ABSTRACT

Objective: Our objective was to evaluate growth performance of feedlot steers and heifers administered a sham terminal implant or Synovex Choice, Synovex Plus, or Synovex ONE Feedlot terminal implant 60 or 120 d after initial implantation with Synovex Choice.

Materials and Methods: Two studies (steer and heifer) were conducted across 4 locations using 2,400 cross-bred steers (n = 1,200; BW = 300.5 ± 31.1 kg) and heifers (n = 1,200; BW = 296.5 ± 27.5 kg). Within sex, cattle were blocked by BW and pen and randomized to 1 of 4 treatments: (1) Choice-Sham, initial implant of Synovex Choice (Zoetis Inc., Parsippany, NJ; 100 mg of trenbolone acetate [TBA] and 14 mg of estradiol benzoate [EB]) followed by terminal reimplantation of an empty needle; (2) Choice-Choice, initial implant of Synovex Choice followed by terminal reimplantation with Synovex Choice; (3) Choice-Plus, initial implant of Synovex Choice followed by terminal reimplantation with Synovex Plus (Zoetis Inc.; 200 mg of TBA and 28 mg of EB); and (4) Choice-One, initial implant of Synovex Choice followed by terminal reimplantation with Synovex ONE Feedlot (Zoetis Inc.; 200 mg of TBA and 28 mg of EB). Within sex, each site was assigned randomly to reimplant on either d 60 or 120. Data were pooled across reimplant interval by sex. Within sex, animal was the experimental unit and treatments were commingled within pen (n = 3 or 4 pens per site per sex). Body weights were recorded on d 0 and 200.

Results and Discussion: Overall ADG from d 0 to 200 was greater for steers (P < 0.01) and heifers (P ≤ 0.02) in the Choice-Choice, Choice-Plus, and Choice-One treatments compared with Choice-Sham, with no differences (P ≥ 0.15) between reimplant treatments. Minimal differences were noted in implant site retention and reaction rates between treatments within sex. There were no differences (steers, P = 0.67; heifers, P = 0.51) between treatments for the percentage of deads and removals nor the incidence of bullers (P = 0.80).

Implications and Applications: Synovex Choice as an initial implant followed by terminal implantation with Synovex Choice, Synovex Plus, or Synovex ONE Feedlot 60 to 120 d later improves ADG in feedlot steers and heifers for at least 200 d.

Key words: feedlot performance, reimplant, Synovex Choice, Synovex ONE Feedlot, Synovex Plus

INTRODUCTION

Growth-promoting implants within the feedlot production phase have been widely used in the US beef industry for over 60 yr to improve growth performance and production efficiencies (Smith and Johnson, 2020). Since the first growth-promoting implants were approved, producers and researchers have been evaluating and implementing implant regimens that use 2 or more implants during the feedlot phase. According to the USDA Feedlot 2011 report (NAHMS, 2013), 79.8% of steers and 98.5% of heifers weighing less than 318.2 kg at feedlot entry received 2 or more implants, whereas 22.2% of steers and 51.2% of heifers weighing more than 318.2 kg at feedlot entry received at least 2 implants during the feedlot phase. Reinhardt (2007) reported that the use of repeated implantation resulted in an improvement of 6% in ADG and 4% in F:G.
comparing with the use of a single combination (trenbolone acetate and estradiol) implant.

Reimplantation has remained prevalent in the beef industry even with the more recent approvals of long-acting implants that pay out over 200 d including Revalor-XH (FDA, 2017b; Merck Animal Health), Revalor-XR (FDA, 2017a; Merck Animal Health), Revalor-XS (FDA, 2007; Merck Animal Health, Madison, NJ), Synovex ONE Feedlot (FDA, 2014a; Zoetis Inc., Parsippany, NJ), and Synovex ONE Grower (FDA, 2021a; Zoetis Inc.). As McLaughlin et al. (2013) stated, a 2-implant regimen may be more suitable for feedlot operations that may also want to treat cattle for parasites or revaccinate cattle at time of reimplantation versus not bringing cattle to the processing chute again as with long-acting, single-use implants.

The authors hypothesized that a terminal implant of Synovex Choice (Zoetis Inc.), Synovex Plus (Zoetis Inc.), or Synovex ONE Feedlot (Zoetis Inc.) administered 60 or 120 d after an initial implant of Synovex Choice would improve rate of weight gain for at least 200 d in steers and heifers fed in confinement for slaughter compared with a single implant of Synovex Choice with no terminal reimplant. The objective of this study was to evaluate growth performance of feedlot steers and heifers administered a terminal implant of Synovex Choice, Synovex Plus, or Synovex ONE Feedlot 60 or 120 d after initial implantation of Synovex Choice and fed for a total of at least 200 d.

**MATERIALS AND METHODS**

These studies (steer and heifer) were conducted at commercial or research feedlots in 4 locations (sites): Texas, Idaho, California, and Nebraska. Each study was conducted under the direction of the study-site Institutional Animal Care and Use Committee (IACUC; Nebraska site, approval #IC19086B and #IC19087B; Idaho site, approval #IC1908 and #IC1909), or if the site did not have an IACUC committee, then the protocols were reviewed and approved by the Zoetis Ethical Review Board in Kalamazoo, Michigan (Texas and California sites). All sites followed US standard and international guidance: Good Clinical Practice standards, FDA Guidance No. 85 (US DHHS, FDA, CVM, 2001). Steer and heifer studies were conducted using similar but separate protocols at each site; therefore, materials and methods will be presented once as they apply to each study whereas results will be separated out by sex.

