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# Voluntary Feed Intake, Grazing Behaviour and Plant Preferences of Ruminants

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**Abstract**
Feed intake, feeding behaviours and plant preferences of grazing animals are the most significant characteristics for performance. Effective utilization of legumes, grasses and other families by grazing ruminants (cattle, sheep and goat) as a nature of their creation is fairly important for both producers and range management. Although feeding behaviours of ruminant animals were widely studied, there is still necessity to information about voluntary feed intake, grazing behaviours and plant preferences, affecting the performance in range-based livestock farming. Therefore, voluntary feed intake, feeding behaviours, plants preferred primarily and willingly and reasons of the preferences of grazing ruminants were observed and discussed in this review. Briefly, factors affecting voluntary feed intake of grazing animals can be ranged as genotype, plant and environment. When these factors are taken into consideration, the botanical composition of grasslands (legumes, grasses and other plant families), and the type of animals to be reared, yield level of genotype should be properly considered while the new pastures are being formed.

**Keywords:** Feeding behaviour, forage, feed selection, rangeland, ruminant, dry matter intake

## 1. Introduction

Feed intake is one of the most crucial factors for ruminants (cattle, sheep, goat, and buffalo) in terms of productivity and performance [59]. If voluntary feed intake (VFI) of animals is low in range-based livestock, production rate of acquired products decreases swiftly [84]. This situation arises from the usage of great proportion of consumed metabolisable energy (ME) for maintenance and a deficiency at the conversion of the consumed nutrients to animal products [84]. All of these are more important for animals having pretty complicated feed intake decisions [62] according to different plant families and species in the rangeland. For example, cattles prefer bioactive fodder crops containing compounds like tannins at a lower rate and thus malnutrition occurs. Therefore, harvesting or afternoon grazing, when non-structural carbohydrate rate of the plants increases, is suggested for decreasing plant preference at the rangelands rich with these plants or increasing palatability of these species [50]. Thus, such bioactive fodder crops are consumed more willingly by the ruminants and animals are naturally controlled against pathogens and there is no deterioration in their productivity and performance [50, 82].

The most significant three factors affecting VFI of ruminants are animals, fodder crops and environmental conditions [54]. It has been determined that preferability of plants and VFI control short period feeding behaviour with homeostatic and long period control of body depending on body reserves and nutrient requirements of animals [43, 60]. Consequently, species, age, yield level and physiologic status (dry, lactating or impregnate) of animals, grazing alone or with another species, number of animals

grazing in an unit area (grazing pressure) affect plant preferences and grazing behaviours of grazing animals [15, 25, 40, 67, 82, 85]. Characteristics of rangeland and fodder crops like family of plant (legumes, grasses and other families), botanical composition like stamina to grazing pressure (decreasing, increasing and invaders) and plant prosperousness of rangeland, negative and positive relations among plants (phytosociology), heights of plants [31] have been found effective on control of short time feed intake [78, 84]. Desired plants for grazing are rich sources in terms of dry matter (DM), organic matter (OM), crude protein (CP), ADF and NDF, digestible dry matter, ME, relative feed value (RFV) and relative forage quality (RFQ) [5, 8]. Although some rangeland plants are from species having lower stamina to grazing pressure, they are preferred at a higher rate by grazing animals [83]. There are some reports that plant nutrient composition affects plant preferences and VFI of ruminants [69, 79]. Considering the difference in nutrient content between the wild and cultured form of plants [8], it is seen that plant preference and VFI may be different in pasture and rangeland.

Environmental factors such as climate (rainfall, temperature), geographic situation, and time zone within a day can be effective on grazing behaviours of animals [3, 12, 51]. As a matter of fact, VFI of animals exposed to heat stress decreases and as a result negative energy balance can occur [45]. As it is seen, it is fairly important to know plant preferences and grazing behaviours of grazing animals for more sustainable and economical production and appropriate range management [31, 74]. Many researchers [10, 47, 57, 66] have studied to determine plant preferences and VFI of grazing animal by observation or mechanical methods. However, it is very difficult to make these estimations if there are some or all of the factors listed above, and especially in the case of heterogeneous rangelands with numerous plants.

