Effects of Penned vs. Pasture Feeding Techniques on Cortisol Levels in Weaned Angus Bulls

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ABSTRACT

The effects of feeding in open pens versus pasture on blood cortisol levels in response to exogenous administrations of adrenocorticotropic hormone (ACTH) was measured in 30 weaned Angus bulls. Twenty-four bulls were allotted to eight 24.4 X 6.1 m pens, and the remaining six were kept in pastures. Threats, butts or physical combat that resulted in a subordinate yielding space to an aggressor (yields), and feeding location were recorded in 2 wk intervals during feeding periods in order to classify penned bulls as being either dominant or submissive. Adrenal response to ACTH treatment was quantified at the beginning, middle, and end of the study (approximately 56 d apart). During each sampling period, 8 dominant, 8 submissive penned bulls and 6 pasture bulls were haltered and blood was collected via jugular cannula every 20 min for 2 h, followed by injection of 100 IU of ACTH via jugular cannula and then blood samples were taken every 20 min for 4 h. Dominant bulls delivered more butts ($P<0.05$) over the entire period than did submissive bulls. Submissive bulls exhibited more instances of yielding space to an aggressor than did dominant bulls ($P<0.05$). Dominant bulls had lower cortisol levels ($P<0.05$) post-ACTH than pasture bulls for the intermediate bleeding period. Pasture bulls had higher ($P<0.05$) post-ACTH cortisol levels than penned bulls for the intermediate bleeding period. There were no differences ($P>0.05$) in pre-ACTH or post-ACTH cortisol levels among bulls across all treatments for the final bleeding period. Bulls raised in pens of this size were not under stress when compared to pasture raised bulls.

KEYWORDS: stress, ACTH, behavior, bulls, cortisol

Over time, humans have subjected cattle to various management schemes in order to maximize productivity. Recently, there has been a great deal of public concern about the well-being of animals used in agriculture. These concerns have brought about the need for animal scientists to develop techniques that will assess behavioral stress in livestock. Mastering these techniques will make it possible to recommend what management practices are optimum for minimizing the impact that behavioral stress can have on animal production.

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Moberg (1987) stated that a behavioral stressor is an event or stimuli that is acknowledged by the animal as a threat to its well-being. Behavioral stressors for animals include being introduced into strange surroundings, being placed into a new herd, or encounters with an aggressive peer. The consequences of stress, the stress response, and the recognition of a threat to homeostasis are the responses that animals have to a stressful event. The recognition of a threat to homeostasis or well-being takes place in the central nervous system. The degree of stress that an animal undergoes will determine how much the pituitary-adrenal axis responds (Dantzer and Mormede, 1983). Both behavioral and hormonal responses are closely related in stressful situations. Stress enhances pituitary-adrenal reactivity and facilitates the return to homeostasis.

Many researchers have stated that animals having increased plasma corticosteroid concentrations are in a stressful state and the conditions that cause these hormonal changes are stressors. Being able to determine when cattle have experienced stressful situations could be of great importance to the animal industry in evaluating management techniques (Friend et al., 1977). Adrenal response testing (ART) to exogenous adrenocorticotropic hormone (ACTH) is one method to determine if cattle have been exposed to stressful conditions. An injection of a large dose of ACTH reveals maximum amounts of glucocorticoids which an animal can produce (Fraser and Broom, 1990). Increased circulating corticoids (cortisol) sustained for 4 to 6 h after administration of ACTH may indicate the adrenal response to stress (Friend et al., 1979). This study was designed to determine the effects of penned versus pasture feeding on blood cortisol levels in response to exogenous administration of ACTH in weaned Angus bulls.

MATERIALS AND METHODS

This study was conducted at Angelo State University's Management, Instruction and Research (MIR) Center. Thirty weaned Angus bulls averaging 250 kg bodyweight were used for behavioral testing. Twenty-four bulls were allotted to eight 24.4 X 6.1 m pens, and the remaining six were kept in pastures under natural management conditions. Penned bulls were blocked by live weight with three bulls in each pen.

There was a 15-d adjustment feeding period, followed by a 112-d feeding period. Both penned and pasture bulls were observed for dominance and stress during feeding periods at 2 wk intervals (Arave et al., 1975). Bulls were monitored for approximately 2 h and threats, butts, and physical combat that resulted in a subordinate yielding space to an aggressor (yields) were recorded. Feeding location was also observed and recorded because previous studies indicated that dominant animals utilize all sections of a feed trough while submissive animals tended to utilize only a portion of a feed trough. Each trough within a pen measured 4.3 m in length. Troughs were divided into three sections by duct tape which provided 1.43 m per section.

