



Sheep and goat feeding behavior profile in grazing systems

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ABSTRACT. Feeding behavior analysis provides information about the relationships between animals and pastures. Therefore, this review aims to describe some aspects of the feeding behavior profiles of both sheep and goats in grazing systems. The structure of the pasture is a key factor in the feeding behavior of grazing animals. The amount of feed consumed in a given period of time is affected by the number of meals, duration and velocity of swallowing, changes in grazing time, bite rate, bite weight, and quality of ingested forage. The different phenological stages of forage also influence the animals' strategies to optimize their intake, which consequently changes their behavioral activities. Sheep and goats tend to be more selective than cattle, and young animals are more selective than older animals; this selectivity characteristic is one of the most important aspects to be observed in pasture management. According to the degree of selectivity, the animals will intake forages of higher or lower nutritive quality. In addition, the intensity and distribution of their daily activities (grazing, ruminating, and resting) are influenced by several factors, such as the availability and nutritive value of the pasture, its management, the animal activity in the group, and the predominant climatic conditions of the region.

Keywords: daily activities; grazing habits; ingestive behavior; intake rate; pasture management.

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Introduction

The definition of 'animal behavior' is everything that an animal does to promote actions and react to stimuli. Thus, the behavior among domesticated livestock species is dependent on factors, such as the animal species and environmental conditions (Goetsch, Gipson, Askar, & Puchala, 2010). Therefore, it is important to understand the diet selection and behavior of sheep and goats on different pastures, to maintain an eco-friendly management strategy, as well as profitable animal production activity (Sanon, Kaboré-Zoungrana, & Ledin, 2007). The different characteristics of sheep and goats become evident when it comes to browsing and grazing; sheep are mainly grazers, while goats are more likely to browse (Ouéndro-Koné, Kaboré-Zoungrana, & Ledi, 2006).

Ruminant animals have been shown to generally select feeds on the basis of their nutrient content. The feeding behavior in ruminants is based on the association between sensory components of the feed and their adaptive capabilities (anatomical structures of the animals and the post-ingestive consequences). Small ruminants (sheep and goats) have different feed intake patterns in the same pastures (Mysterud, 2000). Selectivity is less pronounced in goats than in sheep (Sanon et al., 2007).

Sheep and goats are animals that can consume diverse diets based on native plants, which consequently allows these animals to present a greater flexibility in their behavior to adapt to new habitats under many scenarios and environmental conditions (Perez-Barberia et al., 2001; Koluman, Boga, Silanikove, & Gorgulu, 2016). Based on the above statement, this review aims to describe some aspects of the feeding behavior profiles of sheep and goats in grazing systems.

Feeding behavior in grazing systems

The daily forage intake capacity depends on the time spent grazing and the forage intake rate during this period. Thus, daily intake is a product of the number of bites per unit time (bite rate) and the amount of forage seized per bite (bite mass) (Hodgson, 1990) (Figure 1). However, seasonal variations, such as air temperature, relative humidity, rainfall, plant vegetative stages, and animal productive and reproductive

stages, are factors that interfere with the daily forage intake. Different strategies are performed by animals seeking to increase their nutrient intake under grazing conditions (Newman, Parsons, & Penning, 1994). A decrease in the intake per bite causes a decline in the intake rate, unless there is a compensatory increase in bite rate (Hodgson, 1990). The intake per bite is influenced by the tensile strength of forage, so the bite mass may be limited by the maximum force that the animal is able to exert during the seizure of a bite.

