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**Research Article**

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# Pattern of forage ingestion of sheep in native field with access to summer legume

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**Abstract:** The objective of this work was to evaluate the effect of access to perennial peanut (*Arachis pintoi*) pasture on patterns of forage intake and rumination of sheep in native field. The treatments were exclusive grazing in native field (NF) and grazing in native field with free access to perennial peanut pasture (NF+PP), using four test animals for each area, with offer adjusted to 12% of body weight. Rumination, grazing, and idle time were evaluated, beyond to forage ingestion and forage mericic chewing rates. Grazing time during the diurnal period did not have significant differences between the treatments, but a shorter grazing time was observed during the morning when the animals had access to perennial peanut. Grazing and rumination times were negatively correlated with idle time. In the NF+PP treatment, the animals dedicated 18.00% of the daytime period to rumination, while in the NF treatment it was 26.25% of the daytime. With access to forage legumes, there was a decrease in grazing time and an increase in the rumination time of sheep compared to animals kept exclusively in native fields with the same forage allowance. Animals kept in native field and native field with free access to perennial peanut have similar grazing times throughout the day, but with differences between shifts. The animals show preference for perennial peanut, grazing most of time in this area. The longer grazing time on forage peanuts reduces the rumination time of sheep.

**Key words**: ingestive behavior; natural pasture; perennial peanut; rumination; sheep breeding.

## Introduction

The native grassland of the Pampa Biome is an important forage source for grazing animals. It is often used as a food source in ruminant farming systems. The productivity of native grasslands varies throughout the year, with highest forage production occurring in the spring and normally overgrazed in periods of low forage production such as winter (Jaurena et al, 2021). Thus, nutritional and productivity of native field throughout the year are not enough for grazing animals to express their full productive potential.

Diversification of forages in pastoral systems is one of exploration alternatives to compensate for productive and nutritional deficit that natural pastures present at some seasons of the year. The introduction of tropical legumes that fix nitrogen in soil and produce forage with high levels of protein and low levels of fiber provide animals with a higher quality diet. Systems in which animals have access to pasture areas with better quality allow selection of diet of greater nutritional value, affecting ingestive behavior of animals. In these cases, use of legumes guarantees greater supply of protein in the diet ingested by the animals (Alonzo et al., 2017, Nunes et al., 2020).

Animal performance is dependent on forage intake which, in turn, is influenced by consumption patterns. In heterogeneous pastures such a native grassland, animals change the mechanisms of forage harvest and ingestion, keeping nutrient supply constant (Bonnet et al., 2015), and similar behavior may occur when animals have access to better quality pasture. In turn, pastures with higher fiber content cause the animal to reduce forage consumption (Glienke et al., 2016). When it is possible for the animal to select a better diet quality, changes occur in patterns of ingestion and rumination of grazing animals.

Little is known about the management and use of species such as *Arachis pintoi*, especially about grazing management in systems where animals' food base is native grassland. To combine pasture management with the needs of grazing animals, it is necessary to know the behavior of animals in this breeding system. Therefore, the study was designed to determine forage intake patterns and verify the forage preferences of animals when there is no limitation in access to forage with greater nutritional value. The hypothesis is that when forage peanuts are included in grazing systems based on native grassland, there are changes in the consumption patterns of the animals so that there is a self-regulation of forage intake, with a reduction in grazing and rumination time and consequently increasing the idle time. In this sense, the objective of this work was to evaluate the effect of free access to forage peanut (*Arachis pintoi*) pasture on forage intake and rumination patterns of sheep in native grassland.

## Material and methods

*location and climate*

The work was carried out in January and February 2018, at Centro Agropecuário da Palma/UFPel, km 535 from BR 116, located in the municipality of Capão do Leão, RS, Brazil, at 31º 52' 00" South and 52º 21' 24" West, 13.24 m altitude, South Coast physiographic region. The soil of the experimental area is classified as eutrophic Red-Yellow Podzolic (Cunha and Silveira, 1996). The climate in the region is of the Cfa type (humid temperate climate with hot summer), according to the Köeppen classification (MOTA, 1953). The experiment area consisted of a native field characterized as a representative natural pasture of the region and a contiguous area of forage peanut pasture cv. Amarillo, both fertilized in coverage with 150 kg/ha of DAP (Diamonium phosphate: 18-46-00) in November 2017, remaining deferred until the beginning of the experiment. The two pastures had shelter from sun for animals.

*Treatments*

The treatments were exclusive grazing in native field (NF) and grazing in native field with free access to perennial peanut pasture (NF+PP). The grazing utilization method was continuous grazing with variable animal load. Four 18-month-old test sheep were used per treatment, with a predominance of Corriedale blood, which remained in the experimental area throughout the period and a variable number of regulators to adjust the animal load. The forage allowance was fixed at 12 kg of DM per 100 kg of body weight.

*Assessments*

Pasture evaluations were carried out regarding forage mass, height and contents of crude protein, neutral detergent fiber, acid detergent fiber, acid detergent lignin and mineral matter (Table 1).

**Table 1:** Height, forage mass (FM) and bromatological characteristics of native grassland (CN) and forage peanut (AF) in treatments CN+AF and CN.

| Treatments | Area | Height (cm) | FM (Kg/ha) | CP (%) | NDF (%) | ADF (%) | ADL (%) | MM (%) |
|---|---|---|---|---|---|---|---|---|
| NF | MF | 9.8 | 1609.4 | 9.9 | 47.9 | 37.1 | 8.1 | 5.6 |
| NF+PP | NF | 9.9 | 1620.7 | 8.5 | 48.1 | 36.8 | 8.2 | 5.7 |
| | PP | 14.7 | 2918.0 | 16.1 | 42.1 | 28.7 | 6.6 | 6.3 |

FM = Forage mass; CP = Crude Protein; NDF = Neutral Detergent Fiber; ADF = Acid detergent fiber; ADL= Lignin in acid detergent; MM = Mineral Matter.

For evaluation of animals, weighing was carried out at the beginning and at the end of experiment to determine the average daily gain. Furthermore, evaluations of the ingestive behavior of these animals were carried out. These evaluations were carried out at 16 (24/01), 18 (26/01) and 42 (20/02) days after the beginning of grazing, from sunrise to sunset, directly with data collection every 10 minutes, as described by Jamieson and Hodgson (1979), visually verifying the animals' instantaneous activity. The activities are described as: Grazing - time spent by animal in selecting and holding forage, with its head down, holding food; Rumination - identified as end of grazing and chewing movements without forage ingestion; Idle - time in which the animal remains at rest, without apparent activity, without rumination or ingestion.

To assess the bite rate and mericic chewing, the focal method was used. Grazing and rumination sessions, of approximately 4 minutes, were filmed at close range. The bite rate was recorded through time taken to perform 20 bites (HODGSON, 1982). To determine the number of bites given during the day, the bite rate found was multiplied by the grazing time of each animal. The mericic chewing of each animal was also evaluated, with time to chew and swallow a bolus, in addition to number of chewing movements to swallow each ruminal bolus. To determine the number of mericic chews throughout the day, the value found of number of mericic chews per ruminal bolus was multiplied by total rumination time throughout the day of each animal. The number of ruminal bolus was determined by dividing the daily rumination time by the chewing and swallowing time of each ruminal bouillon.

All observations were carried out with the precaution of not interfering with the environment and the natural behavior of the sheep, avoiding approaches that reached the animals' escape zone, as well as abrupt movements.

