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Influence of Sward Characteristics on Grazing Behaviour and Short-Term Intake of Cattle. A Review

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Target audience: Livestock farmers, Government agencies, Ranch managers, Researchers, Extension agents.

Abstract

Relative to temperate systems, there has been few reported detailed assessments of sward characteristics and associated grazing behavior from natural and established pastures in Nigeria. This study reviewed the important relationship between sward characteristics and grazing behaviour and discusses the implications of canopy characteristics for short-term intake. The review is divided into two sections with the first part highlighting the influence of sward characteristics (sward height, forage mass and sward maturity) as a means of manipulating grazing behaviour of ruminants. The second part brought to fore the process of grazing, bite feature and short-term grazing trials. The review showed that cattle prefer short dense leafy swards compared to senescent plant materials. This is based on research results suggesting that short dense sward possess high quantity of green materials which is relished by ruminants during grazing. The feasibility of intensifying grazing studies in the tropics, particularly in Nigeria, to examine the behaviour of ruminants in highly heterogeneous pastures has the potential to provide integrated (sward, animal, management) strategies for sustainable livestock production in Nigeria.

Key Words: Sward characteristics; Grazing behaviour; Intake rate; Sward height; Forage mass; Ruminants.

Description of the problem

Intake appears to be the most critical determinant of animals' performance (1, 2). Identification of sward characteristics associated with high intake rate of grazing animals will help to devise a practical management approach for optimum production at all levels. In temperate region where ryegrass (*Lolium perenne*) and White clover (*Trifolium repens*) have been continuously stocked, successful results in terms of animal performance had been reported with sward height of 6cm for sheep (3, 4) and 8-10cm for cattle (5). With this regard, understanding the influence of sward characteristics on grazing behavior and short-term intake of ruminants can be incorporated into a conceptual framework to attain sustainable livestock production through pasture management.

In pasture production systems, issues relating to sward characteristics (sward surface height and forage mass), are of great importance for the success of attaining maximum intake by cattle during grazing activity. Thus, it is very critical to understand the thresholds of sward characteristics as it influence cattle grazing behaviour. Alterations in the sward structure and duration of access time significantly affect the behaviour of the animals and response of the pasture plants to grazing. Therefore, swards with high-quality forage are likely to experience a greater rate of herbage defoliation than swards with low-quality forage (6).

Since the 1950's, the grazing behaviour of ruminants fed indoors or at pasture has been extensively studied in the temperate region (7, 8, 9, 10, 11, 12 & 13), with miniature of such research in the tropics (14). The behaviour of grazing cattle is usually modified by sward surface height, forage mass, botanical composition and spatial distribution of herbage on the pasture land. However, sward surface height is more easily determined and is more often used to demonstrate short term intake rate (15) of ruminants. Observing cattle grazing behaviour for a short period may indicate preference between available forage and whether such behaviour will meet management goals for the next several weeks (16).

Plant-animal interactions are of great importance for the success of grazing activity (17). However, development of management recommendations directly from detailed study of the plant-animal interface has not been widely achieved (18). For any given situation, the complexity of pasture-herbivore interactions presents difficulty in predicting intake and performance of grazing animals (2, 9 & 18). Therefore, it is very important to understand the limits of the sward characteristics (i.e sward surface height and forage mass) as it affects short-term intake and grazing behaviour of the animals. Variations in sward height and forage mass influence the responses of both animals and forage crops. Stocking rate, timing of grazing and type of grazing animal are critical factors that influence both grazing behaviour and short-term intake. These factors when properly exploited increases the intake rate of cattle (whether dairy or beef), while protecting the pasture sward from deterioration.

Relatively few studies have reported detailed assessment of sward canopies and grazing behavior in established tropical grassland (19, 20 & 21) with paucity of such information from Nigeria. One of the reasons is that tropical region is characterized with more forage species than do temperate regions, and there is still considerable flux in species choice (2). In addition, the primary research focus in many locations including Nigeria centers on the introduction of new germplasm, evaluation for agronomic performance (growth, yield, persistence, vigour etc), with little or no consideration given to detailed assessment of plant-animal interaction. It is however noteworthy that tropical species are diverse in terms of growth habits and morphology. Hence, different management practices are adopted in their utilization. In view of this, research programs with considerable number of personnel and sufficient long-term funding is required in this demanding but important field.

