Effects of on-arrival versus delayed modified live virus vaccination on health, performance, and serum infectious bovine rhinotracheitis titers of newly received beef calves

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ABSTRACT: Stress commonly associated with weaning, marketing, and shipment of feeder cattle can temporarily compromise immune function, thereby reducing the effective response to vaccination intended to control bovine respiratory disease (BRD). Two vaccination timing treatments were used to evaluate the effect of timing of a multivalent modified live virus (MLV) BRD vaccine on health, performance, and infectious bovine rhinotracheitis (IBR) antibody titers of newly received stocker cattle. Crossbred bull and steer calves (n = 528) were weighed (197 ± 2.4 kg) and randomly assigned to MLV vaccination treatment: 1) MLV vaccination upon arrival (AMLV), or 2) delayed (14 d) MLV vaccination (DMLV). All cattle were processed similarly according to routine procedures, with the exception of the initial MLV vaccination timing. Subsequently, BW were recorded on d 14, 28, and 42. Blood samples were collected on d 0, 14, 28, and 42 to determine serum IBR titers, and comparisons were made between treatments on a receiving-day basis and an equivalent postvaccination day basis. Daily BW gains were greater (P ≤ 0.05) for DMLV calves from d 0 to 14 (1.16 vs. 0.88 ± 0.22 kg/d) and from d 0 to 42 (0.75 vs. 0.65 ± 0.09 kg/d). Days to first treatment, total treatment cost, percentage death loss, and pasture ADG after the 42-d receiving period did not differ (P ≥ 0.15). Morbidity rates for BRD were high for both AMLV and DMLV (71.5 and 63.5%, respectively) and did not differ (P = 0.12). Positive IBR titer seroconversion was greater (P ≤ 0.03) for DMLV calves on d 42 of the study, and for the 28- and 42-d equivalent postvaccination basis. Delaying vaccination by 14 d may increase ADG during the receiving period compared with AMLV, and seroconversion to IBR was greater in DMLV calves, indicating a possible improvement in acquired immune response when MLV vaccination is delayed.

Key words: cattle, performance, stress, timing, vaccination

INTRODUCTION

Bovine respiratory disease (BRD) is the most economically important disease in newly received beef cattle (Edwards, 1996), and is the leading cause of morbidity and mortality in US feedlots (Woolums et al., 2005). A common receiving management strategy includes classification of cattle groups into risk categories (high or low risk) for BRD; this is determined by factors including commingling, transportation stress, immune status, nutritional condition, environment, and the skill level of management personnel (Smith, 2004). Calves purchased at local auctions are typically classified as high risk for developing symptoms of BRD because these cattle are of unknown origin, commingled, and recently weaned from small cow-calf operations that seldom use vaccination or other BRD prevention strategies (National Animal Health Monitoring System, 1997). Stress and previous exposure to BRD pathogens may decrease vaccine efficacy (Blecha et al., 1984; Loerch and Fluharty, 1999). The transportation stress period can endure for as long as 15 d after arrival, based on serum hemolytic complement concentration of calves (Purdy et al., 2000). Perino and Hunsaker (1997) indicated that BRD vaccination on arrival at feedlots is equivocal at best. Other complica-

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doi:10.2527/jas.2007-0593

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tions with on-arrival administration of a modified live virus (MLV) vaccine may include reduced gain performance caused by immunological challenges from antigens contained in a vaccine; however, Stokka and Edwards (1990) reported no detrimental effects on gain of stressed calves receiving a multiple polyvalent MLV vaccine. Current feedlot receiving protocols include multivalent vaccination against BRD viruses within 48 h of arrival for high-risk cattle, although the vaccine response and health benefit are questionable.

Thus, our objective was to evaluate the effect of delayed (14-d) MLV vaccination vs. on-arrival MLV vaccination on health, performance, and serum infectious bovine rhinotracheitis (IBR) titer levels of newly received high-risk stocker calves.

MATERIALS AND METHODS

Animal methods were approved by the University of Arkansas Animal Care and Use Committee.

