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Biomass flows and defoliation pattern of ryegrass grazed by supplemented heifers

Fluxos de biomassa e padrão de desfolhação de azevém pastejado por novilhas suplementadas

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Resumo

Para definir estrategicamente a melhor taxa de lotação para o azevém é importante conhecer em detalhe o processo de crescimento dessa forrageira. O estudo foi realizado para avaliar os fluxos de biomassa foliar, a intensidade e a frequência de desfolhação de azevém (*Lolium multiflorum* Lam), pastejado por bezerras exclusivamente em pastejo, ou em pastejo e recebendo grão de milho ou de aveia como suplemento. O delineamento experimental foi inteiramente casualizado com medidas repetidas no tempo, três sistemas alimentares e três repetições de área. Os fluxos (kg de MS de lâminas foliares ha^{-1} dia^{-1}) de crescimento (40,6), senescência (40,7) e consumo (29,7) foram similares nos diferentes sistemas alimentares. O consumo de lâminas foliares em relação ao peso corporal foi menor quando as bezerras receberam suplemento, independente do tipo de grão. Os sistemas alimentares testados não influenciaram nas eficiências real e potencial de utilização bem como no balanço liquido de utilização do azevém. O fluxo de consumo das laminas foliares 1,4 vezes mais baixo que o fluxo de crescimento ocasionou em eficiência real de utilização inferior a um (0,7) e o fluxo de senescência mais alto que o fluxo de crescimento das lâminas foliares gerou uma eficiência potencial de utilização negativa (-0,2). As lâminas foliares foram desfolhadas com intensidade similar (54,4%) nos diferentes sistemas alimentares. A frequência de desfolhação do azevém aumentou quando as bezerras foram suplementadas. O aumento de 29,2% na taxa de lotação ocasionado pelo uso do grão de milho ou do grão de aveia como suplemento não alterou a dinâmica dos fluxos de biomassa do azevém, porém reduziu o consumo de lâminas foliares em relação ao peso corporal das bezerras e ocasionou alterações na frequência de desfolhação do azevém.
Palavras-chave: Balanço liquido. Consumo de lâminas foliares. Eficiência potencial de utilização. Grão de aveia. Grão de milho.

Abstract

To strategically define the best stocking rate management strategy for ryegrass, it is important to know the growth process of forage plants in detail. The study was conducted to analyze the leaf biomass flows and the defoliation intensity and frequency of Italian ryegrass (*Lolium multiflorum* Lam) grazed by heifers fed exclusively on pasture or on pasture and supplemented with corn or white oat grain. The

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experimental design was completely randomized following a repeated measures arrangement with three feeding systems and three area replications. Biomass flows (kg DM leaf blades ha^{1} day^{1}) for leaf growth (40.6), leaf senescence (40.7), and leaf intake (29.7) were similar in the different feeding systems. Leaf blade intake adjusted to body weight was lower in supplemented heifers regardless of grain type. Actual and potential utilization efficiencies and ryegrass biomass net balance were not affected by feeding system. The leaf intake flow was 1.4 times lower than the growth flow, resulting in an actual utilization efficiency less than one (0.7), whereas the senescence flow was higher than the growth flow, resulting in a negative potential utilization efficiency (0.2). Leaf defoliation intensity was similar (54.4%) across feeding systems and defoliation frequency was higher in supplemented heifers. The 29.2% increase in stocking rate of heifers fed corn or oat grain as supplement did not affect the dynamics of ryegrass biomass flows, but reduced leaf blade intake adjusted to heifer body weight leading to alterations in the defoliation frequency of ryegrass pasture.

Key words: Corn grain. Leaf blade intake. Net balance. Oat grain. Potential utilization efficiency.

Introduction

Providing supplements to grazing animals may result in either positive or negative associative effects between forage and supplement, as a result of digestive and metabolic interactions modifying the energy intake by the animal, due to changes in intake and/or digestibility of fibrous components of forage (DIXON; STOCKDALE, 1999). The higher the level of supplement received by the animal, the lower the content of neutral detergent fiber in the forage it consumes, indicating changes in selectivity. Animals receiving supplements may also reduce grazing time compared to non-supplemented animals (BREMM et al., 2005), hence reducing forage intake, with possible changes in the balance of grass biomass flows.

