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Grazing behaviors of ruminant livestock

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ABSTRACT

Grazing behaviors and different factors affecting grazing behaviors of ruminant livestock were reviewed in this paper.

Key Words: *Grazing behaviors, livestock*

Evcil ruminantlarda otlama davranışları

ÖZET

Bu derlemede, evcil ruminantların otlama davranışları ve bu davranışları etkileyen faktörler incelenmiştir.

Anahtar Kelimeler: *Otlama davranışı, evcil hayvanlar*

INTRODUCTION

Like any other business, the profitability of a grazing system is dependent upon minimizing expenses, maximizing the income of the system, and maximizing utilization of the system's sources. The utilization of a system at maximum rate requires extensive knowledge about the system and how to manipulate it to improve its profitability.

The main objective of a grazing system is to match the animal's requirement with pasture throughout the grazing session. In a grazing system, there are two manageable resources, namely the pasture and the animal grazing it. Before one establishes a grazing system, the producers have to know what kind of problems they may face and how to solve these problems, and how one can improve the income of the system. Producers have to have considerable knowledge about animal behavior, animal-forage interactions, and factors affecting them in order to utilize them at a maximum profitable rate.

One of the most important factors affecting animal performance is grazing behavior. Grazing behavior of animals is directly related to forage intake and, subsequently, animal performance. Any factor influencing the grazing behavior of an animal may cause big economical gain or loss. Therefore, producers should know the factors affecting their animal's grazing behavior and avoid situations which reduce intake. Another important factor is pasture management. Proper pasture management is very crucial in grazing systems. Proper pasture management is also indirectly related to animal grazing behavior because animal grazing behavior differs for different swards and forage types. For example, in taller swards, ruminant palatable forages over less palatable ones. When a producer establishes animals are very selective; however, as sward height declines, animals become less selective. Animals also prefer more a grazing system, he/she should consider all factors which may affect the system and set up an ultimate goal and then build a grazing system according to his/her goal.

Factors affecting the grazing behavior of animals can be divided into four main groups based on the origin of the factors. These main factors include environmental factors, animal factors, grazing management factors, and plant factors.

Methodology of Measuring Grazing Behavior

In general, monitoring of grazing activity requires either direct (eye observations) or indirect (device use) monitoring. The direct eye observation technique (2) requires 24 h observation of animals with 5 to 15 min intervals. This direct technique is used to monitor time spent grazing, ruminating, standing, lying down, and distances traveled. Funston et al. (15) used the telescope to monitor animals from far distances without bothering the animals. However, this technique involves high labor inputs. The most commonly used technique is the indirect technique. This technique requires the use of some kind of device to monitor animal's activity. The use of vibricators, described by Stobbs (32), to determine the grazing time and pedometers, described by Andersor and Kothman (4),to estimate the distance traveled is very common in the literature (5; 13; 15). Scarnacchia et al. (31) and Funston et al. (15) described the use of a watch with a 5 min timer and stopwatch to determine bite size.

In the review of Krysl et al. (24), the importance of selection of experimental period and animals is emphasized. Previous studies suggest that researchers need to choose an appropriate acclimation period for grazing behavior studies. As it has been seen in the study of Dunn et al. (13), the previous grazing experiences can influence thermal stress responses. Previous grazing experience of an animal in the same pasture also influences preference for a plant type. Factors such as the animal's previous grazing experience and the spatial and thermal environments into which animals are placed should be taken into account when one determines the length of adaptation period.

Dougherty et al. (11) describes the importance of design to obtain a meaningful result in behavioral studies. Research on the relationship between grazing animals and their pastures is often handicapped by design and analyses. A method employing tethered animals in which the experimental unit is an individual animal which has its own sward for grazing sessions has been developed. Such animal-sward experimental units permit the employment of more powerful designs and analyses. Although these experimental units can be managed with electric fences, portable fences or corrals, Dougherty et al. (11) reported that tethering allows the researchers better control over the animal and its sward. When an animal-sward unit is used in conjunction with

changeover designs that estimate direct, residual and permanent effects of treatments, the interval between measurement periods can be corrected.

