Comparison of Feed Additives during Preconditioning on Growth and Performance of Beef Calves

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Summary
The objective of this study was to evaluate the response of weaned calves to different feed additives within a preconditioning supplement. Specifically, alternatives to antibiotics and ionophores were evaluated to determine their effectiveness in improving calf performance and mitigating the stress response observed during the weaning process. Following stratification by bodyweight, sex, previous castration status, and breed, 160 calves were randomly allotted to one of four treatments (n = 40 calves/treatment): 1) control calves (CON) were supplemented without additives; 2) Chlortetracycline calves (CTC) were supplemented with added chlortetracycline at 350 g/hd/d; 3) Monensin calves (RUM) were supplemented with added Rumensin at 175 mg/hd/d; and 4) Actigen® calves (ACT) were supplemented with added Actigen® at 5 g/hd/d. Calf bodyweight was similar (P = 0.16) among treatments at the beginning of the trial period. Over the 52-d preconditioning period, ACT resulted in the greatest gain response. Chlortetracycline calves exhibited similar (P = 0.35) weight gains to ACT, which were both greater (P < 0.005) than weight gains exhibited by RUM. Control calves were similar (P ≥ 0.13) to both medicated treatments, but did not gain more (P = 0.02) than ACT. Plasma concentrations of haptoglobin and ceruloplasmin were similar (P ≥ 0.70) among treatments; however, a day effect (P ≥ 0.0001) was observed in both acute phase proteins measured. Our results indicate Actigen® may improve calf performance as effectively as chlortetracycline during a preconditioning period of this length, but neither additive was effective at mediating stress post-weaning.

Introduction
One of the key factors associated with preconditioning is the nutrition of the freshly weaned calf (Cole, 1985). Nutritional aspects of preconditioning not only consider nutritional needs of the weaned-stressed calf, but also include the acclimation of calves to dry feed, feed bunks, and water troughs (Savell, 2008). One of the greatest costs associated with preconditioning programs is the cost of feed inputs (Cole, 1985). The provision of supplemental feeds can increase the cost of preconditioning over grazing alone, but the additional gains associated with supplementation may prove more economical than grazing alone. Supplementation can be a favorable management practice to increase the nutritional profile of the weaned calf and reduce the stress associated with the weaning process.

Although the addition of feed additive technologies resulted in variable economic returns within this preconditioning program, ultimately, it seems that Actigen® is a suitable alternative to antibiotics when the goal is to improve weight gain in a cost effective manner.

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prices (King et al., 2006) primarily due to the improved health status of the calves.

The use of feed additives in the preconditioning diet is one means to positively affect the health status of fresh-weaned calves during preconditioning. Traditionally, preconditioning diets may contain an antibiotic, ionophore, or both. The use of these feed technologies has previously been demonstrated to increase calf performance through suppression of sub-clinical disease and improvement in rumen fermentation. However, there has been an increase in demand for calves that can qualify for “natural” and “never-ever” production programs. The use of antibiotics and ionophores is precluded from natural programs, even during the preconditioning period. The opportunity to incorporate alternative feed technologies into preconditioning diets that replace antibiotics and/or ionophores may offer producers more flexibility when marketing weaned calves.

The objective of this study was to evaluate the response of weaned calves to different feed additives within a preconditioning supplement. Specifically, Actigen ® an alternative to antibiotics and ionophores was evaluated to determine its effectiveness in improving calf performance and mitigating the stress response observed during the weaning process.

Materials and Methods
The experiment was conducted at the University of Florida Santa Fe Beef Research Unit in North Central Florida from August 2010 until October 2010.

Calves were born between December 2009 and April 2010. All calves received similar pre-weaning management, which included vaccination at approximately 4 to 6 mo of age, identification, as well as surgical castration and dehorning when necessary. Cow-calf pairs were gathered off pasture on the morning of August 16, 2010. Steers (n = 80) and heifers (n = 80) of Angus and Brangus breeds were separated from their dams and placed into one of four dry-lot treatment pens (n = 40 calves/pen) at the start of the experiment (d 0).

