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Effects of Limit Feeding and Shade Allocation on Growing Calf Performance, Water Usage, and Animal Comfort

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Cover Page Footnote

Authors thank the Beef Checkoff for financial support and Strobel Manufacturing for providing shade structures for this study.

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Abstract

A group of 852 heifers (553 ± 62 lb) were used in growing studies during the summers of 2021 and 2022 to determine the effects of diet type and shade allocation on growth performance and animal comfort. Heifers were assigned to one of four treatments: high-roughage diet fed for *ad libitum* intake or limit-fed high-energy diet offered at 2.2% of body weight (BW) daily [dry matter (DM) basis] in shaded or non-shaded pens. Pen weights were measured weekly from day 14 to 84 and individual BW were measured on days 0, 90, and 97. Pen weights were used to adjust weekly intakes of limit-fed diets. All calves were fed a single diet at 2.5% of BW daily (DM basis) between days 90 and 97 to equilibrate gut-fill among treatments. Average daily gain was greater ($P < 0.01$) for shaded calves compared with non-shaded calves. Dry matter intake was greater ($P < 0.01$) for calves fed for *ad libitum* intake compared with limit-fed calves. Gain-to-feed ratio was better ($P < 0.01$) for limit-fed calves compared with calves fed for *ad libitum* intake and was also better ($P < 0.01$) for shaded calves compared with non-shaded calves. Limit-fed heifers spent less ($P < 0.01$) time ruminating and more ($P < 0.01$) time active compared with heifers fed diets for *ad libitum* intake. Time spent ruminating was greater ($P = 0.02$) for shaded calves compared with non-shaded calves. Water usage was less ($P < 0.01$) for calves provided shade compared with calves not provided shade and was less ($P < 0.01$) for limit-fed calves compared with calves fed for *ad libitum* intake. Panting scores were lower ($P < 0.01$) for shaded calves compared with non-shaded calves. Overall, limit feeding and provision of shade both improved calf growth and feed efficiency, decreased water usage, and improved animal comfort.

Introduction

Limit feeding high-energy diets can improve feed efficiency in growing calves compared with traditional high-roughage diets fed for *ad libitum* intake. Due to incidence of heat stress across the Central Plains region, the use of shade has been evaluated as a mitigation strategy to improve animal comfort and growth performance of finishing beef cattle. To our knowledge, limited information is available about effects of limit-fed high-energy diets in conjunction with shade on growth performance of growing beef cattle. The objective of this experiment was to evaluate the impacts of limit feeding and shade access as possible strategies to improve cattle efficiency, reduce water usage, and improve animal comfort in growing cattle.

Experimental Procedures

A group of 852 predominately black-hided heifers (553 ± 62 lb) were received at the Kansas State University Beef Stocker Unit during May and June of 2021 and 2022. Heifers were blocked by truckload (eight), stratified by individual arrival weight within block, and assigned to pens containing nine to twelve heifers. Within block, pens were assigned to one of four treatments for a total of 40 pens and 10 replications per treatment per year. The experimental design was a randomized block design with pen serving as the experimental unit.

On arrival, cattle were individually weighed, assigned a visual identification ear tag and an electronic identification ear tag, then provided 5 lb of prairie hay per animal [dry matter (DM) basis] and *ad libitum* access to water. On day 0 in 2021 (year 1), heifers were administered a 3-axial accelerometer ear tag (Allflex Livestock Intelligence Madison, WI) to measure rumination and activity. For both years, the heifers received a 7-way clostridial vaccine (Vision 7 with SPUR, Merck Animal Health, Madison, NJ), a modified-live vaccine to protect against infectious bovine rhinotracheitis, parainfluenza, and bovine viral diarrhea (Vista Once SQ, Merck, Madison, NJ), and an anti-parasitic drench (Valbazen, Zoetis Animal Health).