Considerable research has been conducted to probe the outcome of differences in sward structure and access time on grazing behaviour of various reasonably important tamed ruminants to include sheep, beef or dairy cattle (11, 22 &23). The objective of this review is to summarize existing literature characterizing sward characteristics as a predictor of grazing behavior and short-term intake; the preferential selections of herbage in pastures with varying height are discussed. Lastly, the future merit and potential contribution of detailed plant-animal interface research on grassland to Nigerian livestock industry will be discussed.

Some attributes of sward characteristics

The characterization of tropical grassland swards started with the research by Stobbs (24, 25), (26) and (27). Only a few scientists across the tropical region have followed their footstep since then. This section will describe how sward characteristic in terms of sward height and herbage density as well as sward maturity relates to grazing behavior and short term intake.

Sward height and herbage density

Black and Kennedy (28) and Gordon *et al*. (29) reported that pasture sward containing only one specie of forage, had tall swards offering higher rates of intake based on the premise that larger bites are obtainable through greater penetration into the canopy. In addition, (30) and (31) submitted that consumption rate is greatly influenced by bite mass. Arising from these findings, it could be concluded that sward surface height is a critical factor which modifies the grazing behaviour and short term intake of ruminants, particularly cattle. However, sward height does not function in isolation, but in conjunction with herbage mass which is also a determinant of bite mass. Studies conducted on the utilization of forages often only compare paired choices and so behavioural responses of animals have always been subjected to one alternative. Scientific evidence exists indicating that animals preferentially select the taller sward when given multiple choices between pasture swards in the vegetative growth stage (32; 33, 34 &35). A recent research conducted by (36) showed that grazing calves spent longer time grazing in Panicum/stylo pasture cut back at 15cm height compared to those of 10cm and 20cm cut back height respectively. This was attributed to the observed difference in the leaf :stem ratio of the forage plants. However, sward height is not used as the only benchmark in selecting the preferred forage to graze despite the observed constant sampling of alternative choices as a means of learning about pasture exploitation (32). There are sufficient data showing a range of acceptable sward height, while generalisation is difficult due to the mixture of alternatives, and confounding with maturity contrasts (15, 35 & 37). In a 30 minute test study, heifers spent little time grazing 7 cm vegetative swards when a reproductive sward (sward height unspecified) was the alternative (38). (39) found sward height associated with patch use by deer only during one period and on one plot when sward height drops down below 5 cm. At all other times the effect of sward height on forage choice was not clearly pronounced by deer or sheep.

Due to the significant influence of sward height on bite dimensions, sward height has been designated the prevalent factor that inspires animal choice. The result by (40) showed that reproductive patches were preferred by heifers when the height of the vegetative patches decreased to either 11 or 7 cm, on a shrinking scale, consolidating the opinion that sward height plays an important role in maintaining intake rate of ruminants. (15) investigated the aspects of 'how', 'when' and 'where' ruminants graze in highly heterogeneous pastures and observed that it was possible for grazing animals to change their search strategies in an attempt to increase (or maintain) the efficiency of their forage harvest. This observation can be hinged on the premise that the time spent searching for forage can be modified by the height and density of available forage. This further strengthens the result by (41) and (42) that cattle graze most efficiently, and expend more time where forage density allowed the most rapid intake rate.

Sward maturity

Considerable research exists indicating that deer and sheep preferentially select vegetative swards over mature swards (38, 43&44). This implies palatability and acceptability of forages decline with advancement in age. In a comparative study by (38) and (40), heifers were offered tall vegetative patch (18cm), together with a reproductive patch (unspecified sward height); the vegetative patch was preferentially grazed over the reproductive patch. The ease of harvesting and manipulation of forages for swallowing by animals is majorly dependent on the sward maturity. Thus, vegetative materials are easily defoliated by animals of all classes.

Ruyle *et al*. (45) revealed that heifers preferred vegetative sward over reproductive sward by measuring the time spent grazing each type of sward. This connotes the conclusion of (46) that herbage maturity and sward height are usually confounded in field experiments

The degree of stem maturation has influence on stiffness, which also influences the probability that tillers will regrow (47). When animals are faced with mature swards dominated by stem material, both sheep (4) and cattle (48) have been observed to alter their feeding strategies, taking a number of bites sideways, referred to as side bites (48). This technique helps to exploit the new, young growth found at the base of the sward and probably influences the reduction in grazing time (49) and possible decline of tillers present at the top of plants. Currently, there is need to for more research in grazing management and behaviour as a field of research to help livestock producers in Nigeria. This will help to propose strategic grazing management with respect to the behaviour of different livestock at pasture, which will aid better management of pasture swards for increased livestock production all round year.

