Revista Brasileira de Zootecnia

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.39, n.1, p.51-60, 2010

Grazing ecology of female lambs on Italian ryegrass plus red clover pasture under different defoliation intensities

Carine Lisete Glienke[1], Marta Gomes da Rocha[2], Daniele Gindri Camargo[1], Luciana Pötter[3], Anna Carolina Cerato Confortin[1], Vagner Guasso da Costa[1]

[1] *Programa Pós-graduação em Zootecnia, Universidade Federal de Santa Maria - UFSM, RS.*
[2] *Departamento de Zootecnia, UFSM, RS.*
[3] *UFSM/CESNORS- Palmeiras das Missões, RS.*

ABSTRACT - The relationship between pasture dynamics and ingestive behavior of female lambs was studied on Italian ryegrass (*Lolium multiflorum* Lam.) plus red clover (*Trifolium pratense* L.) mixture under a range of defoliation intensities. Rotational grazing was used and the grazing interval was determined by the thermal sum of 313 degree days. The initial pre-grazing canopy height disappearance values were 65 (very high), 58 (high), 47 (medium) and 37% (low). The sward vertical structure was similar among defoliation intensities. The forage allowance decreased linearly as defoliation intensities increased, with 0.35 bite/minute reduction for each 1% increase in forage allowance. The bite rate and number of bites/feeding station decreased with reduced contribution of leaves in the sward structure. It was associated, respectively, with an increase and a decrease of NDF and CP levels in forage as grazed by female lambs. The pasture cycle proves to be more important than defoliation intensities as a source for changes in feeding stations and displacement patterns of female lambs.

Key Words: bite rate, feeding stations, ingestive behavior, *Lolium multiflorum*, pasture structure, *Trifolium pratense*

Ecologia do pastejo por cordeiras em pastagem de azevém e trevo-vermelho sob diversas intensidades de desfolha

RESUMO - Estudou-se a relação entre a dinâmica do pasto e o comportamento ingestivo de cordeiras em pastagem de azevém (*Lolium multiflorum* Lam.) e trevo-vermelho (*Trifolium pratense* L.) em diferentes intensidades de desfolha. O pastejo foi rotacionado e o intervalo entre pastejos foi determinado pela soma térmica de 313 graus-dia. Os valores de desaparecimento da altura do dossel no pré-pastejo foram de 65 (muito alta), 58 (alta), 47 (média) e 37% (baixa), respectivamente. A estrutura vertical do pasto foi semelhante entre as intensidades de desfolha testadas. A oferta de forragem diminuiu linearmente com o aumento da intensidade de desfolha, com redução de 0,35 bocado/minuto a cada 1% a mais na oferta de forragem. A taxa de bocados e o número de bocados/estação alimentar reduziram com a diminuição da contribuição de folhas na estrutura da pastagem, acompanhada do aumento do teor de FDN e da redução do teor de PB no pasto ingerido pelas cordeiras. O ciclo do pasto é mais importante que as intensidades de desfolha testadas para provocar mudanças nos padrões de deslocamento e nas estações alimentares de cordeiras.

Palavras-chave: comportamento ingestivo, estações alimentares, estrutura do pasto, *Lolium multiflorum*, taxa de bocados, *Trifolium pratense*

Introduction

Italian ryegrass (*Lolium multiflorum* Lam.) plus red clover (*Trifolium pratense* L.) is a common mixture used in cool season forage production systems. However, more than one forage species in a pasture increases its complexity and, consequently, the management could become more laborious. The knowledge of the forage species heterogeneity relationship in dynamic pastoral environments is fundamental for proper use of mixed pastures. The vegetation response is determined by defoliation intensity during pasture management and soil fertility. Ecology applied to pasture management is the manipulation of the environment where plants and animals live to give them a more favorable habitat (Barbosa, 2001).

The pasture structure, as a result of the continuous interaction between defoliation by animals and plant growth (Carvalho et al., 2000), influences the degree of selective grazing by herbivores, which seek to meet their demands despite changes in the chemical and botanical composition of the structure and forage on offer. Animal responses to these variations could include changes in its displacement

Received October 10, 2008 and accepted April 16, 2009.
Corresponding author: marta.gomes@ymail.com

patterns and/or components of ingestive behavior during the grazing process.

Herbivore ingestive behavior may be an indication to distinguish characteristics of their grazing environment related to the abundance and quality of available food. The study of ingestive behavior can be relevant for decision making about use of forage resources to integrate animal performance with an efficient pasture use (Carvalho & Moraes, 2005).

In this context, the objective of this study was to analyze the relationship between the pasture dynamics and ingestive behavior of female lambs on Italian ryegrass plus red clover pasture submitted to a range of defoliation intensities.

Material and Methods

The experiment was conducted from May to November 2007, at the Universidade Federal de Santa Maria (UFSM), located in the Central Depression physiographic region of Rio Grande do Sul, Brazil. The soil of the experimental area is classified as Paleaudalf (EMBRAPA, 1999) with the following means values for chemical characteristics: pH-H_2O: 5,4; % clay: 19 m/V; K: 40 mg/L; % MO: 2.2 m/V; Al: 0.0 cmol/L; Ca: 6.4 cmol/L; P: 6mg/dm³; Mg: 2.7 cmol/L; CTC pH 7: 16.1. The climate in the region corresponds to the humid subtropical (Cfa) type, according to the Köppen classification (Moreno, 1961). The climatological data were recorded at the UFSM Meteorological Station. The average temperature, insolation and rainfall during the experimental period were 14.0ºC, 147.4 monthly hours and 121.7 mm, respectively.

The Italian ryegrass (*Lolium multiflorum* Lam.) cv. Comum was sown on 5/1/2007, with minimum soil tillage using a mechanical planter. On the following day, red clover (*Trifolium pratense* L.) cv. LE 116 was established, by manual sowing, after inoculation with specific inoculants and seed pelleting. The quantity of seeds was 45 and 8 kg/ha for Italian ryegrass and red clover, respectively and 360 kg/ha fertilizer 05-20-20 (N:P:K) and 140 kg/ha triple superphosphate were applied. The nitrogen fertilization was 67.5 kg/ha in urea form, subdivided in three equal applications, on June 15th, July 23th and September 10th.

