they reached above 1,000 eggs per gram of feces.

The pre-weaning average daily gain (ADG) of the lambs were obtained before the experimental period, which comprehended birth to weaning, by the difference between weaning weight (WW) and birth weight (BW), divided by the number of days of this period.

After weaning, the lambs were afforded ten days to adapt to the experimental area. The lambs were weighed to obtain the initial weight (IW) and then in every 21 days in years 1 and 3, and in every 28 days in year 2. At the end of the experiment, when the lambs were eight to nine months, after 12 hours of abstinence from solids and liquids, they were weighted to obtain the final weight (FW). The average daily gain (ADG) was calculated by the difference between FW and IW, divided by the number of days.

Three evaluations of animal daytime ingestive behavior were performed in each experiment year on days 28, 56, and 84. The lambs' diurnal behavior was evaluated by visual observation from sunrise to sunset every 5 minutes in all years, according to the method described by Jamieson & Hodgson (1979). The animals were individually identified in the paddock by different color fabric collars. The times of the activities of grazing, ruminating, and idling was recorded individually for each tester animal. The grazing time was considered the period the lambs spent in the selection and collection of the forage, including the time used in displacement for the selection of the diet. The ruminating time was considered the period when the animal was not eating but was chewing cud. The idling time represented the period when the animals were neither grazing nor ruminating.

The lambs remained continuously on the grazing area, and the forage mass was determined at the beginning of the study and then in every 28 days in year 1, and in every 21 days in years 2 and 3. The herbage mass was measured using a 0.25 m^2 rectangular frame. Six sample points per paddock were established: three ones represented the average pasture height and the other three were random points. In each point, an area of the rectangular frame was cut to ground level and weighed on a five-g precision scale. Each sample was homogenized, and sub-samples of approximately 100 g each were taken to determine the percentage of dry matter (DM). The percentage of forage DM was multiplied by the values of the forage mass in kg ha^{-1} of green matter (GM), to obtain the value of the forage mass in kg of DM per ha.

A leaf lamina allowance (LBA) of 10 kg DM per 100 kg of live weight from guinea grass and pigeon pea was maintained and regulated in every 28 days in years 1 and 2, and in year 3, in every 21 days, utilizing the put-and-take technique (Mott & Lucas, 1952). According to this technique, there were two groups of animals, the testers, which were weaned lambs that grazed continuously and were evaluated, and the grazers, which were used solely to ensure if the forage allowance was regulated within the aimed range. The forage growth rate was obtained using three grazing exclusion cages per paddock according to Klingman et al. (1943).

Forage nutritional quality analysis (Table 1) was performed using the samples collected by grazing simulation by hand plucking technique (Johnson, 1978). In every 28 days in year 1 and in every 21 days in years 2 and 3, the collected samples were dried in an oven with forced air circulation at 55ºC for at least 72 hours, until reaching a constant weight. After drying, the samples were ground through a mill fitted with a 1 mm screen. The DM, mineral matter (MM), and crude protein (CP) content were determined according to the Association of Official Analytical Chemist (AOAC) (Cunniff, 1995), ether extract (EE) was found as described by Silva & Queiroz (2002), and neutral detergent fibre (NDF) was determined according to Van Soest et al. (1991), and amylase was used in the concentrate samples according to Mertens (2002), acid detergent fibre (ADF) as described by Goering & Van Soest (1970) and total digestible nutrients (TDN) were obtained according to the equation described by Sniffen et al. (1992).

In each year, the experiment was set up in a split block design as described by the model mentioned. The whole plot factor was the effect of blocks and feeding systems and the split plot factor was litter size. There were three blocks per year as replications of the whole plot. The statistical model is given by: $Y_{ijk} = \mu + R_i + A_j + (RA)_{ij} + B_k + (AB)_{jk} + e_{ijk}$, where, Y_{ijk} represents the response variable observed at level k of B, level j of A, in block I; μ is the overall mean; R_i the fixed effect of block within each year at level I; A_j is the whole plot fixed effect of feeding system treatment at level j; $(RA)_{ij}$ is the whole plot error; B_k is the split-plot fixed effect of litter size at level k; $(AB)_{jk}$ is the interaction between the feeding system and the litter size treatment; and e_{ijk} is the split-plot error.