In a pastoral ecosystem, the goal of management is to achieve a balance between forage growth and its use and conversion into animal product. The canopy structure is a key determinant of the forage intake process defined by the intensity and frequency of defoliation on forage plants. The intensity of leaf defoliation determines the amount of remaining leaf area in the canopy and thus the time required for the plant to recover (MACHADO et al., 2013). Reducing leaf area affects tillering, the growth of new roots and leaves, and the levels of reserve carbohydrates. In addition, the environment in the canopy is affected, the penetration of light, temperature and soil moisture are modified, affecting forage growth (ZANINE; VIEIRA, 2006).

The morphogenesis of Italian ryegrass (*Lolium multiflorum* Lam.) has been extensively studied due to its importance for livestock production systems in southern Brazil (CONFORTIN et al., 2010, 2013; QUADROS; BANDINELLI, 2005), and studies on biomass flows have been performed for both tropical (CUTRIM JUNIOR et al., 2013; LOPES et al., 2013) and temperate species such as ryegrass (CAUDURO et al., 2007; CONFORTIN et al., 2009; PONTES et al., 2004). However, no studies have been published on the flows of leaf biomass at high stocking rates as a result of intake of different supplements by cattle. To strategically define the best stocking rate management strategy for ryegrass, it is important to know the growth process of forage plants in detail. This information about biomass turnover can be used for planning forage management strategies to ensure productivity and sustainability to the ecosystem.

This study aimed to quantify the flows of leaf blade biomass and the intensity and frequency of defoliation of ryegrass grazed by beef heifers fed exclusively on pasture or receiving corn or oat grain as supplement.

Materials and Methods

The study was conducted from July to November 2012 at Universidade Federal de Santa

Maria, located in the Central Depression of the state of Rio Grande do Sul, southern Brazil. The climate is humid subtropical according to the Köppen classification and the soil in the study area is classified as Paleudalf (EMBRAPA, 2006). The experimental site had an area of 7.2 ha, subdivided into nine paddocks. The ryegrass pasture (*Lolium multiflorum* Lam.) was established on May 2012. Fertilization consisted of 200 kg ha^{-1} of the 05-20-20 NPK formula. Urea was applied twice as top dressing (06/21 and 07/14/2012) at a rate of 78 kg ha^{-1} nitrogen.

This study evaluated the biomass flows and the intensity and frequency of ryegrass defoliation by beef heifers fed exclusively on ryegrass pasture (ryegrass) or on pasture supplemented with either 0.93% body weight (BW) of corn grain (corn: 91.4% dry matter [DM]; 9.9% crude protein [CP]; and 21.7% of neutral detergent fiber [NDF] or with white oat grain (oat: 91.5% DM, 13.8% CP, and 31.1% NDF). The supplements were offered from Monday through Saturday at 14h00. The grazing method was continuous with a variable number of animals, maintaining forage mass between 1,500 and 2,000 kg DM per hectare. The stocking rate was adjusted according to Heringer and Carvalho (2002). The evaluation periods were from July 9 to July 30, from July 31 to August 28, from August 29 to September 26, and from September 27 to October 17. The experimental animals were Angus heifers with an initial age of eight months and initial weight of 168.6 ± 5 kg. Three test animals were used per experimental unit.

Forage mass (kg DM ha^{-1}) was determined by visual estimation technique with double sampling. The forage from cuttings was homogenized for manual separation of structural components. After sorting and drying in a forced air circulation oven at 55 °C for 72 h, the proportion of leaf blades, stems, inflorescences, and dead material was determined, in kg DM, and the leaf blade:stem ratio was calculated. The stocking rate (kg BW ha^{-1}) was calculated by adding the average weight of the test animals to the average weight of each regulator animal multiplied by the number of days that it remained on the paddock divided by the number of experimental days. The daily forage accumulation rate (kg DM ha^{-1} day^{-1}) was determined in three grazing exclusion cages per experimental unit. The forage allowance (FA, in kg DM 100 kg^{-1} BW) was calculated by the equation FA = {[(forage mass/days of the period) + accumulation rate]/stocking rate}*100 (SOLLENBERGER et al., 2005). Leaf blade allowance (kg DM 100 kg^{-1} BW) was calculated by multiplying the forage allowance by the percentage of leaf blades in forage mass.

