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BITING RATE OF WHITE FULANI CALVES AS INFLUENCED BY SPATIAL DISTRIBUTION OF PASTURE BIOMASS AND SWARD HEIGHT

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ABSTRACT

Grazing ruminants are faced with the dilemma of making decisions when searching for and defoliating forage to meet their nutrient requirements, particularly in situations of heterogeneity in forage abundance and sward height. Knowledge of sward-animal interaction at bite level is essential for animal intake, performance and productivity of grazing systems. Here, we investigated the effect of two spatial distributions of forage biomass (dense and sparse) assigned to main plot, and three sward heights (10, 15 and 20 cm) allotted to sub-plot in a split plot design, with three replicates totalling six treatments, aimed at assessing the biting rate of White Fulani (WF) calves. The study was carried out between November and December 2015. Biting rate was recorded with the aid of a Chloride UK 8 channel, H.264 digital video recorder and Chloride UK IR waterproof camera equipped with 3.6 mm lens. WF calves altered their biting rate in an attempt to meet their intake requirement on *Panicum maximum*/*Stylosanthes guianensis* sward, notably with decrease in bite number as access time advanced. The calves, grazing pasture with dense biomass, recorded higher bite number during the occupation time ($p < 0.05$). Measurement of grazing bites of WF calves indicates that the herbage could be defoliated by ruminants on tropical pasture relatively easily.

Key words: forage biomass; sward height; bite number; *Panicum maximum*; *Stylosanthes guianensis*; White Fulani calves

INTRODUCTION

The process of harvesting forage is a particularly time-consuming exercise for ruminants, since a large number of bites are required to meet the nutrient intake requirements for maintenance, growth and reproduction (Wendy and Gordon, 2003). Many studies have been carried out to tease out the independent influence of sward height and sward bulk density on bite rate in the temperate region (Dement *et al*., 1995; Gordon and Lascano 1993; Hodgson *et al*, 1994; Launchbaugh, 1996), with paucity of such information in the tropics. However, given the sufficient available information in this respect, the need to predict intake responses of grazing animals to possible changes in structural vegetation and morphology cannot be overemphasized. Therefore, the report of Illius and Hodgson (1996) on the need for studies, that will mechanically explain sward bite interactions, fits

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well within the context of grazing management.

Animals grazing tropical pastures have been reported to harvest small bites of leafy materials and are faced with the challenge of meeting their intake requirements (Stobbs, 1973). Where sward conditions are confounded, animals tend to alter their behaviour to maximize intake of forage (Jimoh *et al*., 2017), and this is highly correlated to the quantity of green leaf mass in the sward (Gibb and Orr, 1997). A modified bite feature is, however, expected where the leaf to stem ratio and sward bulk density differ. Soder *et al*. (2009) reported that sward height may result in greater exploitation of upright plant species, and that grazing ruminants may prefer to search for underlying plant species, thereby altering sward dynamics.

There is necessity to re-evaluate the principles of grazing management on tropical pastures to make new management target propositions owing to the influence of sward structure on herbage intake by herbivores (Da Silva and Carvalho, 2005). Moreover, it has been noted that changes in sward structure results from plant growth, defoliation and senescence (Mezzalira *et al*., 2014). This consequently leads to continuous reduction in short-term intake (Fonseca *et al*., 2013) and bite area (Ungar *et al*., 2001) by ruminants and, therefore, results in decreased herbage intake on daily basis (Barret *et al*., 2001; Baumount *et al*., 2004). Arising from this, tropical pastures might impose various levels of constraint to grazing animals due to disappearance of leafy materials from the sward relative to their physiological characteristics.

