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Effects of tethering management on feed intake and behaviour of Tanzanian goats

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Abstract

Twenty-four mature, dry, female goats were grazed on *Brachiaria*-dominated pasture to study the effects of tethering on intake. Animals were either tethered for 4 h (T4) or 8 h (T8), or grazed freely for 8 h (FG) during a 28 day period. Intake was estimated by two methods: (1) short-term BW changes and (2) *n*-alkanes as internal markers. The BW technique was suitable for conditions in developing countries, although correction factors for changes in bite rate through the grazing day may be needed in order to estimate total intake. The alkane technique may be more appropriate to estimate total intake, but it involves sophisticated and expensive chemical analyses. Animals grazed for 4 h had similar total daily intakes to those grazed for 8 h: 1055 g day^{-1}, 1183 g day^{-1} and 1259 g day^{-1} for T4, T8 and FG treatments, respectively. The T4 animals compensated for the shorter time available by increasing intake rate and spending a larger proportion of available time eating. Although the reason for higher intake rates observed in T4 animals was unclear, duration of fasting was not considered to be a factor. Lower intake rates observed at the end of the day for tethered animals may have resulted from decreasing herbage mass availability and soiling. Free-grazed animals did not alter intake rate and had total intakes that did not differ from those of T8 animals. Increased rates of intake might be expected to increase rate of passage and decrease digestibility; however, in the present trial, digestibilities (0.49, 0.54 and 0.51 for T4, T8 and FG animals, respectively) did not differ ($P > 0.05$) among treatments. The results showed no serious disadvantage in terms of intake and digestibility, either of tethering per se, or of tethering for 4 h as opposed to 8 h, for mature non-productive goats, which were able to alter behaviour to compensate for limited time available for grazing.

Keywords: Tethering; Goat; Grazing; Intake; Behaviour

1. Introduction

Tethering is a commonly practised technique in the management of small ruminants in tropical countries. In mixed crop/livestock systems, where land is intensively cropped, or labour for herding is unavailable, tethering is often used as a means of controlling animals, preventing them from damaging crops and property. In a survey of two densely populated regions near Morogoro in Eastern Tanzania (D.S.C. Sendalo and I.J. Minde, unpublished results, 1992) 67% of small

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ruminant owners practised tethering. Duration of tethering varied, the main source of variation being the time at which animals were taken out to tether. Although this was usually between 08:00 and 10:00 h, a small proportion were taken out after 12:00 h, farmers arguing that starved animals concentrated better on their grazing. The time at which animals returned from tethering was between 16:00 and 18:00 h. It might be hypothesised that restricting the time spent grazing in this way would negatively affect intake and, consequently, production. Our first objective was to compare the two tethering systems and to compare tethered with free grazing animals. Grazing behaviour was examined as a means of helping to explain any differences in intake as a result of experimental treatment.

There are a number of techniques available for the measurement of intake by grazing animals (Leaver, 1982); however, most have been developed under temperate climate conditions with uniform swards of only a few species. In the tropics, pasture is rarely homogeneous, and many methods remain to be proven under these conditions. We compared two techniques in the present experiment. The first was the weighing technique developed by Penning and Hooper (1985). The second was a method developed for single species or mixed swards, using concurrently odd-chain alkanes present in the plant cuticle as internal markers and dosed even-chain alkanes as external markers (Mayes et al., 1986). Hence our second objective was to examine the suitability of these methods for use under grazing conditions common in the tropics.

2. Materials and methods

2.1. Grazing area

An area of approximately 1.8 ha, consisting mainly of *Brachiaria* spp., but with extensive invasion of other plants, including species of *Bothriochloa*, *Hyperrhania*, *Sporobolas*, *Panicum* and legumes (see Table 1), was subdivided into three plots, two of 7084 m^2 and a third of 4410 m^2. Twelve quadrats (1.25 m^2) per plot were cut at ground level before and after the 28 day experimental period to determine botanical composition and herbage mass. The two larger plots were marked out into 28 sub-plots of 11×23 m^2, each one providing grazing for eight tethered animals for 1 day. The smaller (4410 m^2) plot was fenced.