Blood sampling for cortisol determination was taken at the beginning, middle, and end of the study (approximately 56 d apart). Indwelling jugular catheters were inserted approximately 24 h prior to each sampling period to minimize any cortisol response to the catheterization procedure. During each sampling period, blood (10 ml) was collected via jugular cannula into heparinized tubes with animals restrained

in a chute every 20 min for 2 h to establish baseline cortisol concentrations (pre-ACTH). Then, 100 IU of ACTH was immediately administered intravenously via the jugular catheter and blood samples were taken every 20 min for 4 h to determine the cortisol response of both the penned and pasture bulls to exogenous ACTH (post-ACTH). All blood samples were immediately placed into an ice bath and the plasma was separated by centrifugation. The samples were then frozen and stored at -20 C until analyzed for glucocorticoid hormones.

Blood cortisol (pre-ACTH and post-ACTH) analysis was determined by methods of Radioimmunoassay (RIA). Blood samples at -40, 0 (pre-ACTH); +40, +80, +120, +160, +200, and +240 (post-ACTH) times were analyzed for cortisol concentrations for eight dominant and eight submissive penned bulls and six bulls in the pasture group for all three bleeding periods.

In the statistical treatment of the data, plasma hormone concentrations were subjected to the general linear models (GLM) procedure of SAS (SAS, 1988). A Duncan's multiple range test was also used to statistically differentiate cortisol concentrations between dominant, submissive, and pasture bulls. Statistical data were further analyzed for differences in cortisol concentrations between penned and pasture bulls. The GLM procedure and Duncan's multiple range test were also used for the analysis of dominance within a pen for penned bulls.

RESULTS AND DISCUSSION

Behavioral Analysis

There were no significant differences ($P > 0.05$, Table 1) among dominant and submissive bulls for threats; however, dominant bulls delivered more butts ($P < 0.05$, Table 1) over the entire period than did submissive bulls. Dominant bulls gave a total of 105 butts during the trial versus only 13 for submissive bulls. Throughout the study, submissive animals exhibited more instances of yielding space ($P < 0.05$) to an aggressor than did dominant animals. The total sum of yields was 2 and 24 for dominant and submissive bulls, respectively. Dominant bulls tended to utilize more sections of the feed trough than did submissive bulls, but there were no significant differences between the two treatment groups.

Table 1. Mean behavioral responses to confinement management for penned bulls for an observed feeding period.

Items	Treatment	
	Dominant	Submissive
Threats	0.25	0.25
Butts	13.12a†	1.62b
Yields	0.25a	3.00b
Location of Intake	0.97	0.94

†Within a row means followed by a different letter are significantly ($P < 0.05$) different.

Cortisol Analysis

There were no significant differences ($P > 0.05$, Table 2) in pre-ACTH or post-ACTH cortisol concentrations among dominant, submissive, and pasture bulls for the initial bleeding period. However, pre-ACTH levels were highest for pasture bulls (6.150 ng ml^{-1} $\pm$ 1.533) and lowest for submissive bulls (2.865 ng ml^{-1} $\pm$ 0.606), with dominant bulls being intermediate (5.981 ng ml^{-1} $\pm$ 1.407). These values are similar to those reported by Friend et al. (1977), Friend et al. (1985), and Gwazdauskas et al. (1972). Standard errors were relatively high for both dominant and pasture bulls which accounts for the lack of significant differences among pre-ACTH concentrations. Post-ACTH levels for the initial bleed were 25.000 ng ml^{-1} $\pm$ 3.399, 28.751 ng ml^{-1} $\pm$ 5.465, and 18.278 ng ml^{-1} $\pm$ 5.720 for dominant,

Table 2. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the initial bleeding period†.

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	5.98±1.41	2.86±0.61	6.15±1.53
post-ACTH	25.00±3.40	28.75±5.46	18.28±5.72

†Means ± standard errors.

submissive, and pasture bulls, respectively. Although not statistically different, bulls that were fed in pastures tended to have the lowest cortisol concentrations of the three groups. Cortisol concentrations were slightly lower for dominant bulls than for submissive bulls. Initial bleeding data was further analyzed by combining cortisol levels from dominant and submissive bulls to form a penned group and was then compared to cortisol levels from pasture bulls (Table 3). Penned bulls post-ACTH levels were higher ($P < 0.05$) than pasture bulls.

Table 3. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the initial bleeding period†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.42±0.84	6.15±1.53
post-ACTH	27.00a‡±3.24	18.28b±5.72

†Means ± standard errors.
‡Within a row means followed by different letters are significantly ($P < 0.05$) different.