Grazing behaviour studies in the temperate and sub-tropical regions have shown that cattle (Barrett *et al*., 2001; Robert, 2017) and sheep (Yong *et al*., 2013) have an intensive period of consistent grazing at dawn on daily basis. Hence, investigating the inherent variation associated with the relative ease with which forages could be harvested from pasture sward through biting behaviour within grazing sessions could provide useful information for better management of animals and pasture. Laca *et al*. (1992) stated that sward height and bulk density are the most important cues that determine bite depth and bite area. The difficulty in teasing out the independent effect of sward height and bulk density on bite rate has been widely reported (Hodgson, 1981; Burlison *et al*., 1999; Mitchell *et al*., 1991; McGilloway *et al*., 1999). Therefore, the limited attention paid to variation in cropping or bite rates in a situation where sward height and pasture spatial distribution are confounding in short-term grazing studies may limit our understanding of how ruminants may adjust intake rate in such conditions, because bite rate may be more flexible than the actual time spent foraging (Ruckstuhl *et al*., 2003). In addition, the knowledge of sward-animal interaction at the bite level would provide information on the degree of sown pasture sward utilization by grazing ruminants. The objective of this study was to determine the effects of sward height and spatial distribution of pasture biomass at both main and interaction levels on the bite rate of White Fulani (WF) yearling calves on pasture over a period of 2:00 h.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Cattle Production Venture unit, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The site is located on latitude 7° 10′ N, longitude 3° 20′ E, with altitude of 76 mm within the derived savannah of Nigeria. The area has a mean annual rainfall of 1037 mm and temperature of about 34.7 °C, with relative humidity ranging between 63 - 96 % in the rainy season (April-October) and 55 - 82 % in the dry season (November-March) with an annual average of 82 % (Google Earth, 2015).

Pasture vegetation

The measurements were made on a *Panicum maximum*/*Stylosanthes guianensis* sward established in 2013. The sward also has *Centrosema pubescens* and *Calopogonium mucunoides* as volunteer species. The volunteer species were present in negligible quantity; hence, the botanical composition of the sward was categorized as grass, legume and weed. The total land area of the pasture is 5 ha, and a demarcated section of the land was used for the present study. The mean proportion for each forage type in the plot with dense biomass are (138, 83, and 63 kg DM) and (88, 146, and 90 kg DM) for those with sparse pasture biomass. Following establishment, the pastureland is used for grazing high producing animals (beef cows) from the herd. Prior to the current experiment, the field was used for supplemental grazing of lactating dairy cows. The adopted grazing regimes led to the evolution of dense and sparse biomass areas within the pasture field owing to grazing effects such as trampling and treading. The sparse pasture areas cover relatively low land size; hence, no over sowing was carried out. The grass component of the mixture used in our study is widely relished by ruminants in Nigeria (Olanite *et al*., 2006), while the legume component possess the ability to support ruminants during dry season.

Animals and length of grazing time

Twelve yearling WF calves (mixed-sex, with average body weight of 82 kg) were selected randomly from the herd and tagged for identification. The animals were turned out for daily grazing routine with other animals in the herd from 10:00 h to 17:00 h. Prior to the commencement of the experiment, the selected animals were separated from the larger herd for two weeks, and had similar experience background (Provenza *et al*., 1995) characterized by transhumant grazing system. Prior to weaning of the calves, the animals do co-graze with their dams on the pasture as a way of introducing them to grazing. The animals were not fasted before the grazing sessions, but were turned out for the trials early in the morning (7:00 – 9:00 h).

Experimental design

Two spatial distributions of pasture biomass (dense and sparse) were assigned to the main plot and three sward heights (10, 15, and 20 cm) as the sub-plot. A 15 m × 5 m land area constituted a block and was designated as either dense or sparse pasture. Each block was further partitioned (Boland *et al*., 2011) into a series of 5 m × 5 m plots to have three square shaped plots, with the blocks defined by 3 m space. To ease movement around the blocks, the inter-block spaces were cut down to the ground level. The pastures were cut back six weeks before the onset of the grazing trials to allow for substantial regrowth. The dense sward is characterized with (thick) thoroughly mixed herbage materials, while forages in the sparse pastures were scattered in the plots. We expect that the designated cut back heights will introduce the animals to herbage with varying quality characteristics. Pastures cut to 10 cm height above the ground were perceived to be more succulent but slightly tasking for animals. In contrast, the pasture cut to 20 cm height had higher stem proportion with uneven distribution of leaves. Mechanical mower and sward sticks were used to affirm both pasture heights and uniformity. Simulated grazing samples (*Panicum maximum* and *Stylosanthes guianensis*) were hand plucked from each plot (Mayne *et al*., 1997) and the samples were analyzed for ADF, NDF, Lignin and CP (Boland *et al*., 2011). The field layout of the experiment is shown in Figure 1. The treatments are as listed below:

Treatment 1: Dense pasture biomass cut to 10 cm height
Treatment 2: Dense pasture biomass cut to 15 cm height
Treatment 3: Dense pasture biomass cut to 20cm height
Treatment 4: Sparse pasture biomass cut to 10 cm height
Treatment 5: Sparse pasture biomass cut to 15 cm height
Treatment 6: Sparse pasture biomass cut to 20 cm height

The treatments were assigned randomly to the plots within the dense and sparse pasture biomass blocks, with three replications to give eighteen grazing sub-plots. On departure from the plots, the animals were returned to join the main herd for daily routine grazing.

Biting frequency and monitoring procedure

The animals were trained to become accustomed to the experimental procedure (Dummont and Boissy, 2000; Mezallira *et al*., 2014) before the grazing trials. The 120 minutes pasture access time amounts to about 30 % of the animals' daily grazing time. The animals were allowed to join the main herd for daily grazing on days without measurement. On each trial day (grazing session), two calves were put in their respective plots and allowed to graze uninterruptedly, so that 2 blocks (6 grazing sub-plots) were grazed per day, and 6 blocks (18 grazing sub-plots) were grazed per week, and this was done twice (November and December, 2015) at three-week intervals. The same calves grazed the same treatment throughout the trial period. The CCTV gadget was strategically located outside the blocks, and the video surveillance cameras in waterproof enclosures (CSC-3020W) were mounted 4 m above the ground on poles in each plot to monitor the calves. Colour video containing date and time stamps were recorded digitally during grazing sessions onto a computer hard drive (Boland *et al*., 2011) and were later reviewed using a digital media player (Playback

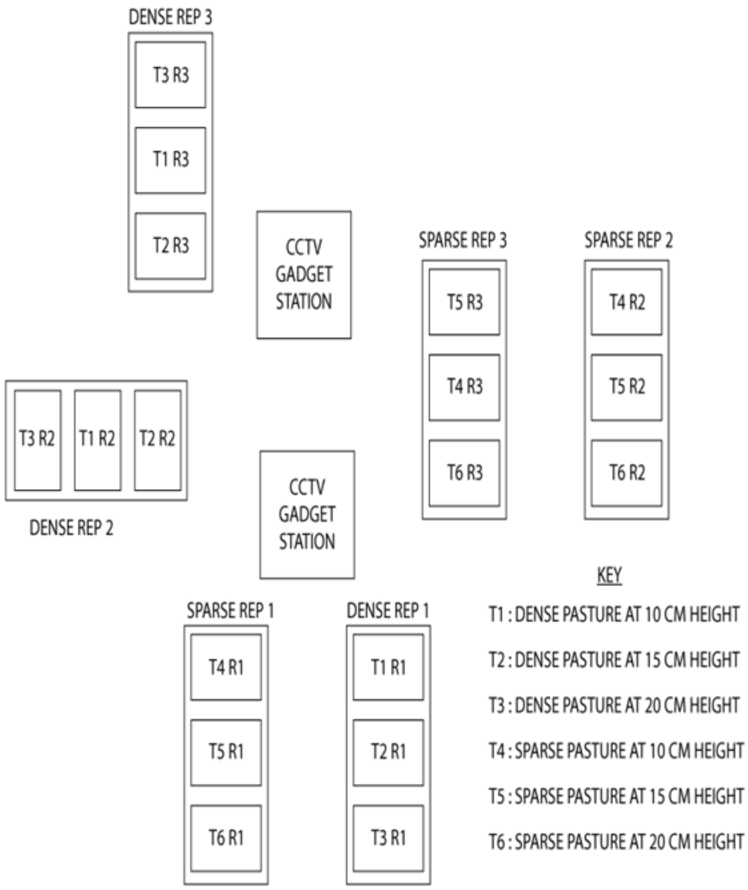
Video Player). The CCTV gadget and the surveillance cameras used have been described by Jimoh *et al*. (2017).