2.2. Animals and experimental design

Twenty-four mature female, non-lactating, non-pregnant goats of the local East African breed, were allocated to three treatment groups (eight animals per treatment) with similar mean live weights. Two groups were tethered for 4 (T4) or 8 (T8) h per day, whereas a third group (FG) grazed freely (8 h day^{-1}) in the fenced plot, which covered an area equivalent to that allocated to each group of tethered animals during the 28 day experimental period. Goats were tethered using sisal ropes, 2 m in length with a neck loop of 0.5 m, allowing each goat access to a circular area of 2.5 m radius (19.6 m^2 per animal). Animals were brought to the experimental areas at 08:00 h (T8 and FG) or 12:00 h (T4) and returned to covered holding pens at 16:00 h, where they remained till the following morning with free access to water. No supplementary feed was offered at any time. The two large plots were allocated to either the T8 or T4 treatments and the goats tethered, in treatment groups, 6 m apart, on a different, randomly selected sub-plot each day. Water was offered once during grazing. All goats were treated against helminths with Levamisole (Nilzan, Pitman-Moore) at the outset of the trial and grease was applied around the anus at approximately weekly intervals to prevent tick attachment.

2.3. Behaviour

On Days 7, 14, 21 and 28, all experimental animals were observed at 5-min intervals throughout the tethering period, and their activity was recorded (eating, rumination or idling). Total time spent on these activities was estimated, assuming activity at the time of observation to be representative of the previous 5 min (Hodgson, 1982).

2.4. Measurement of intake

2.4.1. Technique (1): short-term weight changes

Herbage intake (HI) was estimated using Eqs. (1) and (2) according to the method developed by Penning and Hooper (1985):

$$\text{HI (g day}^{-1}) = \text{IR} \times \text{grazing time} \quad (1)$$

$$\text{IR (g min}^{-1}) = \text{SWC} + (\text{IWL} \times t_1)/t_2 \quad (2)$$

where IR is intake rate (g min^{-1}), SWC is short-term weight change during grazing (g), IWL is insensible weight loss (g min^{-1}), t_1 is time difference between first and last weighings in SWC estimation (approx. 60 min) and t_2 is time spent grazing during estimate of SWC (min)

Body weights were taken using a battery-operated balance with a built-in animal weighing programme accurate to ±20 g, (DT150J Mettler, Switzerland). Canvas faecal collection bags containing baby diapers were fitted to collect any faeces or urine produced. Time spent grazing was estimated from observations of behaviour.

Animals continuously lose weight through respiratory evaporative cooling and this is known as insensible weight loss (IWL). The rate of loss will be affected by factors including activity and temperature and must be corrected for when measuring weight increase as a result of feed consumption. IWL was determined at the same time of day and under the same conditions as short-term weight change (SWC) during grazing, but preventing goats from eating by fitting a plastic mask. IWL was estimated for the first hour (h 1) of grazing for all animals on two occasions (Days 6 and 27). On Day 13, final hour estimates were made, in addition to a further estimate for h 1 in the T8 and FG treatments. The h 1 value was not estimated on Day 13 for T4 goats, since it was considered that to do so in the shorter grazing time was logistically complicated and would cause undue stress to the animals. Mean values over time for individual animals were used in the calculation of intake.

On the days following IWL measurement, intake rate was determined at the same times of day. Intake rate during h 1 of grazing for all treatments was also estimated on Day 21. Since no estimate of h 1 intake rate was made for T4 animals on Day 14, daily intake rate was not estimated, giving a missing value for T4 animals on this day.

Plucked samples of herbage were taken on Day 20 at 08:30 h from T8 and FG plots and at 12:30 h from the T4 plot. Separate samples were not taken for each weighing, as an inconsistent power supply prevented immediate weighing and drying of samples.

2.4.2. Technique (2): n-alkanes as internal markers

An alternative measure of herbage intake was estimated according to the method of Mayes et al. (1986) as shown in Eq. (3):

$$\text{HI (kg day}^{-1}) = [(F_i/F_j) \times D_j]/[H_i - ((F_i/F_j) \times H)], \quad (3)$$

where F_i is concentration of natural, odd chain alkanes in faeces (tritriacontane, C_{33}), F_j is concentration of dosed, even chain alkanes in faeces (dotriacontane, C_{32}), H_i is concentration of natural, odd chain alkanes in herbage (C_{33}), H_j is concentration of dosed, even chain alkanes in herbage (C_{32}) and D_j is daily dose of alkane (C_{32}).

