Effects of Timing of Vaccination Relative to Weaning and Post-weaning Supplementation Frequency on Growth and Immunity of Growing Beef Calves

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Synopsis
Pre-weaning vaccination associated with reduced post-weaning frequency of supplementation caused the greatest reduction on calf growth performance. However, post-weaning vaccination and daily concentrate supplementation alleviated inflammatory response and improved humoral immune response compared to pre-weaning vaccination and reduced post-weaning frequency of supplementation.

Summary
We evaluated the impact of pre- vs. post-weaning vaccination associated with different post-weaning frequency of energy supplementation (daily vs. 3x weekly) on growth and immunity of beef calves. At 14 days before weaning (day -14), 48 Angus-crossbred calves (24 steers and 24 heifers; 537 ± 73 lb; 19 ± 20 days of age) were stratified by body weight, age, and randomly assigned to receive vaccinations against bovine viral diarrhea virus (BVDV-1a) and parainfluenza-3 (PI-3) on days -14 and 0 (PRE) or days 7 and 21 (POS), relative to weaning. On day 7, calves were stratified by vaccination scheme, and randomly assigned to receive similar weekly amount of concentrate dry matter supplementation (1% of body weight multiplied by 7 days) that was divided and offered either daily (7X) or 3 times weekly (3X: Monday, Wednesday, and Friday) until day 43. Effects of timing of vaccination × frequency of supplementation were not detected for any measurement of calf average daily gain, total dry matter intake, and feed efficiency, except for overall average daily gain from days -14 to 43. Post-weaning total dry matter intake and feed efficiency did not differ among treatments. Pre-weaning vaccination increased overall plasma concentrations of cortisol, tended to increase overall plasma concentrations of haptoglobin, and decreased serum PI-3 titers on day 43 compared to post-weaning vaccination. Decreasing the frequency of supplementation tended to increase post-vaccination plasma cortisol concentrations and reduce overall serum BVDV-1a titers. Hence, pre-weaning vaccination combined with reduced post-weaning frequency of supplementation caused the greatest reduction on calf growth performance. Post-weaning vaccination and daily concentrate supplementation alleviated inflammatory response and improved vaccine response compared to pre-weaning vaccination and reduced post-weaning supplementation frequency.

Introduction
Preconditioning programs have been shown to reduce post-weaning stress, incidence of bovine respiratory disease (BRD; Duff and Gaylean 2007), and improve growth performance of calves during feedlot phase (Roeber et al., 2001). However, supplements provided during preconditioning phase can increase total production costs associated with labor, fuel, and equipment (Cooke et al., 2008). Decreasing the frequency of supplementation from daily to 3 times weekly can reduce feeding costs during preconditioning, but also impaired post-weaning growth performance and vaccine-induced immune response of beef steers (Artioli et al., 2015). These negative impacts of reduced frequency of energy supplementation are associated with an exacerbation of the acute phase response (APR) elicited by vaccination during preconditioning. Although APR is an essential early defense mechanism in response to cellular injury (Eckersall and Conner, 1988), nutrient demand is increased (Reeds and Jahoor, 2001), and nutrients partitioned away from growth to support the immune response (Reeds et al., 1994), leading to reduced calf growth performance and feed efficiency (Moriel et al., 2016).

We hypothesized that administering the vaccination against respiratory pathogens during pre-weaning rather than post-weaning phase could be a strategy to overcome the negative impacts of reducing the frequency of energy supplementation on growth and immunity of preconditioning beef calves. Therefore,

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we evaluated the effects of timing of vaccination against respiratory pathogens and frequency of energy supplementation on measurements of growth immunity of beef calves during a 43-day preconditioning period.

Materials and Methods
The study was conducted from October to December 2016 at the Mountain Research Station, Waynesville, NC. Forty-eight Angus crossbred calves were stratified by body weight and age, and randomly assigned, in a 2 × 2 factorial design to receive pre- (PRE; days -14 and 0) or post-weaning (POS; days 7 and 21) vaccinations against BRD pathogens with different post-weaning frequency of energy supplementation (7X or 3X weekly). From days 0 to 43, all calves received free choice access to ground tall fescue hay and similar weekly supplementation of a 50:50 soybean hulls pellets and corn gluten pellets supplement (weekly supplement dry matter intake = 1% of body weight multiplied by 7 days). Individual calf body weight was measured before feeding on days -14 and 43, following 12 hours of feed and water withdrawal. Blood samples were collected to evaluate serum antibody titers against BVDV-1a, and PI-3 viruses and plasma concentrations of haptoglobin and cortisol.