Data collection

The biting rate of the animals was quantified by continuous sampling method from the colour video recording (continuous sampling) on each trial day and three days in a week. The access time was divided into four, each comprising of 30 minutes grazing, and herein after referred to as first, second, third and fourth quarters, respectively. This was aimed at monitoring possible fluctuations in bite rate of the animals relative to the treatments imposed. The access time was monitored by a running time background on the CCTV monitor. The authors state that our study is in compliance with the policy on animal ethics. The study was carried out in accordance with the ethical guidelines of the College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta committee on the use of animals for experiment.

Statistical analysis

The bite rate of the calves in the first, second, third and fourth quarters of the access time, as influenced by spatial distribution of pasture biomass and sward height, were averaged for each treatment prior to statistical analysis (Mezzalira *et al*., 2014). The main and interaction effects of the factors under consideration were tested at significance level of 0.05. The statistical analysis was conducted using General Linear Model (GLM) in R 3.0.1 (R Core Team, 2014). Means were separated using Tukey Honestly Significant Difference (Tukey HSD).



A – D = 15 m (EACH BLOCK)

AB = BC = CD = 5 m (EACH PLOT)

Figure 1. Field layout of the experimental site (Adapted from Jimoh *et al.*, 2017)

RESULTS

The effect of sward height and spatial distribution of forage biomass on the number of bites recorded per minute by WF calves is presented in Table 1. The number of bites recorded in the fourth quarter was significantly affected by sward height, with the plots cut to 10 cm height recording higher bite number (13.71 bites.min^{-1}). With exception of the first quarter, the number of bites recorded per minute during the grazing sessions varied under the influenced of spatial distribution of forage biomass. From the second to the fourth quarter, pasture with dense biomass recorded ($p < 0.05$) higher bite rate of 16.47 bites.min^{-1}, 15.22 bites.min^{-1} and 13.56 bites.min^{-1}, respectively.

The interaction effect of sward height and spatial distribution of pasture biomass on the biting rate of WF calves are presented in Table 2. There were significant differences in the number of bites obtained by the grazing calves across the treatments. In the first quarter, higher biting rate was recorded for plots with dense biomass cut to 10 cm (18.67 bites.min^{-1}), while the least was observed

Table 1. Main effect of sward height and spatial distribution of biomass on number of bites per minute by White Fulani calves

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
	bites.min^{-1}			
Sward height				
10 cm	17.21	15.25	13.79	13.71^{a}
15 cm	16.96	14.92	14.12	11.67^{b}
20 cm	16.38	14.88	14.04	12.00^{ab}
SEM	0.60	0.67	0.70	0.63
Spatial distribution				
Dense	17.44	16.47^{a}	15.22^{a}	13.69^{a}
Sparse	16.25	13.56^{b}	12.75^{b}	11.22^{b}
SEM	0.51	0.49	0.54	0.50

$^{a,b,c:}$ Means on the same column with different superscripts are significantly different ($p < 0.05$), SEM: Standard Error of Mean, First quarter: First 30minutes of grazing, Second quarter: Second 30 minutes of grazing, Third quarter: Third 30 minutes of grazing, Fourth quarter: Last 30 minutes of grazing

Table 2. Interaction effect of sward height and spatial distribution of biomass on number of bite.minutes^{-1} by White Fulani calves