Animals were dosed with 79.7 mg day^{-1} of C_{32} alkanes impregnated onto paper pellets, once daily from Days 10 through 21 at 06:30 h. Faeces were collected twice daily at 07:00 h and 16:30 h on Days 16 through 21 and dried at approximately 70°C for 24 h. Samples from each animal were ground and bulked and a sub-sample taken for analyses. Herbage samples plucked for estimation of DM in the weighing technique were used to estimate alkane concentration of the composite sample. Analysis of herbage and faecal samples for alkane content was carried out using gas chromatography, according to the method described by Mayes et al. (1986) with modifications. Faeces (0.5 g) and herbage (1.0 g) samples were heated directly with 1 M KOH (7 ml or 10 ml, respectively) in screw-capped tubes. The chromatographic column was a 30 m × 0.75 mm (OD) glass capillary column (Supelco SBP1) heated isotherm at 265°C, using helium as the carrier gas.

2.5. Digestibility

Concentrations of the natural alkane, pentatriacontane (C_{35}) were used as internal markers to estimate digestibility with Eq. (4):

$$\text{DMD (\%)} = 100 \times (1 - (H_{35}/F_{35}) \times 0.95) \quad (4)$$

where H_{35} and F_{35} are concentrations of C_{35} in herbage and faeces DM.

To correct for the faecal recovery of C_{35} a factor of 0.95 was used, which was derived from direct measurements made indoors (Mayes et al., 1986).

2.6. Climate

The trial was conducted in the dry season and daily readings of temperature and humidity were recorded. Mean temperatures ± SE were 22.9 ± 0.47°C, 27.8 ± 0.24°C and 28.35 ± 0.30°C and mean humidity ± SE were 74.89 ± 1.10%, 46.68 ± 1.13% and 40.05 ± 0.96% at 09:00 h, 12:00 h and 15:00 h, respectively, for the 28 day experimental period.

2.7. Statistical analyses

Data for which single estimations were made, e.g. intake and digestibility using the alkane technique as well as intake rates during the final hour of grazing, were analysed using a one-way ANOVA. Where significant treatment effects were found, SEM were used to provide more detailed interpretation.

Data generated from the weighing technique were analysed using unbalanced split-plot ANOVA (general linear model) considering the effects of treatment, time (the day the measurement was made) and the treatment × time interaction. The animal within treatment term was used as the error for the treatment effect. Tabulated results present treatment effects only. Individual animals were considered as the experimental unit; however, because tethered animals grazed on a single large plot, there was no replication across pastures.

To make comparisons between intake rates in the first and last hours of grazing and between estimates of intake using the two techniques, differences were calculated for each animal and analysed using a one-way ANOVA. *T*-tests were used to test whether the mean differences differed from zero. In this analysis, measurements using the weighing technique were those made on Day 21 only, which fell during the sampling period for the alkane technique.

3. Results

3.1. Herbage mass

Species composition, chemical composition and herbage dry mass at the beginning and end of the experimental period, in the three plots, are shown in Table 1. Herbage mass of the tethered plots at the end of the trial was estimated from quadrat samples from the grazed areas only.

Table 1
Species composition, herbage mass and chemical composition of a plucked sample representing herbage consumed in the three plots used during the trial for animals tethered for 4 (T4) or 8 (T8), or free grazed (FG)

	T4	T8	FG	SEM
Species composition (% of DM)[a]				
Brachiaria spp	66	51	69	7.1
Bothriochloa spp	22	46	16	6.9
Legume	7	1	7	1.7
Other	0	2	8	2.3
Herbage mass (kg DM ha^{-1})				
At start of trial[a]	6646	6054	8090	753
At end of trial[b]	6702	5709	7948	435
Chemical composition of plucked sample (on Day 20)				
DM %	58.3	60.0	49.5	
CP (% of DM)	4.3	4.1	5.3	
Crude Fibre (% of DM)	28.9	29.7	26.2	

[a]Values are means of 12 sample quadrats.
[b]Values are means of 21 sample quadrats.