Factors Affecting Grazing Behavior

Animal Factors

Animal Species

Several researchers have shown that grazing occurs throughout a day in all ruminant livestock; however, the greatest proportion of grazing takes place during daylight. Approximately 65 to 100 % of grazing occurs between 0600 to 1900 over a wide range of environmental conditions, supplementation regimens, grazing management, and forage types in cattle (24). However, studies in the literature have shown that several factors may alter the grazing pattern of certain animals, such as, temperature (3), mixed grazing (1), and existence of secondary plant compounds (alkoloids) in the forage animals consume (21). Daily grazing ranged from 6.8 to 12.3 h/d for cattle over a wide range of environmental temperatures, supplementation regimens, grazing management schemes, and forage types.

Distances traveled differ among livestock. Goats tend to travel greater distances than sheep. Goats have been reported to travel almost 5.5 km/d during winter months and 3.5 km/d during early spring months (26), whereas cattle traveled 6.1 km/d in summer days compared to 4.6 km/d in winter days (13). Distance traveled is also influenced by several factors such as, stocking rate, distance to water, temperature, age of animals, and type of grazing system. Daily distance traveled ranged from 1.7 to 8.2 km/d for cattle over a wide range of environmental temperature, supplementation regimens, grazing management schemes and forage types.

Grazing is a selective event. However, the level of selectivity differs among livestock. Anatomical and physiological adaptations in ruminants during evolution forced them to differ in grazing habits. Small ruminants have much greater energy requirements per unit body mass since energy and nutrient requirements expressed per unit body mass decline with increasing body mass (34). Total energy requirements in large ruminants can not be met by highly selective feeding behavior because of wide spatial distribution of low cell-wall plant materials and the increased time required to harvest large quantities. Thus, large ruminants can not afford to be concentrate selectors. In contrast, since the small ruminants have higher nutrient requirements and smaller gut capacity and mean retention time for fermentation of forage, they have to be concentrate selectors to meet their nutrient requirements.

In general, all ruminants prefer living to dead materials, young to older materials, and leaves to stems. Among the livestock ruminants, goats are the most selective and cattle are the least selective animals. The fractions which goats often select, buds, leaves, fruits, and flowers, contain less fiber and more protein, and are the most nutritious parts of plants (26). Abaye et al. (1) has demonstrated that the diet of grazing sheep contains a greater concentration of digestible nutrients than does the diet of cattle. In the study of Abaye et al. (1), pastures in which sheep grazed alone were generally higher in NDF, ADF, cellulose and hemicellulose, whereas CP and IVDMD were lower than forages in pastures where cattle grazed alone. Forages in pastures where both animal species (sheep and cattle) were present was generally intermediate in quality. This evidence clearly indicates that sheep select more nutritious fractions of plants than do cattle. Lu (26) also reported that sheep are greater selectors than cattle.

Taste presence of livestock species is also different. Goats are more tolerant of bitter tasting compounds in plants (26). Goats eat plants containing higher levels of tannic acid, whereas cattle and sheep usually reject it. However, sheep are more tolerant of salty fractions of plants and like to have some salt in their diet. Cattle are the most taste discriminative animals among livestock ruminants (26).

Age of Animal

Aging provides more experience for adaptation to the environment in which an animal lives. As an animal gets older, they become more familiar to the environment and vegetation. However, when an animal is taken from the environment where it grew up and placed into another environment, the animal will usually behave differently from other animals in that environment because of lack of experience in the new environment. In a new environment, animals may be presented with new plant species of varying physical form and distribution and chemical composition quite different from those experienced previously. Arnold et al. (6) showed the effect of nutritional experiences in sheep. In that study, Arnold et al. (6) took sheep from different environmental backgrounds and put them all in a new environment. They also used sheep from this new environment to compare the forage preferences of sheep. The preference for plant species were different among sheep, but the differences in preference among sheep declined over the time period indicating the adaptation of sheep to the new environment.

Arnold et al. (6) also noticed some differences in adaptation to climate and other physiological aspects of the environment. It seems that a wide experience of plant species in early life is an advantage when sheep are faced with a new and unfamiliar environment. However, it seems that prolonged experience of one range of stimuli hinders adaptation to a new range.