Spatial distribution	Sward height	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		bites.min^{-1}			
Dense	10 cm	18.67^{a}	17.17^{a}	16.33^{a}	15.75^{a}
	15 cm	16.67^{ab}	16.33^{ab}	14.67^{ab}	12.5^{b}
	20 cm	17.00^{ab}	15.92^{abc}	14.67^{ab}	12.83^{b}
Sparse	10 cm	15.75^{b}	13.33^{c}	11.25^{c}	11.67^{b}
	15 cm	17.25^{ab}	13.50^{c}	13.58^{abc}	10.83^{b}
	20 cm	15.75^{b}	13.83^{bc}	13.42^{bc}	11.17^{b}
SEM		0.81	0.85	0.88	0.81

$^{a,b,c:}$ Means on the same column with different superscripts are significantly different ($p < 0.05$), SEM: Standard Error of Mean, SH: Sward height, SD: Spatial distribution of biomass, First quarter: First 30 minutes of grazing, Second quarter: Second 30 minutes of grazing, Third quarter: Third 30 minutes of grazing, Fourth quarter: Last 30 minutes of grazing each for those with sparse pasture biomass cut to 20 cm height (15.75 bites.min^{-1}). Similar bite numbers were recorded for pastures with dense and sparse biomass cut to 15 cm height. Plots with dense biomass maintained at 10 cm height recorded ($p < 0.05$) higher bite number 17.17 bites.min^{-1}, while those with sparse biomass cut to 15 cm were observed for the lowest bite rate of 13.5 bites.min^{-1} in the second quarter. Dense pasture biomass cut to 10 cm above ground recorded ($p < 0.05$) higher number of bites (16.33 bites.min^{-1}) and the least bite number was observed for plots with sparse pasture biomass cut to 10 cm height (11.25 bites.min^{-1}) in the third quarter. The values recorded for plots with dense pasture biomass cut to 15 cm and 20 cm height were statistically similar. Plots with dense pasture biomass cut to 10 cm height were observed for higher bite number (15.75 bites.min^{-1}) with the least recorded for plots with sparse pasture biomass cut to 15 cm height (10.83 bites.min^{-1}) in the fourth quarter of the access time.

The CP content of the grass varied ($p < 0.05$) from 7.17 % to 9.93 % for the plots cut to 20 cm and 10 cm above ground, respectively (Table 3). Spatial distribution of biomass had ($p < 0.05$) effect on the lignin and CP content of the grass. Higher crude protein was recorded for the dense pasture biomass (9.71 %), while the lowest lignin (11.53 %) was observed in this plot. However, this trend was in opposite direction for plots with sparse biomass.

Table 3. Main effect of sward height and spatial distribution of pasture biomass on the nutritive value of simulated *P. maximum* (Ntchisi) samples grazed by White Fulani calves

	NDF (%)	ADF (%)	Lignin (%)	CP (%)
Sward height				
10 cm	59.33	39.42	12.50	9.93^{a}
15 cm	57.09	29.64	14.45	8.99^{a}
20 cm	60.31	33.54	12.69	7.17^{b}
SEM	1.03	1.84	1.35	0.48
Spatial distribution				
Dense	57.42	33.89	11.53^{b}	9.71^{a}
Sparse	60.76	31.59	15.00^{a}	7.45^{b}
SEM	1.48	1.58	1.02	0.37

$^{a,b:}$ Means on the same column with different superscripts are significantly different ($P < 0.05$), SEM: Standard Error of Mean, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, CP: Crude protein

Table 4. Interaction effect of sward height and spatial distribution of forage biomass on the nutritive value of simulated *P. maximum* (Ntchisi) samples grazed by White Fulani calves

		NDF (%)	ADF (%)	Lignin (%)	CP (%)
Spatial distribution	Sward height				
Dense	10 cm	59.57	35.83	10.83^{b}	11.55^{a}
	15 cm	54.50	32.00	10.83^{b}	10.18^{ab}
	20 cm	57.83	33.86	12.71^{ab}	7.75^{c}
Sparse	10 cm	61.17	34.00	14.17^{ab}	8.31^{bc}
	15 cm	60.20	26.80	18.80^{a}	7.55^{c}
	20 cm	60.83	33.17	12.67^{ab}	6.50^{c}
SEM		2.63	2.55	1.66	0.37