Across the 4 study locations (Texas, Idaho, California, and Nebraska), a total of 2,400 purebred English, crossbred English, or crossbred continental steers (n = 1,200; initial d-0 BW = 300.5 ± 31.1 kg) and heifers (n = 1,200; initial d-0 BW = 296.5 ± 27.5 kg) were sourced from livestock auctions (Texas, Idaho, and Nebraska) or a single ranch (California). Cattle arrived at each feedlot at least 21 d before treatment administration. Cattle were processed upon arrival according to procedures typical of the feedlot industry and the site’s geographical location, which included vaccinations against respiratory and clostridial pathogens as well as administration of antiparasitic products. In addition, cattle were given duplicate unique identification ear tags with one administered in each ear. Cattle were also identified with a colored tag to denote which pen it was assigned to at each site. The colored pen tag did not denote treatment because cattle from all 4 treatments were commingled within a pen. To meet enrollment criteria, at arrival processing, both ears of each animal were palpated for the presence of an existing implant. If an implant was detected, the implant was excised by a veterinarian or under the direction of a veterinarian. Animals with excised implants were checked before treatment administration while the randomization BW were collected (d −3 to −2) to ensure complete removal of the implant and that the ear had healed after explantation, before the animal could be considered for enrollment. Implants had to be removed at least 21 d before d 0 to meet study inclusion requirements. Also, steers were evaluated upon arrival to ensure that there were no bulls or partial castrations; nonsteer males were excluded from study. Heifers were evaluated for pregnancy either via rectal palpation (California and Nebraska) or ultrasound (Texas and Idaho); pregnant heifers were excluded from study. Cattle that were noted to be sick or have musculoskeletal abnormalities were not considered in the candidate pool for study enrollment. To be enrolled, cattle had to be healthy with no abnormalities, meet the 21-d absence of implant requirement, be of the correct sex and physiological status, and be within the approximate desired weight range of 249.5 to 362.9 kg.

A total of 2,400 (1,200 steers and 1,200 heifers) were enrolled in the study and were administered 1 of 4 reimplant treatments: (1) **Choice-Sham**, initial implant of Synovex Choice (Zoetis Inc., Parsippany, NJ; 100 mg of trenbolone acetate [TBA] and 14 mg of estradiol benzoate [EB]; all 4 implant pellets uncoated) administered subcutaneously in the middle one-third of one ear on d 0 followed by reimplantation with a sham implant on d 60 or 120 in which an empty needle was administered and removed subcutaneously in the middle one-third of the opposite ear; (2) **Choice-Choice**, initial implant of Synovex Choice administered subcutaneously in the middle one-third of one ear on d 0 followed by reimplantation with Synovex Choice as terminal implant administered subcutaneously on either d 60 or 120 in the middle one-third of the opposite ear; (3) **Choice-Plus**, initial implant of Synovex Choice administered subcutaneously in the middle one-third of one ear on d 0 followed by reimplantation with Synovex Choice as terminal implant administered subcutaneously on either d 60 or 120 in the middle one-third of the opposite ear; and (4) **Choice-One**, initial implant of Synovex Choice administered subcutaneously in the middle one-third of one ear on d 0 followed by reimplantation with Synovex ONE Feedlot (Zoetis Inc.; 200 mg of TBA and 28 mg of EB; all 8 implant pellets
coated for extended release) as terminal implant adminis-
tered subcutaneously on either d 60 or 120 in the middle
one-third of the opposite ear.

Within sex, each site was assigned randomly to either
be a 60 or 120 d reimplant site. For steers, the California
and Nebraska sites were assigned randomly to reimplant
on d 60, whereas the Texas and Idaho sites were assigned
randomly to reimplant on d 120, with all sites to complete
the study on approximately d 200 (200 DOF). For heifers,
the Texas and Nebraska sites were assigned randomly to
reimplant on d 60, whereas the Idaho and California sites
were assigned randomly to reimplant on d 120, with all sites
to complete the study on approximately d 200 (200 DOF). Study
protocols allowed ±2 d (58 to 62 or 118 to 122) for actual
day of reimplant. Animals were weighed during pre-enrollment evaluation on d −3
to −2 at each site. These pre-enrollment BW were then
adjusted during the study to accommodate ingredi-
ent shortages brought on by COVID-19; however, finishing rations were formulated to meet similar nutrient require-
ments per pen (4 per sex) containing 72 to 76 ani-
mals per pen, with all 4 treatments commingled within
the same pen (18 to 19 animals per treatment per pen).
The Texas and California sites used 6 pens per site (3 per
sex) containing 100 animals per pen, with all 4 treatments commingled within the same pen (25 animals per treat-
ment per pen). There were a total of 2,400 animals fed on
study across all 4 sites including 1,200 steers and 1,200
heifers. Day 0 at the Nebraska site was October 24, 2019,
for steers and heifers. Day 0 at the Texas site was Novem-
ber 8, 2019, for steers and November 7, 2019, for heifers.
Day 0 at the Idaho site was November 22, 2019, for steers
and December 5, 2019, for heifers. Day 0 at the California
site was December 11, 2019, for steers and January 15,
2020, for heifers.