Dunn et al. (13) reported that 3- year old cows spent more time grazing and traveled further each day than 5 or 7-year old cows. However, Adams et al. (3) reported a decreased daily grazing time (DGT) for 3- year old cows compared to older cows in one of two trials conducted during winter. A possible explanation for inter-study differences in the effect of age upon DGT is the importance of previous grazing experiences upon present grazing behavior. The previous grazing experience of the 3-year old cows used in the study of Dunn et al. (13) had been variable with rangeland experience as calves and confined feeding and tame pasture as heifers. It would be logical to assume that the lack of previous grazing experience during winter months would affect foraging behavior by increasing search time for food. A reduction in DGT would result with more grazing experience, as observed in the cows (13). As it is seen from the studies, the significance of age is the experience earned. The age does not alter the grazing behavior itself, but rather the experience earned with aging modifies the grazing behavior of animals.

Herding Behavior Pattern and Formation of Interanimal Relationships

It has been reported that changes in spatial pattern of a herd of cattle were influenced by a variety of factors such as grazing season, the area of pasture, the vegetation of pasture, appetite level, and the appearance of biting flies. This was for herds which consisted of members born and bred in the same farm or herd. However, spatial patterns in a herd composed of different histories vary not only by changes in those factors, but also by association between individual members (19).

Hayasaka (19) described the formation of herds with animals composed of different farm backgrounds. In his study, in the early grazing period, the herd was divided into several subgroups. Cattle usually behave more or less as a herd, not as individuals, but the spatial pattern in this period showed that each individual had a strong tendency to associate more closely with other companions from the same farm than with any other individuals within the herd. It was often observed, for example, that paired heifers moved away from subgroups and behaved as a pair freely. As the grazing season progressed, individual members aggregated as a whole herd. This is not merely because the individuals gradually knew each other by sight but because the individuals behave to take refuge from attacks by large horse flies. Kabuga et al. (23) has given a similar interpretation that the aggregation of individual animals is a self-defensive behavior as a herd against disruptions.

Hayasaka (19) reported that the stronger animals tended to locate around the center of the herd. The reason for this is possibly due to the fact that attacks by large sized horse flies are more frequent on the periphery than around the center of herd. Namely, the stronger animals can obtain the best place that horse flies do not attack, and weaker animals are expelled from that place. Kabuga et al. (23) also reported that stronger animals stay at the center of herd when they scare and do not want to move.

In the late grazing period when the individual members dispersed, mixing was completed (19). This spatial pattern is apparently the least complicated of these three periods and may be caused by the decrease in herbage quality and quantity in fall. The frequency of threats and butts decreased over the experimental period and the herd became more stable (23).

With the lapse of season, relationships between individuals in the herd seem to move in one direction. The close bonds within each original group from different farms break down, and new bonds are gradually formed between individuals within the whole herd.

Management Factors
Supplementation

Providing supplement to grazing cattle has resulted in different grazing behavior. Data from literature (2; 7) reviewed is not consistent. Supplemented cows grazed approximately 1.5 h/d less than unsupplemented cows in the study of Barton et al. (7). However, Adams (2) reported that a trend for supplemented cows at 0730 grazed longer (36 min.) than unsupplemented cows. It is not clear what causes these differences. These differences may be due to other factors, such as the animal's physiological status, environment, or forage types rather than supplements.

DelCurto et al. (10) has demonstrated the effect of protein source on grazing behavior of cattle. In the study of DelCurto et al. (10), alfalfa supplemented cows spent less time grazing during the mid-February grazing period compared to pregnant cows supplemented with dehydrated alfalfa pellets (DEHY) and soybean meal/sorghum grain (SBM/SG).

The effects of the physical form of supplement has been reported (10). Animals receiving alfalfa hay spent less time grazing compared to animals receiving DEHY and SBM/SG. The reduced grazing time might have been due to a greater amount of time involved in consuming the alfalfa because mean supplement consumption times were approximately 10 min vs 1 hr for the DEHY and SBM/SG supplements and alfalfa hay supplement, respectively. Thus, increased time involved in consuming alfalfa may have directly reduced grazing time. Another potential explanation may involve reduced gut capacity with advancing pregnancy and physical characteristics (bulk) of the supplements.

Barton et al. (7) and Adams (2) studied effects of supplementation time on grazing behavior. Barton et al. (7) reported that supplementation time of cotton seed had no effect on grazing, walking, or ruminating. However, Adams (2) concluded that disruption of normal grazing activity by the feeding of supplement grain (corn) has a marked effect on behavior of steers grazing. Further research may be needed to clarify the role of supplements on the grazing behavior of animals.