Except for seroconversion, all data were analyzed as a 2 × 2 factorial design using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC, USA, version 9.4). Pen was considered the experimental unit and the model included the fixed effects of timing of vaccination, frequency of supplementation, and timing of vaccination × frequency of supplementation. Random effects included sex, calf (pen) and pen (vaccination × frequency). Significance was determined at \(P\leq0.05\) and tendencies were considered when \(0.05<P\leq0.10\).

Results
Interaction effect between vaccination × frequency of supplementation was not detected for any variable in this study \((P\geq0.12)\), except for overall average daily gain from days -14 to 43 \((P = 0.04)\). Overall average daily gain tended to be less for PRE-3X calves compared to POS-7X and PRE-7X calves \((P = 0.09)\), and was less for PRE-3X calves compared to POS-3X \((P = 0.006; 1.32, 1.54, 1.54, \text{ and } 1.71\pm0.08 \text{ lb/day for PRE-3X, PRE-7X, POS-7X, and POS-3X calves, respectively})\). Post-weaning total dry matter intake and feed efficiency from days 0 to 43 did not differ among treatments \((P\geq0.11; \text{ data not shown})\). As shown in Table 1, pre-weaning vaccination increased overall plasma concentrations of cortisol \((P<0.0001)\), tended to increase overall plasma concentrations of haptoglobin \((P = 0.10)\), and decreased serum PI-3 titers on day 43 compared to post-weaning vaccination \((P<0.0001)\). Also, decreasing the frequency of supplementation tended \((P = 0.10)\) to increase post-vaccination plasma cortisol concentrations and reduce overall serum BVDV-1a titers.

Hence, pre-weaning vaccination in combination with reduced post-weaning frequency of supplementation (3 times weekly) caused the greatest reduction on overall calf growth performance. Post-weaning vaccination and daily concentrate supplementation alleviated inflammatory response and improved antibody production compared to pre-weaning vaccination and reduced post-weaning supplementation frequency.

Literature cited
Table 1. Plasma and serum measurements calves assigned to receive pre- (days -14 and 0; PRE) or post-weaning (days 7 and 21; POS) vaccination against pathogens associated with respiratory disease, and then, post-weaning concentrate supplementation provided 3 (3X; Monday, Wednesday, and Friday) or 7 (7X; daily) times weekly during a 43-day preconditioning period.

<table>
<thead>
<tr>
<th>Item</th>
<th>Timing of vaccination</th>
<th>P-value</th>
<th>Supplementation frequency</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall plasma concentrations</td>
<td></td>
<td></td>
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<tr>
<td>Cortisol, ng/mL</td>
<td>PRE 21.0 POS 10.3</td>
<td>&lt;0.0001</td>
<td>3X 16.7 7X 14.6 SEM 0.87</td>
<td>0.10</td>
</tr>
<tr>
<td>Haptoglobin, mg/mL</td>
<td>PRE 0.49 POS 0.42</td>
<td>0.031</td>
<td>3X 0.49 7X 0.43 SEM 0.03</td>
<td>0.17</td>
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<tr>
<td>Parainfluenza-3 virus</td>
<td></td>
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<tr>
<td>Serum titers, log_{2}</td>
<td>PRE 1.72 POS 2.31</td>
<td>0.161</td>
<td>3X 1.85 7X 2.18 SEM 0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>Positive seroconversion, %</td>
<td>PRE 25.0 POS 36.1</td>
<td>0.04</td>
<td>3X 29.2 7X 31.9 SEM 3.70</td>
<td>0.59</td>
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<tr>
<td>Bovine viral diarrhea virus 1a</td>
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<tr>
<td>Serum titers, log_{2}</td>
<td>PRE 2.56 POS 2.49</td>
<td>0.109</td>
<td>3X 2.41 7X 2.65 SEM 0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Positive seroconversion, %</td>
<td>PRE 33.3 POS 44.4</td>
<td>0.27</td>
<td>3X 33.3 7X 44.4 SEM 6.94</td>
<td>0.27</td>
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