*Statistical analysis*

Data analysis was performed using the mixed model procedure (PROC MIXED), where treatments were considered as a fixed effect and the evaluation dates as a random effect, following the following model Yijk = μ + αi + βj + +eijk, where: Yijk is the animal's response about treatment i on date j in repetition k; μ is the overall mean; αi is the fixed effect of treatment i; βj is the random effect of date j; eijk is the error associated with handling i, on date j and repetition k. Pearson's correlation coefficients were also estimated (Steel et al. 1997) between continuous variables of ingestive behavior (Rumination, Grazing and idle) at a significance level of 95%.

**Results**

*Pasture characteristics*

The native field had similar productive and nutritional characteristics in both grazing areas (native field with and without access to perennial peanuts). Perennial peanut had a better nutritional composition and, as it is a legume in extreme cultivation, it has a higher crude protein content (Table 1). In addition, perennial peanuts presented greater canopy height.

*Animal performance*

Sheep initial body weights were similar between treatments (Table 2). However, there was a difference in the final weight of sheep, in which the animals that had free access to perennial peanut had higher final weight in the period. Thus, the ADG of the NF+PP treatment was 139 grams, which resulted in a higher final weight (P=0.0094). In turn, when the animals were kept exclusively in the native field, the ADG showed a negative value, but without significantly changing the final body weight of the animals (P=0.4163).

**Table 2:** Initial and final body weights and average daily gain (ADG) of sheep in treatments NF + PP and NF.

| | NF + PP | NF | P |
|---|---|---|---|
| Initial body weight | 35.8 ± 2.7 | 38.7 ± 2.9 | 0.4804 |
| Final body weight | 44.1 ± 3.7 | 37.0 ± 2.0 | 0.0117 |

| | | | |
|---|---|---|---|
| P | 0.0094 | 0.4163 | - |
| ADG | 0.139 ± 0.04 | -0.028 ± 0.03 | 0.0051 |

*Grazing time*

The total grazing time did not differ between treatments (P = 0.2165), with mean times of 492.5 minutes (8:18 h) and 556.5 minutes (9:16 h), respectively for the CN treatments + AF and CN (Figure 1). During the morning, the longest grazing time was observed in collective animals in native field (P = 0.0359), not indicating a difference between treatments in the afternoon shift (P = 0.2449). The animals with access to perennial peanut grazed for a longer time in the afternoon (P=0.0002), with grazing times of 201.5 minutes in the morning and 291.2 minutes in the afternoon. Those kept exclusively in native field, distributed grazing time more evenly throughout the day (P=0.6801), with grazing time of 272.7 minutes in the morning and 283.25 minutes in the afternoon. A longer grazing time on forage peanut was observed in both shifts in the NF + PP treatment which times of 180.4 minutes in the morning and 178.4 minutes in the afternoon were observed. The longest grazing time over the native field in this treatment was observed in the afternoon shift (116 minutes while in the morning the observed grazing time was 17.7 minutes) (Figure 1).

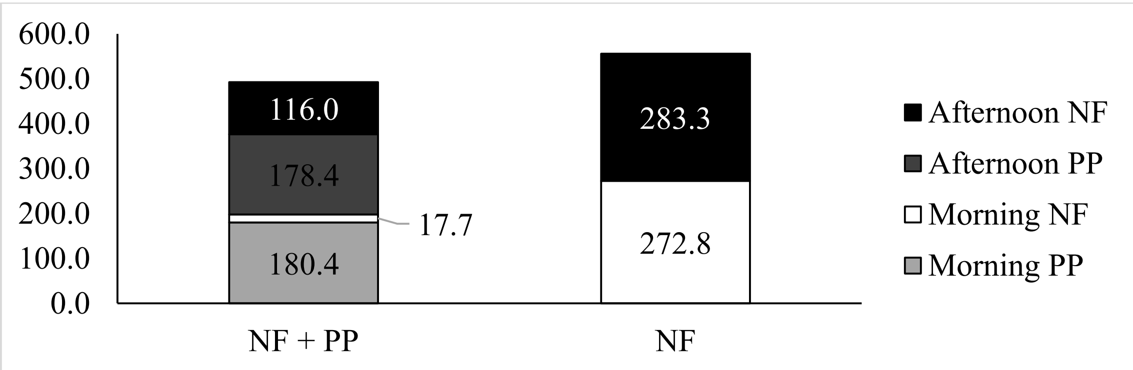


**Figure 1:** Total grazing time (minutes) and in the morning and afternoon shifts in the NF + PP and NF treatments and within the NF + PP treatment (NF + PP - Native field pasture and perennial peanut; NF - Native field).

The longest grazing times occurred in the early morning and late afternoon (Figure 2), coinciding with the mildest temperatures of day. During the day there were significant differences in grazing times in four moments.

Grazing was recorded only in the NF + PP treatment at 7 am, with a preference for forage peanut. The NF treatment, grazing started after 8 am. Differences were also registered between treatments at 9 am and 12 pm, when higher grazing percentages were observed in the NF treatment. In the afternoon period, longest grazing time was observed in the NF + PP around 18h (Figure 2). It was observed that in the NF + PP treatment there was a greater preference for perennial peanut pasture, probably due to the higher nutritional quality of this pasture (Table 2).

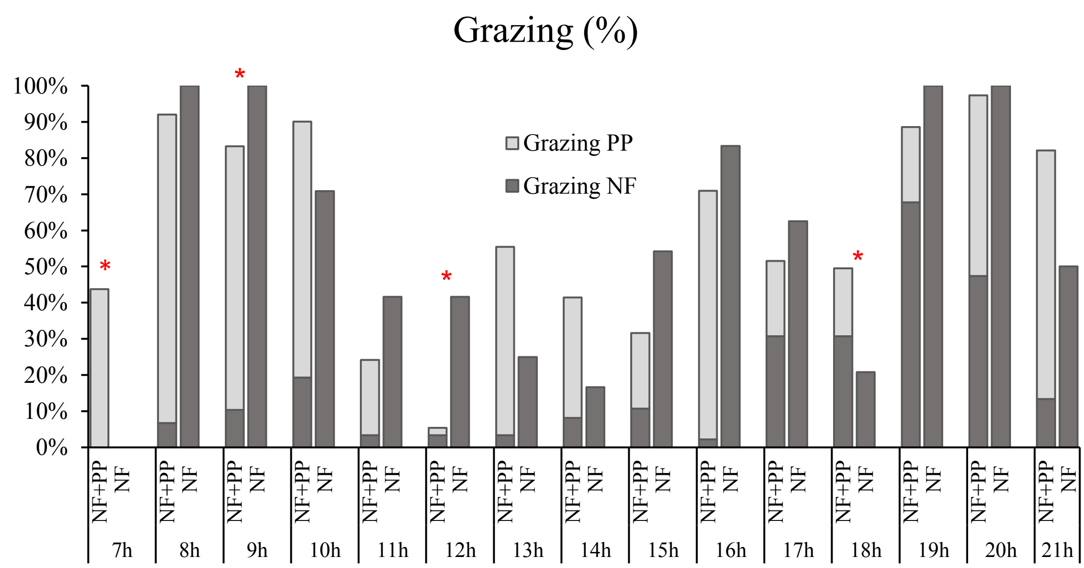


**Figure 2:** Percentage of time devoted to grazing in native field and on forage peanuts each hour in treatments CN + AF and CN. *Significant values $p<0.05$.

The grazing time has strong negative correlation with the animals' idle time (-0.6735 - $p<0.05$), that is, as the animals increased the grazing time, the idle time was reduced. There was no correlation between grazing time and the animals' rumination time (0.0695 – $p>0.05$). However, rumination time also showed a negative correlation with the idle time of sheep during the day (-0.7642 - $p<0.01$). In other words, when the animal needs to increase its grazing or rumination time, its idle time is reduced as expected.