3.2. Insensible weight loss

IWL ± SE measured between 08:00 and 09:00 h (1.25 ± 0.08 g min^{-1}) was less ($P < 0.01$) than IWL measured at 15:00–16:00 h (2.28 ± 0.13 g min^{-1}). This would be expected because of the higher temperature and lower humidity at the later time, increasing losses from respiratory evaporative cooling. No treatment effects were found, although there was a small treatment × hour interaction ($P < 0.05$) for measurements on Day 13, where the difference between morning and afternoon measurements seemed to be greater for animals in the FG (1.12 vs. 2.61) compared with the T8 (1.33 vs. 1.98) group.

3.3. Intake rate

Intake rates during the first hour of grazing did not differ for T8 and FG animals, but were higher ($P < 0.001$) for T4 animals (Table 2), although there is confounding between the treatment and time of day effect. A significant treatment × time (day of trial) interaction was observed for first hour intake rates, which increased with time for T4 (4.8 g min^{-1}, 5.6 g

ble 2
te of intake measured during first and last hour of grazing (g DM
r min) for animals tethered for 4 (T4) or 8 (T8) h, or free grazed
G). Values for the first hour are means of four (T8 and FG) or
ee (T4) values, while last hour values are single estimates

	T4	T8	FG	SEM	Treatment significance
ys 7, 21 and 28[a]					
First hour	5.77	4.16	3.54	0.28–0.29	$P<0.001$
y 14[b]					
First hour	–	4.06	3.65	0.46	NS
Final hour	2.54	0.99	2.94	0.32	$P<0.001$
Difference	–	3.07	0.71	0.46	$P<0.01$

alues are adjusted means from an unbalanced split plot analysis, cluding Day 14 data, $n=24$, 23 and 22 for T4, T8 and FG.
alues are compared using a one-way ANOVA, $n=8$ for all treatnts.

in^{-1} and 6.9 g min^{-1} for Days 7, 14 and 21, respecely) but not T8 or FG animals. In the final hour, rates re lower for the T8 group compared with T4 and FG <0.001) and decreased between the first and last ur of grazing for T8 and FG ($P<0.001$) groups, the gest difference being observed for T8 (Table 2). e final hour value for the T4 group was lower than any observed during the first hour, although the difference could not be tested statistically because first and last hour measurements were not made on the same day.

3.4. Behaviour

Behaviour data are presented in Table 3 and Fig. 1. Animals in the T4 group spent a greater ($P<0.05$) proportion of the available time grazing compared with T8 and FG animals, although the total duration of grazing (min) was less ($P<0.05$) for T4 animals.

Fig. 1 shows the average pattern of grazing behaviour over the experimental period. The T8 animals decreased the proportion of time spent grazing throughout the day from more than 90% in the first 2 h of grazing to less than 60% in the final hour. In contrast, FG animals spent more than 90% of the time eating in both the first and last hour of the grazing period, but spent less time grazing during the middle part of the day. Animals in the T4 group spent more than 85% of the time eating throughout the 4 h at pasture.

ble 3
akes estimated using the alkane and the weighing techniques, live weight (LW) change, total time spent grazing and proportion of time ilable spent grazing, ruminating and idling for animals tethered for 4 (T4) or 8 (T8) h, or free grazed (FG)

	T4	T8	FG	SEM	Treatment significance
haviour					
Minutes grazing[a]	217	319	369	9.8 – 10.3	$P<0.001$
% grazing[a]	93.5	71.1	82.3	2.40– 2.51	$P<0.001$
% ruminating	0.4	7.2	8.3		
% idling	6.1	21.7	9.4		
ake (g day^{-1})					
Using alkane method[b]	1055	1183	1259	52.4	$P<0.05$
Using weigh method Day 21[c]	1145	1587	1317		
Difference	90	404	58	129 –138	NS
Using weigh method[a]	1246	1337	1292	95 –114	NS
e weight					
Initial LW (kg)	28.8	27.8	28.2	1.1	NS
Final LW (kg)	29.0	27.8	29.3	1.2	NS

alues are adjusted means from an unbalanced split-plot analysis of variance excluding the interaction term, $n=24$, 23 and 22 for T4, T8 and ;.
alues were compared using a one-way ANOVA.
alues are mean values for Day 21 only.