Mixed Grazing

Grazing livestock differ in grazing habits. Sheep tend to graze more closely to ground level than cattle. In addition, there may be a difference in the plant species which cattle and sheep prefer (28). Therefore, there is a possibility to improve the harvesting efficiency of a pasture and achieve more gain per unit of grazed area through simultaneous grazing of sheep and cattle.

Some studies have indicated that the benefit of mixed grazing for one plant species increases, when the proportion of this species decreases, provided that stocking rates remain same (9). In mixed-grazed pastures, forage mass, stocking rate, and grazing pressure were more stable over the entire grazing season than in pastures occupied by either cattle or sheep. The most common opinion among researchers is that the favorable effect of mixed grazing is due to better utilization of pasture, which mainly is a result of cattle and sheep having different preferences for both plant species and plant parts (9). Abaye et al. (1) reported that pasture in which sheep grazed alone generally decreased in both forage mass and quality while lambs were in pasture. This decrease in quality and mass was partly a result of a decrease in the percentage of white clover in pasture grazed by sheep alone, indicating the preference of white clover by sheep.

Several studies also showed that sheep, in general, benefit more from mixed grazing than cattle. In mixed areas, sheep were frequently observed to have a more effective grazing technique than cattle. By moving more rapidly and grazing more selectively, sheep probably find a diet of higher nutritive value, on average, than cattle (9). Adaye et al. (1)

reported that pastures in which sheep grazed alone generally were higher in NDF, ADF, cellulose and hemicellulose, whereas CP and IVDDM were lower than in pastures where cattle grazed alone from April through July. However, forages in which both species grazed together was generally intermediate in quality, indicating that sheep are more efficient grazers than cattle. Sheep grazing with cattle spent more time grazing than sheep grazing alone, whereas cattle grazing with sheep spent less time grazing than cattle grazing alone, indicating that mixed grazing increased grazing time of sheep and decreased grazing time of cattle. These observations might explain why sheep performance in mixed grazing areas was more favored by mixed grazing than cattle performance.

Grazing pattern of animals was influenced by mixed grazing (1). During morning and evening cows grazing alone spent more time grazing than cows grazing with sheep. However, cattle grazed with sheep spent more time grazing at night than cows grazing alone. There was no significant difference in time spent grazing between two sheep groups during morning, but sheep grazing with cattle spent more time grazing during night, midday and more total time spent grazing than sheep grazing alone. During hot summer days sheep spent more time resting during the day, whereas cattle grazed intermediately (1).

On range consisting of grass, forbes, and browse, there is an advantage to grazing cattle, sheep and goats together. Cattle prefer grass, sheep utilize the forbes or weeds, and goats consume the browse (28). In the review of Glimp (16), he described the benefit of using goats for vegetation management. Goats can be used to increase harvesting efficiency (HE) of pastures and control the weeds and woody plants in pastures in certain areas of the U.S. Because of the presence of weeds and woody plants in pasture, goats reduce competition with cattle for grass, thereby it increases the HE of pastures.

Early research showed that mixed grazing is beneficial when steer-sheep ratio is 1:3 or 1:6. However, there is no benefit of mixed grazing with a 1:1 steer-sheep ratio (9). Goats are usually managed as part of multiple-species grazing systems, with the addition of one to three goats per cow unit to increase forage production by reducing shrub competition (16).

Grazing Systems

Several different grazing systems have been developed to improve the utilization of forage resources. Each system has some advantages and disadvantages. Each system has a distinct management requirement; therefore, these systems may indirectly influence the grazing behavior of animals. For example, grazing animals have access to greater amounts of forage in rotational grazing than in continuous grazing systems, and pastures in rotational grazing are usually smaller than those in continuous systems. Thus, it would be logical to assume that animals in continuous grazing systems would travel greater distances to seek food than animals in rotational grazing systems.