*Rumination and idle time*

The total rumination time during the day had no significant differences between treatments. In the NF + PP treatment, animals dedicated 151.2 minutes to rumination, while in the NF treatment this time was 220.5 minutes (Figure 3) corresponding, respectively, for 18 and 26.2% of the period of the day. During the morning, animals destined longer rumination time when they grazed exclusively in native field ($p=0.0110$), with no differences being observed between managements during the afternoon ($p=0.4664$). A more balanced distribution of rumination between shifts can also be observed when the animals had access to perennial peanut ($p=0.9397$) and with less time in the afternoon when kept exclusively in the native field ($p=0.0134$).

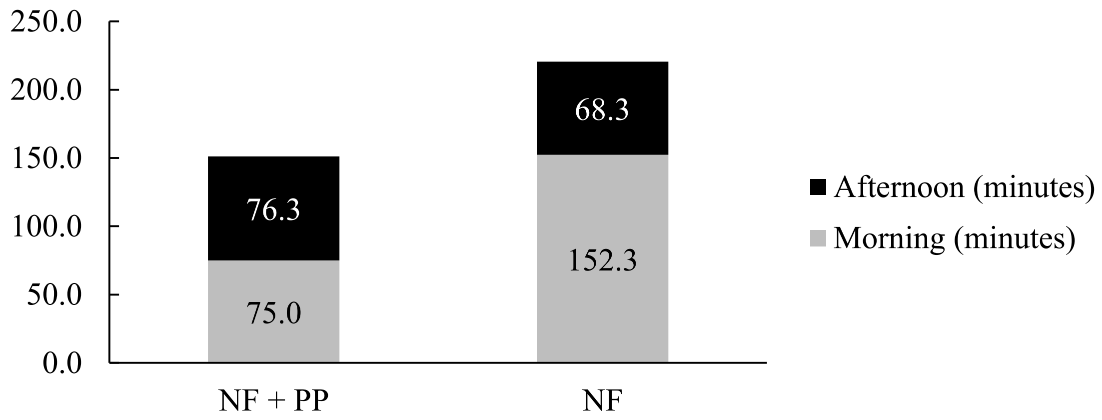


**Figure 3:** Rumination times in the morning and afternoon shifts in NF + PP and NF treatments

The idle time was longer in the NF + PP treatment ($p=0.0039$), where the animals remained 196.2 minutes in this activity during the day, while in the CN this time was 63 minutes (Figure 4). The idle time in the treatment with access to perennial peanuts was higher during the morning (p=0.0178). The same occurred when the animals were managed only in the native field (p=0.1340), but with less time than the animals kept in only the native field (p=0.0272). During the afternoon, idle time was also greater when the animals had access to perennial peanuts (p=0.0058).

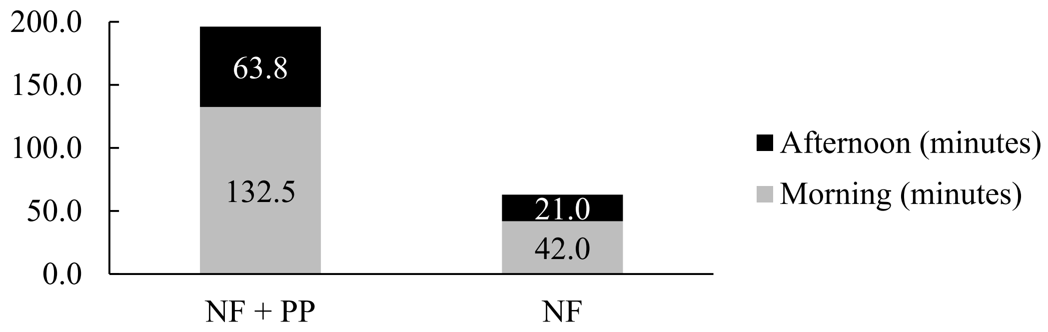


**Figure 4:** Idle times in the morning and afternoon shifts in treatments NF + PP and NF.

*Forage intake*

Bite rates did not differ between treatments, with values of 37.5 bites/min. in the native field and 33.6 bites/min. in forage peanut for the treatment of NF + PP and 43.3 bites/min. for NF treatment. Likewise, the total number of bites during the day also did not differ between treatments, where values were 19641 bites/day for the NF + PP treatment and 19943 bites/day for exclusive treatment in NF (Table 3).

*Mericic chewing*

The mericic chewing time per ruminal bolus showed a significant difference between the treatments. In the NF + PP treatment an average time of 30 seconds per bolus was measured while in the NF treatment the time was 37.5 seconds (Table 3).

Table 3: Forage intake and forage chewing in treatments NF + PP and NF.

| | NF + PP | NF | P |
|---|---|---|---|
| Bite rates (bites/min) | 37.5±3.6[(1)] 33.6±2.9[(2)] | 43.3±3.7 | 0,1995 |
| Total number of bites | 19641±563.1 | 19943±1127.6 | 0,6135 |

| | | | |
|---|---|---|---|
| Time per ruminal bolus (Sec.) | 30±3.0 | 37.5±3.9 | 0.0032 |
| Mericic chewing (Ruminal bolus) | 60±4.3 | 67.3±5.4 | 0.0039 |
| Ruminal bolus (Day) | 302.5±21.3 | 352.8±41.7 | 0.029 |
| Mericic chewing (Day) | 18150±2699.7 | 23743±2030.1 | 0.0093 |

(1) Bite rate in native field; (2) Bite rate in perennial peanut.

The number of mericic chews (ruminal bolus) differed between treatments (p=0.0039). Chewing movements were smaller in the NF + PP treatment, 60 movements, while in the NF this value was 67.3 (Table 3). The number of ruminal bolus per day also differed between treatments, with 302.5 and 352.8 ruminal boluses for treatments NF + PP and NF, respectively. The number of mericic chews per day was influenced by the treatments, so that sheep kept in a native field had a greater number of chewing movements. In the NF + PP treatment, this number was 18,150 mericic chews/day, while in the NF treatment it was higher, 23743 mericic chews/day. Daily mericic chewing is related to the total time of rumination, that is, the longest time of rumination provided a greater number of total chewing, since the number of chewing movements per bolus were similar.

## Discussion

*Grazing time*

The grazing time during the day was not influenced by free access to perennial peanut pasture, with a value below the maximum time of 13 hours per day, indicating that the pasture structure did not offer limitations for forage intake in any of the managements used. This maximum grazing time is rarely reached, as the animal needs to allocate time throughout the day to ruminate, drink water, exercise social activities (CARVALHO et al. 2001). These results are like the found by Zanine et al. (2006), who evaluating the grazing time during the day, also observed similar times between different pastures.

In the morning shift a shorter grazing time was observed in the NF + PP treatment. When using the free access management, there was a greater preference for perennial peanuts, and less for the native field, especially during the morning. The preference was 91.1% for perennial peanuts in the morning and 60.5% in the afternoon. There is a preference for ingesting more fibrous constituents in the afternoon, as it helps to maintain the ruminal environment, providing ruminal filling during the night and increasing time available for its degradation. According to Terra-Braga et al. (2018) sheep tend to graze mostly during the day so that the animals graze for less than an hour during the night period. The preference for forage peanut was 72.8% during the day, values close to those found by Rutter, (2006) who observed values of 70% preference for clover pasture, which would be related to carbon and nitrogen balance in sheep diet.