Although feeding behaviour of ruminants has been well studied and published extensively [83], there is still a need for a well-compiled knowledge about factors affecting performance of grazing animals such as VFI, plant preference and grazing behaviour in terms of range-based livestock. Therefore, VFI of grazing animals, feeding behaviours in rangelands, preferred range plants and reasons of these preferences were examined and discussed in this review.

## 2. Voluntary feed intake

Voluntary feed intake of an animal in rangeland can be explained as which plant or plants were preferred primarily, willingly and heartily. When VFI behaviours of grazing animals are assessed, plant height, fertilizer amount and type applied to range, physiologic status of animals, body reserves, previous nutrition habits, climate, time zone within a day and antinutritional factors of plants must be considered [62]. Factors influencing VFI of grazing animals can be summarized as in the Figure 1 [30].

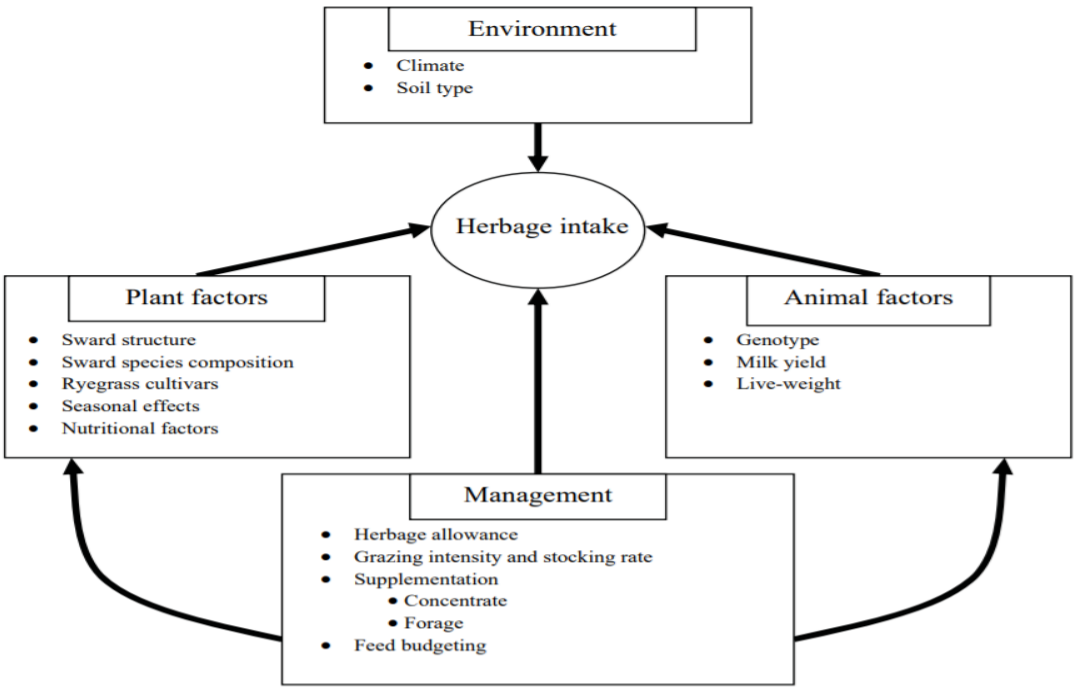


**Figure 1**. Factors influencing herbage intake of grazing animals [30].

Voluntary feed intake of grazing ruminants is proportional to body weight and this proportion shows that not only metabolic but also physical factors regulate intake and these factors mostly support each other. Herbage intake can be seen as a function of factors such as average biting size, biting rate (number of bites per minute) and grazing time. Another factor regulating the VFI in rangeland is fullness of digestive tract [2]. Fullness of digestive tract depends on metabolic rate connected with consumed oxygen [60]. It was stated that different sheep breeds of the same age [87] or animals in different ages from the same breed [88] have different digestive tract characteristics, which may affect feed intake and feed conversion ratios. If DM of the herbage is lower than 20 %, water volume of the rumen increases and this can show a repressive effect on VFI [56, 63]. Moreover, some studies have reported that VFI is related with body weight and metabolic body size [32]. Besides, it is known that there is a relation between grazing speed and herbage intake however individual speed differences prevent using grazing speed as a factor in an estimation equation [39]. Plant preference of grazing animals is also related with nutrient composition of plants [47]. While the effect of this relation on VFI at the plant growth period was 5%, effect of elderly plants on VFI with ADF, NDF and N content was 51 % [69, 79].