Prior to arrival, two shade structures (40 × 40 ft) per block were randomly assigned to cover two pens per structure; for the two pens under a common shade structure, one pen was fed each of the two dietary treatments. Shade structures provided 77 ± 6.3 ft^2 of shade per animal (Strobel Manufacturing Inc., Clarks, NE). Diets (Table 1) included a high-energy diet formulated to provide 60 Mcal of net energy for gain (NE_g) per 100 lb of DM fed at 2.2% of body weight (BW) daily and a high-roughage diet formulated to provide 45 Mcal of NE_g per 100 lb of DM fed for *ad libitum* intake. Animals were fed once daily beginning at 7:00 a.m. using a Roto-Mix feed wagon (Model 414-14B, Dodge City, KS). Bunks were observed prior to feeding to estimate *ad libitum* intake. Refusals for *ad libitum* diets were targeted at 5% of DM fed the previous day. Using a pen scale (Rice Lake Weighing Systems, Rice Lake, WI) pen BW were measured weekly from day 14 to 84 as well as on days 0, 90, and 97. Pen weights were used to adjust feed delivery and calculate animal performance. A gut-fill equilibration period was used to account for gastrointestinal tract fill differences between treatments by providing a diet at 2.5% of BW daily (DM basis) formulated to contain 53 Mcal of NE_g per 100 lb of DM to all treatment groups.

Feed ingredient samples were collected weekly. A portion of the sample was used to determine diet DM and the remaining feed sample was immediately frozen. Diet DM weights were used weekly to adjust feed offerings.

To determine the effects of shade on animal comfort, animals were evaluated at 9:30 a.m., 1:30 p.m., and 5:30 p.m. on days when the temperature humidity index (THI) was estimated to be greater than 74 (US MARC Animal Comfort Index). Using a method adapted from Guaghan et al. (2008; Table 2), individual panting score was determined using respiration rate and breathing conditions. Three animals per pen were selected randomly at each time point to represent each pen. The three values were averaged to obtain a mean panting score for each pen. Water usage was measured via iPERL water meters (SENSUS, Morrisville, NC) connected to individual automatic waterers (Lil' Spring 3000; Miraco Livestock Water Systems, Grinnell, IA) for each pen. The presented water usage and panting scores are only from year one.

Results and Discussion

Effects of diet

On day 0, BW did not differ ($P = 0.90$; Table 3) between dietary treatments; however, on day 90 BW were greater ($P < 0.01$) for calves fed for *ad libitum* intake compared with limit-fed calves. After the gut-fill equilibration period, limit-fed calves had greater ($P < 0.01$) BW compared with calves previously fed for *ad libitum* intake. This demonstrates how the diet affects gut fill and subsequently BW; it is important to equalize gut fill to obtain the best possible estimates of true BW gain. Average daily gains (ADG) from day 0 to 97 were greater ($P < 0.01$) for limit-fed heifers compared with heifers fed for *ad libitum* intake. A diet effect ($P < 0.01$; Table 3) was observed through day 97 where calves fed for *ad libitum* intake had greater DM intake compared with limit-fed calves. Dry matter intake did not differ ($P = 0.69$) between treatments during the gut-fill equilibration period, which was expected because all cattle were limit fed during this time. A diet effect was observed through day 97 for gain-to-feed where calves fed for *ad libitum* intake had worse feed efficiency than limit-fed calves; this is associated with a lower DM intake of limit-fed calves compared with calves fed for *ad libitum* intake, while ADG were greater ($P < 0.01$) for limit-fed calves compared with calves fed for *ad libitum* intake.

Heifers fed for *ad libitum* intake spent more time ruminating than limit-fed heifers ($P < 0.01$; Table 3), and the greater time spent ruminating was associated with greater DM intake and greater dietary forage concentration of the diets fed for *ad libitum* intake. Limit-fed heifers were more active ($P < 0.01$) compared with heifers fed for *ad libitum* intake.

Dietary treatments did not affect the mean panting scores. Limit-fed calves used 9% less ($P < 0.01$) water when compared with calves fed for *ad libitum* intake. Differences in water usage between diets may be attributed to differences in DM intake.