In CN + PP, the highest preference for perennial peanuts was observed. The preference for one or the other pasture in a system with free access could gradually reduce forage mass of this area, occurring its excessive defoliation. On the other hand, the sub grazing of the other pasture would lead to a decrease in its quality. In this sense, it would be necessary to implement some mechanism to control the grazing of perennial peanuts, avoiding its super grazing.

In the morning, grazing was carried out almost in its entirety in forage peanuts, being destined less than 20 minutes of grazing time in native field. Forage peanut pasture may present high leaf density, mainly in the upper stratum, which has a percentage above 65% of leaves (Kröning et al. 2019), where the bits are preferably performed. The preference for leaves with higher nutritional value and digestibility, such as forage peanuts in extreme cultivation, provided longer grazing time in this area, thus increasing the intake and utilization of nutrients by animals (Costa, 2018). Due to this fact, there was a greater daily weight gain (Table 2) with the use of this pasture. Costa et al. (2015) evaluating the ingesive behavior of goats in silvopastoral systems, consisting of *Urochloa plantaginea* and *Leucaena leucocephala*, also verified that the animals preferred the forage that had greater accessibility to grazing, in this case, herbaceous stratum. The distribution of grazing times throughout the day showed that there are grazing peaks in the early morning and late afternoon, coinciding with the mildest hours. At the times around noon there were smaller grazing activities, coinciding with the hottest time of the day, in which the animals are usually in search of shelter from the sun.

Even though the demand for the native field in the treatment with access to perennial peanuts is low, there was an increase in the demand for this pasture in the afternoon, but without reaching 50% of the time.  The consumption of higher fiber species in the late afternoon is related to ruminal filling. As sheep do not graze at night, the animal eats a more fibrous food in the late afternoon to digest at night. This result agrees with Lisbinski et al. (2019) who when evaluating the preference and selection of the diet in a consortium of grasses and legumes observed greater selection of vetch (*Vicia sativa*) which ends up reducing the participation of this forage. The preference for the native field in the afternoon may be related to the process of photosynthesis of plants that occurs during the day, causing there to be a higher concentration of carbohydrates in forage, especially in leaves (Champion et al. 1994; Barbosa et al. 2010; Orr, Penning et al. 1997). In addition, it may be related to longer retention time in the rumem of the native pasture with higher fiber content at end of grazing period without affecting the total grazing time, since the animal would have all night to do the rumination. In addition, the higher fiber intake in the afternoon may be related to the regulation of diet intake by the animal that had the intake of forage with higher digestibility during the day COSTA et al. (2020) found that perennial peanuts presented digestibility of 75.1% in moderate intensity.

*Rumination and Idle time*

The animals that were kept exclusively in the native field tended to have higher times of total rumination due to the higher NDF value of forage (Table 2). The longest rumination time occurs at night with peak activity starting at dawn at around 5 am (RÊGO et al. 2017), at times before sunrise. During daytime rumination time varies with the diet ingested by the animals, which is correlated with the consumption of NDF. In the NF + PP treatment, there was a shorter grazing time in the native field, which consequently reduced the consumption of NDF by the animals, affecting the total rumination time. According to Van Soest, (1994), the increase in NDF content promotes an increase in rumination time due to the greater need for long fiber processing.

Rumination time was longer during the morning when the animals were kept exclusively in the native field, at the expense of idle time. That is, the higher fiber content caused it to increase rumination time, but without compromising grazing time. In this study, idle was impaired activity when there was a need for more time for grazing or rumination. The rumination times observed corresponded to 18% and 26.2% of the daily time, respectively, for the treatments NF + PP and NF.

The highest NDF in the native field, besides interfering in the rumination time, reduced time allocated to the idle of animals. It was observed that the idle time, when the animals accessed the forage peanut, was 152.8% higher in relation to the treatment in which the sheep were kept exclusively in native field, which generates lower energy expenditure by the animal throughout the day. In addition, the animals had more idle time in the morning, when temperatures are milder compared to the afternoon. In the warmer hours animals intended time for rumination. These results differ from Silva et al. (2016)

who found that the animals perform the longest idle time during the day in the warmer hours, when the search for shade occurs.

*Forage Intake*

Bite rate in the present study did not differ, showing that its structures did not influence the intake, even in the case of different pastures (native field and perennial peanut). When the structure of the pasture is limiting for the ingestion of fodder, the animals use mechanisms to increase the intake such as increasing the rate of bites (Fuck, 2013). According to Sampaio et al. (2017) the bite rate is correlated with the height of pasture, so when pasture is lower, the ruminants increase bite rate, which consequently increases grazing time. Animal increases grazing time to compensate for the low bit mass of a lower structure. When the increase in grazing time and the bit rate is not enough to compensate for the lower availability occurs the decrease in consumption, tied to the smallest mass of bite. The heights of the native field were within the range recommended by Gonçalves et al. (2009) who recommend that the height of the pasture should be maintained between 9.5 and 11.4 cm. Bassani Filho and Poli (2010) when evaluating the ingesive behavior of sheep in native field observed that there is a difference in the bite rate throughout the day, since the animals performed 33.8 boc/ min in the morning shift and 39.0 boc/min in the afternoon shift, values that are associated with the length of stay per food station.

The animals increased the intake put half of the increase of grazing time. According to Allden and McDWhittaker (1970), low forage availability would result in high bite rates (70/min), and if sustained for 10 hours throughout the day in a daily number of bits of 42,000. On the other hand, high forage availability would result in low bite rates

(20/min.) and shorter grazing time, and if sustained these rates for 7 hours would result in a daily number of 8000 bits.

*Mericic chewing*

The time for chewing each ruminal bolus was longer in the native field provided by the higher NDF of this pasture (Table 1), which is caused by the longer ruminal bolus handling time. According to Van Soest (1994) the quality of forage, mainly the amounts of cell wall of the fodder interfere in rumination time and more specifically in the number of mandibular movements per ruminal bolus. Bürger et al. (2000) found that there is a linear reduction in total chewing time as there is a reduction in cell wall constituents and an increase in non-fibrous carbohydrates in the diet.

The higher number of ruminal cakes and number of mericic chewing during the day influenced the total time of ruminations during the day, which showed a tendency of superiority when the animals grazed exclusively in the native field. The higher proportion of NDF in a diet provides rumination stimulation and increased meristic chewing, because with increased fiber content of forage animal needs to chew more to stimulate salivary secretion, adjust ruminal pH and optimize ruminal fermentation (Ribeiro et al. 2011).

Even the pastures have distinct structural characteristics, it did not affect the forage harvesting mechanisms. Likewise, no modification was observed in the rumination processes. Thus, the main changes in ingestive behavior observed are related to grazing and ruminating time.

## Conclusion

The free access to perennial peanut pasture interferes with the patterns of ingestion and rumination of sheep in the native field. Sheep have a higher preference for grazing in perennial peanuts with approximately 3/4 of the daytime grazing over this area. The preference for legumes is more pronounced during the morning, especially in the early hours of the day. The total grazing times in native field and in native field with free access to perennial peanut pasture are similar with preference for forage peanuts, which reduces rumination time.

Best performance of animals with access to perennial peanuts is due to the better nutritive value of peanuts, which allowed shorter grazing time, shorter rumination time and longer idle time.

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**Consent to participate:** Not applicable.