Walker et al. (33) reported that a trend is growing towards shorter total grazing time in rotational grazing (RG) compared to continuous grazing (CG). These differences among grazing systems were at least partially responsible for more uniform herbage due to less mixing of dead and live tissue in the RG. This may have resulted in cattle spending less time searching for and selecting bites in the RG pasture (33). The data of Walker et al. (33) supported the fact that longer grazing time in the CG compared to the RG treatment was caused primarily by more time spent searching for food. Hart et al. (18) reported that cows in continuously grazed small pastures spent a smaller percentage of time grazing compared to cows in bigger pastures. The effect of strip-stocking systems on animal performance and presumably grazing behavior is weather dependent. Although strip-stocking systems may improve efficiency of grazed crop residue in a year with little precipitation, benefits of strip-stocking are lost during years of high snow because of reduced access or nutrient loss (29).

Hart et al. (18) concluded that uniformity of grazing use, time spent grazing, resting, and traveling, were similar under continuous and time controlled rotational grazing when the 2 systems were similar in size, shape, and maximum distance to water, but, under continuous grazing, longer maximum distances traveled increased and grazing was much heavier near water than at distances greater than 3 km. In all grazing systems, the shape of a pasture is critical because animals (cattle) graze the pasture in a clock-wise movement; thus, the pasture which is closer to square in shape will be better utilized by grazing animals.

Forage allowance per animal in all grazing systems is a key factor of grazing behavior because there is a close relationship between forage availability and grazing behavior (31). Scarnecchia et al. (31) reported that as available forage decreased, grazing time increased. The regression analysis of the relationship between grazing time (x) and forage availability (y) showed a linear relationship ($Y = 78.16 - 0.75X$; $r^2 = 0.76$). Russell et al. (28) reported a linear increase in forage intake with increasing grazing allowance during winter with animals grazing corn crop residues.

Grazing time decreased as the RG paddocks were progressively defoliated between the first day and last day of grazing (33). Walker et al. (33) speculated that, in his study, shorter grazing time associated with progressive defoliation of the RG paddocks may have been caused by a different behavioral response. Grazing time may increase the first day in a paddock because of exploratory activity in a new paddock.

Water Source

It would be logical to state that water source influences the grazing behavior of animals because when animals become thirsty they search for water. Some researchers suggest that a water source in a pasture should be in equal distances to far sides of the pasture. Hart et al. (18) reported that non-grazing travel in rotational and continuous grazing systems with small paddock size was positively correlated with the number of times cows went to water ($r^2 = .76$ and .78, respectively). As cows grazed farther from water on the large pasture, they went to water less often, regardless of weather. Cows did not go to water at all on cool, damp days.

Hepworth et al. (20) estimated that steers traveled 2.7 km/d in pastures where maximum distance to water was 640

m vs. 1.9 km/d where distance to water was 240 m. Distance to water, not pasture size or grazing system, appears to be the major factor controlling distance traveled (18). Hart et al. (17) reported that pasture use was greater within 300 to 460 m of water in highly and moderately stocked pastures. Significantly more use occurred within 460 m of water on the highly stocked pastures compared to the moderately stocked pastures, 90 % vs. 63 %, respectively. Cattle in the moderately stocked pasture were seen to graze an average of 0.53 km from water vs. 0.27 km in very lightly stocked pastures. These two comparisons suggest that cows were forced to graze farther from water under higher stocking rates. Average distance from water to grazing increased from 0.29 km in week 1 to 0.58 km in week 5 as the grazing session progressed and forage near the water source diminished (17)

Shade

Shading is important during extreme weather conditions. It provides protection for grazing animals. Shade is more used by sheep than cattle. Sheep in a flock with access to shade use it to varying degrees, while shade use by individual sheep is highly consistent (22). Some differences in skin temperature occur with varying degrees of shade use, but body core temperatures of shaded and unshaded sheep are similar. There is no effect of shade use on drinking or ruminating pattern of grazing animals (22).

Leftcourt et al. (25) reported that the effect of shade use on grazing behavior was minimal for cattle at temperatures ranging from 13 to 35 degrees C. However, Sakurai et al. (30) reported that in grazing Japanese Black cows, as temperature raised up to 40 degrees C, animals stopped grazing and sought shade. Also, when chill factor is high, animals stop grazing and use shade as a barrier for the wind and stay on the opposite side of the shade in which direction the wind blows. It is clear that shade is important during extreme weather conditions, otherwise it has little use.