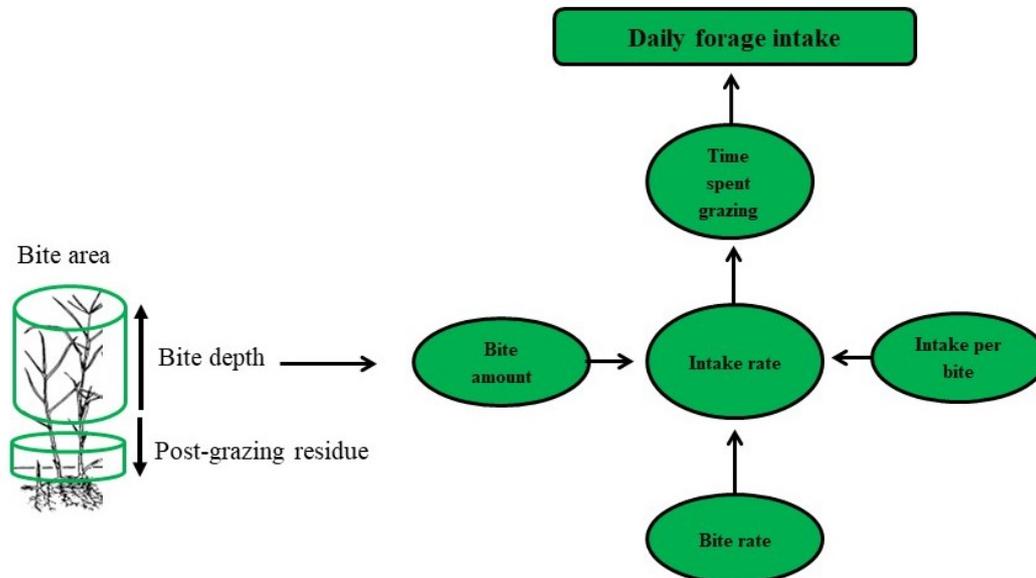


Figure 1. Components of ingestive behavior.

Source: Adapted from Hodgson (1990).

Some characteristics associated with the plant and related to harvesting by the animal are as follows: pasture height, forage mass per unit volume, leaf blade fibrousness, spatial arrangement of the preferred plant tissues, the presence of barriers to defoliation (such as sheaths and stems), and dry matter content. Usually, a higher sward height is related to a greater herbage mass, and a lower number of seizure movements is related to an increase in chewing activity (Penning, Parsons, Orr, & Treacher, 1991; Penning, Parsons, & Orr, 1994).

Plant characteristics, such as maturity stage and differences in composition (mainly between the leaves and stems) are reflected in the greater energy needed by small ruminants to harvest stems compared to that needed to collect leaves (Hendricksen & Minson, 1980). This fact occurs because of the lower resistance to breakdown during chewing and lower retention time in the rumen. Dense pastures promote higher consumption and subsidize the higher productive capacity of animals (Stobbs, 1973, 1974). In contrast, pastures with a high content of stems and senescent material seem to be more difficult to graze and limit the bite mass (Barthram, 1981; Glienke et al., 2016).

One of the most important traits in sheep and goats is their feed selectivity capacity. It is important to observe this characteristic in pasture management. According to the degree of selectivity, the animals will consume a pasture of higher or lower quality, which will influence their productive performance (Animut & Goetsch, 2008). Sheep and goats tend to be more selective than cattle, and young animals are more selective than older animals; however, diet selection patterns may be more unstable in young animals than in adults (Hodgson, 1990). Some authors (Poppi, Hughes, & L'Huillier, 1987, Sanon et al., 2007; Animut & Goetsch, 2008; Goetsch et al., 2010) suggested that the diet selection first involves feeding site selection and is then followed by bite selection. Thus, several factors influence the feeding site selection (Figure 2).

Bite selection is influenced by the animals' preference of plant components and their relative accessibility and abundance, especially in small ruminants. This choice is a reflex response to the chemical and physical characteristics of the leaves and stems of a plant species (Hodgson, 1990). Both preference and selection are relative terms, and the intensity of selection for a particular component of the pasture depends on either component being present and the contrast between them (Hodgson, 1990; Koluman et al., 2016). The degree of selective grazing by animals is determined through

structural characteristics, as well as the efficiency by which the forage is harvested, determining the total amount of ingested nutrients (Stobbs, 1973; Santos et al., 2013). Bite depth did not seem to be limited by the characteristics of the animal’s mouth, but is rather a response to pasture characteristics. Animals tend to concentrate their grazing activity in the canopy layers containing mainly leaf material, and the increase in grazing depth with increasing sward height is parallel to the increase in the depth of the leaf blade layer in the pasture. Normally, the ratio of the total leaves removed by defoliation seems, on average, to not exceed 25%. However, in extreme cases, the combination of a high frequency and high severity of defoliation can result in a leaf removal rate equivalent to 10% per day. This defoliation rate cannot be sustained for a long time without the occurrence of a depression in grass growth (Hodgson, 1990).