**3. Grazing behaviours of ruminants**

Range-based livestock, especially dairy, varies significantly depending on climates of regions [30, 33]. As a matter of fact, dairy farmers have more chance and grazing dairy cows are more common in Western Europe (England, Ireland, and France) than other regions (Northern) because grasses can regularly grow throughout the year in western regions [61]. This system allows increasing the rate of range plant in the total diet of cows and maximizes profitability [28, 29]. It was calculated that increasing 10 % of the range based herbage for the total diet reduces the milk production costs 2.5 cents per liter [29]. For this purpose, grazing behaviour and VFI at rangelands is vital [19, 43, 53].

Nutrient requirements of grazing animals can not be known because of the differences in grazing period, heat stress, total movement amounts and spending energy [4]. The ability of animals to meet their undetermined requirements and to increase body weight or to convert their nutrients to another yield depends on how much digestible food they consume [50]. Grazing behaviour is a process having a direct relation with nutrition and productivity of animals and the effect of animals on rangelands [20, 74]. Comprehending grazing behaviours of grazing animals in rage-based livestock is crucial for improving herd management, range management and decreasing environmental effects of intense animal production [19, 20]. Grazing management is important in determining the grazing timing and grazing sessions required to meet the nutrient requirements of animals. It has been reported that sheep has a high adaptation ability to negative effects of light and heat stress on VFI by arranging grazing and resting periods to proceed OM intake [48]. When cattles having short and long time access to rangelands were compared, it was seen that animals with the low access spent their time mostly by eating and had higher grazing efficiency [46]. Chen et al [20] reported that these results mean that animals have the ability to change their VFI as a result of their behavioral decisions.

It has been stated that grazing behaviour and VFI depend on rangeland characteristics such as DM or OM in unit area, herbage yield, access period to rangeland, plant height and density and botanical composition [23, 51, 78]. Mattiauda et al. [51] have reported that these factors have a direct effect on biting rate and amount (mg DM/bite), influencing herbage intake (g DM/min) and grazing behaviours. Moreover, seeking and choosing behaviours of ruminants also affects DM intake. This situation arises from the differences in the daily grazing period, rumination and resting time [51, 78]. Consequently, shape of the gathering of these models can change the utilization of plants and help an effective VFI to minimize plant preference and selecting [82, 51].

Grazing is a natural part of the ruminants, when temperature is high it was seen that grazing activity decreased and lower temperatures meant higher grazing activity for sheep and cattle [3, 12]. When grazing behaviours and periods of cattle, goat and sheep were examined it was determined that all animals spent their time in the rangelands with numerous plants rather rangelands with single plant and plant preferences of the animal species were different [15]. The effect of previous nutrition habits on plant preferences was explained with sheeps fed with *Lolium perenne* preferred more *Lolium perenne* in a rangeland consisting of *Lolium perenne* and *Trifolium repens* [62].

When evaluated plant preferences of ruminants it is crucial to care which plants were preferred instead of which plants. Both sheep and cattle when they have a chance to choose in a rangelands consisting of *Lolium perenne* and *Trifolium repens* prefer *Trifolium repens* at a 70 % rate of total DM intake [71]. This preference is related with physiological status, nutrient requirements and rumen parameters of animals [73, 86]. Lactating cows with higher nutrient requirements consume more *Trifolium repens* than dry cows. *Trifolium repens* intake of lactating and dry sheep was 79.7 and 65.8 %, respectively [62], and this ratio has been determined for lactating cows as 73.8 % [66, 72].