Table 1. Chemical composition (% of dry matter) of the feed provided to lambs during the three years of the study[(1)].

Variable	Feeding System[(2)]				
	Year	GG	PP	GG+PP	Concentrate feed
Organic matter	1	79.5	81.7	-	90.0
	2	77.1	79.4	78.3	-
	3	88.3	90.5	89.1	-
Crude protein	1	13.0	19.2	-	22.6
	2	15.0	19.2	18.4	-
	3	14.3	20.5	16.6	-
Ethereal extract	1	2.5	4.9	-	3.1
	2	2.7	4.1	3.6	-
	3	2.5	3.1	3.3	-
Neutral detergent fibre	1	52.3	45.0	-	9.2
	2	63.9	51.5	54.2	-
	3	64.1	49.0	57.9	-
Acid detergent fibre	1	26.5	21.8	-	3.3
	2	32.0	29.0	30.3	-
	3	32.3	28.4	30.7	-
Total digestible nutrients	1	68.2	71.9	-	86.3
	2	62.8	68.1	65.6	-
	3	58.2	58.8	54.3	-

[(1)]Data were means ± standard error of the means. [(2)]GG, *Megathyrsus maximus* without supplementation; PP, *Cajanus cajan*; GG+PP, *Megathyrsus maximus* supplemented with controlled grazing in *Cajanus cajan*.

Statistical procedures were similar in all three experiments. BW, WW, and ADG before weaning were used as covariates in the analysis of variance, which was performed to determine the effects of feeding systems and litter size for singleton or twin births on the variables of performance and ingestive behavior through the MIXED procedure of the statistical program SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA).

The data were submitted to the Shapiro-Wilk normality test, and they were found to be normal and did not require transformation. The blocks, feeding system, litter size, and the interaction litter size/feeding system were considered as fixed effects, whereas year was considered as a random effect. Differences and interactions were considered significant when the level of significance was less than 5%.

Results and Discussion

The difference in the live weight performance of lambs before weaning (Table 2) did not remain after weaning, when they were placed on pasture with or without concentrated supplementation. There was no significant interaction between litter size and feeding system effects on any of the variables studied during the three years of the experiment (Table 3). When the litter size was analysed regardless of the feeding system, there was a difference in year 1 for ADG and total gain after weaning (Table 3). Twin lambs in year 1 had an ADG of 0.066±0.007 kg and a TG of 6.22±0.677 kg, while the singleton lambs showed an ADG of 0.038±0.007 kg and a TG of 3.66±0.733 kg. However, in years 2 and 3, there was no effect of the birth type and feeding system on the lambs' final weight.

This great ADG of twins resulted in similar final weights at a similar age at the end of the experiment. The high live weight gain observed for twins in the post-weaning period in year 1 is likely to be a compensation response of the lower ADG by these lambs in the pre-weaning period and, thus, a form of compensatory gain, which is associated with great feed consumption, improved feed conversion, greater live weight gain, and better use of nutrients after a period of malnutrition or feed restriction (Luzardo et al., 2019).

According to Ryan (1990), an animal might present complete, partial, or no compensation. When complete compensation occurs, the growth curve of an animal that has been restricted is greater than that of an animal fed properly, allowing the same slaughter weight to be reached at the same age in the post-restriction period. Poli et al. (2020) demonstrated the great potential of lambs to respond to a better nutritional level after weaning. Therefore, it is possible that twins gain higher live weight than singletons after weaning in tropical herbage based on grazing systems; however, it is reached when a high nutritional level, as concentrate supplements, is offered to the animals.

The variance analysis shows in year 1 that the feeding system effect, regardless of the litter size, was significant on ADG, TG, and FW. The highest level of supplementation (GG+2.5S) displayed greater lamb performance, with the highest ADG, TG, and FW, than the treatment without supplementation (GG)

Table 2. Birth weight, weaning weight, and average daily gain to weaning of singleton and twin lambs(1).