All calves on trial were supplemented with a formulated wheat middlings-cottonseed meal-based pellet (19% crude protein, 76% total digestible nutrients). Supplement pellets were formulated and manufactured by Lakeland Nutrition Group (Eaton Park, FL, USA). Prior to the start of the experiment, a full bodyweight was taken on July 28, 2010 and calves were blocked by bodyweight, breed type, previous castration status, and sex. Calves were then randomly allotted to 1 of 4 treatments (n = 40 calves/treatment): 1) control calves (CON) were supplemented with the formulated basal supplement without additives; 2) Chlortetracycline calves (CTC) were supplemented with the control supplement plus added chlortetracycline at 350 g/head/d; 3) Monensin calves (RUM) were supplemented with the control supplement plus added Rumensin® (Elanco, Greenfield, IN, USA) at 175 mg/head/d; and 4) Actigen® calves (ACT) were supplemented with the control supplement plus added Actigen® (Alltech, Nicholasville, KY, USA) at 5 g/head/d. Supplements were offered daily at a targeted intake of 4.0 lb/head/d; additives were included for the duration of the experiment. All supplements were formulated to be isonitrogenous and isoenergetic.

Calves were held in their dry-lot treatment pens (n = 40 calves/pen) for 1 wk before being transferred to 1 of 32 three-ac pastures (n = 5 calves/pasture) for a total of 8 pastures/treatment. During the dry-lot phase, calves received ad libitum access to perennial peanut hay. Each pasture was composed of a mixture of bahiagrass and bermudagrass. The pastures were previously grazed and fertilized with 60 lb N/acre prior to the initiation of the experiment. The nutritional value of the forage in the pastures for the duration of the experiment was 15% crude protein, 77% in vitro dry matter digestibility. The mean forage available per pen was abundant throughout the experiment. All pens had a feed bunk, water, and shade provided. Calves remained in the same pasture from d 7 to d 52 of the experiment.

Calf bodyweight was obtained on 2 consecutive
days at the initiation (d 0 and 1) and termination (d 51 and 52) of the experiment. Day 0 was the day of weaning, with day 1 considered the first day on the supplement. One-half of the calves on trial were utilized for intensive blood collection to measure plasma acute-phase protein (APP) concentrations. Calves were gathered on d 0, 1, 4, 7, 11, and 14 for collection of bodyweight and blood samples for APP analysis.

Data were analyzed by the MIXED procedure of SAS 9.2 (SAS Inst. Inc., Cary, NC). The model included the main effects of treatment. All variables quantified by day were analyzed using repeated measures. Least square means are reported with standard errors, means were separated for comparison by PDIF. All variables with P-values of ≤ 0.05 were reported as differences, all variables with P-values between 0.05 and 0.10 were reported as tendencies and anything greater than 0.10 was considered non-significant. All two-way interactions found to be significant at P < 0.10 for a particular variable were included in the model for that variable.

**Results**

Supplement refusal did not occur throughout the trial, indicating supplement intake was adequate and similar between treatments. Starting, intermittent, and ending calf bodyweights (Table 1) were similar (P > 0.15) among feed additive treatments. Although, individual bodyweight measurements were not influenced by feed additive supplementation, differences were observed in average daily gain (ADG) during the trial period (P ≤ 0.01). Calves offered supplement with ACT gained more (P ≤ 0.03) total weight over the trial period than RUM and CON calves, and tended (P = 0.10) to gain more weight than CTC calves. Additionally, CTC calves tended (P = 0.06) to gain more than RUM calves, but not more (P = 0.58) than CON calves.