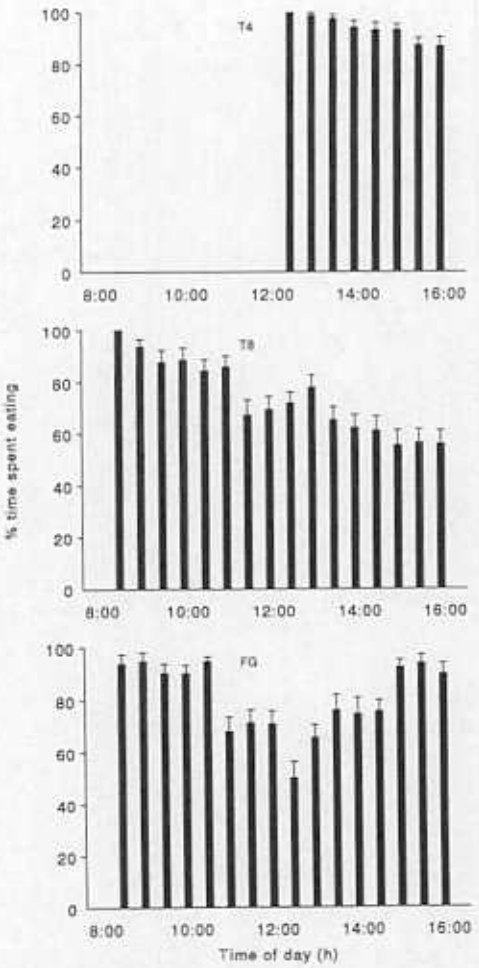

Fig. 1. Proportion of time spent eating during half hour observation periods through the grazing day for animals tethered for 4 (T4) or 8 (T8) h, or free grazed (FG) (percentages are means for 4 days of behavioural observation).

3.5. Herbage intake

Estimates of daily intake measured using both techniques are shown in Table 3. Lowest intakes were observed for T4 animals, although the only treatment difference ($P<0.05$) occurred between intakes of FG and T4 treatments measured using the alkane technique. Values using the weigh method were higher than for the alkane technique, although the difference was only significant for T8 animals ($P<0.001$), the smallest difference being observed for the FG group. The reason for the particularly high intake observed on Day 21 for T8 animals was not clear, but appeared to reflect higher than average times spent grazing.

3.6. Digestibility

Mean digestibilities $\pm$SE, of 0.49 ± 0.02, 0.54 ± 0.02 and 0.51 ± 0.02 for T4, T8 and FG animals, respectively, were calculated using the alkane technique. Although the trend showed lower digestibilities in the T4 group, there were no differences among treatments.

3.7. Live weight gain

Live weight (LW) did not increase during the experimental period for any treatment (Table 3).

4. Discussion

4.1. Methodology

Estimates of intake using the weighing technique tended to be higher than those using the alkane method. The weighing technique relies on the assumption that the rate of intake remains constant throughout the day. For tethered animals, intake rate in the final hour of grazing appeared to be lower than during the first hour. Therefore, because calculation of intake (Eq. 1) was based on intake rates during the first hour only, it would be expected that values would tend to be overestimated. The closest agreement between the two estimates was observed for FG animals, where the difference in intake rates for the first and last hours was small.

In the present study it was not possible to determine whether changes in intake rate arose from changes in bite rate or size. Subjective observations indicated that animals decreased bite rate, spending more time selecting between bites later in the day. Therefore, it may be possible to account for variation in biting rate by counting bites per minute for short periods (e.g. 2 min) at regular intervals throughout the day.

Both intake measurement techniques rely on pluck sampling of herbage consumed by goats, based on subjective observations of selected material. Fistulation at the oesophagus has been commonly used for direct collection of samples of ingested material. However, such severe modification of animals may alter grazing

behaviour in itself, and Jones and Lascano (1992) showed that fistulated steers gave unreliable estimates on tropical grass/legume pastures. Errors of sampling may be exaggerated with the alkane technique, because it relies on accurate sampling of plant parts and species in the correct proportions selected by the animal to obtain a precise estimate of the mean alkane concentrations in the diet. In contrast, the weighing technique only requires an estimate of the water content of the herbage selected.

Although both techniques used had advantages and disadvantages, the weighing technique, with a correction for bite rate where the rate changes during the grazing period, is likely to be more appropriate for use in developing countries where water and electricity supplies are unreliable. Furthermore, an immediate estimate can be made of fresh matter intake. The alkane technique was simple and easy to use at the field level, but it required lengthy chemical analyses with sophisticated and expensive equipment to obtain results.