Treatments corresponded to four defoliation intensities: very high, high, medium and low, represented by the reduction of 75, 60, 45 and 30% of the canopy height at the beginning of each grazing period. To achieve the intended percentages in each defoliation intensity, the stocking rate (kg/ha body weight) was calculated considering the pre-grazing forage mass (kg/ha DM), number of occupation days and the proportion of 6.0% of body weight (BW) DM disappearance (Glienke et al., 2008).

Grazing was carried out using 16 crossbred Ile de France × Texel, 11-month old tester female lambs with an average body initial weight of 36.5 ± 5.1 kg, randomly assigned to the defoliation intensities, and a variable number of additional lambs. The experimental area was divided up into four paddocks of approximately 0.15 ha, totaling 0.6 ha. The experimental lambs had free access to water and mineral supplement, with periodic control of parasites and diseases.

The intermittent grazing method was used and the pasture was first occupied when the forage mass (FM) was approximately 1,500 kg/ha of dry matter (DM). A thermal sum of 313 degree-days was used as a criterion to determine the interval between the end of one grazing period and the beginning of the next. The accumulated thermal sum was calculated by the equation AT = Σ (Dat - 5°C), in which Dat = daily average temperatures (°C) and 5°C = value considered as base temperature of growth for temperate grasses (Cooper & Tainton, 1968). The average daily temperature was calculated based on INMET (2004): DAT = MxT + MnT + T9h + (2*T21h)/5, in which DAT = daily average temperature (°C), MxT = daily maximum temperature (°C); MnT = daily minimum temperature (°C); T9h = temperature at 9 a.m., and T21h = temperature at 9 p.m.

The forage mass was evaluated by the double sampling method (Mannetje, 2000) on pre and post-grazing situations at 20 measurement points in each paddock. Samples for calibration were cut close to the ground, using as reference a 0.0625 m^2 square. The partial forage DM was determined in the collected samples. Sward height (cm) measurements were taken in the same places where the forage mass was evaluated, and corresponded to the distance between the ground and the horizon line defined by the curved top leaves or inflorescences around the ruler. According to these values, the canopy height disappearance percentage was determined, by the formula: DH = (ICH - RCH) / ICH, where DH = canopy height disappearance percentage; ICH = canopy height at the beginning of each grazing (cm) and RCH height = residual height at the end of each grazing (cm).

The pseudostem height (cm) was taken before each grazing period, in 20 places located in four imaginary transects per paddock. The distance was measured from the ground to the ligulae of the last expanded Italian ryegrass leaf. The rate of herbage accumulation (kg/ha/day DM) was estimated using grazing exclusion cages, assessed every 28 days.

The forage losses (kg/ha/day DM) were evaluated in three fixed areas (0.0625 m^2 each one) per paddock, defined by stakes, and before starting the first grazing day any dead forage found in these places was removed. At these points, after each grazing, a square was placed and, in its defined area, the dead material and green material separated from the plants as a result of grazing and trampling effects was collected. This material was dried at 55°C for 72 hours and then weighed. The same drying process was adopted for the other forage samples.

The vertical structure of the pasture was measured (Stobbs, 1973) before and after each grazing period. Sampling was carried out using four quadrats (0.0625 m^2), overlapped at 10 cm intervals from the ground until the base of the sward. Quadrats were placed in two representative areas of forage mass in each paddock. The herbage was cut in each quadrat considering five strata: 0-10, 10-20, 20-30, 30-40 and + 40 cm). Samples from these strata were dissected by hand into leaf blade, stem (stem + leaf sheath) and Italian ryegrass inflorescence, clover (leaflets + stem), dead material components and other species. Samples taken by strata were dried in a forced air oven at 55°C for 72 hours and then weighed to estimate the percentage participation of each botanical and structural component of the pasture and the leaf/stem ratio in each stratum.

Grazing was carried out from July 16th to 22nd, September 3rd to 9th, October 5th to 12th and November 5th to 9th. Before each grazing period the lambs were weighed and identified according to their participation in each defoliation intensity. The average period of pasture occupation was six days. The stocking rate per grazing cycle was calculated as the product from the division of the total body weight by the average weight of the tester-lambs in each grazing period.

The forage allowance (kg of DM/100 kg of BW) was calculated as follows: FA = ((IFM + RFM / 2) + DRA) / number of days) / SR) * 100, where FA = forage allowance; IFM = value of pre-grazing forage mass; RFM = value of post-grazing herbage mass, DRA = daily rate of DM accumulation and SR = stocking rate. The green leaf allowance was obtained by multiplying the forage allowance by the average percentage of Italian ryegrass leaf blades in forage mass.

The ingestive behavior was assessed by visual observation of the tester-lambs in four continuous 24-hour periods, on July 20th-21st, September 8th-9th, October 9th-10th and November 7th - 8th. The grazing activity was recorded at 10 minutes intervals (Jamieson & Hodgson, 1979) and it was considered as the time spent by the animals in selecting and apprehending forage, including the short periods used in the displacement for forage selection (Hancock, 1953) expressed in minutes/day.

Bite rate (bite/minute) was evaluated during the day time, when lambs were in grazing activity, every 10 minutes, by measuring the time taken by the animals to take twenty bites (Hodgson, 1982). The daily number of bites was the product of the bite rate multiplied by the daily grazing time. The time spent by the lambs going through ten feeding stations and the number of footsteps across these stations were calculated. Feeding station was defined as the space corresponding to grazing, without movement of the forelegs (Laca et al., 1992), while the footstep was defined as each movement of the forelegs. These data were used to calculate the number of stations per minute, displacement rate (steps/minute), number of steps between stations and the daily number of feeding stations. The number of bites per station was calculated by dividing the daily bites by the daily number of feeding stations.