Morphogenetic and structural characteristics were evaluated in 40 randomly selected tillers per experimental unit. Twice weekly, the size of fully expanded, expanding, and senescent leaf blades, canopy height, and the height of pseudostem were measured in cm. Every 28 days, a new group of tillers was selected for evaluation. From these measurements, the following variables were calculated: leaf appearance rate (LAR; degree-days), leaf expansion rate (LER; cm^{-1} degree-$days^{-1}$ $tiller^{-1}$), leaf senescence rate (LSR; cm^{-1} degree-$days^{-1}$ $tiller^{-1}$), phyllochron (degree-days), and number of fully expanded and expanding leaf blades (LEMAIRE; CHAPMAN, 1996). Upon defoliation, the leaf blades were marked with a marker pen to identify new grazing. Evaluations were conducted until at least 50% of the tillers had started flowering (10/17/2012).

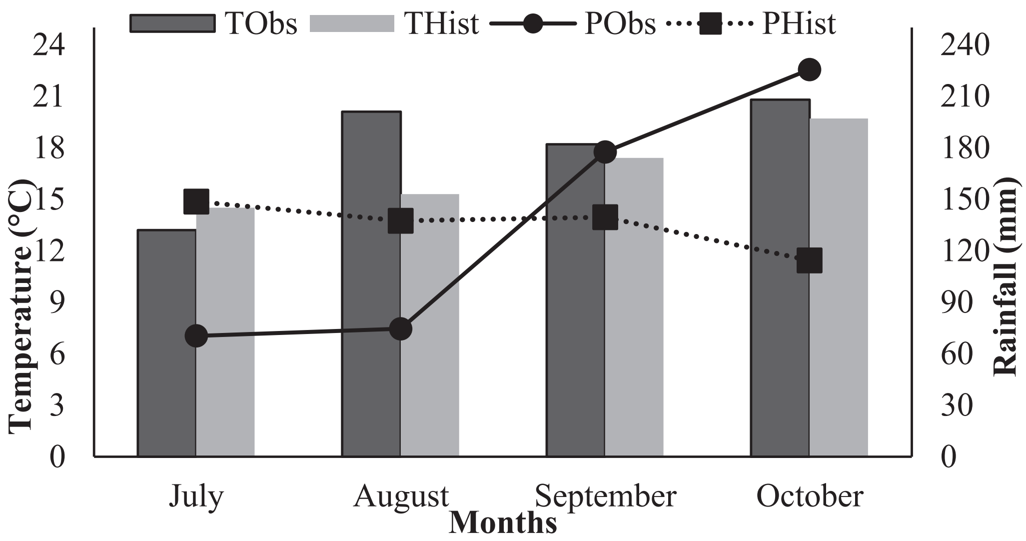
Defoliated leaf blades were identified in all morphogenesis measures to determine the intensity and frequency of defoliation of fully expanded and expanding leaves. The intensity of defoliation (ID; % removed from the leaf blade) was estimated as: ID = [(initial length - final length)/initial length]. The frequency of defoliation (FD; days to return to the same leaf) was obtained by the equation: FD = number of touches/(number of possible touches × number of days). To calculate the percentage of the area grazed daily by heifers, one hectare was considered as 100% of the grazing area. The result obtained by dividing the area by defoliation frequency was divided by the number of animals per hectare for the calculation of the area grazed daily per each animal. To calculate the number of defoliations prior to leaf senescence, the leaf lifespan was divided by the thermal accumulation between defoliations. To calculate the new leaf portion available before the next defoliation, the thermal accumulation between defoliations was divided by the phyllochron value. Ryegrass growth (FGro), intake (FInt), and senescence (FSen) flows were determined according to the methodology described by Pontes et al. (2004). The actual forage utilization efficiency (FUE) was calculated as FUE = FInt/FGro (LOUAULT et al., 1997) and the potential utilization efficiency (PUE) was estimated as PUE = 1 - (FSen/FGro). The equation NB = [FGro - (FSen + FGro)] (PONTES et al., 2004) was used to determine the net balance (NB) between leaf tissue flows. To determine leaf blade intake (% BW), the average intake flow was multiplied by 100 and divided by the stocking rate.