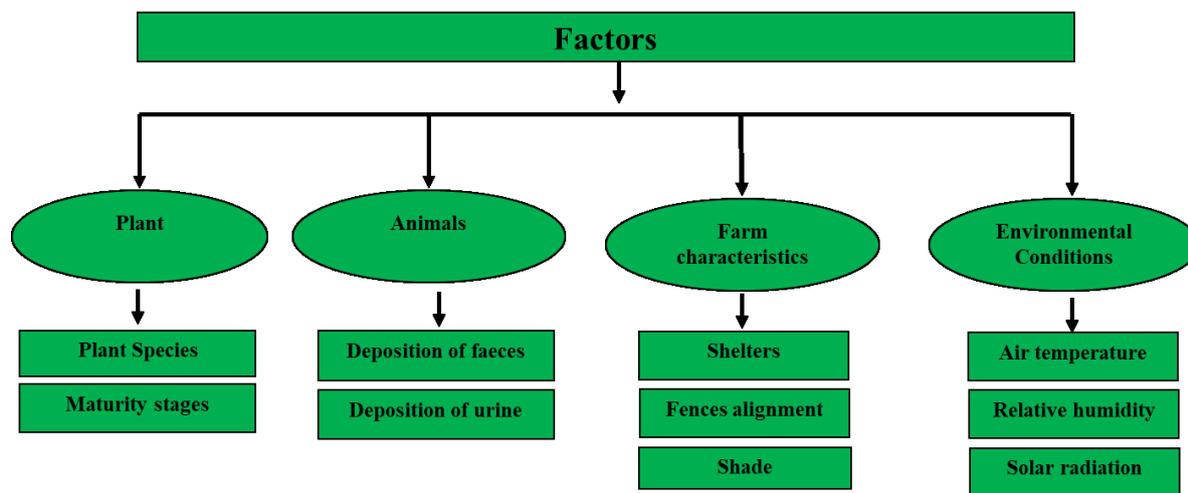


Figure 2. Factors influencing the feeding site selection.

A study showed that lambs feeding on Tanzania grass with a higher pasture height promoted an increase in grazing mass. However, more time was required to perform each bite (increase of 40%). This is because of the increase in the time of handling and chewing the forage to deglutition (Figure 3).

Forage intake by ruminants in pastures appears to be associated with the animals’ behavior. In situations with low forage supply, there is a decrease in bite weight and an increase in bite rate and/or time spent grazing (Penning et al., 1994). Forage intake by bite is very sensitive to structural variations, such as sward height (Silva et al., 2017). A decrease in bite weight promotes a decrease in the intake rate (Figure 3). Therefore, daily forage intake is also affected (Hodgson, 1990). Mass bite, which is influenced by sward structure, was the most important variable in determining forage intake by ruminants (Hodgson, 1985). Some other factors are also related to the bite mass, such as pasture height, blade spread (Flores, Laca, & Griggs, 1993), forage density of the grazing horizon, botanical composition, availability and accessibility of leaves (Hodgson, 1990), and the phenological stage of pastures (Stobbs, 1973; Goetsch et al., 2010). In an experiment conducted by Burlison, Hodgson and Illius (1991) to evaluate the ingestive behavior of sheep using different grasses with different heights, a positive correlation between bite mass and the sward height of higher grasses (>37 cm) was observed. However, there was no significant effect in grasses with heights ranging from 5.7 to 22.1 cm. Pedroso, Medeiros and Silva (2004), evaluating the bite rate and bite mass of ewes in different phenological stages of ryegrass pasture, verified average bite mass values of 0.064, 0.050, and 0.048 g bite⁻¹ for the vegetative, pre-flowering, and flowering stages, respectively (Figure 4). For the bite rate, 0.88, 0.87, 0.68 bites h⁻¹ for the vegetative, pre-flowering, and flowering stages were observed, respectively. These results indicated that the sheep presented a selective behavior according to pasture age (maturity). The bite rate was negatively correlated with the bite mass, and the more forage taken, the more time was required to chew the bite. Similarly, an animal that consumes a higher amount of forage requires more time for rumination (Pedroso et al., 2004; Cardoso et al., 2019).