The collection of forage as grazed was carried out by two trained raters, who observed one tester-lamb per paddock (Euclides et al., 1992). Dry samples were ground in a Wiley type mill with a 1 mm sieve. Crude protein (984.13 method, AOAC, 1995) and insoluble fiber in neutral detergent (Van Soest et al., 1991) were measured in these samples.

The estimated forage disappearance was calculated according to the equation:

FD = 100 - ((RFM * 100) / (IFM + DAR) - LOSS)),

where FL = forage post-grazing disappearance rate; RFM = forage mass pre-grazing value; IFM = forage mass post-grazing value; DAR = herbage accumulation rate for the period and LOSS = loss of forage (kg/ha/day DM). The forage disappearance values divided by the number of days in each period resulted in the daily forage disappearance. This value, divided by the stocking rate and multiplied by 100, was named forage intake, expressed in % BW. The estimated intake value multiplied by the BW of the tester-lambs led to the estimated forage intake, expressed in kg/animal/day DM. The bite mass was calculated by dividing the daily estimated forage intake by the daily number of bites (Jamienson & Hodgson, 1979).

A randomized complete design following a repeated measurement over time was used with four treatments and four replications. Data were submitted to the Shapiro-Wilk normality test and the decimal logarithm transformation was used for bite rate and footsteps among feeding stations variables. For values of feeding stations per minute and displacement rate the arcsine transformation was used. Analysis of variance and the F test were performed and the means compared by Tukey test at 5% significance level. Ingestive behavior data were analyzed using the PROC Mixed procedure and for data related to pasture the PROC GLM procedure of SAS (2001). Correlation analysis and polynomial regression were also performed. In order to identify independent variables that influence the variables of grazing behavior (dependent), the stepwise procedure was used, ignoring variables whose coefficients of determination (r^2) were lower than 0.50.

Results and Discussion

The defoliation intensities observed were 37, 47, 58 and 65% according to the intended values of 30 (low), 45 (medium), 60 (high) and 75% (very high) disappearance of pre-grazing canopy height, respectively. The average stocking rate used at each defoliation intensity was 71.0; 128.7; 134.0 and 149.5 female lambs/ha in the low, medium, high and very high defoliation intensities, respectively. The mean live weight of the tester-lambs was 36.5 ± 5.1; 43.0 ± 5.3; 47.2 ± 4.9 and 47.3 ± 4.4 kg in the first, second, third and fourth grazing, respectively.

The initial pre-grazing forage mass, canopy height and green leaf blades on offer were similar among the defoliation intensities and presented mean values of 3,306.1 kg/ha dry matter (DM), 32.5 cm and 3.9 kg DM/100 kg body weight (BW), respectively (P>0.05). The interval among grazing cycles determined by the thermal sum necessary for the appearance of 2.5 leaves of Italian ryegrass, using a measured phyllochron of 125.08 degree-days (Confortin et al., 2007), allowed a similar recovery of the grass at the different defoliation intensities. The pasture regrowth was also probably related to the joint action of the post-grazing sward light interception efficiency, the organic reserve content of the plants and the interaction between pasture crop and stocking rate (Vickery, 1981).

Canopy structure changes, among the defoliation intensities, were observed at extreme values of 37 (low) and 65% (very high) (P<0.05; Table 1), represented by post-grazing forage mass and canopy height differences as well as by a reduction in the pseudostem height.

The pseudostem height may be considered as a partial barrier and as a factor of grazing depth regulation (Griffiths et al., 2003). Female lambs removed 13.5 and 23.5% of pseudostem height at the end of the grazing period (Table 1) at the high and very high defoliation intensities. The depth of the surface leaf blade layer represents the main factor for individual performance of female lambs on Italian ryegrass pasture, with an additional eight grams per head of daily gain, for each additional cm of leaf blade depth (Roman et al., 2007). This indicated that individual lamb performance at high and very high intensities would probably be lower than at mean and low intensities. Considering the entire period of pasture use, the pseudostem height increased linearly with the development of the Italian ryegrass growth cycle (Y = 6.88+0.14x; P<0.0001; r^2 = 0.42).

The quantity of green leaf blades on offer showed a linear decrease according to the days of pasture use (Y = 8.46-0.075x; P=0.0015; r^2 = 0.53) and it reflected the variations in green leaf participation in response to the Italian ryegrass growth cycle, with a decrease in the proportion of this component at the beginning of the plant reproductive stage.

The forage on offer decreased 0.4% at each 1% increase in defoliation intensity (Y = 30.30-0.38x; P=0.0006; r^2 = 0.59). According to this equation, the forage on offer values at each tested intensity were 16.2 (low), 12.4 (mean), 8.3 (high) and 5.6% (very high). Forage allowance, with a mean value of 10.6%, was similar among the evaluation dates (P>0.05). Forage allowance is one of the crucial factors that limits forage intake by grazing animals which therefore is closely related to the animal performance (Carvalho et al., 1999). Thus, it suggests that female lambs at low, high and very high defoliation intensities would face a limited performance if compared to lambs at the mean intensity grazed pasture, because the DM daily allowance of 10 to 12% BW would lead to the best individual performance of grazing animals (Hodgson, 1990).

Among the pasture variables, pre and post-grazing forage mass and canopy height presented differences in terms of days of use (P<0.05; Figure 1). The maximum initial

Table 1 - Structural parameters of Italian ryegrass plus red clover pasture in a range of defoliation intensities by female lambs

Item	Defoliation intensities (%)				CV[2]
	Low[1]	Mean	High	Very high	
Post-grazing forage mass (kg/ha of DM)[3]	2,587.4a	2,145.9ab	1,775.1ab	1,368.5b	20.9
Post-grazing canopy height (cm)[4]	19.6a	16.3ab	12.8bc	9.1c	19.4
Pseudostem height (cm)	19.7a	14.1ab	14.8ab	11.9b	19.9

Means followed by different letters within lines differ (P<0.05) according to Tukey test.
[1] Low – 37% disappearance of pre-grazing canopy height (PGH); Mean – 47% disappearance of PGH; High – 58% disappearance of PGH; Very high – 65% disappearance of PGH.
[2] Coefficient of variation.
[3] Residual forage mass (Y = 4,146.20-0.42x; P=0.0716; r^2 = 0.21).
[4] Residual canopy height (Y = 33.34-0.36x; P=0.0096; r^2 = 0.39).