$^{a,b,c:}$ Means on the same column with different superscripts are significantly different ($P < 0.05$), SEM: Standard Error of Mean, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, CP: Crude protein, SH: Sward height, SD: Spatial distribution of biomass

At interaction level, lignin and CP of the grasses differs (Table 4). Plots with sparse pasture biomass cut to 15 cm height recorded higher lignin than other treatments. The highest CP was observed for plots with dense pasture cut to 10 cm (11.55 %) height and the least recorded for sparse pastures cut to 20 cm (6.50 %) above the ground level.

The effect of sward height on CP of *S. guianensis* was significant (Table 5). The highest CP was recorded for the legumes in the plots cut to 10 cm (20.59 %) and the least observed for those in the plots cut to 20 cm height. There was no interaction effect ($p > 0.05$) of sward height and spatial distribution of biomass on the nutritive value of *S. guianensis* (Table 6).

DISCUSSION

The ease of forage defoliation from the pasture sward was teased out by the biting rate of the animals during grazing, particularly at the onset of grazing. The results from our study indicate variation in the number of bites recorded per minute by the grazing animals under the influence of spatial distribution of pasture biomass (except in the first quarter). Higher bite number was obtained by the calves grazing on pastures with dense biomass from the second to the fourth quarter implying that frequent herbage defoliation was carried out by animals grazing in these plots compared with those grazing in the plots with sparse pasture biomass. In contrast,

Table 5. Main effect of sward height and spatial distribution of forage biomass on the nutritive value of simulated *S. guianensis* grazed by White Fulani calves

	NDF (%)	ADF (%)	Lignin (%)	CP (%)
Sward height				
10 cm	50.50	33.00	17.50	20.59[a]
15 cm	51.00	23.80	11.00	18.11[ab]
20 cm	49.50	24.00	9.25	16.06[b]
SEM	5.03	2.94	2.80	0.86
Spatial distribution				
Dense	56.00	21.33	9.33	18.41
Sparse	48.25	27.12	12.38	17.89
SEM	3.71	2.50	1.78	0.91

[a,b:] Means on the same column with different superscripts are significantly different ($P < 0.05$), SEM: Standard Error of Mean, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, CP: Crude protein

Table 6. Interaction effects of sward height and spatial distribution of pasture biomass on the nutritive value of simulated *S. guianensis* grazed by White Fulani calves

		NDF (%)	ADF (%)	Lignin (%)	CP (%)
Spatial distribution	Sward height				
Dense	10 cm	55.00	20.00	9.00	20.62
	15 cm	56.00	21.33	9.33	18.79
	20 cm	57.25	22.10	9.25	15.84
Sparse	10 cm	50.50	33.00	17.50	20.57
	15 cm	43.50	27.50	13.50	17.43
	20 cm	49.50	24.00	9.25	16.23
SEM		4.13	2.95	2.31	1.04

SEM: Standard Error of Mean, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, CP: Crude protein, SH: Sward height, SD: Spatial distribution of biomass

Ruckstuhl *et al*. (2003) reported higher biting rate in areas with lower forage mass, but the higher biting rate, observed for dense plots in our study, could be attributed to defoliation at smaller bites by the yearling calves, as noted by Hilario *et al*. (2017).

The result from this study further affirms the report by McGilloway *et al*. (1999), that intake.bite^{-1} rate was higher for swards with higher bulk density during grazing, particularly at the commencement of grazing. However, the observed decline in biting rate.min^{-1} in both pasture types could be linked to continuous disappearance of herbage materials as access time advances, which invariably reduces instantaneous intake rate, due to the bite size reduction, particularly in sparse plots where forage is limited. Alternatively, decreasing bite rates could be related to increased selectivity, when forage quality is high, as reported by Ferrari *et al*. (1988) in a temperate sward. Mayne *et al*. (1997) concluded that higher intake rate.bite^{-1} could be obtained in short-term grazing studies with dairy cows offered dense grass/legume swards and our result further corroborates this report. The observed close disparity in the bite numbers from the pasture types, although significant, may be due to group foraging, as noted by Dehn (1990).