The experimental design was completely randomized following a repeated measures arrangement with three feeding systems and three area replications. To compare the feeding systems, the variables with normal distribution were evaluated considering the fixed effects of feeding system and evaluation period and their interactions and the random effects of residuals and paddocks nested within feeding systems using the MIXED procedure of SAS 8.2 software. The structure selection test was performed using the Bayesian information criterion (BIC). Whenever significant differences were found, mean values between feeding systems and evaluation periods were compared using the lsmeans option. The interaction between feeding systems and evaluation periods was broken down, when significant at 10% probability, and the responses of the variables in terms of days of grazing were modeled using up to third order polynomial function. In the regression analysis, models were selected according to the significance of the linear and quadratic coefficients using the Student's t-test. The variables were also analyzed using Pearson correlation analysis. The variable potential utilization efficiency of pasture was arcsine transformed.

Results and Discussion

Meteorological data for the months of July, September, and October show that the average temperature (17.4 °C) was similar to the historical average for the period. In August, the temperature observed was 23.9% higher than the historical average (15.3 °C, Figure 1). The average rainfall for July and August was 72.4 mm and 1.97 times lower than the historical average for the same period (Figure 1). The months of September and October were the wettest with rainfall 21.4 and 49.3% above historical averages, which are 139.5 and 114.3 mm, respectively (Figure 1).

Figure 1. Observed (Obs) and historical (Hist) averages for temperature (T) and rainfall (P) in the study site.



Maintaining forage mass within the intended range resulted in similar leaf blade allowance, leaf:stem ratio, canopy height, pseudostem height, leaf depth, and number of fully expanded and expanding leaves for paddocks of heifers managed under different feeding systems (P>0.10; Table 1). The similar canopy structure (Table 1) led to similar leaf appearance and leaf expansion rates (P>0.10; Table 1) among the feeding systems. This was expected, as these morphogenic characteristics are not affected by the use of supplements, but rather are genetically determined and affected by management and environmental factors like temperature, light intensity, and availability of water and nutrients, especially nitrogen (POMPEU et al., 2009).

There was no interaction between feeding systems × evaluation periods for variables: flows of growth, senescence and intake, actual and potential utilization efficiency of forage, net balance and intake of leaf blades adjusted to body weight of heifers (Table 2). The similar canopy structure among the different feeding systems paddocks (Table 1) also resulted in similar flows (kg DM leaf blades ha^{-1} day^{-1}) for leaf growth (40.6 ± 5.8), leaf senescence (40.7 ± 4.7), and leaf intake (29.7 ± 2.7) across feeding systems (Table 2). The similarity in the intake flow of leaf blades was due to the balance between leaf blade intake in % BW and stocking rate. The stocking rate was 29.2% higher (P<0.10) for heifers fed corn or oat grain compared with heifers fed exclusively on pasture (1434.6 kg BW ha^{-1} vs 1111.8 kg BW ha^{-1}), whereas the estimated leaf blade intake (1.9% BW) was 29.6% lower (P<0.10) in heifers receiving supplement compared with heifers fed exclusively on pasture (2.7% BW) (Table 2). The reduced intake of leaf blades in heifers fed supplement indicates a shift in dry matter intake, which occurs when animals receiving supplement reject a significant amount of the forage available. This behavior is probably due to the fact that, for these animals, the point of satiation may have been chemically signaled by metabolites in the bloodstream such as leptin, which seems to be associated with appetite control in ruminants (ROCHE et al., 2008), causing supplemented heifers to reduce forage intake.

Table 1. Structure and morphogenesis of ryegrass grazed by heifers managed in different feeding systems.

Variable	Ryegrass	Corn	Oat	P[1]	P[2]	CV[3]
Forage mass[4]	1761	1926	1946	0.6402	0.9217	7.8
Leaf blade allowance[5]	4.4	3.5	4.0	0.1316	0.1079	7.0
Leaf:stem ratio	1.8	1.5	2.1	0.3243	0.2107	14.5
Canopy height[6]	14.6	13.8	13.9	0.7678	0.3501	5.7
Pseudostem height[6]	7.3	6.7	6.3	0.2768	0.4972	6.3
Leaf depth[6]	7.2	7.2	7.8	0.8664	0.5985	11.9
Fully expanded leaves	2.9	2.9	2.9	0.9640	0.2966	2.2
Expanding leaves	1.3	1.3	1.3	0.8347	0.7436	1.6
Leaf appearance[7]	0.007	0.008	0.008	0.2090	0.9712	4.0
Leaf expansion[8]	0.062	0.062	0.061	0.9734	0.1415	6.4

Ryegrass = beef heifers fed exclusively on ryegrass (*Lolium multiflorum* Lam.) pasture; Corn = beef heifers fed on ryegrass pasture and supplemented with 0.93 BW of whole grain corn; Oat = beef heifers fed on ryegrass pasture and supplemented with 0.93 BW of white oat grain; [1]Feeding system; [2]Interaction between feeding system × period; [3]Coefficient of variation (%); [4]kg DM ha^{-1}; [5]% BW; [6]cm; [7]degree-days; and [8]cm degree-days $tiller^{-1}$.