Studies on animal species in terms of grazing behaviour have shown that goats are different in terms of nutrition, feeding levels, diet selection, taste discrimination and grazing behaviours based on the anatomy and physiology from sheep and cattle [15, 81]. In a study on plant preferences of sheep and goats, it has been determined that sheep prefer plants containing high N concentration and preference of goats is tended to low NDF [82]. Differences of the nutrients preferred by sheep and goats can arise from the differences in proportion of body, leaf, stem and shoots of plants based on different grazing behaviours of sheep and goats [82]. This situation should be taken into account especially grazing in rangelands and pastures.

It has been reported that competition for unit area in grazing single or multi species increases the rate of intake by affecting grazing behaviour of animals. Therefore, insufficient herbage intake may occur even in a well-balanced pasture due to the grazing behaviour of animals. This situation shows that inter-species social interactions affect VFI at range-based livestock. It can cause some animals in or among species to not be able to enter the group such a grazing period or to be excluded by a dominant member of the herd and not to have enough chance for plant preference; this can result with low VFI for the otherized animals. Although grasses increase range productivity and stability, legumes increase productivity and nutrients and other families can contribute to the quality of the rangelands [8, 83]. Intensive N fertilizer application without considering the quality in terms of rangeland improvement can increase grasses causing lower nutrients and a negative effect on DM intake of ruminants [6, 7]. It has been determined that fertilization of rangelands with fertilizers including Na and K [21] increased DM intake of ruminants especially with lower milk yield. On the other hand, DM intake decreased almost 30 % after application of slurries consisting of wastes with high mineral contents. This situation can be an indicator of negative effects of rangeland pollution on VFI depending on physical and physiological starvation of animals. Indeed, grazing animals have been observed to deny plants with feces or the neighbors of these plants as long as they do not starve [18, 38, 47, 77].

**4. Plant preferences**

Some fodder crops are preferred more willingly by grazing animals. There are significant differences in and among species for these preferences (Table 1). Age, body weight, body condition score, potential yield level, days in a lactation, plant height and supplemental feeding are the variables affecting on total and rangeland DM intake [11]. A grazing experiment was carried out with single or mixed animal species formed cattle, cattle and sheep or goat in a shrubland area consisting of a mixture *Lolilum perenne* and *Trifolium repens* [15]. The results showed that animals in mixed herds had more grazing time in pasture compared to herds with single species. In addition, goats (68 %) spent more time than cattles (19%) and sheep (35%) in bushland. While consumed plants of cattle and sheep were herbaceous (85-95%), consumed shrubs by goats were 28%. Therefore, it can be said that cattle and sheep prefer herbaceous legumes and grasses in approximately 60-70% and this ratio is 20 % for goats [81]. On the other hand, the preference levels of consumable herbaceous and shrubby weeds were found to be approximately equal (20 and 30% for cattle-goat and sheep, respectively). In contrast, preference level of shrubby legumes and other plant families were 10, 10 and 60 % for cattle, sheep and goats, respectively [81].

Significant differences in the preference of goats especially from sheep and cattle depend on the fact that goats display a browser grazing behaviour and prefer high plants [15, 81]. While cattle do not prefer to consume plants shorter than 2.5 cm, sheep can graze almost to the level of soil surface [15]. These preferences may be related to the physical and chemical properties of the carbohydrates in plant structures as well as the growth form [69, 82]. On the other hand, some fodder crops have an herbaceous development form, while others have shrubby-type development. Therefore, the reason of different preferences of different animal species in different plant families can be explained with the higher feed value of herbaceous legumes than grasses and other families [8] which affect VFI [69] of the grazing animals. Plant preferences in rangeland and pastures, which are composed of the same plant species, may also differ as a result of the improvement in nutrients and feed values.

In a study examined plant preferences according to nutrients among animal species [69], while crude protein (CP) content of plants had a positive effect with the variations among species, this affected DM intake and DM digestibility in the same way for all species. It has been determined that water buffalos are more sensitive to plant CP than sheep, goat and cattle, respectively. Plant ADF content negatively affected DM intake for all species except water buffalo and the effect of ADF on DM intake was more powerful for sheep and cattle than goats. While NDF decreased DM digestibility of cattle, it had a tendency to be positive in sheep and goats. Acid detergent fiber content significantly decreased DM digestibility of sheep and goat but it affected DM digestibility of cattles only numerically.