The positioning and mixing of senescent material in the sward is also important to the grazing animal (50). This enhances the animal to exhibit selectivity and preference in relation to the available herbage on the pasture. (39) and (51) reported that sheep and deer selected against senescent material, desiring young green material regardless of its location in the sward. Although, these selection patterns are supported by a narrow jaw, and may not be as profound with cattle as with sheep (46). In a bid to uphold intake rate, senescent material located at the top of the sward may lead to the total rejection of a pasture by cattle or probably result in a decline of diet quality.

The grazing process

Alternative period of grazing, rumination and rest constitute the diurnal activity of livestock (46, 52). The act of defoliation of plant parts can be seen as the sequence of a succession of bites from any one of the primary food groups (grasses, legumes or browse) halted or defined by locomotion. While grazing, the animal is faced with a series of tactical decision about which food to accept, and how to move through its habitat and the complexity reflects the level of heterogeneity of the pasture sward (19).

Grazing activity of cattle on grasslands is initiated when the animal lowers its head down in search of food, with a bite removed when the muzzle is inserted into the sward canopy and a series of manipulative jaw movements (with or without protruding tongue sweeps) gathers herbage which is then held between the lower incisors and dental pad and severed with a jack swing action of the head (30, 47). (53) showed that grasses are easier to break, thereby making the bite action of herbivores stress free. This explains why large herbivores, such as cattle, do not use teeth for biting, rather grasping herbage and breaking clumps of grass in tension using the strength of their large muscle mass (53, 54 & 55). When ingested, the material is manipulated for swallowing and this chewing action employs the use of shearing force which constitutes a more expensive energetic process than the harvesting of material (55).

Grazing behaviour

Since the 1950's, the grazing behaviour of ruminants fed indoors or at pasture has been extensively studied (9, 10, 11, 12 &13). The behaviour of grazing cattle is dependent on a number of factors which include canopy height and density, plant-part and species proportion and spatial arrangement, herbage chemical composition and digestibility, and many other canopy and non-canopy factors (2). With regard to this, correct exploitation of these factors will assist in the management of both animals and pasture.

Memory may be the most critical component of long-term grazing success (56). This can be hinged on the premise that ruminants have the ability to identify and return to grazing locations that offer higher satisfaction and potential intake.

(57) reported that animals grazing on unfamiliar rangelands consumed less forage, spent more time walking, and suffered more often from malnutrition and predation than animals grazing in familiar environments. On the contrary, cattle grazing in familiar environments were able to associate food availabilities with specific locations on pasture, with the ability to remember where they foraged for up to 8 h using working memory (58). (8) suggested that forage quality, forage mass and the concentration of certain secondary compounds in forage influence grazing decision. Grazing animals return to nutrient rich areas more often than less-productive areas of pastures (58) and match ingestion rate with availability of preferred forage species (59).

Teasing out the independent effects of canopy structure on grazing behaviour has been difficult since canopy variables are strongly correlated in natural swards (60). To overcome these challenges, many researchers have created micro swards which were offered to animals (28, 61 & 62). These researchers attempted to minimize sward heterogeneity in order to separate the confounding effects of sward characteristics, thereby ensuring that the grazed area is clearly represented by sampling (9). This technique has been widely used with temperate forages (2, 9), but to a limited extent with tropical and subtropical species (28, 63 & 64).

Bite number and grazing time

Bite number is expressed as either the total number of bites from each choice or as the proportion of total bites (33, 43 & 65).Bite rate refers to number of severing jaw movements per unit time and changes in bite rate have been viewed as a compensatory mechanism attempting to maintain intake relatively constant when bite weight is changing (2, 4 & 66) and also reflect the degree of non-biting jaw movements or canopy manipulation associated with a bite (18). The findings by (63) and (67) showed that bite number decreased with increasing pasture height and herbage mass. In contrast, (68) found little effect of the canopy height on bite number. It could be concluded that pasture height is not the only cue to be considered when investigating bite number of grazing ruminants.

The activity of the animal at pasture is divided into periods of grazing, ruminating, rest, and social interaction (69). The amount of time spent for each activity is a function of the sward characteristics, environmental conditions, and the nutrient requirements of the animal (70, 71). For a given short-term intake rate, daily intake of the animal depends on the length of time it spends grazing, thus the assertion-grazing time is the link between short-term intake rate and daily forage intake as submitted by (72) and (73) sits well.