Table 2. Mean values for biomass flows, utilization efficiency, net balance, and leaf blade intake for heifers managed in different feeding systems.

Variable	Ryegrass	Corn	Oat	P[1]	P[2]	CV[3]
Growth flow[4]	40.7	45.1	35.9	0.5711	0.2272	14.2
Senescence flow[4]	45.4	43.7	32.9	0.2066	0.7646	11.5
Intake flow[4]	30.0	31.2	28.0	0.7169	0.1686	8.9
Potential utilization efficiency[5]	-0.22	-0.24	-0.08	0.6289	0.8886	28.2
Actual utilization efficiency[5]	0.8	0.8	0.7	0.7743	0.5040	8.9
Net balance[5]	-34.7	-29.6	-24.7	0.2413	0.9004	12.6
Leaf blade intake[5]	2.6a	2.2ab	1.9b	0.0827	0.7662	8

Ryegrass = beef heifers fed exclusively on ryegrass (*Lolium multiflorum* Lam.) pasture; Corn = beef heifers fed on ryegrass pasture and supplemented with 0.93 BW of whole grain corn; Oat = beef heifers fed on ryegrass pasture and supplemented with 0.93 BW of white oat grain; [1]Feeding system; [2]Interaction between feeding system × period; [3]Coefficient of variation (%); [4]kg DM leaf blades ha^{-1} day^{-1}; and [5]% BW.

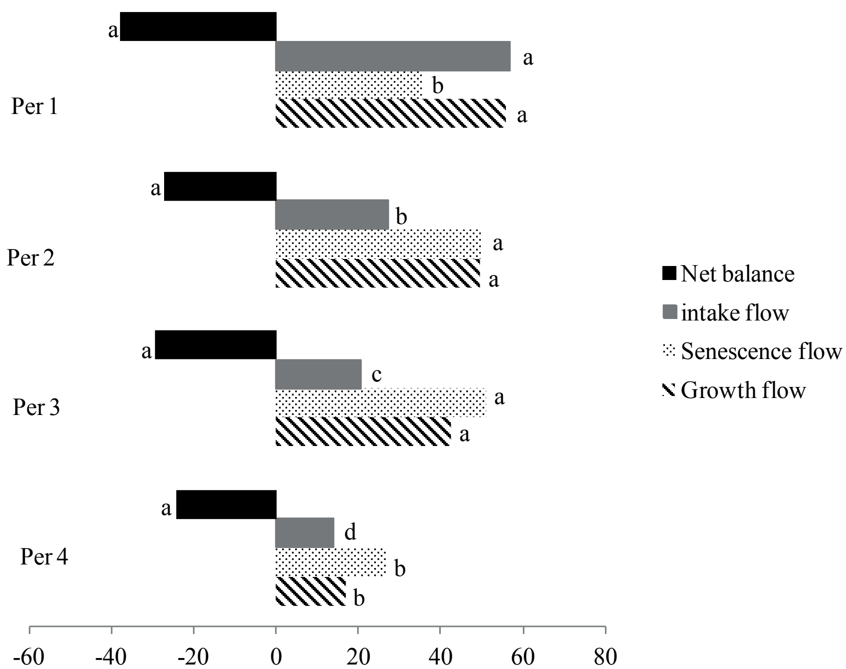
The leaf growth flow was 65.8% lower (P<0.10) in the fourth evaluation period (16.8 kg DM leaf blades ha^{-1} day^{-1}, Figure 2) compared with the first three periods, on average 49.2 kg DM leaf blades ha^{-1} day^{-1}. This reduction in leaf growth flow can be explained by the decrease in the number of green leaves with the advance of the phenological cycle, from 4.4 in the first three periods to 3.6 in the fourth period (P<0.10), as leaves are responsible for capturing incident light and transforming it into photoassimilates that promote plant growth. As for the senescence flow, it was, on average, 31.1 kg DM leaf blades ha^{-1} day^{-1}, 38% lower (P<0.10) for periods one and four than for periods two and three, when the senescence flow values averaged 50.2 kg DM leaf blades ha^{-1} day^{-1} (Figure 2). Leaf senescence processes had not yet started in the first period, during initial tiller growth, and the lifespan of leaf blades determined the maximum number of green leaves in a tiller (LEMAIRE; AGNUSDEI, 2000). As the average lifespan of ryegrass leaves during the first utilization period was 526.3 degree-days and, in that same period, the cumulative thermal sum was 156.6 °C, the first leaf blades only began senescing during the second evaluation period. The lowest senescence flow recorded in the fourth period may be explained by the 84.8% reduction in leaf:stem ratio (P<0.10), from 3.2 in the first period to 0.5 in the fourth period, which allowed more light to reach the lower layers of the canopy, thus reducing leaf senescence.