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ments as previous finishing rations at each site. Ingredients of the finishing ration at each study site are presented in Table 1. Feed was delivered once daily in Idaho, California, and Nebraska and twice daily in Texas. At each site, cattle were fed ad libitum, and slick bunks were not permitted per the study protocol for these studies and never occurred at the Idaho and California sites, while occurring sporadically at the Texas site and more frequently at the Nebraska site. Feed delivered was measured daily, and feed refusals (orts remaining) were weighed and sampled on d 200 and at times of ration changes at each site. Two samples (~2–3 kg) of the ration being fed at each site, a primary and backup, were taken weekly from arrival through slaughter for each sex (2 samples per sex).

Primary feed samples were sent to ServiTech Laboratories in Amarillo, Texas, for proximate analysis. Proximate analysis included DM (%), CP (%), NPN (% of protein), NDF (%), crude fiber (%), crude fat (%), ash (%), TDN (%), Ca (%), P (%), and energy calculations (NE and NE\textsubscript{m}). The TDN, NE\textsubscript{a}, and NE\textsubscript{m} were calculated via Adams (1995). Study rations at each site met or exceeded nutrient requirements for the type and class of cattle on study (NASEM, 2016; Table 2). Backup samples were retained frozen (~20°C) at each site and were not disposed of until review of the ration analysis was performed by the site nutritionist and the sponsor (Zoetis) nutritionist. Feed refusals were collected and weighed from each study pen, and then, the feed refusals of each pen within sex at each site were composited and subsampled to determine the percentage DM of the feed refusal. Analysis of the percentage DM of feed refusals was performed at each site. Water was provided ad libitum throughout the study at all sites via automatic waterers. No other feed additives or growth promoters including ionophores, β agonists, in-feed antibiotics, or melengestrol acetate were administered.

Dry matter intake was not analyzed by treatment because steers and heifers of all treatments were commingled within pens of similar sex. Overall DMI from d 0 to 200 across treatment and site for steers and heifers was 9.2 ± 0.6 and 8.6 ± 0.7 kg/d, respectively.

Body weights were recorded on individual animals 4 times throughout the study: upon arrival, d −3 to −2 (BW for randomization), d 0 and d 200 ([steers: Texas = d 201, Idaho = d 200, California = d 201, and Nebraska = d 200], [heifers: Texas = d 201, Idaho = d 201, California = d 201, and Nebraska = d 200]). Body weights were not recorded at time of reimplantation at any site. Body weights on d 0 and 200 were recorded after a 12 h fast (feed not water) at each site. If an animal was removed from the study early or died before d 200, that animal’s BW was measured on the day of removal or death. Before study initiation, weight scales for measuring individual animal BW were professionally certified. A scale check using a reference range of expected BW was performed before recording animal BW. Final BW after d 200 and directly before slaughter were not collected because of the COVID-19 pandemic, which did not allow for the attainment of carcass data; therefore, the decision was made to not weigh cattle directly before slaughter to prevent any injuries or additional antemortem stress. Average daily gain was calculated for each animal by subtracting the initial BW taken on d 0 from the final BW taken on d 200 (or day of removal or death) and dividing by the number of days the animal was on study (deads-in calculation).

General health observations were performed twice daily to identify any abnormal health events, including adverse reactions to treatments, and to ensure feed and water were considered “normal.” Abnormal health events were defined as any unfavorable or unintended observations for any animal, regardless of whether or not they were considered related to treatment. Routine estrus behavior in heifers was considered normal and was not documented for heifers because estrus suppression was not implemented (i.e., melengestrol acetate).

A total of 55 steers and 57 heifers were removed from study after treatment (includes any death, euthanasia, and an animal removed from study but returned to herd). A total of 7 steers and 4 heifers were euthanized. A total of 20 steers and 25 heifers died during the study. A total of 28 steers and 28 heifers were removed from study (independent of the animals that died or were euthanized) and returned to the herd.

Of the 11 animals that were euthanized, one steer was euthanized due to a ruptured bladder (Texas, Choice-Sham), 2 steers (Texas, Choice-Sham, Choice-One) were euthanized after sustaining mechanical injuries during reimplantation, one steer was euthanized due to clinical coccidiosis (Idaho, Choice-Choice), one steer was a buller and was euthanized due to lameness (California, Choice-Choice-Sham), one steer was euthanized due to bilateral hind limb paralysis (Nebraska, Choice-Choice), and one steer was euthanized due to heat stress (Nebraska, Choice-Plus). One heifer was euthanized due to declining body condition, and necropsy determined the animal had congestive heart failure (Texas, Choice-One). Two heifers were euthanized in California after sustaining mechanical injuries directly after initial implant administration on d 0 (Choice-One, Choice-Plus), and one heifer was euthanized due to being nonambulatory (California, Choice-One). Euthanasia was performed by qualified personnel under supervision of a licensed veterinarian in a humane manner consistent with the AVMA Guidelines (AVMA, 2013).

Steers (n = 20) and heifers (n = 25) that died during the study and steers (n = 7) and heifers (n = 4) that were euthanized were examined postmortem by a licensed veterinarian or one or more persons under veterinary supervision trained in bovine medicine to determine the cause of death unless death or euthanasia occurred due to mechanical injury; no animal deaths were determined to be related to treatment.