 

**Table 1.** Plant preferences of grazing animal

| Animal species, physiological status | Plants | The most preferred plants | The least preferred plant | Reference |
|---|---|---|---|---|
| *Sheep (lactating)* | *Lolium perenne, Trifolium repens* | *Trifolium repens* | *Lolium perenne* | *[62]* |
| *Sheep (lactating)* | *Lolium perenne, Trifolium repens* | *Trifolium repens* | *Lolium perenne* | *[64]* |
| *Cattle (dry)* | *Lolium perenne, Lotus corniculatus* | *Lotus corniculatus* | *Lolium perenne* | *[80]* |
| *Cattle (lactating)* | *Cynodon dactylon, Panicum virgatum, Pennisetum flaccidum, Tripsacum dactyloides* | *Cynodon dactylon* | *Panicum virgatum* | *[17]* |
| *Cattle (lactating)* | *Lolium multiflorum, Hedysarum coronarium* | *Hedysarum coronarium* | *Lolium multiflorum* | *[71]* |
| *Lamb* | *Lotus corniculatus, Medicago sativa, Festuca arundinacea, Dactylis glomerata* | *Medicago sativa* | - | *[85]* |
| *Weaned calf* | *Lolium perenne, Trifolium pratense, Trifolium repens, Cichorium intybus, Plantago lanceolate* | *Trifolium pratense* | *Trifolium repens* | *[9]* |

Development form of the plants affects structural and nonstructural carbohydrates fractions and this influences the plant preferences of grazing animals [42, 52, 68]. In a study with two rangelands (1st *Lolium perenne* and 2nd *Plantago lanceolata*, *Trifolium pratense*, *Trifolium repens* ve *Cichorium intybus*) it has been determined that calves grazed *Lolium perenne* spent more time by resting and ruminating but most consumed plant was *Trifolium pretense* [9]. On the other hand, animals grazed in a rangeland consisting of *Veratrum album*, *Peucedanum ostruthium*, *Adenostyles alliariae*, *Nardus stricta*, *Festuca rubra*, *Anthoxanthum alpinum*, *Poa alpina*, *Leontodon hispidus*, *Trifolium badium*, *Trollius europaeus* spent 25% of their time with high plants forming the 13% of the total botanical composition [57]. Although herbaceous legumes have a higher feed value than other plants, the main benefits for livestock arise from the fact that some species such as *Trifolium repens* and *Lotus corniculatus* are more consumable [42]. Rangelands consisting of plants, consumed willingly by grazing animals, such as *Lotus corniculatus* L., *Lolium perenne* L. and *Plantago lanceolata* L. was stated that they increase the VFI of the ruminants. Dry matter intakes for these three plants were determined by Aydın and Ocak [8] as 3.06, 1.82 and 2.86 % of the body weight, respectively. It was determined that cattle differed in preference between annual and perennial plant varieties such as *Lolilum multiflorum and Lolium perenne* [11,76]. However, there is little evidence that long-lasting grass with high sugar content has a significant effect on DM intake. This can only occur if there is a lack of metabolisable protein [86].

It is known that plant height has a significant effect on plant preferences and time spent in the rangeland. The highest reachable points of cattle, sheep and goats are 1.90, 1.17 and 2.10 meters, respectively [74]. In addition, the time spent of species for browsing and grazing is also different. For example cattles and goats spend most of their time by grazing and browsing, respectively [22]. Grazing animals abstain to consume some plants due to the lack of nutrients, undesirable chemical composition and properties of plant surface [32]. This situation means that fodder crops have different nutrients in different periods so they will not be exposed to the same preference every time. It is still among the topics studied which plants are more preferred by lactating and dry cows when they have the option of freely prefer legume and grass forage crops in rangelands. The highest legume intake was observed in sheep as 88% of total DM intake, while the lowest was 60% of total DM intake in fattening cattle [65].