Leaf intake flow showed a negative linear relationship with evaluation periods ($\hat{Y} = 59.4413 - 0.4957x$; P <0.0001, $r^2 = 0.68$). According to Roman et al. (2007), stems represent a structural barrier to grazing. Thus, the negative linear behavior observed for leaf:stem ratio ($\hat{Y} = 3.9863 - 0.0313x$; P <0.0001, $r^2 = 0.55$) may not only have increased the resistance to grazing, but also resulted in smaller bite size, negatively affecting forage intake by heifers.

There was no interaction between feeding system × evaluation period for the following variables: leaf growth, senescence, and intake flows, actual and potential utilization efficiency of forage, net balance, and leaf blade intake adjusted to body weight of heifers (Table 2).

The balance of ryegrass biomass flows (29.7 kg DM ha^{-1} day^{-1}) was similar (P>0.10) and negative across feeding systems (Table 2) and periods (Figure 2). The negative balance was due to the growth flow, which was on average 42% lower than the sum of intake and senescence flows for the three feeding systems. Similar leaf growth flow (40.6 kg DM leaf blades ha^{-1} day^{-1}) and leaf senescence flow (40.7 kg DM leaf blades ha^{-1} day^{-1}) values indicate that the intake flow was the main factor responsible for the negative balance. Under negative balance conditions, pseudostems comprise a large part of the consumed forage; in the current study, their contribution to canopy height was approximately 48% (Table 1). Actual and potential forage utilization efficiencies were similar (P>0.10) between feeding systems (Table 2). The actual utilization efficiency was below unit (0.7) in all feeding systems (P>0.10), and the leaf intake flow was 1. fold lower than the growth flow. The potential utilization efficiency was negative (-0.2 on average) because the senescence flow was higher than the growth flow.

Figure 2. Ryegrass biomass flows (kg DM leaf blades ha^{-1} day^{-1}) and net balance in different evaluation periods (Per). Different letters on the side of each bar indicate significant difference among the bars (P<0.10).



Actual and potential forage utilization efficiencies varied along the evaluation periods (P<0.10). In the first and last periods (mean value = 1.0), actual FUE was significantly higher (P<0.10) than in the second and third evaluation periods (mean value = 0.5). This may be because intake flows (24 kg DM leaf blades ha^{-1} day^{-1}) were lower than growth flows (45.9 kg DM leaf blades ha^{-1} day^{-1}) in the second and third evaluation periods, and actual forage utilization efficiency values represent the relationship between leaf production and leaf intake. Thus, an actual utilization efficiency of 1.0, as observed in the initial and final evaluation periods of this study, denotes that the heifers consumed the entire leaf tissue produced. This is undesirable, for proper management should maintain some leaf area for regrowth. For potential utilization efficiency, values were positive in the first three periods, averaging 0.02, and negative (P<0.10) in the fourth period (-0.73). Consistent with this, growth flow in the fourth evaluation period (16.8 kg DM leaf blades ha^{-1} day^{-1}) was 65.8% lower than in the three previous periods (49.2 kg DM leaf blades ha^{-1} day^{-1} on average).

No interaction was found between feeding systems × utilization periods for intensity of defoliation of fully expanded and expanding leaves (P>0.10). The use of different feeding systems promoted no changes (P>0.10) in defoliation intensity, which was 54.4% for both fully expanded and expanding leaves, which can be explained by the similarity in canopy height, pseudostem height, leaf:stem ratio, and leaf depth across feeding systems (Table 1). These results are consistent with a report by Lemaire et al. (2009) that the proportion of leaf length removed varies between 50 and 55% in tropical and temperate pastures. The similarity in the canopy height, pseudostem height, leaf: stem ratio, leaf depth in the different feeding systems (Table 1) were the factors determining the similar defoliation intensity found.