**Consent for publication:** Not applicable

**Code availability:** Not applicable.

**Authors contributions:** “All authors contributed to the study conception and design. Material preparation, data collection was performed by [Alexsandro Bahr Kroning], [Joice Rodal Gruppelli], [Allan Patrick Timm de Oliveira], [Pâmela Peres Farias], [Pablo Tavares Costa] and [Luiza Padilha Nunes]. Data analyses were performed by [Alexsandro Bahr Kroning], [Otoniel Geter Lauz Ferreira], and [Pablo Tavares Costa]. The first draft of the manuscript was written by [Alexsandro Bahr Kroning] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.”

**Data availability statements:** The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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# Pattern of forage ingestion of sheep in native field with access to summer legume

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**Abstract:** The objective of this work was to evaluate the effect of access to perennial peanut (*Arachis pintoi*) pasture on patterns of forage intake and rumination of sheep in native field. The treatments were exclusive grazing in native field (NF) and grazing in native field with free access to perennial peanut pasture (NF+PP), using four test animals for each area, with offer adjusted to 12% of body weight. Rumination, grazing, and idle time were evaluated, beyond to forage ingestion and forage mericic chewing rates. Grazing time during the diurnal period did not have significant differences between the treatments, but a shorter grazing time was observed during the morning when the animals had access to perennial peanut. Grazing and rumination times were negatively correlated with idle time. In the NF+PP treatment, the animals dedicated 18.00% of the daytime period to rumination, while in the NF treatment it was 26.25% of the daytime. With access to forage legumes, there was a decrease in grazing time and an increase in the rumination time of sheep compared to animals kept exclusively in native fields with the same forage allowance. Animals kept in native field and native field with free access to perennial peanut have similar grazing times throughout the day, but with differences between shifts. The animals show preference for perennial peanut, grazing most of time in this area. The longer grazing time on forage peanuts reduces the rumination time of sheep.

**Key words**: ingestive behavior; natural pasture; perennial peanut; rumination; sheep breeding.

## Introduction

The native grassland of the Pampa Biome is an important forage source for grazing animals. It is often used as a food source in ruminant farming systems. The productivity of native grasslands varies throughout the year, with highest forage production occurring in the spring and normally overgrazed in periods of low forage production such as winter (Jaurena et al, 2021). Thus, nutritional and productivity of native field throughout the year are not enough for grazing animals to express their full productive potential.

Diversification of forages in pastoral systems is one of exploration alternatives to compensate for productive and nutritional deficit that natural pastures present at some seasons of the year. The introduction of tropical legumes that fix nitrogen in soil and produce forage with high levels of protein and low levels of fiber provide animals with a higher quality diet. Systems in which animals have access to pasture areas with better quality allow selection of diet of greater nutritional value, affecting ingestive behavior of animals. In these cases, use of legumes guarantees greater supply of protein in the diet ingested by the animals (Alonzo et al., 2017, Nunes et al., 2020).

Animal performance is dependent on forage intake which, in turn, is influenced by consumption patterns. In heterogeneous pastures such a native grassland, animals change the mechanisms of forage harvest and ingestion, keeping nutrient supply constant (Bonnet et al., 2015), and similar behavior may occur when animals have access to better quality pasture. In turn, pastures with higher fiber content cause the animal to reduce forage consumption (Glienke et al., 2016). When it is possible for the animal to select a better diet quality, changes occur in patterns of ingestion and rumination of grazing animals.

Little is known about the management and use of species such as *Arachis pintoi*, especially about grazing management in systems where animals' food base is native grassland. To combine pasture management with the needs of grazing animals, it is necessary to know the behavior of animals in this breeding system. Therefore, the study was designed to determine forage intake patterns and verify the forage preferences of animals when there is no limitation in access to forage with greater nutritional value. The hypothesis is that when forage peanuts are included in grazing systems based on native grassland, there are changes in the consumption patterns of the animals so that there is a self-regulation of forage intake, with a reduction in grazing and rumination time and consequently increasing the idle time. In this sense, the objective of this work was to evaluate the effect of free access to forage peanut (*Arachis pintoi*) pasture on forage intake and rumination patterns of sheep in native grassland.

## Material and methods

*location and climate*

The work was carried out in January and February 2018, at Centro Agropecuário da Palma/UFPel, km 535 from BR 116, located in the municipality of Capão do Leão, RS, Brazil, at 31º 52' 00" South and 52º 21' 24" West, 13.24 m altitude, South Coast physiographic region. The soil of the experimental area is classified as eutrophic Red-Yellow Podzolic (Cunha and Silveira, 1996). The climate in the region is of the Cfa type (humid temperate climate with hot summer), according to the Köeppen classification (MOTA, 1953). The experiment area consisted of a native field characterized as a representative natural pasture of the region and a contiguous area of forage peanut pasture cv. Amarillo, both fertilized in coverage with 150 kg/ha of DAP (Diamonium phosphate: 18-46-00) in November 2017, remaining deferred until the beginning of the experiment. The two pastures had shelter from sun for animals.

*Treatments*

The treatments were exclusive grazing in native field (NF) and grazing in native field with free access to perennial peanut pasture (NF+PP). The grazing utilization method was continuous grazing with variable animal load. Four 18-month-old test sheep were used per treatment, with a predominance of Corriedale blood, which remained in the experimental area throughout the period and a variable number of regulators to adjust the animal load. The forage allowance was fixed at 12 kg of DM per 100 kg of body weight.

*Assessments*

Pasture evaluations were carried out regarding forage mass, height and contents of crude protein, neutral detergent fiber, acid detergent fiber, acid detergent lignin and mineral matter (Table 1).

**Table 1:** Height, forage mass (FM) and bromatological characteristics of native grassland (CN) and forage peanut (AF) in treatments CN+AF and CN.

| Treatments | Area | Height (cm) | FM (Kg/ha) | CP (%) | NDF (%) | ADF (%) | ADL (%) | MM (%) |
|---|---|---|---|---|---|---|---|---|
| NF | MF | 9.8 | 1609.4 | 9.9 | 47.9 | 37.1 | 8.1 | 5.6 |
| NF+PP | NF | 9.9 | 1620.7 | 8.5 | 48.1 | 36.8 | 8.2 | 5.7 |
| | PP | 14.7 | 2918.0 | 16.1 | 42.1 | 28.7 | 6.6 | 6.3 |

FM = Forage mass; CP = Crude Protein; NDF = Neutral Detergent Fiber; ADF = Acid detergent fiber; ADL= Lignin in acid detergent; MM = Mineral Matter.

For evaluation of animals, weighing was carried out at the beginning and at the end of experiment to determine the average daily gain. Furthermore, evaluations of the ingestive behavior of these animals were carried out. These evaluations were carried out at 16 (24/01), 18 (26/01) and 42 (20/02) days after the beginning of grazing, from sunrise to sunset, directly with data collection every 10 minutes, as described by Jamieson and Hodgson (1979), visually verifying the animals' instantaneous activity. The activities are described as: Grazing - time spent by animal in selecting and holding forage, with its head down, holding food; Rumination - identified as end of grazing and chewing movements without forage ingestion; Idle - time in which the animal remains at rest, without apparent activity, without rumination or ingestion.

To assess the bite rate and mericic chewing, the focal method was used. Grazing and rumination sessions, of approximately 4 minutes, were filmed at close range. The bite rate was recorded through time taken to perform 20 bites (HODGSON, 1982). To determine the number of bites given during the day, the bite rate found was multiplied by the grazing time of each animal. The mericic chewing of each animal was also evaluated, with time to chew and swallow a bolus, in addition to number of chewing movements to swallow each ruminal bolus. To determine the number of mericic chews throughout the day, the value found of number of mericic chews per ruminal bolus was multiplied by total rumination time throughout the day of each animal. The number of ruminal bolus was determined by dividing the daily rumination time by the chewing and swallowing time of each ruminal bouillon.