Effects of shade

On day 0, BW did not differ ($P = 0.22$; Table 3) between shaded and non-shaded calves. Heifers provided with shade had heavier ($P < 0.01$) day 90 and day 97 BW compared to heifers without access to shade. Average daily gains from day 0 to 97 were greater ($P < 0.01$) for shaded heifers compared with non-shaded heifers. Calves fed for *ad libitum* intake in shaded pens had greater ($P < 0.01$) DM intake compared with calves in non-shaded pens fed for *ad libitum* intake, whereas limit-fed calves in non-shaded pens and shaded pens did not differ in DM intake. Gain-to-feed was better ($P < 0.01$) for calves in shaded pens compared with calves in non-shaded pens.

Limit-fed heifers in shaded pens spent less time ruminating ($P < 0.01$) compared with limit-fed heifers in non-shaded pens; however, rumination time of calves fed for *ad libitum* intake was not affected by provision of shade. Heifers in shaded pens tended to be more active ($P = 0.10$) compared with heifers in non-shaded pens.

Calves in non-shaded pens had greater ($P < 0.01$; Figure 1) mean panting scores than calves in shaded pens. We attribute this difference to an increase in animal comfort due to reduced solar radiation exposure in shaded pens leading to lower heat load during the summer.

Water usage was 11% less ($P < 0.01$; Table 3) for shaded calves compared with non-shaded calves. This can be attributed to a decrease in heat load of calves in shaded pens compared with calves in non-shaded pens.

Implications

These data demonstrate that limit feeding a high-energy diet during the receiving period can improve feed efficiency and reduce water usage when compared to a higher forage diet fed for *ad libitum* intake. During periods of heat stress, shade can improve animal performance, reduce water usage, and improve animal comfort.

Acknowledgments

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References

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Table 1. Composition of experimental diets

	Diet[1]		
Ingredient, % DM	**45**	**60**	**53**
Dry-rolled corn	8.6	38.8	23.8
Supplement[2]	6.4	8.2	6.9
Sweet bran[3]	40.0	40.0	40.7
Alfalfa hay	22.5	6.5	14.2
Prairie hay	22.5	6.5	14.4

[1]45 = diet containing 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) offered for *ad libitum* intake; 60 = diet containing 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of body weight (BW) daily (DM basis); 53 = diet containing 53 Mcal of NE_g per 100 lb of DM limit-fed at 2.5% of BW daily (DM basis).
[2]Supplement pellet formulated to contain (DM basis) 8.5% calcium, 0.64% phosphorus, 0.76% potassium, 5.0% salt, and 307 g/ton monensin (Rumensin; Elanco, Greenfield, IN).
[3]Cargill Corn Milling (Blair, NE).

Table 2. Panting score evaluation[1]

Panting score	Breathing conditions
0	No panting. Respiration <60 breaths per minute
1.0	Slight panting, mouth closed, no drool, easy to see chest movement. Respiration ~60 to 90 breaths per minute.
1.5	Moderate panting, no drool present, easy to see chest movement, mouth closed. Respiration ~60 to 90 breaths per minute.
2.0	Fast panting, drool present, mouth closed. Respiration ~90 to 120 breaths per min
2.5	Fast panting, drool present, occasional mouth panting. Respiration ~90 to 120 breaths per minute.
3.0	Occasional open mouth panting, excessive drooling, neck extended, head held up. Respiration ~120 to 150 breaths per minute.
3.5	Open mouth panting, excessive drooling, tongue slightly extended or occasionally extended for short periods. Respiration ~120 to 150 breaths per minute.
4.0	Open mouth with extended tongue for a prolonged period, excessive drooling, neck extended, and head up. Respiration may decrease. Respiration ~120 to 150 breaths per minute.
4.5	Open mouth with extended tongue for a prolonged period, excessive drooling, neck extended, head up, visible breaths from the flank, drooling may be ceased. Respiration may decrease. Respiration ~120 to 150 breaths per minute.

[1]Panting score evaluation was adapted from Guaghan et al. (2008).