Significant interaction was observed for feeding systems × evaluation periods for the defoliation frequency of fully expanded leaves (P<0.10). The same quadratic regression model (P<0.10) fitted this variable over the evaluation periods for heifers supplemented with either corn or oat grain ($\hat{Y} = 9.7168 - 0.1228x + 0.0014x^2$; P = 0.0008; $r^2 = 0.72$). The shortest time for animals to return to grazing on fully expanded leaves was seven days, observed on the 44th evaluation day, in the second utilization period of ryegrass pasture. In this period, the number of expanded leaves was 2.9, 9.4% smaller (P<0.10) than the number of expanded leaves observed in the first period (3.2). In addition, the stocking rate for supplemented heifers in the second evaluation period (1681.1 kg BW ha^{-1}) was higher (P<0.10) than the stocking rate for heifers fed exclusively on pasture in the same period (1200 kg BW ha^{-1}). Because defoliation frequency can change with the number of leaves per tiller and with the stocking rate (MACHADO et al., 2013), the combination of these factors explains the more rapid return of heifers to expanded ryegrass leaf blades observed in the second utilization period , when heifers were given corn or oat grain as a supplement. The defoliation frequency of fully expanded leaves for heifers fed exclusively on pasture averaged 8.3 ± 0.2 days, and could not be fitted to any regression model. Even though a decreasing linear model ($\hat{Y} = 3.4013 - 0.0081x$; P = 0.0035; $r^2 = 0.59$) was fitted to the number of expanded leaves during the grazing period, the defoliation frequency was not altered. This result is probably due to the concomitant change in stocking rate across evaluation periods, to which a decreasing linear model was also fitted ($\hat{Y} = 1353.5667 - 3.4531x$; P = 0.0265; $r^2 = 0.40$).

There was no interaction (P>0.10) between feeding system × utilization period for the defoliation frequency of expanding leaf blades, which averaged 5.07 days for heifers to return to the same leaf and was similar between feeding systems (P>0.10). The defoliation frequency of expanding leaves increased linearly with time ($\hat{Y} = 3.4740 + 0.0258x$, P <0.0001, $r^2 = 0.53$), which is explained by changes in canopy structure such as reduced leaf:stem ratio and internode elongation with ryegrass development. Leaf:stem ratio decreased 84% (P<0.10) from the first (3.2) to the fourth (0.5) evaluation period, whereas pseudostem height remained unchanged (6.8 cm; P>0.10) with ryegrass development. In this situation, leaf blades were more dispersed in the pseudostem of tillers, which may have hindered their selection and grasping by heifers (CONFORTIN et al., 2010). Thus, the animals may have modified their grazing behavior by reducing bite size and increasing defoliation frequency to maintain similar forage intake.

Considering the 8.3 day-interval between defoliations for animals fed exclusively on pasture and the seven day-interval for animals fed with supplements, heifers grazed an area equivalent to 12.1 and 14.3% of a hectare per day, respectively. Thus, heifers fed exclusively on ryegrass grazed an area of 232.7 m² per day, whereas those receiving corn or oat grain as a supplement grazed an area of 213.4 m² per day. Considering that the leaf lifespan was 662.4 degree-days and the thermal accumulation observed between defoliations was 148.3 degree-days for heifers fed exclusively on pasture and 125 degree-days for heifers fed with supplement, each leaf blade was grazed 4.5 and 5.3 times during its lifespan, respectively. Moreover, because the phyllochron was 161 degree-days, the thermal accumulation between defoliation intervals for heifers fed exclusively on pasture was sufficient for the emergence of 92% of a new leaf blade before the next defoliation event. In the supplemented feeding systems, thermal accumulation led to the emergence of 78% of a new leaf blade before the next defoliation.

Conclusions

Supplementing beef heifers with whole grain corn or white oat grain decreased ryegrass intake adjusted to body weight but, combined with a higher stocking rate, did not affect leaf biomass flows and actual and potential forage utilization efficiency. Furthermore, using corn or oat grain as a supplement to ryegrass pasture did not affect defoliation intensity, although it did affect ryegrass defoliation frequency.

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