A total of 28 steers and 28 heifers were removed from study (independent of the animals that died or were euthanized) and returned to the herd. Seven of the steers that were removed from study and 4 of the steers that
died or were euthanized were removed, died, or euthanized after final BW collection and before slaughter. Twelve of the heifers that were removed from study and 3 of the heifers that died or were euthanized were removed, died, or euthanized after final BW collection and before slaughter. Cattle were intended to be slaughtered shortly after the d-200 BW measurement, and carcass data was intended to be collected by the West Texas A&M University—Beef Carcass Research Center. However, the COVID-19 pandemic caused delays in the marketing and slaughtering of cattle. Additionally, all slaughter facilities prohibited access for nonpersonnel. Thus, there was not a path forward for the West Texas A&M University—Beef Carcass Research Center to collect carcass data. Furthermore, the inability of beef processors to match individual identification to individual carcasses prohibited collection of camera data. Cattle continued to be observed and adequately managed after d 200 until slaughter. This included multiple general health observations performed daily to ensure cattle were healthy, ambulatory, and of the proper condition before slaughter given the extra time on feed compared with when cattle were intended to be slaughtered. In addition, cattle were observed during loading, transit to, and unloading at the slaughter facility to ensure cat-

<table>
<thead>
<tr>
<th>Ingredient, %</th>
<th>Texas</th>
<th>Idaho</th>
<th>California</th>
<th>Nebraska</th>
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<tr>
<td>Steam-flaked corn</td>
<td>75.5</td>
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<td>Dry-rolled corn</td>
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<td>34.7</td>
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<td>High-moisture corn</td>
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<td>Earlage</td>
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<td>Wheat straw</td>
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1Cargill Animal Nutrition (Wayzata, MN).
2Supplement contained 35.41% ground cottonseed, 20.09% limestone, 14.49% corn gluten feed, 11.27% urea, 8.25% dolomite, 6.84% salt, 2.55% ammonium sulfate, 0.38% zinc sulfate (36%), 0.32% vitamin A, 0.16% sodium selenite (0.2%), 0.12% manganese sulfate, 0.08% copper sulfate (25%), 0.03% vitamin E, 0.002% cobalt carbonate (46%), and 0.0005% ethylene diamine dihydroiodide.
3Supplement contained 22.94% limestone, 21.79% corn-soy blend, 15.86% urea, 11.25% corn syrup, 10.34% water, 10.00% Attaflow (BASF Corporation, Charlotte, NC), 7.07% salt, 0.25% zinc sulfate (36%), 0.25% beef tallow, 0.10% manganese sulfate (32%), 0.06% copper sulfate (25%), 0.05% anhydrous ammonia, 0.02% vitamin E premix (60%), 0.01% vitamin A, 2,205 IU/kg, 0.01% selenium (4%), 0.002% vitamin D, 1,102 IU/kg, 0.001% cobalt carbonate (32%), and 0.001% ethylene diamine dihydroiodide (79.5%).
4Supplement contained 64.88% soybean meal (47.5%), 11.25% canola pellets, 10.00% almond shells (ground), 3.75% calcium carbonate, 3.75% wheat millrun, 2.00% molasses cane, 1.50% salt, 1.25% dicalcium phosphate, 0.50% fat, 0.50% vitamin ADE, 0.38% calf trace mineral, and 0.25% vitamin B premix.
5Supplement contained processed grain by-products, molasses products, calcium carbonate, sodium chloride, zinc sulfate, manganese sulfate, copper sulfate, sodium selenite, copper chloride, ethylene diamine dihydroiodide, soybean oil, and cobalt carbonate.
were ambulatory and healthy before slaughter. Texas steers were slaughtered on d 221 at JBS in Cactus, Texas (USDA Establishment # M3D), and heifers were slaughtered on d 223 at National Beef in Liberal, Kansas (USDA Establishment # M208A). Idaho steers were slaughtered on d 229, and Idaho heifers were slaughtered on d 218. Both were slaughtered at Washington Beef in Toppenish, Washington (USDA Establishment # M235). California steers were slaughtered on d 208 at Washington Beef, and California heifers were slaughtered on d 202 at One World Beef Packers in Brawley, California (USDA Establishment # M21488). Nebraska steers and heifers were slaughtered on d 235 at Greater Omaha Packing in Omaha, Nebraska (USDA Establishment # M960).

Statistical Analysis

Steers and heifers were managed under a separate protocol and were analyzed separately. Each of the 4 study locations within a sex were randomly assigned to either reimplant cattle on d 60 or 120 such that there were 2 study locations per reimplant day for each sex. Within sex, the study was a randomized complete block replicated across multiple sites. Blocking was based on the pen location and BW at pre-enrollment (d −3 to −2). Animals of similar pre-enrollment BW were randomly assigned to a pen. Within a pen, animals were blocked on BW such that there were equal numbers of blocks of 4 animals per pen, with up to 25 blocks per pen of 100 animals. Within a block of 4, animals were randomly assigned to treatment. Animal was the experimental unit. All statistical analyses of data used SAS Release 9.4 (SAS Institute Inc., Cary, NC). Treatment contrasts comparing each reimplant treatment (Choice-Choice, Choice-One, Choice-Plus) to the positive control (Choice-Sham) were assessed using 2-sided tests at the 5% level of significance ($P \leq 0.05$).