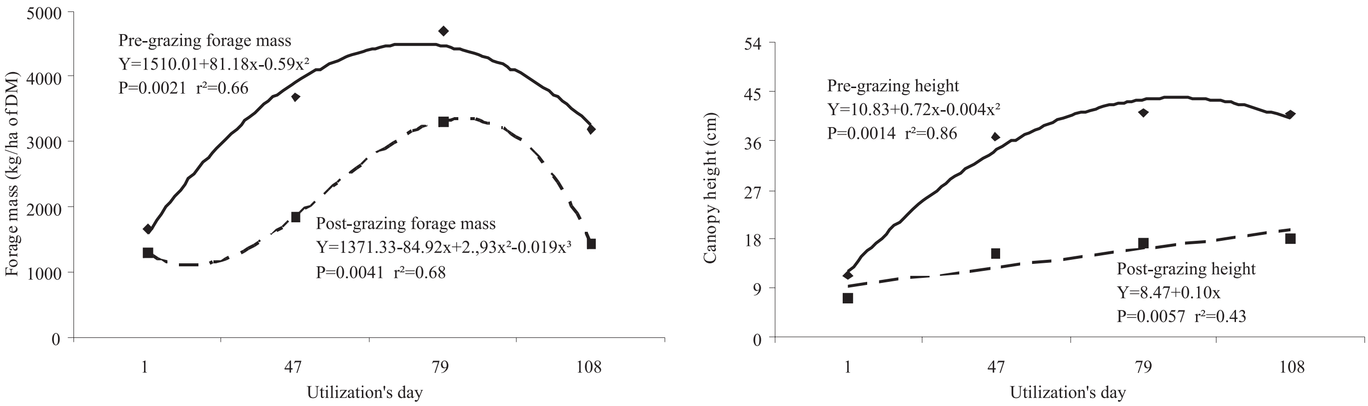

Figure 1 - Pre and post-grazing forage mass and canopy height of Italian ryegrass plus red clover pasture in a range of defoliation intensities by female lambs.

values of forage mass and canopy height were found on the 69th and 90th days of pasture use, respectively, and correlated positively with each other ($r = 0.85$; $P<0.0001$).

Values of forage mass and canopy height in the first pasture use (Figure 1) were in agreement with the recommended values for forage mass, between 1,136.8 and 1,739.1 kg/ha DM (Roman et al., 2007) and for canopy height, between 10 and 15 cm (Silveira, 2001; Pontes et al., 2004).

The pre-grazing structure formed on the following grazing periods consisted of forage mass and canopy height values higher than those recommended. This situation was probably caused by the thermal sum value used, as a criterion to determine the interval among grazing periods, as previously mentioned. Another contributing factor that could be taken in consideration is the number of planned days, in each pasture use, of more than four days. It caused difficulties in reaching the targets of defoliation intensities, mainly in the high extreme tested, whose post-grazing forage mass values were responsible for inadequate sward structure at the following grazing use.

The post-grazing forage mass presented its lowest value on the 17th day of pasture use. From that day onwards, there was a daily increase of 2.93 kg/ha DM until it reached the highest value on the 85th day (Figure 1). Values of post-grazing canopy height increased linearly during the pasture use cycle. Canopy height increase was caused by internode elongation, typical of this cycle phase of Italian ryegrass (Rocha et al., 2007). At the end of the grass growth cycle, there was a reduction in herbage accumulation at the beginning of the reproductive stage.

The pasture strata composition at the beginning of each grazing period was similar for different grazing intensities, except for dead material percentage, which differed at very high intensity ($P=0.0183$). The vertical profile distribution of botanic and morphological components, on pre and post-grazing, at the first grazing cycle (Table 2) demonstrated that the green leaves were the main component, especially in the 0-10 cm stratum at all tested intensities (Table 2). This represented a favorable grazing environment for lambs, that graze pastures more easily during a vegetative stage (Barthram & Grant, 1984).

As consequence of preferential leaf blade intake, greater participation of stems and dead material was observed in the post-grazing forage mass. Dead material accumulation followed mainly the increasing effects of trampling. Clover presence occurred only in a small proportion at the beginning of the grazing period, since its peak of forage production occurred at the end of the Italian ryegrass use.

The mean percentage for the clover presence was 5 and 4% in the 0-10 and 10-20 cm strata, respectively, at the end of pasture use (Table 3). This reduced contribution of clover probably was due to shading promoted by the Italian ryegrass when it was the principal component at forage mass values from 1,676.0 to 4,694.0 kg/ha DM. The great competition between clover and Italian ryegrass probably made it impossible to observe the influence of clover participation on the ingestive behavior variables.

The smaller proportion of leaf blades in the post-grazing period (Table 3) in the lower stratum (0-10 cm) was observed at the high and very high intensities and in the medium stratum (10-20 cm) at the low intensity, which suggested that high defoliation intensities led the lambs to graze leaves at the lowest level of the pasture. The stem participation occurred up to 30 cm height, which indicated that high values of canopy height occurred mainly because of the internode elongation. At the low grazing intensity there was a higher proportion of stems in the 0-10 cm

Table 2 - Morphological and botanical composition (%) of the vertical profile of Italian ryegrass plus red clover pasture in the first grazing cycle (16 to 7/22/2007) when submitted to a range of defoliation intensities by female lambs