A total of 528 crossbred bull (n = 364) and steer (n = 164) calves (initial BW = 197 ± 2.4 kg) were purchased from a northern Arkansas auction barn and shipped approximately 9 km to the University of Arkansas, Livestock and Forestry Branch Station, near Batesville, AR. Cattle were received on 6 dates: September 9, 2004 (block 1, n = 110), September 16, 2004 (block 2, n = 98), January 10, 2005 (block 3, n = 80), January 13, 2005 (block 4, n = 80), February 14, 2005 (block 5, n = 70), and February 17, 2005 (block 6, n = 90). Pen was designated as the experimental unit. For each date block, 6 pens (3 pens/treatment) were used; therefore, each treatment was replicated a total of 18 times. Because the number of animals per block varied, the number of animals per pen ranged from 10 to 19, but within each block the number of animals assigned to each treatment was equivalent.

Upon arrival (d = 1), cattle were weighed (unshrunk), assigned a unique ear identification tag, and arrival castrate status (bull or steer) was determined. Calves remained commingled overnight, with access to hay and water. The following day (d 0), bulls and steers were assigned to treatment based on castrate status, which was equally distributed to treatments by assigning a similar number of bull and steer calves to each treatment pen, with pens then assigned to treatment. Treatments included 1) initial vaccination of a multivalent BRD MLV on arrival (d 0; AMLV), or 2) 14-d delayed initial vaccination of the BRD MLV (DMLV). On d 0, calves were reweighed, administered a clostridial bacterin with tetanus toxoid (Covexin-8, Schering-Plough Animal Health Inc., Elkhorn, NE), treated for internal and external parasites (Ivomec, Merial, Iselin, NJ), and bull calves were castrated using the California banding method (InoSol Co. LLC, El Centro, CA). Calves were administered 2 injections of an MLV BRD vaccine 14 d apart. Arrival MLV calves were vaccinated with a 5-way MLV vaccine containing isolates of IBR, bovine virus diarrhea (BVD) types I and II, bovine respiratory syncytial virus (BRSV), and parainfluenza (PI3) in combination (Express5, Boehringer-Ingelheim Vetmedica Inc., St. Joseph, MO), whereas cattle assigned to the DMLV treatment did not receive their initial 5-way MLV vaccination until d 14 of the study.

In addition, the rectal temperature of each calf was determined using a digital thermometer (Model No. M216, GLA Agricultural Electronics, San Luis Obispo, CA). Calves with rectal temperatures of ≥40°C during the initial processing were administered prophylactic treatment with tilmicosin phosphate (10 mg/kg of BW, Micotil, Elanco Animal Health, Indianapolis, IN) as described by Galyean et al. (1995). The percentage of animals administered antibiotic on arrival (AMLV = 18.6%; DMLV = 23.4%) was not different (P = 0.19), and these calves were excluded from subsequent morbidity analysis. After cattle were randomly sorted, they were moved to 0.4-ha pens separated by electrified fencing and provided a 16% CP supplement at 1% of BW (DM basis) and free-choice access to Bermudagrass hay (10% CP, 56% TDN) for the entire 42-d receiving study. The receiving supplement contained (as-fed basis) 67% corn, 19% cottonseed meal, 12.5% corn gluten feed, 1.5% limestone, and 0.04% Rumensin 80 (Elanco Animal Health) and supplied 368 g of CP and 200 mg of monensin/d.

To determine differences in BW gain performance, cattle were weighed (unshrunk) at 14-d intervals during the study (d 14, 28, and 42). On d 14, both AMLV and DMLV cattle received a booster vaccination of the clostridial bacterin with tetanus toxoid (Covexin-8), AMLV cattle received a booster vaccination of the 5-way MLV (Express5), and DMLV cattle received their initial dosage of 5-way MLV (Express5). Two weeks later (d 28), DMLV cattle received their respective booster vaccination of 5-way MLV (Express5). At the conclusion of the 56-d receiving period, calves were implanted with 40 mg of trenbolone acetate and 8 mg of estradiol (Revalor G, Intervet Inc., Desoto, KS) and the pasture phase of the study began.