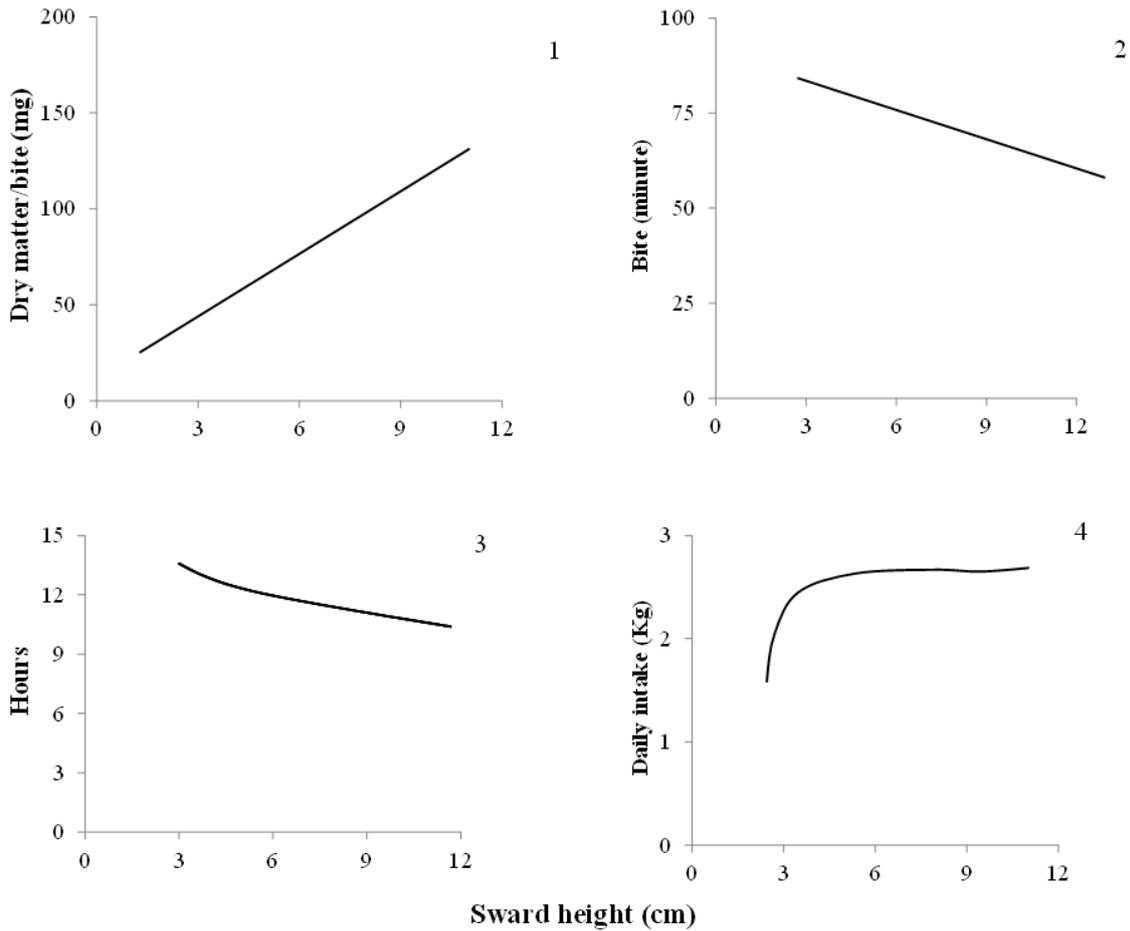


Figure 3. Relationship between sward height and (1) bite size, (2) bite rate, (3) time spent grazing e (4) forage intake in azevém pasture.
 Source: Adapted from Hodgson (1990).