The time spent grazing can be said to be a function of bite number. Thus, grazing time is commonly expressed as the proportion of test time spent eating each choice (38, 74). However, grazing cannot take place in isolation of bite being taken from the pasture sward. The duration of grazing at a feeding station or patch is greatly dependent on the number of bites obtainable from the patch. This consequently translates to increased grazing time and intake. (75) submitted that cows increased their bite rate, as a compensatory mechanism facilitated by a reduction in the proportion of grazing jaw movements required for manipulation and mastication of the herbage harvested.

Significant research results have shown that grazing time declines in a situation of reduced herbage mass for Lablab purpureus (76), for Setaria sward (77) and for limpo grass/Aeschynomene mixture (67). The reduced grazing time is compensatory in nature relative to the sward characteristics. Grazing time has also been reported to be influenced by green leaf proportion (68). A grazing study carried out in Southern Brazil with Panicum maximum and Brachiaria spp indicated decreased grazing time with increasing percentage of green leaves and green herbage mass (78). This implies that with higher leaf proportion, animals would have access to fill their mouth sufficiently, thereby reducing grazing time and bite number.

One versus two grazing sessions

Besides the interest in reducing the period of daily access to pastures, the possible benefits or otherwise of dividing the reduced duration of access into two sub periods have received much attention (11, 13). Unfortunately, relatively few reported studies examining the effect of access time on grazing behaviour have been designed to answer these questions (16, 13). Mattiauda and co-authors reported that restricting access time at pasture from 8 to 4 h decreased dry matter intake (DMI) and cows grazing within the 4 h treatments that commenced grazing session at 11.00 h recorded a slightly higher intake rate (IR) than those that started grazing session earlier in the morning.

Grazing time (short or long) and/or intake rate have been proposed as pointers of feeding motivation. Short-term changes in cattle physiological condition (e.g. a period of fasting, lactation) induce changes in grazing strategy (11). (16) submitted that monitoring cattle grazing behaviour for short term have management implications, as it helps to determine areas where grazing occurs and vice versa; and assist in balancing resource use. It is worthy of note however, that grazed pastures can be conserved by relatively extending the onset of grazing towards mid-day on daily basis. This will help to prevent the pasture sward from treading, trampling and fouling due to wetness (dew) in the early morning, which can lead to increased soil contamination of the pasture (78).

Summary of discussion

It is sufficient to presume that the importance of sward characteristics as a signal on intake of ruminants and their behaviour cannot be underestimated. Trade-off between the structure of the sward (sward surface height, leaf proportion, green mass proportion and forage density) as a criteria for selection is a mechanism ruminants apply as a means of regulating their intake in the short or long term with increasing heterogeneity. The total leaf bulk density of the grazed areas of tropical pastures is often relatively lower than in temperate pastures. This might be attributed to the greater height attained by most tropical grasses. The review has clearly demonstrated that herbivores relish short leafy swards. However, this conclusion is in accordance with the results of studies conducted offering alternative choices of sward height to grazing animals. This is merely describing an observation, which emphasizes that much of the research has focused on describing the effect of sward height on short-term intake and grazing behaviour. It is increasingly evident that sward height alters the behaviour of ruminants at pasture, complementing the view that the decisions animals make to synchronize their intake reflect the spatial arrangement of leaf and stem strata and their height in relation to sward height.

Conclusion and application

1. It is seemingly appropriate to consider whether detailed studies of pasture swards and grazing behaviour deserves priority in the tropics, particularly in Nigeria. Considering the needs of the end users of this study, it becomes apt to demand on what conditions such research should be carried out if funding is provided. Due to the diversity of forage plants and the cost of undertaken such studies, the research approach must be carefully directed at certain evaluated species and the most widely applicable management practices should be adopted in a bid to proffer solution to key production problems through detailed understanding of sward-animal relationship.
2. The potential to enhance sward characteristics as a promoter of efficient defoliation by grazing animals sits within the basic components of pasture swards. This would help to provide grazing animals with pasture canopy that offers easy access to the most preferred sward component i.e leaf.
3. The need for a grazing-friendly sward structure, that would include higher quantity of desired component i.e leaf, is very much feasible. The canopy of the existing, well adapted pasture species in Nigeria can be manipulated through the use of Near Infrared Spectroscopy (NIRS) and the emerging application of genomic procedures. With this in mind, a strong purpose and justification exists for plant-animal oriented research in Nigeria.
4. Players in the livestock industry that depend largely on pasture lands need to identify this potential and make funding available to bield research in this area.

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