All observations were carried out with the precaution of not interfering with the environment and the natural behavior of the sheep, avoiding approaches that reached the animals' escape zone, as well as abrupt movements.

*Statistical analysis*

Data analysis was performed using the mixed model procedure (PROC MIXED), where treatments were considered as a fixed effect and the evaluation dates as a random effect, following the following model Yijk = μ + αi + βj + +eijk, where: Yijk is the animal's response about treatment i on date j in repetition k; μ is the overall mean; αi is the fixed effect of treatment i; βj is the random effect of date j; eijk is the error associated with handling i, on date j and repetition k. Pearson's correlation coefficients were also estimated (Steel et al. 1997) between continuous variables of ingestive behavior (Rumination, Grazing and idle) at a significance level of 95%.

## Results

*Pasture characteristics*

The native field had similar productive and nutritional characteristics in both grazing areas (native field with and without access to perennial peanuts). Perennial peanut had a better nutritional composition and, as it is a legume in extreme cultivation, it has a higher crude protein content (Table 1). In addition, perennial peanuts presented greater canopy height.

*Animal performance*

Sheep initial body weights were similar between treatments (Table 2). However, there was a difference in the final weight of sheep, in which the animals that had free access to perennial peanut had higher final weight in the period. Thus, the ADG of the NF+PP treatment was 139 grams, which resulted in a higher final weight (P=0.0094). In turn, when the animals were kept exclusively in the native field, the ADG showed a negative value, but without significantly changing the final body weight of the animals (P=0.4163).

**Table 2:** Initial and final body weights and average daily gain (ADG) of sheep in treatments NF + PP and NF.

| | NF + PP | NF | P |
|---|---|---|---|
| Initial body weight | 35.8 ± 2.7 | 38.7 ± 2.9 | 0.4804 |
| Final body weight | 44.1 ± 3.7 | 37.0 ± 2.0 | 0.0117 |

| | | | |
|---|---|---|---|
| P | 0.0094 | 0.4163 | - |
| ADG | 0.139 ± 0.04 | -0.028 ± 0.03 | 0.0051 |

*Grazing time*

The total grazing time did not differ between treatments (P = 0.2165), with mean times of 492.5 minutes (8:18 h) and 556.5 minutes (9:16 h), respectively for the CN treatments + AF and CN (Figure 1). During the morning, the longest grazing time was observed in collective animals in native field (P = 0.0359), not indicating a difference between treatments in the afternoon shift (P = 0.2449). The animals with access to perennial peanut grazed for a longer time in the afternoon (P=0.0002), with grazing times of 201.5 minutes in the morning and 291.2 minutes in the afternoon. Those kept exclusively in native field, distributed grazing time more evenly throughout the day (P=0.6801), with grazing time of 272.7 minutes in the morning and 283.25 minutes in the afternoon. A longer grazing time on forage peanut was observed in both shifts in the NF + PP treatment which times of 180.4 minutes in the morning and 178.4 minutes in the afternoon were observed. The longest grazing time over the native field in this treatment was observed in the afternoon shift (116 minutes while in the morning the observed grazing time was 17.7 minutes) (Figure 1).

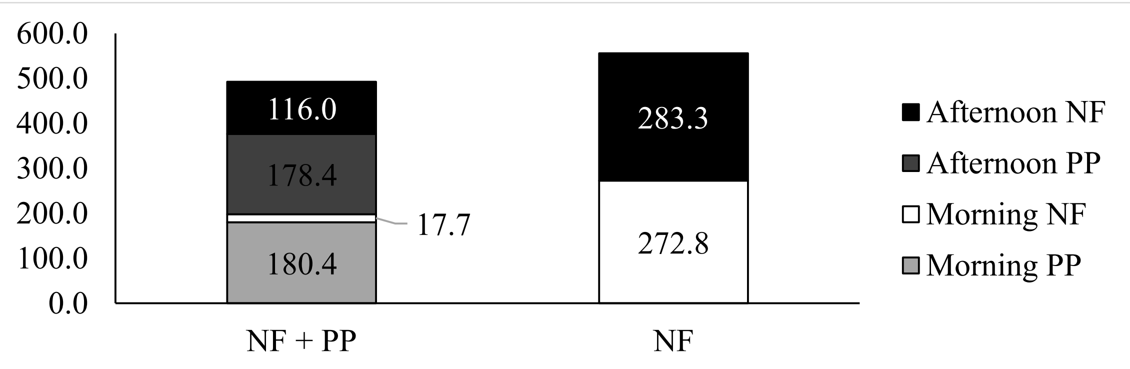


**Figure 1:** Total grazing time (minutes) and in the morning and afternoon shifts in the NF + PP and NF treatments and within the NF + PP treatment (NF + PP - Native field pasture and perennial peanut; NF - Native field).

The longest grazing times occurred in the early morning and late afternoon (Figure 2), coinciding with the mildest temperatures of day. During the day there were significant differences in grazing times in four moments.

Grazing was recorded only in the NF + PP treatment at 7 am, with a preference for forage peanut. The NF treatment, grazing started after 8 am. Differences were also registered between treatments at 9 am and 12 pm, when higher grazing percentages were observed in the NF treatment. In the afternoon period, longest grazing time was observed in the NF + PP around 18h (Figure 2). It was observed that in the NF + PP treatment there was a greater preference for perennial peanut pasture, probably due to the higher nutritional quality of this pasture (Table 2).

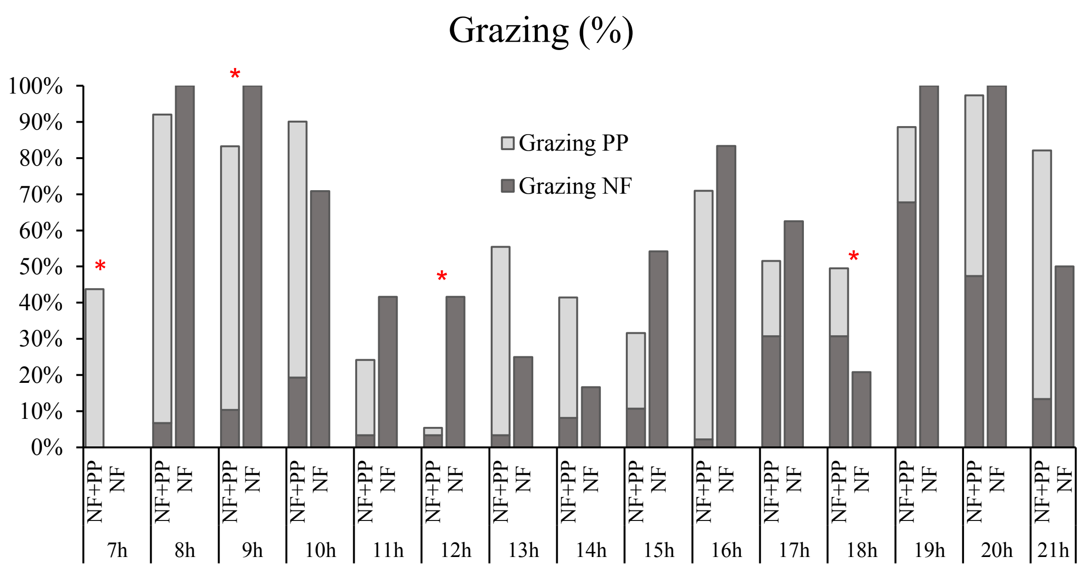


**Figure 2:** Percentage of time devoted to grazing in native field and on forage peanuts each hour in treatments CN + AF and CN. *Significant values $p<0.05$.