Variable	Year	Birth		p-value
		Singleton	Twin	
Birth weight (kg)	1º	4.610±0.180a	3.840±0.172b	0.0036
	2º	4.640±0.223a	3.690±0.247b	0.0072
	3º	5.100±0.274a	3.940±0.171b	0.0012
Weaning weight (kg)	1º	25.450±0.662a	22.270±0.631b	0.0013
	2º	22.750±0.703	21.080±0.777	0.1202
	3º	23.110±1.167a	20.000±0.730b	0.0313
Average daily gain (kg day^{-1})	1º	0.236±0.007a	0.198±0.006b	0.0004
	2º	0.190±0.006a	0.154±0.006b	0.0004
	3º	0.198±0.010	0.176±0.006	0.0843

(1)Means followed by equal letters, in the rows, do not differ from each other by Tukey's test, at 5% probability. Data were means ± standard error of the means.

and the treatment with the tropical legume *Cajanus cajan* (GG+PP) (Table 4). Lambs under GG treatment showed the lowest performance, and those under GG+PP treatment did not differ from those under GG and GG+1.5S treatments. In years 2 and 3, regardless of the litter size, there was no effect of the feeding systems on ADG and FW.

The lambs that did not receive concentrate presented a higher variation of live weight, which shows that weight gain on tropical pastures is potentially uncertain, and it suggests that, under tropical herbage grazing scenarios, concentrates are a management tool to ensure consistent live weight gain in lambs. This result was similar to what was observed by Fajardo et al. (2015), evaluating supplementation on tropical pastures for finishing lambs during the summer-autumn, in which supplementation with 1.5% allowed similar daily gains as supplementation with 2.5% of live

Table 3. Average daily gain, total gain, and final weight of lambs, considering the interaction between the effects of different types of feeding systems and litter size over three-year experiments.

Feeding system[1]	Birth	Average daily gain (kg day^{-1})		Total weight gain (kg)		Final weight of lambs (kg)	
		1º year	2º and 3º year	1º year	2º and 3º year	1º year	2º and 3º year
GG	Twin	0.020±0.01	0.057±0.01	1.93±1.31	4.92±0.92	25.60±1.95	26.82±1.77
	Singleton	-0.005±0.01	0.075±0.01	-0.53±1.42	6.51±0.84	25.28±2.12	27.44±1.64
GG+1.5S	Twin	0.074±0.01	-	7.00±1.33	-	30.33±1.99	-
	Singleton	0.049±0.01	-	4.76±1.82	-	33.66±2.72	-
GG+2.5S	Twin	0.133±0.01	-	12.48±1.47	-	35.05±2.19	-
	Singleton	0.077±0.01	-	7.22±1.42	-	36.17±2.12	-
GG+PP	Twin	0.037±0.01	-	3.48±1.31	-	25.68±1.95	-
	Singleton	0.034±0.01	-	3.19±1.12	-	29.55±1.67	-
PP	Twin	-	0.041±0.01	-	3.70±0.82	-	24.09±1.64
	Singleton	-	0.025±0.01	-	2.06±0.95	-	25.93±1.88
GG/PP	Twin	-	0.055±0.00	-	4.76±0.59	-	26.41±1.32
	Singleton	-	0.065±0.01	-	5.58±0.96	-	29.29±1.83
p-value[2]	Birth	0.0140	0.6498	0.0151	0.7126	0.0900	0.1350
	Feeding system	<0.0001	0.0823	<0.0001	0.0039	<0.0001	0.3796
	Interaction	0.3552	0.2993	0.3624	0.2027	0.7146	0.7285

[1]GG, *Megathyrsus maximus*; GG+1.5S, *Megathyrsus maximus* with supplementation of 1.5% of live weight; GG+2.5S, *Megathyrsus maximus* with supplementation of 2.5% of live weight; GG+PP, *Megathyrsus maximus* supplemented with controlled grazing in *Cajanus cajan*; PP, *Cajanus Cajan*; GG/PP, half of the paddock with *Megathyrsus maximus* and the other half with *Cajanus cajan*. [2]p-value is the probability that an observed difference could have occurred just by random chance in each column. Data were means ± standard error of the means.