Date	Stratum (cm)	Compound (%)				
		Leaf blade	Stem	Clover	Dead material	Other species
				Low intensity (37%)		
Pre-grazing	0-10	79.5	9.5	2.8	6.8	1.4
Post-grazing		66.9	20.6	0.0	11.5	1.0
Pre-grazing	10-20	100.0	-	-	-	-
Post-grazing		100.0	-	-	-	-
				Mean intensity (47%)		
Pre-grazing	0-10	82.4	9.6	3.3	2.8	1.9
Post-grazing		72.7	20.3	0.7	5.7	0.7
Pre-grazing	10-20	0.0	-	-	-	-
Post-grazing		100.0	-	-	-	-
				High intensity (58%)		
Pre-grazing	0-10	85.0	8.0	1.4	2.7	2.9
Post-grazing		63.7	22.5	0.0	12.3	1.5
Pre-grazing	10-20	80.0	-	-	20.0	-
Post-grazing		100.0	-	-	0.0	-
				Very high intensity (65%)		
Pre-grazing	0-10	80.4	12.8	1.4	3.2b	2.2
Post-grazing		57.9	31.4	0.0	10.7a	0.0
Pre-grazing	10-20	100.0	-	-	-	-
Post-grazing		100.0	-	-	-	-

Means followed by different lower case letters in the column differ (P<0.05) by Tukey test.

Table 3 - Morphological and botanical composition (%) of the vertical profile of Italian ryegrass plus red clover pasture (5 to 11/9/2007) when submitted to a range of defoliation intensities by female lambs

Date	Stratum (cm)	Compound (%)					
		Leaf blade	Stem	Infloresc.[1]	Clover	Dead material	Others species
					Low intensity (37%)		
Pre-grazing	0-10	20.4	46.7a	-	8.4	24.4	-
Post-grazing		2.4	8.5b	-	3.2	85.9	-
Pre-grazing	10-20	25.8a	48.2	11.8	7.0	7.2a	0.0
Post-grazing		5.9b	28.2	17.7	3.1	45.0b	0.5
Pre-grazing	20-30	32.2	28.9	43.1a	2.8	2.9	-
Post-grazing		11.3	19.0	33.1b	0.0	26.5	-
Pre-grazing	30-40	25.1	1.8	73.0	-	-	-
Post-grazing		0.0	0.0	0.0	-	-	-
					Mean intensity (47%)		
Pre-grazing	0-10	22.3	56.3	-	4.2	17.1	-
Post-grazing		8.2	28.7	-	3.6	59.5	-
Pre-grazing	10-20	17.9	49.6	21.7	0.0	9.4	1.5
Post-grazing		9.1	25.5	40.4	4.2	10.5	10.4
Pre-grazing	20-30	12.9	18.1	61.8	-	7.1	-
Post-grazing		13.0	5.5	29.6	-	1.8	-
Pre-grazing	30-40	13.3	-	86.7	-	-	-
Post-grazing		0.0	-	0.0	-	-	-
					High intensity (58%)		
Pre-grazing	0-10	21.4a	53.6	-	4.1	21.0b	0.0
Post-grazing		0.8b	16.0	-	0.3	82.5a	0.3
Pre-grazing	10-20	25.9	48.4	16.9	7.2	1.5	-
Post-grazing		5.1	52.6	9.0	0.0	33.3	-
Pre-grazing	20-30	26.9	26.9	43.6	2.1	0.6	-
Post-grazing		0.0	25.0	12.5	0.0	12.5	-
Pre-grazing	30-40	20.0	1.6	78.4	-	-	-
Post-grazing		0.0	0.0	0.0	-	-	-
					Very high intensity (65%)		
Pre-grazing	0-10	31.2a	48.4	-	8.4	12.0	0.0
Post-grazing		2.4b	11.2	-	2.4	74.5	2.4
Pre-grazing	10-20	27.9	39.9	20.7	4.2	4.2	3.1
Post-grazing		9.3	36.5	40.6	0.0	13.6	0.0
Pre-grazing	20-30	17.4	6.8	71.9	3.8	0.0	-
Post-grazing		3.8	11.4	30.8	0.0	3.8	-
Pre-grazing	30-40	14.6	-	85.4	-	-	-
Post-grazing		0.0	-	0.0	-	-	-

Means followed by different letters in the column differ (P<0.05) according to Tukey test.
[1] Infloresc. = Italian ryegrass inflorescence.

stratum at the pre-grazing (P=0.050), indicating that they would have been consumed.

The proportion of leaves was reduced at the Italian ryegrass reproductive stage and the highest participation of inflorescence was in the strata 20 cm above the canopy height (Table 3). This structure was not limiting to grazing by the lambs, which could graze the whole pasture profile, removing the leaf blades even in the lower stratum, 0-10 cm, reinforcing the findings by L'Huillier et al. (1986) that lambs graze at all horizons where leaf blades are distributed.

The animal displacement within the paddocks was partly explained by leaf mass (LM) in the 10-20 cm stratum at the end of grazing, represented by variation in the number of footsteps among the feeding stations (STBFS = 1.28 +0.0009 LM, P = 0.0057, R^2 = 0.22).

The greater presence of leaf blades was favorable to the achievement of heavier bites due to easier apprehension of leaves compared to stems. This allowed the animals to dislocate between feeding stations chewing the food apprehended in the last bite taken in the previous station (Palhano et al., 2006).

The displacement rate (DR, steps/minute) was reduced by the increase in the pseudostem height (PH) and was increased by the presence of inflorescences (IM) in the 30-40 cm stratum in pre-grazing (DR = 12.48-0.15PH + 0.0013IM; P = 0.0127; R^2 = 0.33). The increase in pseudostem height represented a difficulty for food to be harvested, causing displacement reduction due to more time spent on apprehension, while inflorescences were easily collected by lambs, but still with greater handling time than leaf blade manipulation.

The bite rate was correlated (P<0.0001) with the proportion of leaf blade on the 0-10 cm stratum (r = 0.69) in the post-grazing of each grazing period and with the canopy leaf:stem in the pre-grazing (r = 0.83) as much as in the post-grazing period (r = 0.71).

There was a defoliation intensity × evaluation date interaction for the number of steps between feeding stations (P = 0.0189) and a difference between tested defoliation intensities (P=0.0003) and evaluation dates (P<0.0001) for bite rate. The number of bites per feeding station (P<0.0001), number of feeding stations per minute (P = 0.0003) and the displacement rate (P = 0.0120) were different between evaluation dates.