The study was designed to investigate both reimplant days pooled together and not evaluate the effect of reimplant day. Because each site was randomly assigned to a reimplant day (60 or 120) within sex, the effect of site is confounded with the effect of reimplant duration, and the experimental unit for testing the effect of reimplant day is site. Therefore, within sex, cattle reimplanted on either d 60 or 120 were pooled together with no comparison made on the effect of reimplant day on study outcomes.

Average daily gain was analyzed using a general linear mixed model (PROC MIXED) that evaluated fixed effect of treatment. Random effects included site, pen within site, block within site and pen, site × treatment interaction, and error. Body weights of steers and heifers were analyzed by general linear mixed model for repeated measures with fixed effects of treatment, time points, and treatment by time points, and random effects of site, pen within site, block within pen and site, site × treatment interaction, site × treatment by time points interaction, and treatment × block within site and pen.

The occurrence of deads, removals, and bullers (steers) was analyzed using a generalized linear mixed model

### Table 2. Analyzed nutrient composition of final rations fed to steers and heifers at each site

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Texas Steer</th>
<th>Texas Heifer</th>
<th>Idaho Steer</th>
<th>Idaho Heifer</th>
<th>Nebraska Steer</th>
<th>Nebraska Heifer</th>
<th>California Steer</th>
<th>California Heifer</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>80.70 ± 0.94</td>
<td>80.73 ± 0.99</td>
<td>70.69 ± 2.84</td>
<td>70.64 ± 2.99</td>
<td>70.69 ± 2.84</td>
<td>70.64 ± 2.99</td>
<td>70.69 ± 2.84</td>
<td>70.64 ± 2.99</td>
</tr>
<tr>
<td>CP, %</td>
<td>13.24 ± 0.83</td>
<td>13.18 ± 0.89</td>
<td>13.48 ± 1.37</td>
<td>13.12 ± 1.00</td>
<td>13.48 ± 1.37</td>
<td>13.12 ± 1.00</td>
<td>13.48 ± 1.37</td>
<td>13.12 ± 1.00</td>
</tr>
<tr>
<td>NPN, % of CP</td>
<td>2.10 ± 0.39</td>
<td>2.07 ± 0.36</td>
<td>3.05 ± 0.34</td>
<td>3.06 ± 0.33</td>
<td>3.05 ± 0.34</td>
<td>3.06 ± 0.33</td>
<td>3.05 ± 0.34</td>
<td>3.06 ± 0.33</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>6.95 ± 1.87</td>
<td>6.95 ± 1.77</td>
<td>12.89 ± 7.91</td>
<td>11.23 ± 5.39</td>
<td>4.34 ± 0.57</td>
<td>4.41 ± 0.69</td>
<td>6.64 ± 0.79</td>
<td>6.64 ± 0.87</td>
</tr>
<tr>
<td>NDF, %</td>
<td>16.26 ± 3.29</td>
<td>16.18 ± 3.29</td>
<td>24.34 ± 11.21</td>
<td>22.06 ± 7.78</td>
<td>10.91 ± 0.54</td>
<td>10.85 ± 0.77</td>
<td>19.80 ± 1.46</td>
<td>19.93 ± 1.52</td>
</tr>
<tr>
<td>TDN, %</td>
<td>87.68 ± 3.18</td>
<td>87.97 ± 2.16</td>
<td>79.24 ± 11.83</td>
<td>79.24 ± 11.83</td>
<td>90.47 ± 0.67</td>
<td>90.48 ± 0.88</td>
<td>89.01 ± 0.96</td>
<td>89.02 ± 1.11</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td>4.99 ± 0.83</td>
<td>5.02 ± 0.82</td>
<td>5.69 ± 1.89</td>
<td>6.05 ± 1.50</td>
<td>3.04 ± 0.22</td>
<td>3.07 ± 0.26</td>
<td>4.02 ± 0.26</td>
<td>3.92 ± 0.31</td>
</tr>
<tr>
<td>Ash, %</td>
<td>4.93 ± 1.16</td>
<td>4.97 ± 1.16</td>
<td>4.53 ± 1.21</td>
<td>4.53 ± 1.21</td>
<td>3.04 ± 0.15</td>
<td>3.04 ± 0.15</td>
<td>3.04 ± 0.15</td>
<td>3.04 ± 0.15</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>0.67 ± 0.10</td>
<td>0.67 ± 0.11</td>
<td>0.61 ± 0.11</td>
<td>0.61 ± 0.11</td>
<td>0.38 ± 0.03</td>
<td>0.38 ± 0.03</td>
<td>0.38 ± 0.03</td>
<td>0.38 ± 0.03</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0.32 ± 0.02</td>
<td>0.32 ± 0.02</td>
<td>0.35 ± 0.04</td>
<td>0.36 ± 0.03</td>
<td>0.32 ± 0.02</td>
<td>0.32 ± 0.02</td>
<td>0.32 ± 0.02</td>
<td>0.32 ± 0.02</td>
</tr>
<tr>
<td>NE, Mcal/kg</td>
<td>2.18 ± 0.03</td>
<td>2.15 ± 0.02</td>
<td>1.92 ± 0.07</td>
<td>1.92 ± 0.07</td>
<td>1.98 ± 0.02</td>
<td>1.98 ± 0.02</td>
<td>1.98 ± 0.02</td>
<td>1.98 ± 0.02</td>
</tr>
<tr>
<td>NE, Mcal/kg</td>
<td>1.50 ± 0.04</td>
<td>1.50 ± 0.05</td>
<td>1.26 ± 0.33</td>
<td>1.26 ± 0.33</td>
<td>1.57 ± 0.02</td>
<td>1.57 ± 0.02</td>
<td>1.57 ± 0.02</td>
<td>1.57 ± 0.02</td>
</tr>
</tbody>
</table>

Multiple ration types (i.e., starter, transition, finisher) were fed at each site; however, only the finishing ration is summarized in this table. Rations did not contain medicated feed additives including ionophores, antibiotics, β agonists, or melengestrol acetate.
(PROC GLIMMIX) with binomial distribution and logit link. The model included the fixed effect of treatment. The random effects included site, pen within site, block within site and pen, and site × treatment interaction.