Table 3. Effects of shade and diet type on growth performance, feed efficiency, rumination, activity, and water usage

	Treatment[1]							
	No shade		Shade			*P*-value		
Item	**45**	**60**	**45**	**60**	**SEM**	**Diet**	**Shade**	**D × S**
Number of pens	20	20	20	20				
Number of animals	214	213	215	210				
Body weight, lb								
Day 0	551	551	548	549	3.0	0.90	0.22	0.76
Day 90	784	772	801	787	6.2	<0.01	<0.01	0.80
Day 97	785	799	802	811	6.3	<0.01	<0.01	0.58
Average daily gain, lb/day								
Days 0 to 97	2.25	2.39	2.44	2.53	0.056	<0.01	<0.01	0.47
DM intake, lb/day								
Days 0 to 90	20.14	14.84	21.45	14.92	0.274	<0.01	<0.01	<0.01
Days 90 to 97	20.78	20.75	21.00	20.94	0.164	0.69	0.07	0.90
Gain to feed, lb/lb								
Days 0 to 97	0.112	0.158	0.114	0.165	0.003	<0.01	<0.01	0.15
Feed to gain, lb/lb								
Days 0 to 97	9.04	6.37	8.82	6.09	0.157	<0.01	0.03	0.76
Rumination,[2,3] minutes/day	473.5	423.5	476.4	399.0	6.53	<0.01	0.02	<0.01
Activity,[2,3] minutes/day	312.7	316.7	313.0	322.7	2.76	<0.01	0.10	0.14
Water usage,[3,4] gallons/day per heifer	11.9	10.8	10.6	9.8	0.28	<0.01	<0.01	0.13

[1]45 = diet containing 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) offered for *ad libitum* intake; 60 = diet containing 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of body weight (DM basis) daily.
[2]Measured using 3-axial accelerometer ear tags (Allflex Livestock Intelligence, Madison, WI).
[3]Analysis of year one data only: non-shaded 45 = 105 animals; shaded 45 = 106 animals; non-shaded 60 = 100 animals; shaded 60 = 102 animals. Treatments in year one comprised 10 pens each.
[4]Measured using iPERL water meters (SENSUS, Morrisville, NC).

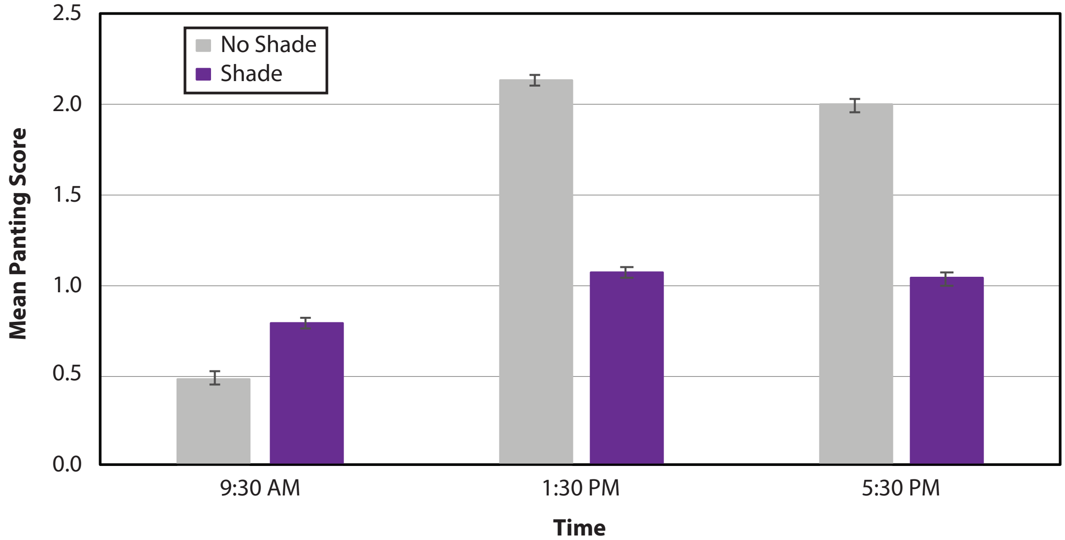

Figure 1. Effect of shade allotment on mean panting scores. Shade effect: *P* < 0.01. Standard error of the mean = 0.033. Panting score evaluation adapted from Guaghan et al. (2008).