Table 4. Average daily gain, total gain, and final weight of lambs, regardless of the litter size effect on singleton and twin birth, in different feeding systems in tropical pasture, across the three years of the study[1].

Variable	Year	Feeding System[2]						p-value
		GG	GG+1.5S	GG+2.5S	GG+PP	PP	GG/PP	
Average daily gain (g day^{-1})	1º	7.00±10.000c	62.00±12.000ab	105.00±10.000a	35.00±9.000bc	-[3]	-	<0.0001
	2º and 3º	66.00±7.000	-	-	-	33.00±7.000	60.00±7.000	0.0823
Total gain (kg)	1º	0.70±0.960c	5.88±1.133ab	9.85±1.019a	3.34±0.857bc	-	-	<0.0001
	2º and 3º	5.72±0.624a	-	-	-	2.88±0.610b	5.17±0.548a	0.0039
Final weight (kg)	1º	25.67±1.031c	31.51±1.284ab	34.40±1.203a	28.26±0.927bc	-	-	<0.0001
	2º and 3º	27.13±1.368	-	-	-	25.01±1.351	27.85±1.262	0.3796

[1]Means followed by different letters, in the rows, differ from each other by Tukey's test, at 5% probability. [2]GG, *Megathyrsus maximus*; GG+1.5S, *Megathyrsus maximus* with supplementation of 1.5% of live weight; GG+2.5S, *Megathyrsus maximus* with supplementation of 2.5% of live weight; GG+PP, *Megathyrsus maximus* supplemented with controlled grazing in *Cajanus cajan*; PP, *Cajanus cajan*; GG/PP, half of the paddock with *Megathyrsus maximus* and the other half with *Cajanus cajan*. [3]-, the respective treatments were not tested in the respective year. Data are means ± standard error of the means.

weight. In addition, this study showed that a tropical legume, such as *Cajanus cajan*, can provide an amount of nutrients similar to the concentrate supplied at 1.5% LW. As observed in recent studies (Abebe & Tamir, 2016; Tadesse et al., 2024; Tulu et al., 2024), *Cajanus cajan* leaves can be a good supplement to improve the sheep performance, manly when associated to a low-quality pasture.

According to Silva et al. (2020), lamb feeding behavior, of which grazing usually demands the longest period of time during the day, can be altered by the production system. The feeding behaviour observed in this study was similar to that found by Jochims et al. (2010), when assessing lamb grazing behavior on the tropical grass pearl millet with and without supplementation. Although Silva et al. (2020) showed that lamb LW is a key factor influencing the grazing harvest ability of lambs in tropical grassland, the difference of LW between singleton and twin lambs in the present experiment was not enough to cause differences.

Considering the ingestive behaviour results of year 1, there was no interaction between feed system and litter size (Table 5). In addition, in year 1, there was no difference in the time spent grazing, ruminating, and idling when comparing the litter size, regardless of the feeding system. However, when evaluating the effect of different feeding systems, independent of the litter size effect in year 1, there were differences in ingestive behavior for grazing and idling time. The use of concentrate supplementation reduced grazing time in relation to those animals that did not receive concentrate (324.1±22.84 and 459.1±20.14 min., respectively). The highest level of supplementation (GG+2.5S) promoted longer periods of idling (232.6±20.08 min.), compared to treatments without concentrate (124.9±17.91 min.).

According to Fajardo et al. (2015), the reduction of grazing time is due to the substitution of pasture by concentrate, which might have promoted a reduction of nutrient intake from pasture. This result shows that the system with concentrate supplementation can be more expensive than expected, since pasture is a generally cheaper source of nutrients. In addition, shorter grazing time caused by concentrate supplementation, can have deleterious effects on tropical pasture structure, decreasing its nutritional quality (Fajardo et al., 2015), resulting in further negative effects. Fajardo et al. (2015) observed a reduction of the guinea grass leaf/stem ratio as the amount of concentration supplementation increased.