The grazing time has strong negative correlation with the animals' idle time (-0.6735 - $p<0.05$), that is, as the animals increased the grazing time, the idle time was reduced. There was no correlation between grazing time and the animals' rumination time (0.0695 – $p>0.05$). However, rumination time also showed a negative correlation with the idle time of sheep during the day (-0.7642 - $p<0.01$). In other words, when the animal needs to increase its grazing or rumination time, its idle time is reduced as expected.

*Rumination and idle time*

The total rumination time during the day had no significant differences between treatments. In the NF + PP treatment, animals dedicated 151.2 minutes to rumination, while in the NF treatment this time was 220.5 minutes (Figure 3) corresponding, respectively, for 18 and 26.2% of the period of the day. During the morning, animals destined longer rumination time when they grazed exclusively in native field ($p=0.0110$), with no differences being observed between managements during the afternoon ($p=0.4664$). A more balanced distribution of rumination between shifts can also be observed when the animals had access to perennial peanut ($p=0.9397$) and with less time in the afternoon when kept exclusively in the native field ($p=0.0134$).

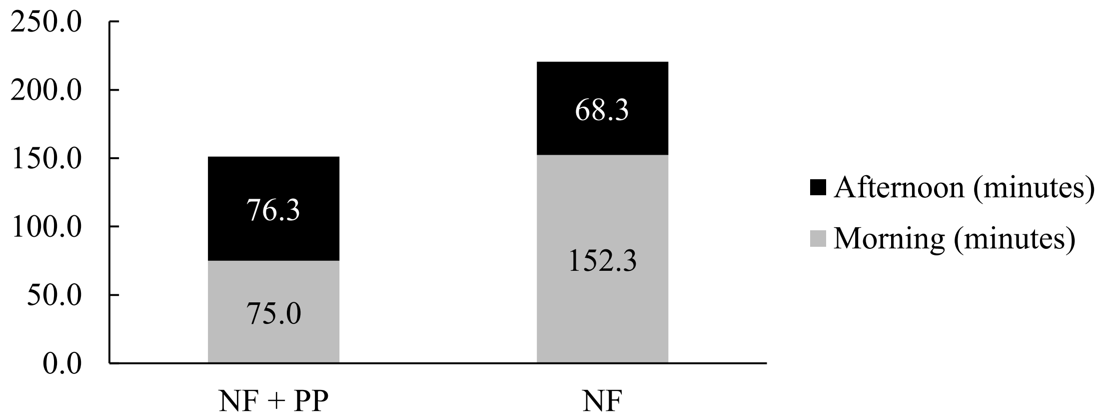


**Figure 3:** Rumination times in the morning and afternoon shifts in NF + PP and NF treatments

The idle time was longer in the NF + PP treatment ($p=0.0039$), where the animals remained 196.2 minutes in this activity during the day, while in the CN this time was 63 minutes (Figure 4). The idle time in the treatment with access to perennial peanuts was higher during the morning (p=0.0178). The same occurred when the animals were managed only in the native field (p=0.1340), but with less time than the animals kept in only the native field (p=0.0272). During the afternoon, idle time was also greater when the animals had access to perennial peanuts (p=0.0058).

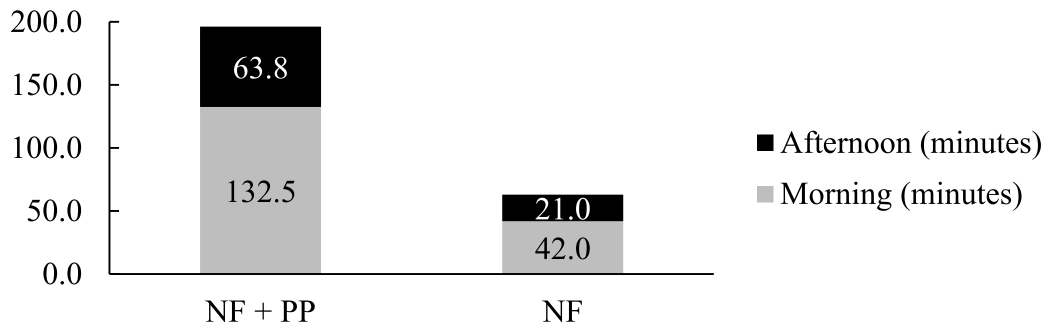


**Figure 4:** Idle times in the morning and afternoon shifts in treatments NF + PP and NF.

*Forage intake*

Bite rates did not differ between treatments, with values of 37.5 bites/min. in the native field and 33.6 bites/min. in forage peanut for the treatment of NF + PP and 43.3 bites/min. for NF treatment. Likewise, the total number of bites during the day also did not differ between treatments, where values were 19641 bites/day for the NF + PP treatment and 19943 bites/day for exclusive treatment in NF (Table 3).

*Mericic chewing*

The mericic chewing time per ruminal bolus showed a significant difference between the treatments. In the NF + PP treatment an average time of 30 seconds per bolus was measured while in the NF treatment the time was 37.5 seconds (Table 3).

Table 3: Forage intake and forage chewing in treatments NF + PP and NF.

| | NF + PP | | NF | P |
|---|---|---|---|---|
| Bite rates (bites/min) | 37.5±3.6(1) | 33.6±2.9(2) | 43.3±3.7 | 0,1995 |
| Total number of bites | 19641±563.1 | | 19943±1127.6 | 0,6135 |

| | | | |
|---|---|---|---|
| Time per ruminal bolus (Sec.) | 30±3.0 | 37.5±3.9 | 0.0032 |
| Mericic chewing (Ruminal bolus) | 60±4.3 | 67.3±5.4 | 0.0039 |
| Ruminal bolus (Day) | 302.5±21.3 | 352.8±41.7 | 0.029 |
| Mericic chewing (Day) | 18150±2699.7 | 23743±2030.1 | 0.0093 |

[(1)] Bite rate in native field; [(2)] Bite rate in perennial peanut.

The number of mericic chews (ruminal bolus) differed between treatments (p=0.0039). Chewing movements were smaller in the NF + PP treatment, 60 movements, while in the NF this value was 67.3 (Table 3). The number of ruminal bolus per day also differed between treatments, with 302.5 and 352.8 ruminal boluses for treatments NF + PP and NF, respectively. The number of mericic chews per day was influenced by the treatments, so that sheep kept in a native field had a greater number of chewing movements. In the NF + PP treatment, this number was 18,150 mericic chews/day, while in the NF treatment it was higher, 23743 mericic chews/day. Daily mericic chewing is related to the total time of rumination, that is, the longest time of rumination provided a greater number of total chewing, since the number of chewing movements per bolus were similar.

## Discussion

### *Grazing time*

The grazing time during the day was not influenced by free access to perennial peanut pasture, with a value below the maximum time of 13 hours per day, indicating that the pasture structure did not offer limitations for forage intake in any of the managements used. This maximum grazing time is rarely reached, as the animal needs to allocate time throughout the day to ruminate, drink water, exercise social activities (CARVALHO et al. 2001). These results are like the found by Zanine et al. (2006), who evaluating the grazing time during the day, also observed similar times between different pastures.

In the morning shift a shorter grazing time was observed in the NF + PP treatment. When using the free access management, there was a greater preference for perennial peanuts, and less for the native field, especially during the morning. The preference was 91.1% for perennial peanuts in the morning and 60.5% in the afternoon. There is a preference for ingesting more fibrous constituents in the afternoon, as it helps to maintain the ruminal environment, providing ruminal filling during the night and increasing time available for its degradation. According to Terra-Braga et al. (2018) sheep tend to graze mostly during the day so that the animals graze for less than an hour during the night period. The preference for forage peanut was 72.8% during the day, values close to those found by Rutter, (2006) who observed values of 70% preference for clover pasture, which would be related to carbon and nitrogen balance in sheep diet.