Environmental Factors

Temperature

Temperature is one of the most important environmental factors affecting the behavior of grazing animals. Animals wintering on open land are confronted with environmental stresses that may contribute to increased maintenance cost. This change may cause a shift in the grazing behavior of animals. Malechek et al. (27) reported that daily air temperature was related to time spent grazing (Y = 16.58 + 0.10X). Mean daily wind velocity was highly but inversely correlated to daily distance traveled. Anderson et al. (5) found a decrease in distance traveled with decreasing air temperature. It is likely that traveling distance increases with increasing wind velocity (27).

Dunn et al. (13) reported that short term thermal stress (STTS) did not reduce DGT. This finding does not agree with the hypothetical acclimation model. This model is constructed based on grazing behavior data obtained over a 12 month period. It is very possible that thermal acclimation lengths vary within and between seasons (13). The data of Dunn et al. (13) demonstrated that within the winter season and its inherently variable, but consistently cold thermal environments, daily grazing time (DGT) did not respond to temperature fluctuations. For example, DGT did not decline below 8 h day-1 for more than one successive day, regardless of persistent temperature changes and regardless of recorded temperatures ranging from 8 to -26 degrees C. Adams (2) reported that cattle start grazing later in the day as temperatures become colder. Reducing mean daily temperature from 0 to -40 degrees C resulted in about 50 % reduction of total daily grazing activity.

Data from literature reviewed suggested that the effects of temperature are seen at extreme temperatures. When temperature increases over 30 degrees C, daytime grazing decreases and nighttime grazing increases.

The effects of hot temperature on grazing activity has been studied by Lefcourt et al. (25) and Sakurai et al. (30). Lefcourt et al. (25) found little effect of ambient temperature ranging from 13 to 35 degrees C on measurable grazing behavior. Sakurai et al. (30) reported direct correlation between ambient temperature and hair, skin, and rectal temperatures (r^2 = 0.97, 0.86, 0.69 respectively) in grazing Japanese Black cattle. Below 30 degrees C ambient temperature, grazing restarted after rumination, but in direct sunlight, when hair temperature was above 40 degrees C for about 30 min, grazing stopped and cattle sought shade. Under direct sunlight, animal's hair temperature went above 45 degrees C, panting increased from 80 to 120-160 min^{-1}, tongues lolled out and mouths foamed. A tight standing group formed and heads were shaded under the bellies of other cattle (30). These types of behavior are also very typical for sheep flocks.

Plant Factors

Sward Characteristics

One of the most important plant factors affecting ingestive behavior of animals and animal performance is sward characteristics. It has been reported that there is a close relationship between rate of pasture intake, sward height, bulk density of herbage in the grazed horizon, and herbage mass per unit area. However, these relationships are not consistent across experiments (8).

Black et al. (8) reported that the rate of pasture intake was reduced with sward height, but only when tiller density did not differ. The less dense the tiller density, the height must be greater before maximum intake for that material can be accomplished. Bulk density has a close relationship with rate of intake only when sward height is constant. The combined representation of bulk density and height is herbage mass. Herbage mass has a better relationship with intake rate than the previous relationship discussed. The variability of intake rate for similar mass per unit area would be big if forage availability is less than 1 ton/hectare.

The rate of chewing declines with shorter pastures. A decline in chewing was observed when sheep were offered a 10 mm high pasture compared to taller swards (8). Prehending bites become a greater proportion of total jaw movements with shorter swards. In the study of Black et al. (8), there was a significant negative correlation between size of prehending bite and prehending bite rate (r^2 = -0.67).

Forbes et al. (14) reported that there was a significant animal-sward interaction in both rate of biting and grazing time, suggesting that sheep are more sensitive to different swards than are cattle. Sheep tend to select feed that can be eaten quickly. This is true even when intake rate of the same forage is altered by making it less available. Sheep select short materials when grazing under pasture conditions because of its immaturity. However, if potential intake rates of the long and short herbage were similar when both were freely accessible, they would select the long materials whenever accessibility of short materials was such that it reduced intake rate below the potential (8).

As herbage mass declines, the bite rates increase to reach optimal intake. Dougherty et al. (12) reported that rate of intake may decline within a measured session because of depletion of the sward by grazing, therefore, reducing the availability and allowance of herbage. Consistent decline in mass per bite occurs over the grazing period in cattle and sheep. This reduction may be related to the decline in either herbage mass or sward surface height (14). Trampling also changes sward structure within grazing sessions and may contribute to reduced intake. The presence of urine and feces in pasture may moderate intake since animals reject contaminated forages.

