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Ingestive behaviour, herbage intake and grazing efficiency of beef cattle steers on Tanzania guineagrass subjected to rotational stocking managements[1]

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ABSTRACT - The objective of this experiment was to evaluate the ingestive behaviour, herbage intake and grazing efficiency of beef cattle steers grazing on *Panicum maximum* Jacq. cv. Tanzania subjected to different rotational stocking intensities. Treatments corresponded to two post-grazing conditions (residues of 25 and 50 cm) associated with a pre-grazing condition of 95% sward canopy light interception during regrowth (LI). The grazing time increased linearly with the duration of the occupation period (475 to 630 minutes/day). On paddocks grazed down to a residue of 25 cm, the bite rate increased linearly along the occupation period, with an average of 42.5 bites/minute. On paddocks grazed down to a residue of 50 cm, the bite rate was stable and equal to 39 bites/minute. There was no difference in herbage intake between grazing intensities. However, grazing at 25 cm residue resulted in greater herbage removal (68.0 vs. 45.6%) and greater grazing efficiency (90.4 vs. 49.8%) than grazing at 50 cm residue. Post-grazing residues of Tanzania guineagrass under rotational stocking management may be set at either 25 or 50 cm, since the herbage intake was not affected within this grazing intensity range. However, herbage removal and grazing efficiency were reduced with the 50 cm post-grazing height and grazing time increased with long occupation periods.

Key Words: grazing management, *n*-alkanes, *Panicum maximum*, post-grazing height

Comportamento ingestivo, consumo de forragem e eficiência de pastejo de novilhos em pastos de capim-tanzânia em pastejo rotativo

RESUMO - O objetivo neste trabalho foi avaliar o comportamento ingestivo, o consumo e a eficiência de pastejo de novilhos em pastos de *Panicum maximum* Jacq. cv. Tanzânia submetidos a diversas intensidades de pastejo rotativo. Os tratamentos corresponderam a duas condições de pós-pastejo (25 e 50 cm) associadas a uma condição de pré-pastejo (95% de interceptação da luz incidente dossel forrageiro). O tempo de pastejo aumentou linearmente com o período de ocupação (475 a 630 minutos/dia). Em piquetes manejados com resíduo de 25 cm, a taxa de bocados aumentou linearmente ao longo do período de ocupação, com média de 42,5 bocados/minuto. Em piquetes manejados com resíduo de 50 cm, a taxa de bocados foi estável e igual a 39 bocados/minuto. Não houve diferença no consumo de forragem entre as intensidades de pastejo. No entanto, nos pastos manejados com 25 cm de resíduo, verificou-se maior remoção de forragem (68,0 vs 45,6%) e maior eficiência de pastejo (90,4 vs 49,8%) que naqueles manejados com 50 cm de resíduo. Resíduos pós-pastejo em capim-tanzânia sob lotação rotativa podem ser fixados em 25 ou 50 cm, pois o consumo de forragem não é afetado nessa amplitude de intensidade de pastejo. A remoção de forragem e a eficiência de pastejo são mais baixas nos pastos manejados com 50 cm de resíduo e o tempo de pastejo aumenta com longos períodos de ocupação dos piquetes.

Palavras-chave: altura pós-pastejo, manejo do pastejo, *n*-alcanos, *Panicum maximum*

Introduction

The daily amount of dry matter ingested is the most important measurement to allow for inferences regarding animal performance and responses (Burns et al., 1994). In spite of the enormous effort on the part of the scientific community, advances in obtaining reliable predictions of intake assessments in different feeding

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systems have been limited (Kyriazakis, 2003; Carvalho et al., 2007).

The classic hypothesis found in literature is that herbage intake would be controlled by the capacity of the digestive tract to digest low-quality herbage and by the feedback mechanism of the nutrient metabolites absorbed when animals are fed with highly digestible diets. These are called physical and chemiostatic or physiological mechanisms, respectively (Conrad et al., 1964). However, Carvalho et al. (2001) argued that the sward structure would have a relatively greater importance than physical and chemiostatic mechanisms of satiety in a pastoral environment, and Da Silva & Carvalho (2005) endorsed that by reporting the high animal performance indexes obtained in recent research on tropical pastures, where control of sward structure was an important feature of the experimental protocols used.