Calves were observed each morning (0800 h) by Livestock and Forestry Branch Station personnel for symptoms of respiratory illness (depression, lethargy, rapid breathing, nasal or ocular discharge), slowness in going to the feed bunk when supplement was provided, and a gaunt or emaciated appearance. Personnel were blinded to the treatment allotment of each pen. Cattle with observed visual symptoms of BRD were removed, restrained using a hydraulic squeeze chute (Flying W Inc., Watonga, OK), and considered morbid if their rectal temperature was ≥40°C. Morbid animals from both experimental treatments were administered antibiotic therapy following a predetermined antibiotic treatment protocol, which included initial antibiotic therapy with tilmicosin phosphate (Micotil, 10 mg/kg of BW). Cattle were reevaluated 72 h later, and those with a rectal temperature of ≥40°C were considered morbid a second time and administered a second anti-
biotic treatment with enrofloxacin (Baytril, Bayer Animal Health, Shawnee Mission, KS). After reevaluation, cattle requiring treatment a third time were administered florfenicol (Nuflox, Schering-Plough Animal Health, Summit, NJ). After 3 treatment events, cattle were considered nonresponsive and no further antibiotic therapy was administered regardless of the symptoms. Cattle were returned to their respective home pens immediately after each antibiotic treatment. Treatment data recorded for individual animals included the treatment date and the amount, type, and cost of the antibiotic administered.

Blood samples were collected from 3 randomly selected animals in each pen to evaluate serum IBR titer levels. Blood was collected via jugular venipuncture from the same animals on d 0, 14, 28, and 42 for AMLV and d 0, 28, 42, and 56 for DMLV and stored in 15-mL Vacutainer tubes (BD Inc., Franklin Lakes, NJ). Blood was placed in a refrigerator at 4°C for 6 h after collection, and serum was separated by centrifugation at 1,000 × g for 30 min. Serum was then decanted and stored at −5°C for subsequent analysis, when all samples from the entire study were compiled. Once all serum samples were collected, they were packaged and shipped overnight to the diagnostic laboratory (Oklahoma Animal Disease Diagnostic Center, Stillwater, OK) for assay of IBR virus antibodies by the serum neutralization method, as described by Rosenbaum et al. (1970). Titers were reported as the reciprocal of the greatest dilution of serum that provided complete protection of the cells. The lowest dilution of serum tested was 1:4, whereas the greatest dilution tested was 1:256. Serum that did not provide protection at the 1:4 level were reported as <4, and was considered negative for seroconversion to IBR. Samples with a reported serum neutralization value of ≥4 were considered positive for seroconversion to IBR. Titers were evaluated to determine differences in the percentage of animals in each treatment with positive seroconversion to IBR. According to laboratory results (Oklahoma Animal Disease Diagnostic Center), samples with a reported serum neutralization value of <4 were considered negative and those ≥4 were considered positive for IBR seroconversion. Titers <4 were assigned a value of 0, whereas titers ≥4 were assigned a value of 1 and analyzed by χ² analysis to determine the percentage positive for differences in treatment by day. Percentage of IBR seroconversion was compared on both a receiving-day basis and a vaccination timing-equivalent basis. Receiving-day IBR titer comparisons were made from samples collected on d 0, 28, and 42. Vaccination timing-equivalent comparisons were made for IBR titers based on the number of days postinitial vaccination (d 0 AMLV vs. d 14 DMLV) and postbooster vaccination (d 14 AMLV vs. d 28 DMLV). Therefore, a blood sample was collected from DMLV calves after the receiving period had ended (d 56) to allow a final vaccine timing-equivalent comparison (d 42 AMLV vs. d 56 DMLV).