All treatment groups lost weight following weaning, and gains made during the drylot period indicate weight lost as a result of the weaning process was not fully recovered by d 7 in all treatment groups. Calves offered supplement with ACT and RUM lost 0.17 and 0.90 lb/d, respectively, under drylot conditions. Drylot gains for calves offered supplement with the feed-grade antibiotic CTC were greater (P < 0.05) than the RUM and ACT additive treatments. Chlortetracycline improved gain nearly 2.0 lb/d over that of RUM, and by nearly 0.86 lb/d compared to ACT. Inclusion of CTC in the diet tended to increase (P = 0.07) ADG over that of CON calf gains. It appears offering CTC at a subtherapeutic rate in a preconditioning supplement may be more effective at improving calf performance under drylot conditions immediately following weaning. Losses in gain of ACT calves during drylot were not as severe as losses exhibited in the RUM treatment (P = 0.05). However, these losses cannot be attributed to reduced supplement intake in either the ACT or RUM treatment groups since supplement consumption met desired levels and weigh-back was never collected during the drylot period. This indicates that feeding ionophores and yeast-derived additives in conjunction with the stress of weaning, adaptation to a dry diet, and a drylot environment may not always elicit positive gains or changes in bodyweight in brief post-weaning scenarios. In the current experiment, at the conclusion of the second week, ADG and body weight change were positive for all treatments, and calves continued to gain steadily for the remainder of the preconditioning period. It can take calves between two and three weeks to recover and gain bodyweight post-weaning. Our results indicate calves had adapted to the supplement offered and overcome the stress of weaning by the d 14 of the trial. Calves were transitioned to pasture on d 7, which may have also aided in calf weight gain from d 7 to 14. Placement on pasture during the second week of the current study may have reduced stress while offering calves a more familiar nutrition source than hay offered during the drylot period, eliciting positive gains. Performance response to preconditioning and feed additive supplementation during the pasture period (d 7 to 52) indicates ACT calves gained more (P < 0.01) weight than CON, CTC, and RUM calves. Average daily gain response to
ACT supplementation was 1.25 lb/d compared to ADG of 0.79 lb/d for the other treatments. Over the entire preconditioning period calves receiving supplement with ACT exhibited a greater ($P < 0.02$) cumulative ADG than RUM and CON treatment groups. Calves receiving supplement with CTC also gained at a faster ($P < 0.01$) rate over the 52-d preconditioning period than RUM supplemented calves. Feed additive response between ACT and CTC was similar ($P = 0.35$), with ACT calves gaining 1.06 lb/d and CTC calves gaining 0.92 lb/d.

Our results indicate ACT may elicit a greater response than supplement alone in a grazing system. Pasture system and ionophore supplementation rate may have also allowed ACT supplemented calves to outperform RUM calves since ionophore response is dependent on these factors. Additionally, our results indicate ACT may work as effectively as CTC and other subtherapeutic antibiotics in pasture-based preconditioning programs.

Treatment differences in plasma concentration of haptoglobin and ceruloplasmin were not observed throughout the sampling period. However, measures of both APP indicate all calves experienced stress as a result of the weaning process. Both plasma haptoglobin (Figure 1) and ceruloplasmin (Figure 2) concentrations significantly increased from weaning to d 4 ($P < 0.0001$) regardless of treatment. Our results suggest weaning is a stressful management practice for beef calves since plasma concentrations of haptoglobin are often detectable only in cattle undergoing stress (Arthington et al., 2003). Plasma haptoglobin levels at weaning (d 0) for all calves averaged 6.01 units. Plasma haptoglobin levels peaked on d 4, averaging 7.57 units across all treatments. Plasma concentration of ceruloplasmin exhibited a similar trend post-weaning, peaking on d 7 and then steadily declining through d 14 of the preconditioning period. Although haptoglobin levels trended downward between d 4 and 14, the inflammatory response to weaning was not fully mitigated when blood collections ceased on d 14. Day 14 haptoglobin levels remained elevated ($P < 0.0001$) from d 0 levels, but were not different ($P > 0.59$) than levels on d 7 or 11.