Although there was no significant effect of the interaction between feeding systems and litter size on

Table 5. Grazing, rumination, and idling times of lambs, for the interaction between the effects of different types of feeding systems and litter size on singleton or twin birth, of experiments across three years[(1)].

Feeding system[(2)]	Birth	Ingestive behavior (min.)					
		Grazing		Rumination		Idling	
		1º year	2º and 3º year	1º year	2º and 3º year	1º year	2º and 3º year
GG	Twin	405.5±29.023	452.7±14.310a	118.5±8.251	107.8±8.662b	180.80±25.805	167.6±13.368
	Singleton	505.3±31.523	424.7±12.995ab	137.1±8.962	119.7±7.865ab	77.45±28.028	149.1±14.722
GG+1.5S	Twin	345.6±29.667	-	122.8±8.434	-	202.90±26.378	-
	Singleton	338.9±40.503	-	136.7±11.515	-	199.40±36.012	-
GG+2.5S	Twin	279.9±32.576	-	138.4±9.261	-	260.80±28.964	-
	Singleton	332.1±31.526	-	144.3±8.963	-	204.40±28.030	-
GG+PP	Twin	467.6±29.030	-	138.9±8.253	-	114.60±25.811	-
	Singleton	458.1±24.892	-	134.7±7.077	-	126.80±22.132	-
PP	Twin	-	392.4±12.7420b	-	143.0±7.713a	-	170.1±13.109
	Singleton	-	434.1±14.8060ab	-	106.4±8.962b	-	166.4±15.232
GG/PP	Twin	-	448.1±9.1769a	-	122.0±5.554ab	-	139.9±9.440
	Singleton	-	425.5±14.8530ab	-	125.2±8.991ab	-	151.0±15.281
p-value		0.2459	0.0349	0.5470	0.0174	0.1467	0.7456

[(1)]Means followed by different letters on the column, within each measured variable, differ statistically by the Tukey test at 5% probability. [(2)]GG, *Megathyrsus maximus*; GG+1.5S, *Megathyrsus maximus* with supplementation of 1.5% of live weight; GG+2.5S, *Megathyrsus maximus* with supplementation of 2.5% of live weight; GG+PP, *Megathyrsus maximus* supplemented with controlled grazing in *Cajanus cajan*; PP, *Cajanus Cajan*; GG/PP, half of the paddock with *Megathyrsus maximus* and the other half with *Cajanus cajan*. Data are means ± standard error of the means.

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idling time in years 2 and 3, there was a significant interaction on grazing and rumination time in these years (Table 5). Twin lambs spent less time grazing in the legume (PP treatment) compared to twins in the GG or in the GG/PP treatments. Conversely, lambs that showed the shortest grazing time had longest rumination times. In addition to the shorter grazing time, the animals in the PP treatment also showed lower total weight gain (Table 4). These results indicate that the use of a tropical legume as monoculture may limit lamb production, contrary to what is observed with the use of temperate species (Lagrange et al., 2021). As observed in the present study, tropical legumes display similar cell wall concentration as tropical grasses (Table 1), and the plant morphology structure of PP is shrubby (Tontini et al., 2019). The combination of these characteristics can make harvesting and utilizing their leaves difficult for lambs.

Conclusions

1. On tropical pasture system, twin lambs fed with high levels of concentrate can gain more live weight than singletons, showing a compensatory growth and reaching the singletons live weight.
2. Sheep litter size does not affect weaned lambs' grazing behaviour under different feeding systems based on tropical grassland.
3. The use of concentrate supplementation changes lambs' ingestive behavior by reducing grazing and increasing idling times.
4. Pigeon pea (*Cajanus cajan*), as a monoculture or associated with grass, can be an important source of nutrients for lambs; however, it is not sufficient to ensure the same performance of twin and singleton lambs.

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