Implant retention rate (present = yes or no) and reaction rate (present = yes or no) were summarized by treatment, using frequency distribution tables at time of reimplantation (presence or reaction of initial implant) and at time of final BW collection (d 200; presence or reaction of terminal implant).

Animals Excluded from Statistical Analysis

The growth performance (ADG and BW) analysis presented in this study included animals that died, were euthanized, or were removed from the study and returned to the herd up until they were no longer on study. Exceptions to this applied to 11 steers and 15 heifers that were excluded from the growth performance analysis. All 11 of the steers and 11 of the heifers were excluded because they were removed from study, died, or were euthanized before reimplantation treatment administration, which at the time of removal, would not differentiate treatments because terminal implants had yet to be administered.

One heifer at the Texas site (Choice-Sham) was found dead in the pen on d 182 after experiencing dystocia during calving. On d 144, a heifer at the Idaho site (Choice-Choice) was observed to be calving with dystocia and subsequently gave birth to a dead calf. On d 173, a heifer at the Idaho site (Choice-Sham) gave birth to a premature calf that was born dead. On d 179, a heifer at the Idaho site (Choice-One) gave birth to a live calf. All 4 of these heifers were incorrectly identified as open during their prestudy pregnancy evaluation, and therefore, they did not meet inclusion criteria at the time of the start of the study and should not have been enrolled. Therefore, they were excluded from the growth-performance (ADG and BW) analysis.

RESULTS AND DISCUSSION

Growth Performance

Growth-promoting implants have been used since their discovery in the 1930s and approval during the 1950s in the United States to make beef cattle more efficient, leaner, and heavier muscled while reducing days on feed (Raun and Preston, 2002). However, the use of a second, terminal implant roughly 80 d after the initial implant and approximately 100 d before slaughter is very common among beef producers rather than a single implant (Nichols et al., 2014). The reason for using more than one implant during a feeding period is that short-acting, uncoated growth-promoting implants typically pay out over an approximately 60- to 120-d period (Mader, 1998; Hilscher Jr. et al., 2016). Because most cattle are fed longer than 120 d, producers are left with the option to use a single, long-acting, coated implant that pays out over 200 d, or they can implement a reimplant strategy that will extend payout of the implant hormones over the entire duration of the feeding period in an effort to sustain the benefits of implants previously described (Preston, 1999; Samuelson et al., 2016; Smith et al., 2019).

Feedlot growth performance of steers fed for 200 d is presented in Table 3. There was a significant (P = 0.04) treatment × day interaction for BW throughout the 200-d study in feedlot steers. There was no difference (P ≥ 0.80) in steer BW between treatments on d 0. Final BW (d 200)
for steers that were reimplanted were heavier \((P < 0.01)\) compared with steers receiving a single Choice implant. On d 200 (final BW), steers administered Choice-Choice, Choice-Plus, and Choice-One weighed 617.1, 625.2, and 617.3 kg, respectively, compared with Choice-Sham (599.1 kg). There was no difference \((P \geq 0.21)\) between any of the reimplant treatments (Choice-Choice, Choice-Plus, or Choice-One) for final BW on d 200. Average daily gain from d 0 to 200 was greater \((P < 0.01)\) in steers for Choice-Choice (1.57 kg/d), Choice-Plus (1.60 kg/d), and Choice-One (1.56 kg/d) compared with Choice-Sham (1.48 kg/d). There was no difference \((P \geq 0.15)\) between any of the reimplant treatments for ADG in steers during the 200-d study. Use of reimplantation in the current study yielded an improvement in overall ADG in steers from d 0 to 200 of 0.09, 0.12, and 0.08 kg/d for Choice-Choice, Choice-Plus, and Choice-One, respectively, compared with steers only receiving a single implant (Choice-Sham). This resulted in a 6.1, 8.1, and 5.4% improvement in ADG for reimplanted steers on Choice-Choice, Choice-Plus, and Choice-One, respectively, compared with the single-implant control steers.

Table 4 summarizes the growth performance of feedlot heifers implanted with Synovex Choice (Zoetis Inc.) on d 0 followed by terminal reimplantation on either d 60 or 120 for a total of 200 d on feed.

<table>
<thead>
<tr>
<th>Item</th>
<th>Choice-Sham</th>
<th>Choice-Choice</th>
<th>Choice-Plus</th>
<th>Choice-One</th>
<th>SEM</th>
<th>Treatment</th>
<th>Day</th>
<th>Treatment × day</th>
</tr>
</thead>
<tbody>
<tr>
<td>n, head</td>
<td>293</td>
<td>298</td>
<td>297</td>
<td>297</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0</td>
<td>297.3</td>
<td>298.0</td>
<td>297.2</td>
<td>297.4</td>
<td></td>
<td>0.56</td>
<td>&lt;0.01</td>
<td>0.57</td>
</tr>
<tr>
<td>d 200</td>
<td>568.0</td>
<td>581.0</td>
<td>584.0</td>
<td>580.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0 to 200</td>
<td>1.35a</td>
<td>1.41a</td>
<td>1.42a</td>
<td>1.40a</td>
<td>0.05</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(a,b\) Values within rows without common superscripts differ, \(P < 0.05\).