Cosgrove (1997) stated that it is difficult to predict herbage intake of animals on pastures under any circumstance. Much of this difficulty is due to the fact that herbage intake is influenced by several factors of the animal behaviour. Performance depends directly on daily herbage intake and indirectly on the effects of the grazing process on morphological composition, structural characteristics and herbage production (Palhano et al. 2005). Thus, knowledge about the mechanisms involved in the grazing process is important to understand aspects regarding control and regulation of herbage intake on pastures (Romney & Gill, 2000).

Generally, intake and animal performance increase with increases in sward height, herbage mass, post-grazing residue and herbage allowance to a certain limit. This increase tends to a maximum specific value for each animal species and category that is characterized by their limitation to process and, or to digest the herbage ingested. Identifying this sward condition for each animal species and category allows comparison with the corresponding values for efficient herbage accumulation, resulting in the establishment of sward conditions that should be generated, so that pre-determined animal performance targets can be achieved (Da Silva & Corsi, 2003).

Thus, the objective of this study was to assess herbage intake, ingestive behaviour, herbage removal and grazing efficiency of beef cattle steers on *Panicum maximum* Jacq. cv. Tanzania subjected to different rotational stocking intensities characterized by post-grazing heights of 25 and 50 cm and a common rest period corresponding to the time necessary for swards to reach 95% interception of the incident light during regrowth.

Material and Methods

The experiment was carried out at EMBRAPA – Gado de Corte, Campo Grande, MS, Brazil (20º27' S, 54º37' W and 530 m a.s.l.) on a *Panicum maximum* Jacq. cv. Tanzânia pasture established in January 1995 and used for grazing since August 1995. The use of the area for this experiment started in 09/29/2004 and finished in 5/18/2005, totalling 232 days. During the first 75 days (9/29 to 12/12/2004) the area was prepared for the experiment and activities involved such as collecting soil samples for chemical analysis, weed control, renovation and adjustments on fences and water lines and troughs, application of limestone and fertilizers, and mowing. The next 157 days (12/13/2004 to 5/18/2005) corresponded to the experimental period itself, during which measurements were made and data were collected.

The climate in Campo Grande corresponds to the humid tropical type, sub-type Aw (Köppen classification), with a dry season during autumn and winter. Rainfall data were recorded on the experimental site and data for relative air humidity and temperatures recorded in a meteorological station located at approximately 800 m (Figure 1).

The soil in the experimental area is a Rhodic Ferralsol (FAO, 2006), and fertility was monitored aiming at maintaining levels from 50 to 70% base saturation, 8 to 12 mg/dm^3 phosphorus (P – Mehlich) and 80 to 100 mg/dm^3 potassium. Soil samples were collected on Sept. 30 and Oct. 01, 2004, being 12 from the 0-10 cm of depth, 12 from the 0-20 cm of depth and 12 from the 20-40 cm of depth, a total of 36 samples from each 2500 m^2 paddock. The chemical analysis was performed according to EMBRAPA (1997) (Table 1).

Paddocks received 1000 kg/ha of limestone, 800 kg/ha of gypsum and 500 kg/ha of a 0:20:20 compound fertiliser (N:P:K). Paddocks also received 150 kg/ha of N (urea), applied in instalments. Since the interval between successive grazing varied with treatments and time of the year, quantities and dates of N fertiliser application also varied, but ensuring that the same amount of fertiliser was used for each treatment at the end of the experimental period.