The bite rate was lower at the low (27.1 bites/min) compared to the mean (34.0 bites/min) that was similar to the very high intensity (32.2 bites/min). The very high was similar to the high intensity (29.4 bites/min), which did not differ from the mean intensity. The bite rate is determined by the interaction between chewing and sward structure (Galli et al., 1996). The relationship found between bite rate and structural components of the pasture suggests that the bite rate responds directly to sward changes and they are not an attempt by the animal to compensate changes in bite weight (Galli et al., 1996).

Bite rate reflects the easiness of forage apprehension (Hodgson, 1990) which was demonstrated by correlations (P<0.0001) between the bite rate and pre-grazing forage mass (r = -0.71), and the pre-grazing (r = -0.79) and post-grazing (r = -0.72) canopy height. There was difference in the lamb's grazing strategy promoted by changes in the forage allowance and for each 1% increase in forage allowance there was a 0.35 bite/minute (BT) decrease (BT = 32.11-0,35FA; P<0.0001; R^2 = 0.43).

The estimated forage intake by female lambs (P=0.7226), 6.1% body weight, on average, and the bite weight (P = 0.9516), mean value 0.17 g DM/bite, were not affected by the defoliation intensities (P>0.05). The

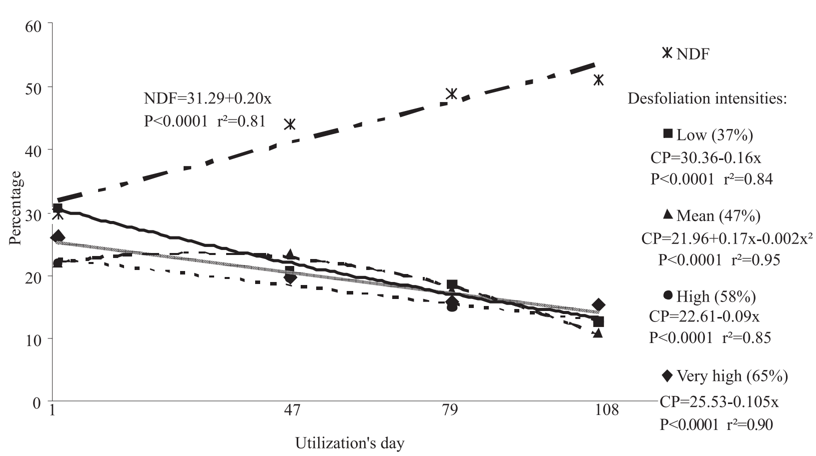

Figure 2 - Percentages of neutral detergent fiber (NDF) and crude protein (CP) of the forage as grazed by lambs on Italian ryegrass plus red clover when submitted to a range of defoliation intensities.

chemical composition of the forage as grazed showed a defoliation intensity × evaluation date interaction (P<0.0001) for the percentage of crude protein (%CP). The percentage of neutral detergent fiber differed among the evaluation dates (P<0.0001) and defoliation intensities (P=0.0020) (Figure 2).

The variation in the percentage of NDF and CP (Figure 2) with the advance of the maturity grass stage is dependent upon the increase in the cell wall component proportion whereas the cell contents proportion decreases (Bruinenberg et al., 2002). The %NDF values increased linearly 0.20% per day throughout the growth cycle of species. The CP percentage decreased linearly 0.16, 0.09 and 0.10% each day at the low, high and very high intensities, respectively. At the mean intensity, there was a 0.17% increase in the CP percentage until the 42nd day, when it started to decrease 0.002% per day. The variation of %CP apparently ingested by lambs had very close values among the different defoliation intensities, which indicated that the lambs were able to select forage with similar CP levels, even under different management practices.

The variation in the chemical composition of the forage as grazed by lambs over the evaluation dates showed correlation with changes in the ingestive behavior of female lambs. The preference for leaf blades and high quality nutritional compounds showed the selectivity of lambs that is partially represented by the correlations of the % CP and bite rate (r = 0.55, P<0.0001), bites/feeding station (r = 0.65, P<0.0001), feeding stations per minute (EST = 11.04-0.29CP; P<0.0001; R^2 = 0.46) and number of steps among feeding stations (r = 0.46, P = 0.0002).

The increased proportion of cell wall components was negatively correlated with bites apprehended at each feeding station (%NFD: r = -0.70; P<0.0001) and with bite rate (%NFD: r = -0.73; P<0.0001). A higher resistance to breaking while the herbage is harvested and the more difficult process of forage manipulation during feeding are caused by the increased fiber content of the grass (Minson, 1990). The quantity of time necessary for forage harvesting is the main factor influencing the intake in homogeneous pastures (Cosgrove, 1997). Displacement among feeding stations occurs when the forage availability per feed station is lower than the established forage availability of the grazing area (Palhano et al., 2002).

The bite rate (P<0.0001) and the number of bites per feeding station (P<0.0001) were different among evaluation dates, and these variables were positively correlated (r = 0.60; P<0.0001) (Figure 3).

The bite rate reached the lowest value on the 85th day while the number of bites/station decreased linearly over the pasture evaluation period. Bite rate changes in response to grazing conditions seemed to be a result of how the animals distribute chewing movements to gather, apprehend and chew forage (Cosgrove, 1997). Changes in the apprehension speed and decisions to maintain one or more bites at the same feeding station were linked mainly to sward structural changes and to the forage chemical composition as grazed as shown by the correlations presented above.