1Choice-Sham = Synovex Choice administered on d 0 followed by reimplantation with a sham implant (empty needle) on d 60 or 120; Choice-Choice = Synovex Choice administered on d 0 followed by reimplantation with Synovex Choice administered on d 60 or 120; Choice-Plus = Synovex Choice administered on d 0 followed by reimplantation with Synovex Plus (Zoetis Inc.) administered on d 60 or 120; and Choice-One = Synovex Choice administered on d 0 followed by reimplantation with Synovex ONE Feedlot (Zoetis Inc.) administered on d 60 or 120.

2Number of head included in growth analyses.

The results from this study align with a report by Reinhardt (2007), who indicated that compared with a single combination (trenbolone and estradiol) implant, the use of 2 sequential combination implants improved ADG by 6%. There were no ADG differences within the reimplant treatments for either Choice-Choice, Choice-Plus, or Choice-One as terminal implant when implanted at either d 60 or 120 after initial implant with Synovex Choice on d 0. The Choice-One treatment group would likely have benefited from greater DOF because Synovex ONE Feedlot is approved and has showed efficacy in a single implant application for at least 200 d in feedlot steers and heifers (Cleale et al., 2012). With Synovex Choice as an initial implant and paired with Synovex ONE Feedlot as a terminal implant, effectiveness in increasing growth performance may be optimized for a total of at least 300 DOF; however, more research is needed for the ideal DOF for the Choice-One combination. Furthermore, there were slight numerical differences in Choice-Choice or Choice-Plus with a 0.03 and 0.01 kg/d improvement in steers and heifers, respectively, compared with Choice-Choice. Synovex Choice and Synovex Plus contain identical hormone pel-
lets; however, Synovex Choice contains 4 pellets totaling an implant dose of 100 mg of TBA and 14 mg of EB, whereas Synovex Plus contains 8 pellets totaling an implant dose of 200 mg of TBA and 28 mg of EB.

Overall, these data indicate that steers respond greater to reimplantation than heifers, which has been repeatedly reported in the literature (Herschler et al., 1995; Hilscher et al., 2016) due to steers having more muscle fibers than heifers and due to heifers having greater levels of endogenous estrogen circulating in their blood compared with steers, lessening the effects of greater doses of growth-promoting implants (Heitzman, 1976). The use of a 2-implant strategy, using any of the 3 terminal implants used in this study, improved ADG in feedlot steers and heifers compared with a single, initial implant of Synovex Choice on d 0.

### Implant Retention and Reaction Rates

Implant retention and reaction rates of steers for initial and terminal implants are presented in Table 5. Ears palpated at time of reimplantation yielded initial implant retention rates of 99.0, 98.3, 98.0, and 99.0% for Choice-Sham, Choice-Choice, Choice-Plus, and Choice-One, respectively. Reaction rates of initial implants at time of reimplantation were 0.3, 0.3, 0.7, and 0.3% for Choice-Sham, Choice-Choice, Choice-Plus, and Choice-One, respectively. Terminal implant retention rates at time of final evaluation (d 200) were 0.0, 0.0, 0.0, and 0.7% for Choice-Sham, Choice-Choice, Choice-Plus, and Choice-One, respectively.

<table>
<thead>
<tr>
<th>Item</th>
<th>Choice-Sham</th>
<th>Choice-Choice</th>
<th>Choice-Plus</th>
<th>Choice-One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial implant retention rate, %</td>
<td>299 99.0</td>
<td>299 98.3</td>
<td>295 98.0</td>
<td>297 99.0</td>
</tr>
<tr>
<td>Initial implant reaction rate, %</td>
<td>299 0.3</td>
<td>299 0.3</td>
<td>295 0.7</td>
<td>297 0.3</td>
</tr>
<tr>
<td>Terminal implant retention rate, %</td>
<td>289 0.0</td>
<td>289 73.7</td>
<td>287 71.1</td>
<td>290 72.4</td>
</tr>
<tr>
<td>Terminal implant reaction rate, %</td>
<td>289 0.0</td>
<td>289 73.7</td>
<td>287 71.1</td>
<td>290 72.4</td>
</tr>
</tbody>
</table>

1Choice-Sham = Synovex Choice administered on d 0 followed by reimplantation with a sham implant (empty needle) on d 60 or 120; Choice-Choice = Synovex Choice administered on d 0 followed by reimplantation with Synovex Choice administered on d 0 or 120; Choice-Plus = Synovex Choice administered on d 0 followed by reimplantation with Synovex Plus (Zoetis Inc.) administered on d 0 or 120; and Choice-One = Synovex Choice administered on d 0 followed by reimplantation with Synovex ONE Feedlot (Zoetis Inc.) administered on d 60 or 120.

2n = number of total steers for each treatment.

3Evaluation of the initial implant at time of reimplantation on either d 60 or 120.