The experimental area was divided up into three 3.0 ha modules, with 12 paddocks each, totalling 9.0 ha. Each module was divided up into two sets of 6 paddocks (2,500 m^2). One of the modules was used as a reserve area, where animals used for adjustments in the stocking rate were kept throughout the experiment. Two grazing intensity levels characterised by post-grazing heights of 25 and

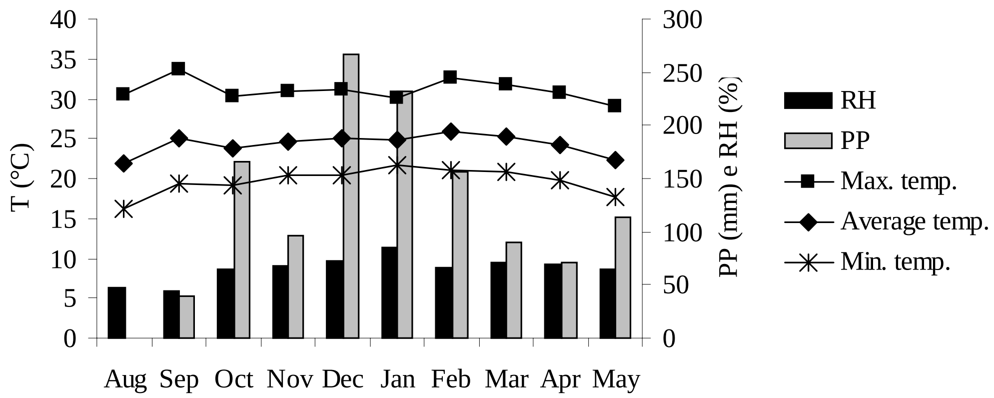

Figure 1 - Rainfall (PP, mm), relative air humidity (RH, %), maximum, average and minimum temperatures (°C) during the experimental period.

Table 1 - Chemical characteristics of the soil on the experimental area at the 0-10 cm, 0-20 cm and 20-40 cm depths

Depth	P	OM	pH	K	Ca	Mg	H+Al	S	T	V
cm	mg/dm^3	%	$CaCl_2$	mg/dm^3			cmol$_c$/dm^3			%
0 - 10	3.74	5.00	5.31	162.48	2.58	1.85	4.50	4.84	9.09	53.34
0 - 20	2.08	5.41	5.01	128.38	1.84	1.23	5.32	3.39	8.71	41.05
20 - 40	0.78	2.99	4.70	39.40	0.78	0.48	3.27	1.36	4.88	28.02

50 cm associated to a common pre-grazing condition characterised by 95% LI, and were designated as follows:

95/25 = 95% LI pre-grazing and 25 cm post-grazing height

95/50 = 95% LI pre-grazing and 50 cm post-grazing height

These were assigned to experimental units (sets of 6 paddocks) according to a complete randomised block design, with two replicates. The six paddocks per experimental unit allowed that each experimental unit was managed as a self-contained farmlet, with animals assigned to them corresponding to the "farmlet herd". A total of 24 paddocks were used for this purpose.

Grazing was carried out using 60 young Nellore bulls (approximately 12 months of age) with an average initial body weight of 221 kg. The grazing method used was the rotational stocking, with variable stocking rate and rest period determined by the level of sward canopy light interception (LI). In November 2004, paddocks started to be grazed and mowed, soon after grazing, in order to ensure that the targets of post-grazing heights had been precisely achieved. Mowing was carried out on a weekly basis on one paddock per module with the objective of ensuring a regrowth gradient between paddocks within modules. This procedure was used until all paddocks of each module had been mowed.

Monitoring of canopy light interception was made throughout each regrowth cycle using a canopy analyser *AccuPAR Linear PAR/LAI ceptometer, Model PAR –80 (DECAGON Devices)*. At the beginning, the regrowth measurements were made on a weekly basis, starting at the post-grazing condition, but when readings started to get close to 90%, the measurements were performed every two to three days until the target of 95% LI was reached. Readings were made along three transect lines with six sampling points each, totalling 18 sampling points per paddock. In each point, 1 reading was taken above the canopy and 5 at the ground level (optical sensor placed at the mid distance between tussocks), totalling 18 readings above the canopy and 90 at the ground level per paddock for each measurement date.

Sward height was measured using a 1 m ruler, and readings taken on 8 points randomly chosen along each of 5 transect lines across the paddocks, totalling 40 readings per paddock. At each point, the sward height corresponded to the distance between the ground and the horizon line defined by the curved top leaves around the ruler. Sward height measurements were made at the same dates that canopy light interception measurements were made throughout regrowth.