A positive correlation between sward height and biting rate of grazing dairy cows was reported by Mayne *et al*. (1997), when sward height ranged from 75 to 150 mm and from 170 to 230 mm at varying bulk densities in separate experiments. In our study, we expected bite rate to vary with sward height, but that was obviously not the case, except for the fourth quarter where variation was observed, and this contradicts the report by Laca *et al*. (1992), who listed sward height among factors that affect bite rate of animals grazing temperate swards. Meanwhile, higher bite rate has been linked with newly growing forage with easily digestible plant parts, structure and height of vegetation (Ruckstuhl *et al*. 2003), which is typical of the pasture used in this study.

The rate of herbage defoliation by the animals, especially in the first quarter gave some insight into animals' ability to satisfy intake requirements on tropical pasture. However, the observed variation in bite rate across the treatments is an indication that bite rate could be a more precise intake measurement than grazing time. This is because animals could lower their muzzle into pasture sward without actually harvesting forage, and this is usually estimated as part of grazing time. Where bite rate is high as observed at the onset of grazing in this study, it could be a strategy by ungulates to compensate for reduced bite size, as bite sizes and bite rates are usually inversely related (Spalinger and Hobbs, 1992). Biting rate could, on the other hand, be viewed as a highly flexible behavior, which may be opportunistically utilized to reimburse for higher energy demands of growth (Ruckstuhl *et al*. 2003).

The number of bites per minute, obtained by the animals investigated in this study irrespective of the factors to which they were subjected, was lower than the range of 34-40 bites per minute reported by Nadin *et al*. (2010) for Holstein-Friesian calves grazing winter oats with different structure. It is also lower than the mean of 66.5 bites per minute reported by Orr *et al*. (2005) for yearling beef cattle grazing four intermediate-heading perennial ryegrass (*Lolium perenne* L.) varieties. The observed difference might be attributed to a number of factors including but not limited to the botanical composition of the pasture, sward height, age of the animals, temperate vs tropical environment and sensitivity of the recording gadgets used in the former and the latter studies. However, the study by Jimoh (unpublished data) showed that calves spent longer time grazing *Panicum maximum* than *Stylosanthes hamata*, when both were offered as a mixture. Gibb (1996) noted that several bites defoliated by an animal at a particular feeding station excluding interruption makes a grazing bout, which cover a few square meters and last between 10 to 100 seconds (Andriamandroso *et al*., 2015). Observation from this study conforms to this submission. Several grazing bouts occurring during each grazing session spans from minutes to hours which allows a significant portion of the sward to be explored (Andriamandroso *et al*., 2016).

Bite rate during grazing provides a valuable clue to the relative ease with which herbage is harvested from tropical pasture swards (Stobbs, 1974). In this study, the general linear decline in number of bites severed per minute is in consonance with the report by Stobbs (1974), who reported a decrease in the biting rate of Jersey cows grazing mature Rhodes and Setaria swards, respectively. Similarly, Boland *et al*. (2011) reported a decline in the bite rate of steers grazing Alfalfa as a novel forage compared to when the steers had been used to the legume (62 bites.min^{-1} vs 66 bites.min^{-1}). This clearly indicates that the bite rate of ruminants on both temperate and tropical pastures tends to decline relative to maturity of forage, novelty and bulk density. Moreover, bite.minute^{-1} strongly varied with regard to spatial distribution of pasture biomass indicating that in order to achieve high intake of grazed sown pasture, management strategies should focus on maximizing biting rate on dense swards.