### Table 1. Effect of bovine respiratory disease vaccination timing on performance of newly received cattle

<table>
<thead>
<tr>
<th>Item</th>
<th>AMLV¹</th>
<th>DMLV²</th>
<th>SE²</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW,³ kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0</td>
<td>197.7</td>
<td>195.9</td>
<td>2.42</td>
<td>0.33</td>
</tr>
<tr>
<td>d 14</td>
<td>208.6</td>
<td>212.7</td>
<td>3.03</td>
<td>0.007</td>
</tr>
<tr>
<td>d 28</td>
<td>217.4</td>
<td>219.9</td>
<td>2.93</td>
<td>0.16</td>
</tr>
<tr>
<td>d 42</td>
<td>224.4</td>
<td>228.1</td>
<td>4.08</td>
<td>0.07</td>
</tr>
<tr>
<td>ADG,³ kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0 to 14</td>
<td>0.88</td>
<td>1.16</td>
<td>0.22</td>
<td>0.007</td>
</tr>
<tr>
<td>d 14 to 28</td>
<td>0.61</td>
<td>0.53</td>
<td>0.15</td>
<td>0.45</td>
</tr>
<tr>
<td>d 28 to 42</td>
<td>0.45</td>
<td>0.56</td>
<td>0.10</td>
<td>0.12</td>
</tr>
<tr>
<td>d 0 to 42</td>
<td>0.65</td>
<td>0.75</td>
<td>0.09</td>
<td>0.05</td>
</tr>
<tr>
<td>Pasture ADG,⁴ kg</td>
<td>0.89</td>
<td>0.84</td>
<td>0.08</td>
<td>0.15</td>
</tr>
</tbody>
</table>

¹Treatments were vaccination of incoming stocker cattle with Express5 (Boehringer-Ingelheim Vetmedica Inc., St. Joseph, MO) modified live infectious bovine rhinotracheitis virus, parainfluenza virus, bovine respiratory syncytial virus, and bovine virus diarrhea type I and II vaccine either on arrival at initial processing (AMLV) or on d 14 (DMLV). Cattle were revaccinated 14 d after the initial vaccination.

²n = 48.

³All analyses (except d 0 BW) were conducted by using BW on d 0 as a covariate and arrival castrate status (steer vs. bull) as a source of variation.

⁴Grazing performance was calculated subsequent to the 42-d receiving period.

### Statistical Analysis

Treatment data were analyzed as a randomized complete block design. Pen was identified as the experimental unit. Date of shipment arrival was treated as the random block effect in the model. The treatment × block interaction was used as the denominator mean square for the treatment effect test. Gain performance data, days to first pull, and treatment cost were analyzed using PROC MIXED (SAS Inst. Inc., Cary, NC). Initial BW was used as a covariate, and arrival castrate status (steer vs. bull) was used as a source of variation in the model to minimize the unwanted effects of arrival BW and castrate status on treatment outcome.

### RESULTS AND DISCUSSION

#### Performance and Health

Body weight and ADG during receiving and grazing are presented in Table 1. Body weight of calves in the DMLV treatment was greater (P = 0.007) on d 14 and tended to be greater (P = 0.07) on d 42 than those in the AMLV treatment. Average daily gain was greater (P = 0.007) for DMLV cattle compared with AMLV from d 0 to 14 of the study (1.16 vs. 0.88 ± 0.22 kg/d). For the first 14 d of the study, AMLV had been administered an MLV vaccine, whereas DMLV had not yet received an initial MLV vaccine and could be considered a negative control. The difference in gain performance remained for the overall 42-d receiving period, with AMLV averaging 0.65 vs. 0.75 (± 0.09) kg/d. 
Table 2. Effect of bovine respiratory disease (BRD) vaccination timing on morbidity, mortality, and treatment cost of newly received cattle

<table>
<thead>
<tr>
<th>Item</th>
<th>AMLV</th>
<th>DMLV</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectal temperature on d 0, °C</td>
<td>39.6</td>
<td>39.6</td>
<td>0.23</td>
<td>0.83</td>
</tr>
<tr>
<td>BRD treatment, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>71.5</td>
<td>63.5</td>
<td>7.61</td>
<td>0.12</td>
</tr>
<tr>
<td>Retreat</td>
<td>25.1</td>
<td>30.8</td>
<td>9.80</td>
<td>0.17</td>
</tr>
<tr>
<td>Days to first treatment</td>
<td>7.2</td>
<td>7.7</td>
<td>1.34</td>
<td>0.72</td>
</tr>
<tr>
<td>Death loss, %</td>
<td>2.3</td>
<td>0.8</td>
<td>0.75</td>
<td>0.16</td>
</tr>
<tr>
<td>BRD treatment cost, $</td>
<td>9.00</td>
<td>8.75</td>
<td>2.09</td>
<td>0.76</td>
</tr>
</tbody>
</table>