Pre-grazing herbage mass was determined by cutting two 1 m^2 quadrats on three of the six paddocks of each experimental unit, totalling 6 quadrats per post-grazing conditions replication. Quadrats were placed on representative areas of the sward at the sampling time (visual assessment of herbage mass and height) using two 25 cm tall stands in order to achieve the cutting heights of 25 and 50 cm. In each sampling point (quadrat), herbage was cut considering three strata: (1) above 50 cm from the ground; (2) between 50 and 25 cm from the ground; and (3) between 25 cm and ground level. From these samples, a sub-sample about half-size the sample was separated, put into paper bags and dried in forced draught oven at 65^{o}C until constant weight, which was used to calculate the dry matter content of the herbage and the dry weight of samples. Pre-grazing herbage mass was obtained as the sum of the herbage dry weight from the three strata. Another two sub-samples were generated and hand dissected into leaf (leaf blade), stem (stem + leaf sheath) and dead material. Components were dried in forced draught oven, similarly to the herbage mass samples, and dry weights were used to calculate the morphological composition of samples expressed as percentage. Post-grazing herbage mass and morphological composition were determined using procedure similar to that described for pre-grazing herbage mass.

The daily grazing time (minutes/day) was recorded on six animals (three per treatment) equipped with vibracorders with 24-hour recording capacity. Assessments were made throughout the occupation period of one paddock per treatment from 23/03/05 to 01/04/05, and recording cards replaced daily at 6 a.m. The bite rate (bites/minute) was determined from the time necessary for animals to perform 20 bites (Hodgson, 1982). For this, all test animals were observed during grazing activity periods, with several recordings performed on each animal. Means for each replication were generated from observations on each animal.

The herbage intake was estimated using controlled *n*-alkanes release capsules (*Captec*-New Zealand) (Mayes et al., 1986) on 13 animals, with an average body weight of 327 kg. These were randomly distributed into groups of six and seven animals for the 50 and 25 cm post-grazing height, respectively. After a seven-day stabilization period of *n*-alkane release, daily faeces collections started, and were consistently performed at 6:00 a.m. and 6:00 p.m. during 10 days (23.03.05 – 01.04.05).

Samples of herbage as grazed were collected using two oesophageal fistulated animals everyday during the occupation period of a paddock. Fistulated animals were taken to a pen early in the morning, so cannules could be removed and collection bags attached to them. Animals were then taken to paddocks for a grazing period of approximately 20 minutes in each treatment. After sampling, animals were once again restrained to remove the collection bags and replace the cannules on the fistulae.

Faecal and extrusa samples were frozen shortly after collection. Processing of samples, after completion of the field work, involved drying in a forced draught oven at 55°C until constant mass and grinding. Processed samples were then used to generate one composite sample per animal per day. Both fecal and extrusa samples were subjcted to chemical analyses to determine their *n*-alkane profile. Herbage intake was estimated using the $C_{33:}C_{32}$ pair and herbage digestibility using the C_{35}, according to methodology reported by Oliveira (2004).

The stocking rate per grazing cycle was calculated as the product from the total mean body weight (testers and variable stock) by the number of days the animals remained in each module, according to Petersen & Lucas Jr. (1968).

The herbage removal during grazing was calculated as the difference between pre-grazing green herbage mass (leaf + stem) and post-grazing green herbage mass. These values were transformed into percentage in relation to the pre-grazing green herbage mass. The grazing efficiency was calculated by dividing the total amount of herbage dry matter ingested (product of stocking rate during the paddock occupation period by the individual herbage intake) by the total amount of herbage removed during grazing (difference between pre and post-grazing herbage mass), and values were expressed as percentage.

The sward descriptive characteristics (light interception and pre and post-grazing heights) are presented using descriptive statistics only. Data were analysed using the PROC Mixed of SAS© (SAS,1993), and means calculated using LSMEANS command. When appropriate, comparison of means was made using a 5% significance level by Tukey test.