In Table 4, the intermediate bleeding pre-ACTH concentrations were similar for dominant, submissive, and pasture bulls, with dominant bulls having the lowest level. Pre-ACTH values are similar to those reported by Dunlap et al. (1981). Post-ACTH cortisol concentrations for the intermediate bleeding were higher ($P<0.05$) for pasture bulls when compared to dominant bulls. There were no significant differences in post-ACTH concentrations between submissive bulls and dominant bulls, or submissive bulls and pasture bulls. However, submissive bulls had lower post-ACTH cortisol levels than did pasture bulls.

Table 4. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the intermediate bleeding period†.

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	2.04±0.64	5.10±2.40	5.07±1.92
post-ACTH	7.11b‡±0.83	10.40bc±1.33	14.09c±1.20

†Means ± standard errors.
‡Within a row means followed by different letters are significantly ($P<.05$) different.

When dominant and submissive cortisol concentrations were combined to compare penned concentrations to pasture bulls for the intermediate bleeding period, there were no differences ($P>0.05$, Table 5) among pre-ACTH values between the two treatment groups with penned bulls having slightly lower cortisol levels than pasture bulls. Post-ACTH cortisol levels were higher ($P<0.05$) for pasture bulls than for penned bulls.

Table 5. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the intermediate bleeding period†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	3.57±1.26	5.07±1.92
post-ACTH	8.76a‡±0.88	14.09b±1.20

†Means ± standard errors.
‡Within a row means followed by different letters are significantly ($P<0.05$) different.

Table 6 indicates no differences ($P > 0.05$) in pre-ACTH cortisol concentrations among dominant (2.663 ng ml^{-1} ± 0.671), submissive (5.625 ng ml^{-1} ± 2.264), and pasture (4.950 ng ml^{-1} ± 0.902) bulls for the final bleeding period. In addition, there were no differences ($P > 0.05$) in post-ACTH cortisol concentrations between all groups for the final bleeding period. However, pasture bulls exhibited the highest cortisol concentrations (16.667 ng ml^{-1} ± 2.921) when compared to the other two treatment groups and submissive bulls had the lowest cortisol concentrations (11.537 ng ml^{-1} ± 1.208).

Table 6. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the final bleeding period†.

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	2.66±0.067	5.62±2.26	4.59±0.90
post-ACTH	12.59±1.93	11.54±1.21	16.67±2.92

†Means ± standard errors.

Table 7 shows that there were no differences ($P > 0.05$) in cortisol concentrations for both pre-ACTH and post-ACTH between treatment groups when cortisol data from dominant and submissive bulls was combined and compared to cortisol concentrations from pasture bulls. Pre-ACTH values were slightly lower for penned bulls (4.144 ng ml^{-1} ± 1.203) than for pasture bulls (4.950 ng ml^{-1} ± 0.902). Post-ACTH cortisol concentrations were lower for penned bulls (12.062 ng ml^{-1} ± 1.107) than for pasture bulls (16.667 ng ml^{-1} ± 2.921), and this difference approached significance ($P = 0.12$).

Table 7. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the final bleeding period†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.14±1.20	4.95±0.90
post-ACTH	12.06±1.11	16.67±2.92

†Means ± standard errors.

When hormonal data from all three bleeding periods was combined, no differences ($P > 0.05$) appeared between penned and pasture bulls (Table 8).

However, both pre-ACTH and post-ACTH cortisol concentrations were slightly lower for penned bulls than for pasture bulls.

Table 8. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the entire study†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.00±0.65	5.40±0.95
post-ACTH	15.34±1.19	16.35±2.60

†Means ± standard errors.

CONCLUSIONS

ACTH was used successfully in eliciting maximum secretion of cortisol from the adrenal glands with post-ACTH levels being similar to other research. Pre-ACTH levels were also similar to levels reported by Friend et al. (1977). It was also stated by Friend et al. (1977) that there is great variability in basal corticosteroid concentrations. This was true with this study as well resulting in standard errors relatively high for both dominant and pasture bulls which accounts for the lack of significant differences among pre-ACTH concentrations. The lack of significant differences in pre-ACTH or post-ACTH cortisol concentrations between dominant and submissive bulls for the initial, intermediate, and final bleeding periods is consistent with the findings of Arave et al. (1975).

Data presented in this study indicate that bulls raised in confinement are not under stress, and acclimate to confinement conditions very rapidly as evidenced by cortisol response to ACTH, when compared to bulls raised in pastures under natural management conditions. However, more study is needed at varying rates of density within a pen to determine the amount of space required for normal cortisol levels.

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