An interesting finding from this research was that calves grazing in dense plots, irrespective of sward height, commenced grazing at a faster rate and continued to graze at a higher rate of biting for a considerable longer period (40 min) than those grazing in sparse plots (10-15 min). However, the rate of decline in bite number was slower in dense plots at 10 cm height, and this could be associated with availability of sufficient prehensible herbage within the plot. The time available for foraging and the biting rate may limit an animals' daily forage intake and therefore affect its growth and survival (Ruckstuhl *et al*., 2003). In addition to satisfying its daily nutrient needs, ruminants grazing tropical pastures must harvest sufficient bites to ascertain the level of sown pasture utilization.

Harvesting and mastication bites were observed during grazing, but this study was focused on harvesting bite. Calves grazing in sparse plots cut to 20 cm height defoliate small amount of herbage, often one or two bites, and this can be linked to reduced dedicated time to forage selection (Chilibroste *et al*., 2007), occasioned by limited forage within the plot. Meanwhile, this does not necessarily lead to reduced jaw movements. On the contrary, calves grazing dense plot cut to 10 cm height were observed to gather large mouthfuls of forage with every tongue sweeps and continue to chew this herbage several times prior to swallowing. Thus, the process of herbage defoliation and mastication of the harvested forage prior to swallowing became confounded at this level, leading to over or under-estimation of harvesting bites. Since the animals were led to the pastures early in the morning, it is possible that the observed differences in biting rate of the animals could be due, in part, to hunger, as noted by Greenwood and Demment (1988), since the animals did not forage overnight.

The structure of pasture influences the time of search, harvest and chewing of forage, which combine to determine forage intake (Daniel *et al*., 2011). The potential for selection was inherent in sparse plots. However, this potential appears to be greatest in sparse plots cut to 20 cm height than for other treatments. This was evident as the animals put in this plot were observed to harvest small bites, perhaps due to maturity and sparse nature of the plot. If animals in this circumstance are able to extend length of time spent grazing in order to meet their intake requirement, animal production is not likely to be affected. Calves grazing in pasture with dense biomass cut to 10 cm height recorded higher bite number from the first to the fourth quarter of the access time than other treatments, and this contradicts the submission of Mezzalira *et al*. (2014) that bite mass; a derivative of bite rate, increases with increasing sward height.It is, therefore, worthy of note that grazing pastures before maturity offers higher intake of herbage and nutritive forage to the grazing animal, but this also depends on the botanical composition of the pasture.

Practically, it is impossible to prevent the accumulation of stem and dead materials in pasture swards, despite variation between species (Stobbs, 1974). Given this situation, the removal of top parts of pasture plants through cut back, especially where senescent materials become dominant; can significantly increase accessibility to young shoots by grazing animals, thereby increasing animal production. Such a practice is however not generally advocated for sown grass/legume tropical pastures because of some deleterious effect on some legumes (Stobbs, 1974). Pasture swards with large quantities of available succulent leafy herbage and accessible for grazing offer higher animal production potential. Whilst further studies are in progress to evaluate the effect of grazing on botanical composition of sown grass/legume sward and evaluation of regrowth potential of such sward, increasing biting rates, rather than increasing time spent foraging, might be the optimal strategy to ensure high intake rate on sown pastures.

CONCLUSION

There was a progressive decline in the biting rate of WF calves from both pasture types at varying sward height, with the highest recorded for dense pasture biomass cut to 10 cm height. It is concluded that biting rate of WF calves is strongly correlated to sward height and spatial distribution of pasture biomass. There is evidence that offering calves' dense pasture cut to 10 cm height in short-term grazing may lead to increased intake, as a result of reduced bite mass on the shorter sward. The data obtained in this study are valid as an indication of the investigated animals' potential. Measurement of biting rate during early morning grazing session provides insight on the relative ease of pasture defoliation by grazing animals.

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Conflict of interest

The authors hereby declare that there is no financial/personal interest or belief that could affect our objectivity on this research. In addition, no potential conflict from individual or group exists regarding this study. We also certify that this research has not being published elsewhere or submitted to other journals for publication.

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