In CN + PP, the highest preference for perennial peanuts was observed. The preference for one or the other pasture in a system with free access could gradually reduce forage mass of this area, occurring its excessive defoliation. On the other hand, the sub grazing of the other pasture would lead to a decrease in its quality. In this sense, it would be necessary to implement some mechanism to control the grazing of perennial peanuts, avoiding its super grazing.

In the morning, grazing was carried out almost in its entirety in forage peanuts, being destined less than 20 minutes of grazing time in native field. Forage peanut pasture may present high leaf density, mainly in the upper stratum, which has a percentage above 65% of leaves (Kröning et al. 2019), where the bits are preferably performed. The preference for leaves with higher nutritional value and digestibility, such as forage peanuts in extreme cultivation, provided longer grazing time in this area, thus increasing the intake and utilization of nutrients by animals (Costa, 2018). Due to this fact, there was a greater daily weight gain (Table 2) with the use of this pasture. Costa et al. (2015) evaluating the ingesive behavior of goats in silvopastoral systems, consisting of *Urochloa plantaginea* and *Leucaena leucocephala*, also verified that the animals preferred the forage that had greater accessibility to grazing, in this case, herbaceous stratum. The distribution of grazing times throughout the day showed that there are grazing peaks in the early morning and late afternoon, coinciding with the mildest hours. At the times around noon there were smaller grazing activities, coinciding with the hottest time of the day, in which the animals are usually in search of shelter from the sun.

Even though the demand for the native field in the treatment with access to perennial peanuts is low, there was an increase in the demand for this pasture in the afternoon, but without reaching 50% of the time. The consumption of higher fiber species in the late afternoon is related to ruminal filling. As sheep do not graze at night, the animal eats a more fibrous food in the late afternoon to digest at night. This result agrees with Lisbinski et al. (2019) who when evaluating the preference and selection of the diet in a consortium of grasses and legumes observed greater selection of vetch (*Vicia sativa*) which ends up reducing the participation of this forage. The preference for the native field in the afternoon may be related to the process of photosynthesis of plants that occurs during the day, causing there to be a higher concentration of carbohydrates in forage, especially in leaves (Champion et al. 1994; Barbosa et al. 2010; Orr, Penning et al. 1997). In addition, it may be related to longer retention time in the rumem of the native pasture with higher fiber content at end of grazing period without affecting the total grazing time, since the animal would have all night to do the rumination. In addition, the higher fiber intake in the afternoon may be related to the regulation of diet intake by the animal that had the intake of forage with higher digestibility during the day COSTA et al. (2020) found that perennial peanuts presented digestibility of 75.1% in moderate intensity.

*Rumination and Idle time*

The animals that were kept exclusively in the native field tended to have higher times of total rumination due to the higher NDF value of forage (Table 2). The longest rumination time occurs at night with peak activity starting at dawn at around 5 am (RÊGO et al. 2017), at times before sunrise. During daytime rumination time varies with the diet ingested by the animals, which is correlated with the consumption of NDF.  In the NF + PP treatment, there was a shorter grazing time in the native field, which consequently reduced the consumption of NDF by the animals, affecting the total rumination time. According to Van Soest, (1994), the increase in NDF content promotes an increase in rumination time due to the greater need for long fiber processing.

Rumination time was longer during the morning when the animals were kept exclusively in the native field, at the expense of idle time. That is, the higher fiber content caused it to increase rumination time, but without compromising grazing time. In this study, idle was impaired activity when there was a need for more time for grazing or rumination. The rumination times observed corresponded to 18% and 26.2% of the daily time, respectively, for the treatments NF + PP and NF.

The highest NDF in the native field, besides interfering in the rumination time, reduced time allocated to the idle of animals. It was observed that the idle time, when the animals accessed the forage peanut, was 152.8% higher in relation to the treatment in which the sheep were kept exclusively in native field, which generates lower energy expenditure by the animal throughout the day. In addition, the animals had more idle time in the morning, when temperatures are milder compared to the afternoon. In the warmer hours animals intended time for rumination. These results differ from Silva et al. (2016)

who found that the animals perform the longest idle time during the day in the warmer hours, when the search for shade occurs.

*Forage Intake*

Bite rate in the present study did not differ, showing that its structures did not influence the intake, even in the case of different pastures (native field and perennial peanut). When the structure of the pasture is limiting for the ingestion of fodder, the animals use mechanisms to increase the intake such as increasing the rate of bites (Fuck, 2013). According to Sampaio et al. (2017) the bite rate is correlated with the height of pasture, so when pasture is lower, the ruminants increase bite rate, which consequently increases grazing time. Animal increases grazing time to compensate for the low bit mass of a lower structure. When the increase in grazing time and the bit rate is not enough to compensate for the lower availability occurs the decrease in consumption, tied to the smallest mass of bite. The heights of the native field were within the range recommended by Gonçalves et al. (2009) who recommend that the height of the pasture should be maintained between 9.5 and 11.4 cm. Bassani Filho and Poli (2010) when evaluating the ingesive behavior of sheep in native field observed that there is a difference in the bite rate throughout the day, since the animals performed 33.8 boc/ min in the morning shift and 39.0 boc/min in the afternoon shift, values that are associated with the length of stay per food station.

The animals increased the intake put half of the increase of grazing time. According to Allden and McDWhittaker (1970), low forage availability would result in high bite rates (70/min), and if sustained for 10 hours throughout the day in a daily number of bits of 42,000. On the other hand, high forage availability would result in low bite rates

(20/min.) and shorter grazing time, and if sustained these rates for 7 hours would result in a daily number of 8000 bits.

*Mericic chewing*

The time for chewing each ruminal bolus was longer in the native field provided by the higher NDF of this pasture (Table 1), which is caused by the longer ruminal bolus handling time. According to Van Soest (1994) the quality of forage, mainly the amounts of cell wall of the fodder interfere in rumination time and more specifically in the number of mandibular movements per ruminal bolus. Bürger et al. (2000) found that there is a linear reduction in total chewing time as there is a reduction in cell wall constituents and an increase in non-fibrous carbohydrates in the diet.

The higher number of ruminal cakes and number of mericic chewing during the day influenced the total time of ruminations during the day, which showed a tendency of superiority when the animals grazed exclusively in the native field. The higher proportion of NDF in a diet provides rumination stimulation and increased meristic chewing, because with increased fiber content of forage animal needs to chew more to stimulate salivary secretion, adjust ruminal pH and optimize ruminal fermentation (Ribeiro et al. 2011).

Even the pastures have distinct structural characteristics, it did not affect the forage harvesting mechanisms. Likewise, no modification was observed in the rumination processes. Thus, the main changes in ingestive behavior observed are related to grazing and ruminating time.

**Conclusion**

The free access to perennial peanut pasture interferes with the patterns of ingestion and rumination of sheep in the native field. Sheep have a higher preference for grazing in perennial peanuts with approximately 3/4 of the daytime grazing over this area. The preference for legumes is more pronounced during the morning, especially in the early hours of the day. The total grazing times in native field and in native field with free access to perennial peanut pasture are similar with preference for forage peanuts, which reduces rumination time.

Best performance of animals with access to perennial peanuts is due to the better nutritive value of peanuts, which allowed shorter grazing time, shorter rumination time and longer idle time.

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