The number of steps among feeding stations at low (Y = 2.50-0.086x; P = 0.0046, r^2 = 0.31) and mean intensities (Y = 2.75-0.017x; P = 0.0010; r^2 = 0.61) decreased linearly over the grazing evaluation period. There was no fit to any regression model at the high and very high defoliation intensities, and the number of steps among stations was 1.6, 1.8, 1.7 and 1.4 steps at 1, 2, 3 and 4 dates, respectively. Reducing the number of steps among feeding stations may reflect the low bite mass or the difficulty of forage

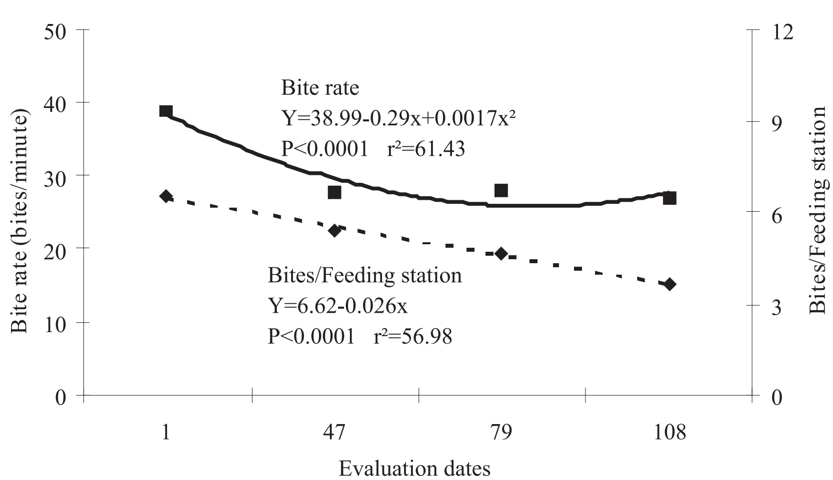

Figure 3 - Bite rate and number of bites/feeding station on Italian ryegrass plus red clover pasture when submitted to a range of defoliation intensities by lambs.

apprehension, because the grass was in the reproductive growth stage with a high NDF content at the end of pasture use, (Figure 2), which also increased the handling time of each bite (Minson, 1990).

The choice of feeding stations is related to the abundance and quality of available forage and plant species present in the vertical profile of the pasture (Palhano et al., 2006). The highest number of feeding stations per minute, with less time spent by lambs at the same station at the end of the pasture cycle (Table 4) occurred in response to the sward structure on this occasion (Table 3).

The displacement rate was different between the first and second evaluation date (P=0.0120), and the lowest value in the second evaluation (Table 4) coincided with the longest stay of lambs at the same feeding station, represented by the lower numeric value of feeding stations per minute. Between these dates, there was an increase of 54% in the pre-grazing forage mass and 69% in the canopy pre-grazing height, which may have promoted a greater opportunity for food selection in relation to the earlier date, increasing the length of stay at one feeding station.

Table 4 - Feeding station and displacement patterns by lambs on Italian ryegrass plus red clover pasture under different defoliation intensities

Variable	Evaluation dates			
	20 and 7/21/2007	8 and 9/9/2007	9 and 10/10/2007	7 and 11/8/2007
Feeding station per minute	6.1bc	5.2c	6.2b	7.5a
Displacement rate (steps per minute)	13.1a	10.1b	10.4ab	12.5ab

Means followed by different lower case letters on lines differ (P<0.05) by Tukey test.

Conclusion

The bite rate of lambs, on Italian ryegrass plus red clover mixture, under intermittent grazing, was modified in response to changes in sward structure promoted by defoliation intensities of pre-grazing sward height varying from 37 to 65%. The pasture cycle was more important than the range of defoliation intensities because of its influence on the displacement patterns and number of feeding stations visited by the lambs. The bite rate and the number of bites/feeding station were reduced by an increase in the proportion of stems, a decrease in the proportion of leaves combined, respectively, with increasing and decreasing contents of neutral detergent fiber and crude protein in forage as grazed.

References

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTRY - AOAC. **Official methods of analysis**. 16.ed. Arlington: AOAC International, 1995. 1025p.

BARBOSA, M.A.A.F. [2001]. **Ecologia em relação ao pastejo.** Disponível em: <http://www.tdnet.com.br/domicio/Ecolog.htm>. Acesso em: 25/5/2008.

BARTHRAM, G.T.; GRANT, S.A. Defoliation of ryegrass-dominated swards by sheep. **Grass and Forage Science**, v.39, p.211-219, 1984.

BRUINENBERG, M.H.; VALK, H.; KOREVAAR, H. et al. Factors affecting digestibility of temperate forages from seminatural grasslands: a review. **Grass and Forage Science**, v.57, p.292-301, 2002.

CARVALHO, P.C.F.; MORAES, A. Comportamento ingestivo de ruminantes: bases para o manejo sustentável do pasto. In: SIMPÓSIO SOBRE O MANEJO SUSTENTÁVEL DAS PASTAGENS, 2005, Maringá. **Anais...** Maringá, 2005. (CD-ROM).

CARVALHO, P.C.F.; POLI, C.H.E.C.; NABINGER, C. Comportamento ingestivo de bovinos em pastejo e sua relação com a estrutura da pastagem. In: PECUÁRIA 2000: A PECUÁRIA DE CORTE DO III MILÊNIO, 2000, Pirassununga. **Anais...** Pirassununga: UNESP, 2000. (CD-ROM).

CARVALHO, P.C.F.; PRACHE, S.; DAMASCENO, J.C. O processo de pastejo: desafios da procura e apreensão da forragem pelo herbívoro. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 36., 1999, Porto Alegre. **Anais...** Porto Alegre: Sociedade Brasileira de Zootecnia, 1999. p.253-268.

CONFORTIN, A.C.C; ROCHA, M.G.; QUADROS, F.L.F. et al. Características morfogênicas de azevém *Lolium multiflorum* Lam. sob diferentes intensidades de desfolha. In: CONGRESSO BRASILEIRO DE ZOOTECNIA, 17., Londrina. **Anais...** Londrina: ZOOTEC, 2007. (CD-ROM).

COOPER, J.P.; TAINTON, N.M. Light and temperature requirements for the growth of tropical and temperate grasses. **Herbage Abstracts**, v.38, p.167-176, 1968.