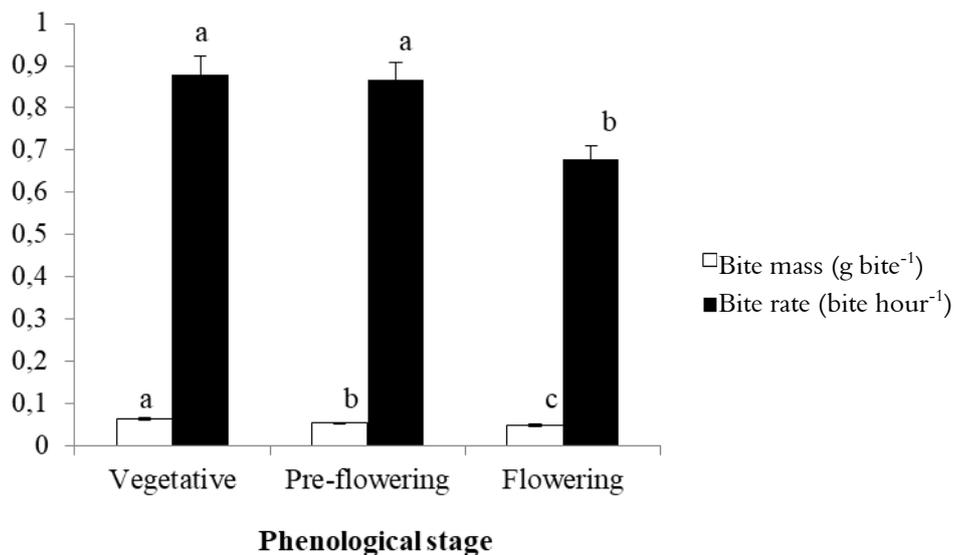


Figure 4. Bite rate and bite mass of ewes in different Phenological stages of azevém pasture.
 Source: Adapted from Pedrosa et al. (2004).

Grazing habits of sheep and goats

A well-defined feature of ruminants is collective grazing (grazing on lots), reflecting herd behavior. This behavior is defined as a gregarious habit. Woolled sheep behave differently by exploring the pasture more and walking further in the search for and selection of feed; they have a tendency to be more independent.

Woolled sheep form small groups within the pasture or graze alone. They also prefer small plant species. In contrast, hair sheep show a higher intake of shrub species, including legumes, probably because of the plants' chemical composition and the location of the pasture.

Regarding feed preferences, sheep and goats both have intermediate feeding behaviors, giving preference to grasses and broadleaf plants, herbaceous, and shrubs. In addition, small ruminants are efficient selectors, choosing tender and palatable parts rather than fibrous parts of the plant; they are unable to continuously ingest large quantities of fibrous feeds. Sheep and goats have a limited ingestive capability, in terms of both amount and retention time of the digesta in the rumen (Bartocci, Amici, Verna, Terramocchia, & Martillotti, 1997).

The intermediate behaviors of sheep and goats are related to their mouths' anatomical adaptations, which allow this grazing characteristic. Goats, in an evolutionary-adaptive process, developed upper lips that enable them to pluck desirable leaves out from among thorns; however, whether or not this advantage is significant depends on the composition of available forage. The more uniform the forage, the less beneficial selective grazing is. Furthermore, if the plant quality in the maturity stage differs greatly, as in tropical pasture, the higher selection may impair an animals' ability to survive in this type of environment. However, factors such as feed availability, thermal conditions, and plant preferences can affect the selection. Goats tolerate more bitter feeds than sheep and often consume browse plants in preference to grasses (Table 1) (Welch & Hooper, 1993; Moreno & Mitzi, 2008).

Table 1. Diet composition of sheep and goats on grazing system.

Forage type	Diet (%)	
	Sheep	Goat
Shrubs	10	60
Herbaceous	30	20
Grasses	60	20

Source: Adapted from Moreno and Mitzi (2008).

Sheep begin to graze by performing a visual assessment of the pasture site, establishing references in terms of quality and quantity of available forage. If the forage height is below the established average, the animal moves in search of a site that ensures a better forage intake (Palhano, Carvalho, & Barreto, 2002). According to Medeiros, Pedroso, Jornada, Silva and Saibro (2007), when subjected to feed restriction, the animals developed different grazing strategies to adapt to the new ambient condition. Exploratory feeding occurs because of hunger, which is motivated by nutritional demand. In addition, when there is little supply, mainly in feed quality, sheep and goats presented compensatory feeding strategies to maintain the intake of their nutritional requirements. During feed selection, performed by small ruminants, it is possible to observe that the animals have preferences for certain parts of forage. Sheep are more selective than goats in terms of nutrition. They prefer leaves, stems, and moisture-containing feedstuffs, rather than dry matter. However, hunger tends to decrease the selectivity of the animals.