Results and Discussion

Targets of pre-grazing sward light interception and post-grazing sward height were maintained relatively stable throughout the experimental period, regardless of post-grazing conditions (Table 2). Grazing to a post-grazing height of 25 cm was relatively more difficulty than to 50 cm, a result of the animal reluctance to consume herbage at the end of the occupation period, with only 11.5% of leaves. There was no difference in pre-grazing herbage mass between post-grazing conditions, a likely consequence of the same target of sward light interception used to interrupt regrowth (P = 0.0635). At post-grazing, herbage mass was lower for the 25 than the 50 cm post-grazing height (P = 0.0006), a common and expected result for the higher grazing intensity associated with lower grazing residues.

Table 2 - Sward height and pre and post-grazing herbage mass of tanzania guineagrass subjected to rotational stocking managements

Item	Post-grazing conditions (cm)	
	25	50
Pre-grazing sward height (cm)	65.0	68.4
Post-grazing sward height (cm)	26.5	47.8
Pre-grazing herbage mass (kg/ha of DM)	7,130a(3.82)	8,600a(3.21)
Post-grazing herbage mass (kg/ha of DM)	3,810b(372.30)	5,080a(329.20)

Means followed by the same letter in lines are not different (P>0.05) - Tukey.
Values in parentheses refer to the standard error.

The distribution of the pre-grazing herbage mass and its morphological components varied across the vertical profile of swards (P = 0.0260; Table 3). There was a higher concentration of herbage mass at the bottom of the sward (0-25 cm), which decreased in the higher strata (25-50 and >50 cm). The morphological composition of the herbage mass also varied with sward vertical strata (P<0.010), with the lowest percentage of leaf at the bottom increasing towards the upper strata and the reverse occurring with stem and dead material. This herbage mass and morphological components distribution pattern is typical of pastures (Hodgson, 1990) and applies both to those formed by temperate and tropical plants (Stobbs, 1973, Palhano et al., 2007).

There was no difference between post-grazing conditions in daily herbage intake (P = 0.3007), even though animals on the 50 cm post-grazing height consumed 7.1 kg DM and those on the 25 cm post-grazing height consumed 6.6 kg DM (2.2 x 2.0 kg/100 kg LW) (Table 4). The digestibility of the consumed herbage was 68.5 and 67.3% for the 25 and 50 cm post-grazing height, respectively (P = 0.6951).

In spite of no differences in daily herbage intake between post-grazing conditions, animals grazing at 50 cm post-grazing height ingested 10% more dry matter than those grazing at 25 cm. This was recorded during the short period of measurements used in this experiment (23 March to 01 April), but given the cumulative characteristic of this response, it could evolve to significant differences when considering the overall experimental period. The daily herbage intake was 2.1 kg/100 kg LW, considered high for tropical pasture standards and compatible with daily gains of 664 and 801 g/animal.day (Difante, 2005). The digestibility of the consumed herbage was high (average of 68%), and certainly a result of the higher percentage of leaf in the sward strata exploited by the grazing animals when grazing paddocks down to residue targets (75.8 and 97.9% for the 25-50 and >50 cm strata, respectively; Table 3).

Table 3 - Pre-grazing herbage mass (kg/ha of DM) and morphological composition (%) of the vertical profile of tanzania guineagrass swards subjected to rotational stocking managements

Strata	Herbage mass	Leaf	Stem	Dead material
>50 cm	990c(85.86)	97.9a(1.62)	1.1c(0.98)	1.0c(1.87)
25-50 cm	2,420b(85.86)	75.8b(1.62)	12.3b(0.98)	11.9b(1.87)
0-25 cm	4,350a(85.86)	8.2c(1.62)	30.5a(0.98)	61.3a(1.87)

Means followed by the same lower case letter in columns are not different (P>0.05) - Tukey.
Values in parentheses refer to the standard error.