No treatment by day interaction was observed for haptoglobin concentrations during the sampling period; however, an interaction ($P = 0.01$) between treatment and day was detected for ceruloplasmin post-weaning (Figure 3). Despite the interaction, no clear trend in treatment effect was observed for any of the sampling days used to measure stress. Differences between treatments on d 0 were numerically greatest ($P = 0.07$) between the ACT and CTC calves (2.61 mg/100 mL ± 1.41). Actigen® and CTC continued to exhibit the largest numerical ($P = 0.16$) differences between treatments when plasma concentrations peaked on d 7 (1.98 mg/100 mL ± 1.41). By the conclusion of the measurement period, differences in ACT and CTC calves on d 14 were reduced to 0.61 mg/100 mL ± 1.41, which was less than the differences observed between ACT and RUM calves (0.91 mg/100 mL ± 1.41) and ACT and CON calves (0.98 mg/100 mL ± 1.41) on d 14.

The interactions detected may be statistically significant, but do not conclusively provide insight into how these feed additives mitigate stress and influence performance of preconditioned calves. Others have concluded that such interactions are a consequence of the magnitude and time of increase in acute phase concentrations post-weaning rather than individual treatment differences within sampling day (Arthington et al., 2003). The lack of a relationship between plasma acute phase protein concentrations and average daily gain ($P > 0.23$) as well as the lack of morbidity and mortality over the trial period suggests none of the feed additives were more or less effective at mitigating stress over that of supplementation alone when calf health was excellent and post-weaning performance was marginal.

A summary of the costs associated with supplementing calves in this preconditioning trial is given in Table 1. Supplement cost differed between treatments, with ACT being the most expensive ($38.87/head) and CON being the least expensive ($35.88). However, incremental costs of all additives used were minimal and not a significant ($P = 0.19$) component of feed cost. Although total
preconditioning costs were not included in this economic evaluation, profitability of the different preconditioning treatments was calculated by comparing the calves receiving a supplemental feed additive (ACT, CTC, RUM) to calves not receiving a supplemental feed additive (CON). Profit (or loss) was calculated for each treatment by subtracting the feed cost of gain from the value of gain obtained during the 52-d preconditioning period, and then multiplying by the total weight gained during preconditioning. Assuming preconditioned calves would sell for the same price as non-preconditioned calves, value of gain obtained during the preconditioning period was calculated to be $3.77/lb/head. In this evaluation, ACT was the only profitable treatment ($3.74/head), with all other treatments resulting in losses following the preconditioning period. Actigen® supplementation was $20.47/head more ($P = 0.002) profitable than RUM and tended ($P = 0.09) to be $10.71/head more profitable than CON. At the same time, ACT profitability was similar ($P = 0.20) to CTC, suggesting it may be both an effective and affordable alternative to antibiotic feed additive supplementation when preconditioning does not result in a management premium at marketing.

When assuming a premium of $0.24/lb at the time of sale, which would not be uncommon if calves were marketed through a certified sale, the value of gain was calculated to be $6.19/lb/head. In this evaluation, all treatments except RUM resulted in a profit. Supplementation with ACT and CTC resulted in a $31.14/head and $16.53/head profit, respectively. Control calves not receiving a supplemental feed additive produced a profit of $11.62/head, while RUM supplementation resulted in a loss of $3.66/head. Again, profitability outcomes for ACT and CTC were similar ($P = 0.16), while ACT was approximately $35/head more ($P = 0.002) profitable than RUM. This indicates ACT would be equally or more cost effective than feed grade antibiotics and ionophores in a preconditioning program of this length. Actigen® also tended ($P = 0.06) to be more profitable than CON, producing approximately $20/head more profit than supplementation alone. Chlorotetracycline supplementation tended ($P = 0.06) to be more profitable than supplementation with RUM. Control calves were intermediate ($P > 0.14) in profitability to calves supplemented with the traditional antibiotic additives RUM and CTC, indicating producers may not necessarily benefit from the inclusion of these additives at preconditioning when calves are kept on the ranch of origin and calf health is excellent.