1Treatments were vaccination of incoming stocker cattle with Express (Boehringer-Ingelheim Vetmedica Inc., St. Joseph, MO) modified live infectious bovine rhinotracheitis virus, parainfluenza virus, bovine respiratory syncytial virus, and bovine virus diarrhea type I and II vaccine either on arrival (AMLV) or on d 14 (DMLV). Cattle were revaccinated 14 d following initial vaccination.

2Cattle that received on-arrival antibiotic metaphylaxis were not included in the BRD treatment analysis.

3Initial treatment of cattle with observed symptoms of BRD and temperature in excess of 40°C were injected with tilmicosin phosphate at 1.5 mL/45 kg of BW.

4Initial treatment of cattle with observed symptoms of BRD and temperature of ≥40°C were injected with enrofloxacin (Baytril, Bayer Animal Health, Shawnee Mission, KS) at 4.0 mL/45 kg of BW.

5Retreat, 72 h following initial treatment, cattle with observed symptoms of BRD and temperature of ≥40°C were injected with enrofloxacin (Baytril, Bayer Animal Health, Shawnee Mission, KS) at 4.0 mL/45 kg of BW.

6Treatment cost for BRD assuming a value $1.10/mL of Micotil (Elanco Animal Health, Indianapolis, IN) and $0.53/mL of Baytril

The high rate of BRD morbidity is not uncommon in calves purchased at local auction barns and received at the Livestock and Forestry Branch Station. In this study, on-arrival MLV vaccination did not seem to be advantageous for either gain performance or disease prevention based on our results.

Duff et al. (2000) used 2 studies to evaluate the effects of viral vaccine route of administration and vaccine timing on the health and performance of newly received beef cattle. In the first study, ADG was greater for calves receiving an intranasal vaccine compared with an i.m. MLV IBR-PI3 vaccine but was not greater than for unvaccinated control calves, yet the rate of morbidity did not differ. In the second study, Duff et al. (2000) reported no differences in BW gain among nonvaccinated calves, calves with 4-way MLV vaccination delayed until d 7, calves that received an intranasal IBR-PI3 vaccine administered on d 0 with 4-way MLV vaccination delayed until d 7, or calves that received a 4-way MLV vaccination on both d 0 and 7. However, G:F tended to be improved for vaccinated calves vs. nonvaccinated calves. Kreikemeier et al. (1996b) found that during the initial 21 d of the feedlot receiving period, calves vaccinated with a killed virus on the farm before weaning and revaccinated with a killed virus at the time of commingling at a sale barn tended to gain faster than calves given an MLV upon arrival at the feedyard and revaccinated 21 d after feedyard arrival. Preweaning BRD vaccination is certainly preferable; however, newly received calves of unknown origin that are allowed a period to adjust to their new environment and recover from previous stressors may be better suited to respond to MLV vaccination. Kreikemeier et al. (1996a) used a 2 × 2 factorial arrangement of treatments, which included mass medication with either tilmicosin phosphate or chlorotetracycline or no mass medication, and routine processing on either d 1 or 21. Processing included a growth implant, an 8-way clostridial vaccine, a 4-way MLV vaccine, and an injectable dewormer. For the entire 56-d receiving period, calves that received processing on d 1 gained faster than calves with processing delayed until d 21. This is inconsistent with our results of increased ADG for DMLV; however, their study also included delayed administration of a growth implant and dewormer for 21 d, which could explain the difference in results.