4.2. Grazing behaviour

Goats tethered for 4 h during the afternoon seemed to be able to maintain similar levels of intake to those tethered for 8 h. Animals compensated for the restricted duration of grazing by increasing intake rate and spending a larger proportion of the available time grazing. For tethered animals, there seemed to be no advantage, in terms of intake or live weight gain, to tethering for the longer period. Free-grazed animals had similar intakes to the T8 group suggesting that tethering per se had no effect on intake.

Intake rates of tethered animals seemed to have decreased by the end of the grazing period. Within a day, intake rate is likely to have been affected by depletion of available herbage biomass, because only a small area was accessible for tethered grazing. Soiling also has been shown to affect intake adversely (Forbes and Hodgson, 1985). Both factors may have contributed to the very low rates of intake observed for T8 animals at the end of the day. Fig. 1 shows that T8 animals steadily decreased the proportion of time spent grazing throughout the day, which also may reflect soiling and herbage availability. Meanwhile FG animals spent less time grazing during the middle of the day but a similar amount of time during the first and last hours, which may have resulted from these goats being able to move to areas of shade.

The greater intake rates observed for T4 animals than for T8 and FG during the first hour of grazing cannot be explained by altered herbage mass. Previous studies have shown that ruminants increase rates of intake in response to fasting (Sidahmed et al., 1977; Dougherty et al., 1987, 1989; Greenwood and Demment, 1988). It might thus be expected that the higher rates observed for T4 animals in the first hour were a response to the longer period of fasting (20 h) compared with T8 and FG treatments (16 h). However, Sidahmed et al. (1977) found that intake rates by sheep were only significantly increased after 36 h of fasting. Furthermore, Dougherty et al. (1987, 1989) suggested that intervals of only 3 h between grazing sessions alleviated most limitations on appetite induced by herbage intake from the previous grazing session. It is therefore unlikely that a fast of 20 h (on the T4 treatment) would induce significantly higher intake rates compared with a fast of 16 h (on T8 and FG treatments). Intake rates were measured after the goats had been adapted to the tethering strategies for more than 7 days. However, during the experimental period it was observed that intake rates for T4 goats increased, and it may be that decreased access to feed enabled the animal to 'learn' to increase intake rate.

Adjustments in the proportion of grazing time spent eating, as observed by T4 animals, have been found in response to decreased herbage mass in uniform grass swards (Allden and Whittaker, 1970; Chacon and Stobbs 1976; Penning et al., 1991). Cattle grazing tropical pastures also have been observed to increase time spent grazing following restricted access to pastures (Smith, 1961; Bayer, 1990).

It should be noted that in our trial, the goats were mature, non-pregnant, non-lactating animals with low nutrient requirements. In animals with higher levels of production and higher intakes, the mechanisms by which the goats were able to maintain intakes may be insufficient to compensate for decreased access to grazing. Further trials are planned to study lactating goats to examine this aspect.

4.3. Digestibility

Demment and Greenwood (1988) suggested that animals modify behaviour in order to maximise energy

digestion per unit time (DE/T), and that ingestive behaviour is a compromise between mastication, which increases passage rate, and biting fresh forage, which increases intake. The same authors showed that increased intake rate derived from increased bite rate and decreased mastication, suggesting a tendency to decrease rate of passage as a result of an increase in particle size ingested. However, the animal may compensate for decreased mastication by increasing the time spent ruminating. Increased rate of eating also may decrease the capacity to select for the higher quality forage. In the present trial, there was some indication, though not significant, that digestibility of ingested herbage was less for T4 animals and that bite rate diminished during the day. However, further research would be required to ascertain whether quality of herbage consumed or efficiency of herbage utilisation were affected by alterations in ingestive behaviour as a response to restricted access to pastures.

5. Conclusion

The results of the present trial suggest that there is no serious disadvantage to tethering dry, non-pregnant goats in terms of intake. It also seemed that the goats were able to change their behaviour in response to restricted access to grazing in order to maintain herbage intake when tethered only during the afternoon. It should be noted, however, that the animals used in the present study were mature, with low nutrient requirements and that growing, lactating or pregnant animals may not be able to compensate sufficiently for decreased access to feed.

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