Plant Species

Animals normally discriminate forages containing toxic compounds if they have a choice. Secondary compounds such as alkaloids modify the grazing behavior of animals. Howard et al. (21) has reported the effects of forages containing different levels of endophyte (Johnstone tall fescue, low endophyte containing forage, and Kentucky-31 tall fescue, high endophyte containing forage). He found that animals grazing Kentucky-31 (K) changed their daytime grazing behavior. Animals grazing Johnstone (J) grazed 65 min more during daytime than animals grazing the K swards. However, nighttime grazing was similar except in period 4. In period 4, animals grazing K swards tended to graze more to reach their maximum gut-fill capacity. Nighttime grazing was associated with ambient temperature. As temperature increased, nighttime grazing increased (21).

It has been well documented that animals consuming endophyte-infected forages are more susceptible to heat stress. Greater time spent standing by steers grazing K swards, in addition to more time spent idling and less spent grazing has been reported by Howard et al. (21), may represent a behavioral response by steers to interactive plant-environmental stress.

CONCLUSION

One basic objective of a forage-livestock system is to match the needs of grazing animals with changes that occur in the quality and quantity of forage throughout the grazing season. Forage-livestock systems are very complex and composed of numerous interactive, changing factors. All of these factors somewhat influence the grazing behavior of animals and, subsequently, animal performance. One of the most important factors affecting ingestive behavior is sward characteristics. It directly affects herbage intake. The effects of many other factors have been studied, however, none of them is as effective as sward characteristics to determine overall animal performance.

Each animal species has its own grazing habit and plant preference; therefore, there are animal species differences in grazing behavior. As an animal gets older, it becomes more familiar to its environment. This experience provides some advantages during grazing. The formation of a herd or flock takes time to become more stable. As time of grazing advances, animals become more stable and less aggressive.

The role of supplementation is somewhat unclear; however, protein supplementation seems promising, especially when animals graze low quality forage and forage becomes less available. Different grazing systems have different advantages and disadvantages. In all grazing systems, the most important factors affecting an animal's grazing behavior is herbage mass, stocking rates or animal density, and distance to water. The use of shade is weather dependent. Mixed grazing provides an opportunity to improve the HE of pasture due to different plant preference of different animal species.

It has been reported by several researchers that changes in sward conditions such as forage mass, in particular the amount of green leaves, is an important factor in determining bite size. Dougherty et al. (11) reported that when alfalfa is managed according to most recommendations, grazing animals respond with high rates of intake that are attributable to sward characteristics that permits the animal to harvest large bite sizes. Resulting relatively low rates of biting may reflect a negative relationship between rate of biting and herbage intake per bite that has often been reported. Another major plant factor is plant species. Plants containing alkaloids alter the grazing time of animals; therefore, producers should allow animals to graze these types of plants during the night, especially during hot days.

Two approaches can be applied to improve pasture utilization or increase herbage intake depending upon the objectives of the producer. If the objective is to achieve high herbage intake, then management of pastures is critical. Management of pastures based on sward height can be used to improve herbage intake. As sward height increases, bite size of animals becomes larger and diet selection becomes lesser. Forbes et al. (14) reported that management of pastures based on sward height has been used for several years in the United Kingdom. Typically, rate of intake declines within a grazing session as satiety increases (11) and sward height declines. In this case, supplementation may improve the total intake. In literature, the effect of supplementation is not very clear, but protein supplementation seems better than concentrate supplementation (energy). Protein supplements may improve the total digestibility of diets and the intake of animals grazing forage low in protein, whereas concentrate supplementation, in general, decreases the intake and total digestibility of the diet of animals grazing low quality forages.

Manipulation of pasture size, animal density or stocking rate, and length of grazing period in rotational grazing systems is generally thought to improve animal distribution and reduce forage selectivity, thus, improving pasture utilization. Another approach to improve pasture utilization is

mixed species grazing. Since different animal species differ in grazing habit and diet selection, it provides an opportunity to improve pasture utilization. Cattle mixed with either sheep or goats have been reported. In both cases, better pasture utilization has been experienced.

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