In goats, it is usually assumed that they will explore all potential areas for grazing within a few days after being placed in a new grazing area. According to Goetsch et al. (2010), goats spent 62% of the time within 10 m of the fence, which was a cleared area, and 38% of their time was spent within the forested interior. Goats were more active in foraging within the interior pasture area and rested more in the cleared perimeter. It was observed that goats presented two grazing peaks, one at 9 h and another at 14 h, characterizing the activity of the animals as bimodal, and they quickly explored the entire pasture area (Goetsch et al., 2010). The authors also verified that goats tend to modify their feeding behavior when placed in the same area but at a different time (in this case, after one year), presenting different patterns of exploration in the interior pasture area. The authors suggested that this behavior can be influenced by genotype, environmental conditions, differences in vegetation conditions (quality), and preference for different plant species (Goetsch et al., 2010; Mphinyane, Tacheba, & Makore, 2015).

Sheep are more negatively affected by drought because herbaceous plants are more sensitive to periodic moisture stress than are woody plants. In contrast, goats can better withstand drought periods with relatively fewer browse species in their diet because they are more nutritious; they are also succulent, and therefore less sensitive to drought. In addition, their ability to forage selectively on younger and more highly nutritious plant parts allows them a competitive edge in surviving periods of below average forage supply. This means that goats can withstand harsh conditions better than sheep.

Daily activities of the animals during grazing

The daily activities performed by the animals include alternating periods of grazing, ruminating, and resting. The intensity and distribution of these activities are influenced by several factors, such as the availability and nutritive value of the pasture and its management, as well as the predominant climatic conditions of the region (Silva et al., 2008).

Most of the behavioral activities have been assessed via visual observation and tracking by researchers (Lachica & Aguilera, 2005), using previously described methods (Barroso, Alados, & Boza, 2000; Agreil & Meuret, 2004; Papachristou, Platis, & Nastis, 2005; El Aich, El Assouli, Fathi, Morand-Fehr, & Bourbouze, 2007) in which they quantify the ingestive behavior of sheep and goats. When the animals are assessed by visual observation, a principle to be respected is that observers do not disturb animals to obtain a close proximity, including the use of land familiar to the group and identification of specific individuals indifferent to the presence of observers. Beyond visual observation, researchers use electronic devices, including the following: equipment systems to measure lying, standing, and walking (Champion, Rutter, & Penning, 1997); pedometers to record step distance (Sharma, Saini, Singh, & Ogra, 1998); sensors placed around the mouth to record the time spent grazing, time spent ruminating, and number of bites (Abijaoudé, Morand-Fehr, Tessier, Schmidely, & Sauvant, 2000); geographical information system software to estimate the distances traveled (Ouéndro-Koné et al., 2006); electrical conductivity sensors to record patterns of jaw movements or bites (Patra et al., 2008); and GPS collars to monitor location and movement (Schlecht et al., 2009).

Time spent grazing

The time spent grazing is normally 8 h day⁻¹. Changes in the activity of rumination and other behavioral activities can occur with grazing times of more than 12-13 h day⁻¹. The main factors that influence dry matter intake in ruminants are related to the animal (breed, sex, genotype, body weight, growth, age, lactation stage, pregnancy, last feed, and body condition), feed (plant species, diet composition, chemical composition, digestibility, degradation levels, pass rate, conservation quality, dry matter content, quality, fermentation rate, acceptability, and fat content), management and environment (feed access time, frequency of grazing, anabolic agents, feed additives, minerals, availability, photoperiod, temperature, and humidity) (Silva et al., 2016).

Feed restriction can cause animals to increase their eating rate to maximize the intake during periods of feed availability. However, a rapid intake of nutrients can promote changes in ruminal microbiota and acid production. This fact is evident in animals fed milled rations or high grain diets, which either lower the rumen pH or stop rumination.