Table 4 - Herbage intake, herbage removal and grazing efficiency in tanzania guineagrass subjected to rotational stocking managements

Item	Post-grazing conditions (cm)		Mean
	25	50	
Herbage intake (kg/100 kg LW)	2.0a	2.2a	2.1
Herbage removal (%)	68.0a	45.6b	56.8
Grazing efficiency (%)	90.4a	49.8b	70.1
Digestibility of the consumed herbage (%)	68.5a	67.3a	67.9

Means followed by the same lower case letter in lines are not different (P>0.05) - Tukey.

The herbage removal was also influenced by post-grazing conditions, with higher values registered when paddocks were grazed to 25 than to 50 cm (Table 4), indicating that higher post-grazing height resulted in lower grazing efficiency. However, the greater herbage removal on paddocks grazed to 25 cm resulted in lower sward residual leaf area and, consequently, lower canopy light interception soon after grazing, which caused the grazing interval to be longer (33 and 50 days for the 25 and 50 cm post-grazing height, respectively) and the number of grazing cycles to be smaller (Difante, 2005) under these circumstances.

Variation of herbage removal throughout the experimental period indicates little difference between grazing cycles as the experiment progressed (Figure 2), with values ranging from 37 to 53% and from and 62 to 73% for the 50 and 25 cm post-grazing heights. The grazing efficiency was higher and consequently grazing losses were lower for the 25 than for the 50 cm post-grazing height (90.4 and 49.8% and 9.6 and 49.8%, respectively).

The grazing time increased linearly with the occupation period of paddocks (Figure 3), with recorded values ranging from 475 to 630 minutes/day (7.9 to 10.5 hours). This increase in grazing activity can be explained by the changes in sward

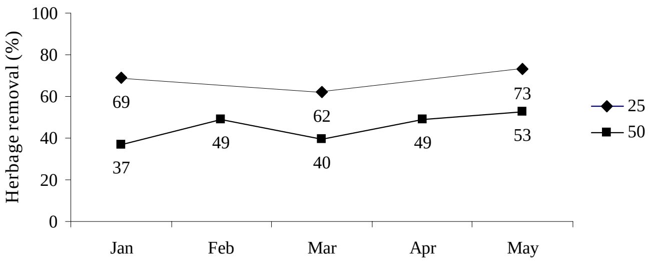

Figure 2 - Herbage removal (%) in tanzania guineagrass swards subjected to rotational stocking managements.

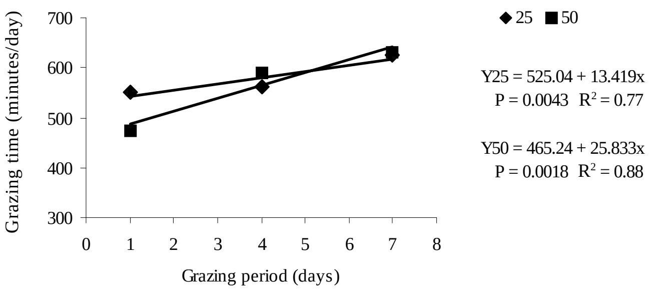

Figure 3 - Grazing time (minutes/day) of beef cattle steers during the grazing down period of Tanzania guineagrass subjected to rotational stocking managements.

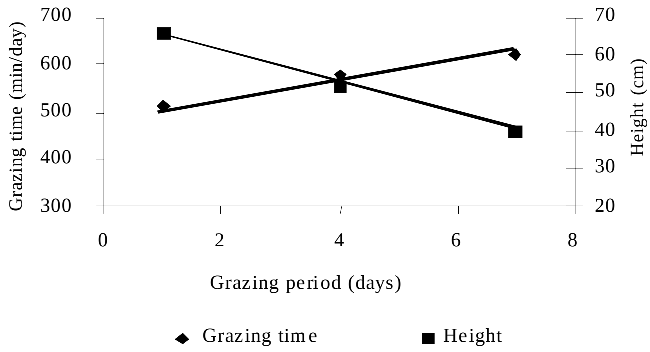

Figure 4 - Relationship between grazing time (minutes/day) and sward height during the grazing process of tanzania guineagrass swards subjected to rotational stocking managements.