Based on the assumptions outlined above, cattle supplemented with Actigen® received the largest economic returns; with Rumensin® supplementation receiving the lowest, regardless of if a premium was offered. Although the addition of low levels of feed additive technologies resulted in variable economic returns within this preconditioning program, ultimately, it seems that Actigen® is a suitable alternative to antibiotics when the goal is to improve weight gain in a cost effective manner.

**Literature Cited**
Table 1: The effect of supplemental feed additive treatment on calf growth during and economic outcome during preconditioning

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>CON</th>
<th>ACT</th>
<th>CTC</th>
<th>RUM</th>
<th>SE²</th>
<th>P-Value</th>
</tr>
</thead>
</table>
| Initial weight (d 0)
| lb                                  |           |      |      |      |      |      |         |
| Final weight (d 52)
| lb                                  |           |      |      |      |      |      |         |
| ADG\(^5\), lb/d                     |           |      |      |      |      |      |         |
| Day 0 to d 7 \(^6\)                 |           | 0.57\(^a\) | -0.17\(^b\) | 1.03\(^a\) | -0.90\(^c\) | 0.18 | <0.001  |
| Day 0 to d 14                        |           | 0.80\(^a\) | 0.97\(^a\) | 0.62\(^a\) | 0.14\(^b\) | 0.18 | 0.01    |
| Day 7 to d 14                        |           | 1.02\(^a\) | 2.11\(^b\) | 0.48\(^a\) | 1.18\(^a\) | 0.31 | 0.01    |
| Day 7 to d 52 \(^7\)                |           | 0.74\(^a\) | 1.25\(^b\) | 0.91\(^a\) | 0.72\(^a\) | 0.13 | 0.02    |
| Day 14 to d 52                       |           | 0.69\(^a\) | 1.09\(^b\) | 0.95\(^ab\) | 0.64\(^ab\) | 0.13 | 0.05    |
| Day 0 to d 52                        |           | 0.72\(^ae\) | 1.06\(^b\) | 0.92\(^ab\) | 0.50\(^c\) | 0.22 | 0.002   |
| Feed cost of gain, $/lb              |           | 6.28 | 3.55 | 6.52 | 9.47 | 1.87 | 0.19    |
| Profit (loss) with no premium, $/head|           | (6.97)\(^ab\) | 3.74\(^a\) | (4.25)\(^a\) | (16.73)\(^b\) | 4.34 | 0.02    |
| Profit (loss) with premium\(^8\), $/head |           | 11.62\(^ab\) | 31.14\(^a\) | 16.53\(^a\) | (3.66)\(^b\) | 7.14 | 0.02    |

\(^{a,b}\) LS means within a row with different superscripts are different P < 0.05.
\(^1\) CON (control, supplement without feed additives) ACT (supplement with Actigen at 5 g/hd/d) CTC.
\(^2\) (supplement with chlortetracycline at 350 mg/hd/d) RUM (supplement with monensin at 175 mg/hd/d).
\(^3\) Standard error (n = 32).
\(^4\) Starting weight (d 0) mean of d 0 and d 1 body weight measurements.
\(^5\) Ending weight (d 52) mean of d 51 and d 52 body weight measurements.
\(^6\) Average daily gain.
\(^7\) Day 0 to d 7 drylot period.
\(^8\) Day 7 to d 52 pasture period.
\(^9\) Premium of $0.24/lb of calf bodyweight included in profit (loss) calculation.
Figure 1. Effect of day post weaning on plasma concentration of haptoglobin in weaned beef calves.

Figure 2. Effect of day post weaning on plasma concentration of ceruloplasmin in weaned beef calves.
Figure 3. Effect of feed additive treatment and sampling day on plasma concentration of ceruloplasmin in weaned calves (treatment x day interaction $P < 0.001$).