COSGROVE, G. Animal grazing behaviour and forage intake. In: INTERNATIONAL SYMPOSIUM OF ANIMAL PRODUCTION UNDER GRAZING, 1997, Viçosa, MG. **Anais...** Viçosa, MG: Universidade Federal de Viçosa, 1997. p.59-80.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. Centro Nacional de Pesquisa de Solos. **Sistema brasileiro de classificação de solos**. Brasília: EMBRAPA, 1999. 412p.

EUCLIDES, V.P.B.; MACEDO, M.C.M.; OLIVEIRA, M.P. Avaliação de diferentes métodos de amostragem sob pastejo. **Revista Brasileira de Zootecnia**, v.21, n.4, p.691-702, 1992.

GALLI, J.R.; CANGlIANO, C.A.; FERNÁNDEZ, H.H. Comportamiento ingestivo y consumo de bovinos en pastoreo. **Revista Argentina de Producción Animal**, v.16, n.2, p.119-142, 1996.

GLIENKE, C.L.; ROCHA, M.G.; CONFORTIN, A.C.C. et al. Comportamento ingestivo de cordeiras em pastagem consorciada de inverno sob diferentes intensidades de desfolha. **Revista Brasileira de Zootecnia**, v.37, n.11, p.1919-1927, 2008.

GRIFFITHS, W.M, HODGSON, J.; ARNOLD, G.C. The influence of sward canopy structure on foraging decisions by grazing cattle. I. Regulation of bite depth. **Grass and Forage Science**, v.58, p.125-137, 2003.

HANCOCK, J. Grazing behaviour of cattle. **Animal Breeding Abstracts**, v.21, n.1, p.1-13, 1953.

HODGSON, J. Ingestive behavior. In: LEAVER, J.D. (Ed.) **Herbage intake handbook**. British Grassland Society, Hurley, 1982. p.113.

HODGSON, J. **Grazing management**. Science into practice. England: Longman Scientific & Technical, 1990. 203p.

INSTITUTO NACIONAL DE METEREOLOGIA - INMET. Divisão de Observação Meteorológica. **Curso de atualização para observador meteorológico de superfície**. Porto Alegre, 2004. 57p.

JAMIESON, W.S.; HODGSON, J. The effect of daily herbage allowance and sward characteristics upon the ingestive behavior of calves under strip-grazing management. **Grass and Forage Science**, v.34, p.261-271, 1979.

LACA, E.A.; UNGAR, E.D.; SELIGMAN, N.G. et al. An integrated methodology for studying short-term grazing behaviour of cattle. **Grass and Forage Science**, v.47, p.81-90, 1992.

L'HUILLIER, P.J.; POPPI, D.P.; FRASER, T.J. Influence of structure and composition of ryegrass and prairie grass-white clover swards on the grazed horizon and diet harvested by sheep. **Grass and Forage Science**, v.41, p.259-267, 1986.

MANNETJE, L t'. Measuring biomass of grassland vegetation. In: MANNETJE, L.t'; JONES, R.M. (Eds.) **Field and laboratory methods for grassland and animal production research**. Cambridge: CABI, 2000. p.151-178.

MINSON, D.L. **Forage in ruminant nutrition**. San Diego: Academic Press, 1990. 483p.

MORENO, J.A. **Clima do Rio Grande do Sul**. Porto Alegre: Secretaria da Agricultura, 1961. 41p.

PALHANO, A.L.; CARVALHO, P.C.F.; DITTRICH, J.R. et al. Padrões de deslocamento e procura por forragem de novilhas leiteiras em pastagem de capim-mombaça. **Revista Brasileira de Zootecnia**, v.35, n.6, p.2253-2259, 2006.

PALHANO, A.L.; CARVALHO, P.C.F.; BARRETO, M.Z. Influência da estrutura da pastagem na geometria do bocado e nos processos de procura e manipulação da forragem. **Ciência e Cultura**, n.31, FACIAG 02, p.33-52, 2002.

PONTES, L.; CARVALHO, P.C.F.; NABINGER, C. et al. Fluxo de biomassa em pastagem de azevém anual (*Lolium multiflorum* Lam.) manejada em diferentes alturas. **Revista Brasileira de Zootecnia**, v.33, n.3, p.529-537, 2004.

ROCHA, M.G.; QUADROS, F.L.F.; GLIENKE, C.L. et al. Avaliação de espécies forrageiras de inverno na Depressão Central do Rio Grande do Sul. **Revista Brasileira de Zootecnia**, v.36, n.6, p.1990-1999, 2007.

ROMAN, J.; ROCHA, M.G.; PIRES, C.C. et al. Comportamento ingestivo e desempenho de ovinos em pastagem de azevém anual (*Lolium multiflorum* Lam.) com diferentes massas de forragem. **Revista Brasileira de Zootecnia**, v.36, n.4, p.780-788, 2007.

SILVEIRA, E.O. **Produção e comportamento ingestivo de cordeiros em pastagem de azevém anual (*Lolium multiflorum* Lam.) manejada em diferentes alturas**. Porto Alegre: Universidade Federal do Rio Grande do Sul, 2001. 250f. Dissertação (Mestrado em Zootecnia) - Universidade Federal do Rio Grande do Sul, Porto Alegre.

STATISTICAL ANALYSIS SYSTEM – SAS. **Statistical analysis system user's guide**. Version 8.2. Cary: SAS Institute, 2001. 943p.

STOBBS, T.H. The effect of plant structure on the intake of tropical pasture. II-Differences in sward, nutritive value and bite size of animals grazing *Setaria anceps* and *Chloris gaiana* at various stages of growth. **Australian Journal of Agricultural Research**, v.24, p.821-829, 1973.

VAN SOEST, P.J.; ROBERTSON, J.B.; LEWIS, B.A. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysacharides in relation to animal nutrition. **Journal of Dairy Science**, v.74, p.3583-3597, 1991.

VICKERY, P.J. Pasture growth under grazing. In: MORLEY, F.H.W. (Ed.) **Grazing animals**. World Animal Science, v.B-1. Amsterdam: Elsevier Science Publishers, 1981. p.55-77.