structural characteristics during the three days that animals remained on paddocks, particularly sward height and morphological composition of the herbage mass (Table 3). The grazing time increased 13.4 and 25.8 minutes for each occupation day when swards were grazed to 25 and 50 cm, respectively. These results are in line with those of Trindade et al. (2007), who described variation in sward structure during the grazing process of marandu pallisadegrass. The authors explained variations in the grazing behaviour such as increase in grazing time, reduction in bite size etc. as being related to the reduced probability of encountering leaves as herbage during the occupation period of paddocks. Carvalho et al. (2001) also reported similar response pattern at the beginning and end of the occupation period of paddocks. At the beginning, the amount of herbage available is very high and leaves are the main component in the upper strata of swards. As grazing progress and herbage is removed from paddocks, the herbage available is reduced and the presence of leaves diminished in the medium/lower remaining strata, leading animals to change the grazing behavior spending more time searching for leaves and when encountering them, taking smaller bites because of physical limitations imposed by herbage characteristics.

The grazing time had a negative correlation (r = -0.59) with sward height (P = 0.0191; Figure 4). This finding was also reported by Hendricksen & Minson (1980), in an experiment where the grazing time increased as the percentage of leaf in sward herbage mass decreased.

The average bite rate on swards grazed to 25 cm was 42.5 bites/minute and varied linearly with occupation days at a rate of 0.64 bite/minute (Figure 5). This represents 371 additional bites for each additional occupation day. On swards grazed to 50 cm, the bite rate did not vary during the occupation period and averaged 39.1 bites/minute, indicating that the higher post-grazing residue did not interfere severely enough with the sward structure in order to cause variations in bite harvesting.

The inverse relationship between bite rate and sward height during the occupation period of paddocks (r = -0.91; P<0.0001) (Figure 6). This variation pattern is in agreement with results of Sarmento (2003), who reported reduction in

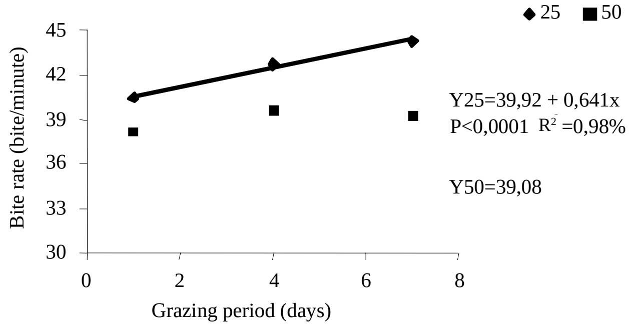

Figure 5 - Bite rate (bites/minute) of beef cattle steers during the grazing period of Tanzânia guineagrass swards subjected to rotational stocking managements.

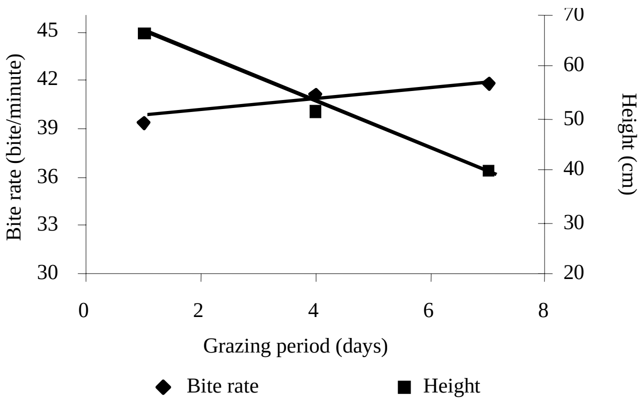

Figure 6 - Relationship between bite rate (bites/minute) and sward height during the grazing process of tanzania guineagrass swards subjcted to different rotational stocking intensities.

bite weight with decreasing heights of potentially grazed strata and herbage mass on swards. Under these circumstances, animals responded to increasing bite rate and grazing time.

Conclusions

Tanzania guineagrass subjcted to different rotational stocking intensities can be managed at either 25 or 50 cm post-grazing height without interfering with daily herbage intake of the grazing animals, but herbage removal and grazing efficiency are higher with the lower residue. Long occupation periods can result in considerable increase in grazing activity of the animals.

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