The type of supplementation can interfere with the time spent grazing. According to Li (2013), the time spent grazing and its intensity are closely related not only to the morphological characteristics of grasses, the time spent on grass seizure, and on reducing grass particles, but also to the characteristics of the concentrated feed supplement. According to Silva et al. (2015), the use of concentrate supplementation was expected to directly affect forage intake because of the substitution effect. However, there was no change in the grazing patterns of sheep, possibly owing to an excess of rumen-degradable protein in the supplement, and therefore they used the pasture to compensate for the excess protein and maintain a good protein:fermentable carbohydrate ratio for homeostasis in the rumen (Silva et al., 2015). In contrast, Confortin et al. (2010) reported a reduction in diurnal grazing time and an increased amount of time devoted to other activities; however, patterns of intake, displacement, and demand were unchanged.

In the particular case of semi-arid regions, where there is high solar radiation (mainly in the afternoon) combined with a decrease in relative humidity (Silva et al., 2013), this greatly influences the feed intake of ruminants and therefore their productive functions. Thus, the morning is more favorable for grazing and herbage intake by ruminants. Given the above, the grazing behaviors of sheep and goats are affected by several factors.

Time spent ruminating

The processes of regurgitation, reinsalivation, remastication, and redeglutition of rumen ingesta are defined as the time spent on rumination. The rumination process is repeated approximately once per minute and may last for up to 2 h. In small ruminants, long particles cannot be regurgitated in significant quantities. Particles measuring 7 cm are ideally sized to be returned to the mouth, promoting a continuous

process that maintains rumen and animal health. Chewing during breaks down foodstuffs into particles small enough to be regurgitated. However, chewing during rumination is relatively deliberate and at a slower rate than that during eating. The time spent ruminating is estimated to be around 1/3 of the day (8 h). This value can range between 4 and 9 h, split into 15-20 short periods throughout the day (Fraser, 1983; Van Soest, 1994), with 15,000-20,000 chewing movements (Hodgson, 1990); this is observed mainly during the night (Bremm et al., 2005). The main factors that can promote changes in the amount of time spent ruminating are the physical and chemical properties of the diet, which are proportional to the cell wall content of the feed (Van Soest, 1994). However, other factors, such as supplementation, climatic conditions, and breed, affect this behavior. The average particle size that passes from the rumen is less than 1 mm for almost all plant species. The rumination process is most important in the reduction of particle size. Furthermore, rumination is very important for feed degradation, with increased specific gravity of forages, breaks in plant tissue coatings, and increased forage surface areas available to the rumen microbiota maximizing digestion.

Rumination and eating time represent the total chewing time. For each unit of dry matter consumed, the total chewing time is associated with forage quality, provided the forage is in its natural long form. The forage component that is most strongly related to rumination time is neutral detergent fiber, most common in dry feeds. However, for some types of silage, a longer time spent ruminating can occur, as some high-moisture feedstuffs require longer rumination.

Periods spent on feed intake are interspersed with one or more periods of rumination or idleness, and the feed supply influences the rumination rate, which is higher at night. Differences in the duration and division of activities between individuals may be conditioned by the appetite of the animals, their anatomy, and energy requirements, which would be affected by the forage:concentrate ratio (Pines and Phillips, 2013).

According to Pompeu et al. (2009), sheep subjected to different supplementation levels spent more time ruminating while standing to dissipate the excessive heat caused by high daytime temperatures.

Conclusion

The daily forage intake is the result of the time spent by the animal grazing and the forage intake rate during this period. The selectivity of sheep and goats is one of the most important aspects to be observed in pasture management. According to the degree of selectivity allowed, the animals will intake a pasture of higher or lower quality, which will influence its productive performance. The degree of selective grazing is determined by structural characteristics, as well as the efficiency in which the forage is harvested, determining the total amount of ingested nutrients.

Sheep and goats both display intermediate feeding behavior; their mouths' anatomical adaptations permit this type of grazing, giving preference to grasses, broadleaf plants, herbaceous plants, and shrubs. However, factors such as feed availability, thermal conditions, and preferences can affect feed selection. Goats tolerate more bitter feeds than sheep, and often consume browse plants in preference to grasses.

The daily activities of animals include alternating periods of grazing, ruminating, and resting. Factors related to the animals, feed, farm management, and environment can affect these daily activities.

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