No differences were detected (P > 0.11) for the effects of MLV vaccination timing on initial treatment for BRD-associated morbidity, percentage of calves retreated for BRD, mortality, or treatment cost (Table 2). The overall consensus among animal health professionals and veterinarians seems to support arrival vaccination against BRD as an effective method of disease prevention, and a study by Hansen et al. (1992) supports this view when the morbidity rate is high. However, several groups have reported a neutral outcome when vaccinating newly received beef cattle for BRD (Bateman, 1988; Johnson et al., 1988; Duff et al., 2000). Martin et al. (1982) reported an increased risk of
of mortality when a respiratory vaccine was administered within 14 d of arrival. In that study, delaying the BRD vaccination in calves for 14 d from arrival decreased the mortality and treatment cost in cattle fed corn silage-based diets; however, no vaccination timing differences were noted when cattle were fed dry hay-based diets. In the current study, the initial morbidity rate for BRD was high for both AMLV and DMLV (71.5 and 63.5%, respectively) but did not differ between treatments \( (P = 0.12) \). Overall, 93% of BRD pulls occurred within the first 14 d of receiving (Figure 1). These data suggest little or no advantage of administering a 5-way MLV vaccine to high-risk stocker cattle on arrival. The high morbidity rate (Figure 1) observed before d 14 indicates that few changes in the receiving protocol could have affected morbidity rates.

**IBR Titers**

Serum titers are used as an indication of antibody protection against a specific pathogen, thereby providing an indication of vaccine efficacy (Callan, 2001). It is poorly understood how acquired antibody levels may be affected by the timing of vaccination before or during the receiving period; however, stress is known to compromise immune function (Chirase et al., 2004), and label guidelines according to the vaccine manufacturers recommend that vaccination of stressed cattle be avoided.

No differences \( (P = 0.94) \) were detected for the percentage of positive IBR titers on d 0 (Figure 2), and positive seroconversion was low (AMLV = 8.8%; DMLV = 8.4%). On the basis of the vaccination timing-equivalent comparison, DMLV resulted in a greater percentage \( P \leq 0.03 \) of animals seropositive to IBR 28 and 42 d after the initial vaccination (Figure 2). When treatments were compared at the conclusion of the receiving period (d 42) the DMLV treatment exhibited greater \( P = 0.01 \) IBR virus antibody titer seroconversion. Results of IBR titer level comparisons suggest an improved vaccine response for DMLV. Natural disease exposure and subsequent host immune response may have contributed to the increased IBR antibody titers in this study; however, the extent to which natural exposure affected IBR seroconversion is unknown. No difference in arrival (d 0) IBR titer levels were detected \( P \geq 0.95 \) in animals that became morbid once or twice compared with those never treated during the study (data not shown). Martin et al. (1999) reported seroconversion of BRSV and BVD viruses from d 0 to 28 in unvaccinated animals; however, mean

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**Figure 1.** Cumulative percentage of calves receiving arrival modified live virus vaccination (AMLV) or delayed modified live virus vaccination (DMLV) for bovine respiratory disease (BRD), by treatment and receiving date \( (P = 0.21, SE = 0.10) \), excluding cattle receiving on-arrival metaphylaxis with tilmicosin phosphate at 1.5 mL/45 kg of BW.
Figure 2. Percentage of infectious bovine rhinotracheitis seroconversion for calves receiving arrival modified live virus vaccination (AMLV) or delayed modified live virus vaccination (DMLV) on arrival (d 0), on equivalent days past the initial vaccination, and at the end of the receiving period (d 42).

IBR titers were low and were not different on either d 0 or 28 in unvaccinated calves both treated for BRD and not treated. Measurement of neutralizing antibody titers has been reported to provide an indication of the amount of BVD protection present in calves (Bolin and Ridpath, 1995) and has been positively correlated with disease prevention (Howard et al., 1989). This has not been studied as extensively in IBR; thus, further research on the role IBR titers may relate to BRD protection in the field is warranted.

Delaying initial MLV vaccination by 14 d improved the gain performance of high-risk, newly received cattle during the receiving period compared with MLV vaccination on d 0. Morbidity rate or cost associated with BRD was not different. Moreover, serum IBR titers were greater when initial MLV vaccination was delayed. Because no differences in morbidity or mortality were detected for the 2 treatments, and performance for DMLV cattle was slightly improved, results of the current study suggest an economic advantage to delaying initial MLV vaccination until 14 d after arrival.

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