Results of studies [16, 36, 37, 45] explored the effects of plant height on grazing behaviours of animals have showed that both the differences of plant heights due to topographic structure and the shortening

fodder crops height could significantly affect the VFI. The most effective strategy for providing sufficient DM for grazing animals in rangelands consisting of short plants is increasing grazing span. However, this situation limits the rumination and grazing activities affected by qualitative and quantitive factors of plants [58]. Thus, VFI could significantly be affected due to the changes of the digestive system fullness. The other effect of plant height on the VFI is the differences in resistance of the plant to the bites of the animals due to the degree of maturity of the remaining part of the plants in different heights and number of leaves, even in rangelands where the same kind of fodder crops exist. As a matter of fact, in a study with grazing dairy cattle [44] showed that increase in leafless plant height resulted in approximately 33% change in VFI. This result shows that the effect of the difference in plant height on the VFI is mainly due to the number of leaves on the plant. In a study conducted with dairy heifers in a rangeland consisting of perennial grasses and *Trifolium repens,* grazing behaviour of the animals was observed after mowing and regrowth period of the plants. It was allowed to animals to decrease the plant height from 20-38 cm to 8-9 cm and it was determined that almost all leaves were consumed by animals and due to the decreasing plant height feed mass taken by bite was lower. This situation did not affect the grazing span but low leaf: trunk ratio decreased rumination time.

It has been determined that different time zone in a day has a significant effect on VFI. During a one-day period, the VFI of grazing animals influenced by characteristics such as grazing behaviour and botanical composition and in particular by the DM and sugar content of plants [1, 13]. As the day progressed, the increase in bite rate and bite mass led to an increase in the DM and OM intake [70, 71]. These researchers have reported that preferences of legumes and grasses by grazing dairy cattles have changed from morning to afternoon. This is related to the fact that plant DM and sugar content are at the highest level in the afternoon and at the same time synchronize the fragmentation of carbohydrates with N compounds and rumen fermentation characteristics [55, 75]. When ruminants have freely preferring chance of feed materials, it is determined that the animals can make the best selection to increase their performance without affecting their health status [73, 86]. This may be an explanation of why the preference between families of fodder crops changes throughout the day. On the other hand it has been determined that fodder crops containing high sugar content are preferred more willingly. It should be kept in mind that these behaviours will be influenced by climate factors such as precipitation, temperature or dew presence, additional feeding levels, type and quality of feed used in nutrition [24, 27, 34, 35].

## 5. Conclusion

Nutrition level and competition for grazing area have a great effect on grazing behaviour. Present studies about this topic focused on effects of botanical composition of rangeland and phytosociology, fertilization in terms of rangeland improvement, herd and range management, association among species of animals (sex, genetic potential, age, lactation period etc.) and supplemental feeding on plant preferences and grazing behaviours of grazing animals. In this review it has been determined that 1) legumes in herbaceous form have higher feed value than grasses and other families, 2) perennial plants are more preferred to annuals by ruminants especially cattles, 3) plant species and varieties of the rangeland and the physical and chemical properties of plants in each botanical composition affect the preferences and VFI, 4) single or mixed species grazing can be preferred for different rangeland plants, 5) application of fertilizer including Na and Mg beside N, P and K increase VFI, 6) bite mass, biting rate and VFI of grazing ruminants increase afternoon due to the increment of nonstructural carbohydrates in plants 7) supplemental feeding is not beneficial unless grazing conditions are poor 8) genetic potential of grazing animals affects and there is a correlation among DM intake from grasses, total DM and yield of animals. Factors affecting VFI of grazing animals briefly include animal and environmental factors. Rainfall, temperature, time zone within a day, DM content of plants, plant height, nutrient content of plant, single of mixed species grazing, previous nutrition habits and physiological status of animals. Although the preferences of rangeland plants are quite complex, it has been observed that 60-88% of the total DM requirements in all species are met by consuming legumes. For this reason while the pasture composition is being formed, animal species, physiological status of animals and desired production type must be considered. Moreover, the effects of legumes on reproduction system of grazing animals need to be investigated.

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