4Evaluation of the terminal implant at time of final BW collection on d 200.

The minimal observations of implant site reactions for each of the treatment groups in the current study are supported by the decades of research and approvals of growth-promoting implants in beef cattle by the US Food and Drug Administration (FDA) since the 1950s. Results from the current study for both implant retention rate and reaction are similar to those of the original approval documentation of each of the individual implants used in the current study (FDA, 1996, 2002, 2014b; Cleale et al., 2012).
### Deads and Removals

Summary of the occurrence of deads, removals, and bullers for feedlot steers is presented in Table 7. There was no difference ($P = 0.67$) between treatments for the percentage of deads and removals for steers, with 3.5, 4.5, 5.5, and 3.8% deads and removals for Choice-Sham, Choice-Choice, Choice-Plus, and Choice-One, respectively. In addition, there was no difference ($P = 0.80$) in the percentage of bullers identified during the study, with 0.0, 0.3, 0.3, and 0.3% bullers for Choice-Sham, Choice-Choice, Choice-Plus, and Choice-One, respectively.

There were no differences observed regardless of sex between the percentage of animals that died or were removed from study. Results from the current study align with those from the study by Hilscher et al. (2016) when 3 different reimplant strategies were evaluated and there was no effect on the percentage of deads or rejected cattle. Furthermore, Munson et al. (2012) reported that steer mortality was not affected when comparing an initial to a delayed implant treatment and was similar to a lesser- and greater-dose initial implant, which is supported by Hilscher et al. (2016). Data from this study along with previous literature suggest that reimplantation does not negatively affect the frequency of deads and removals. In addition, reimplant had no effect on the prevalence of buller syndrome, with only one buller identified in each of the 3 reimplant treatments, whereas there were none in the steers receiving a single implant. Data from the current study disagree with previous research that indicates that increasing the number of hormonal implants increased the prevalence of bullers (Reinhardt, 2007).

### FDA Center of Veterinary Medicine Label Guidance

In 2021 the FDA Center of Veterinary Medicine released guidance to the US beef industry that within a single production phase (i.e., suckling calf, stocker, feedlot), repeated use of hormonal implants (reimplantation) will not be allowed unless specified on the implant product label (FDA, 2021b). Until 2022 only 2 implants (Synovex C [Zoetis Inc.] and Synovex S [Zoetis Inc.]) had a reimplantation label indication in confined cattle on feed for slaughter; most of the implants approved over the last 25 yr do not have indications allowing reimplantation as of August 2022 (FDA 2022a,b). Going forward, implants that do not have a labeled indication for reimplantation will now have a contraindication on the product label describing that the implant is not approved for repeated use (reimplantation) within a production phase. In July 2022 Zoetis received approval by the FDA Center of Veterinary Medicine of these growth-promoting-implant combinations (Choice-Choice, Choice-Plus, and Choice-One) for increased rate of weight gain for up to 200 d in growing beef steers and heifers fed in confinement for slaughter when Synovex Choice is the first implant and the terminal implant of Synovex Choice, Synovex Plus, or Synovex ONE Feedlot is administered 60 to 120 d later (FDA, 2022a,b). The approvals allow for additional options and flexibility for the US beef industry moving forward.

### Table 6. Implant site evaluations in feedlot heifers implanted with Synovex Choice (Zoetis Inc.) on d 0 followed by terminal reimplantation on either d 60 or 120 for a total of 200 d on feed

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>n²</th>
<th>%</th>
<th>n²</th>
<th>%</th>
<th>n²</th>
<th>%</th>
<th>n²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial implant retention rate,3 %</td>
<td>Choice-Sham</td>
<td>295</td>
<td>74.9</td>
<td>295</td>
<td>74.9</td>
<td>297</td>
<td>74.7</td>
<td>298</td>
<td>74.8</td>
</tr>
<tr>
<td>Initial implant reaction rate,3 %</td>
<td>Choice-Choice</td>
<td>295</td>
<td>0.3</td>
<td>299</td>
<td>1.0</td>
<td>297</td>
<td>0.3</td>
<td>298</td>
<td>0.7</td>
</tr>
<tr>
<td>Terminal implant retention rate,4 %</td>
<td>Choice-Plus</td>
<td>292</td>
<td>0.0</td>
<td>293</td>
<td>62.5</td>
<td>287</td>
<td>72.5</td>
<td>288</td>
<td>85.4</td>
</tr>
<tr>
<td>Terminal implant reaction rate,4 %</td>
<td>Choice-One</td>
<td>292</td>
<td>0.0</td>
<td>293</td>
<td>0.0</td>
<td>287</td>
<td>0.3</td>
<td>288</td>
<td>0.3</td>
</tr>
</tbody>
</table>

1Choice-Sham = Synovex Choice administered on d 0 followed by reimplantation with a sham implant (empty needle) on d 60 or 120; Choice-Choice = Synovex Choice administered on d 0 followed by reimplantation with Synovex Choice administered on d 0 or 120; Choice-Plus = Synovex Choice administered on d 0 followed by reimplantation with Synovex Plus (Zoetis Inc.) administered on d 60 or 120; and Choice-One = Synovex Choice administered on d 0 followed by reimplantation with Synovex ONE Feedlot (Zoetis Inc.) administered on d 60 or 120.

2n = number of total heifers for each treatment.

3Evaluation of the initial implant at time of reimplantation on either d 60 or 120.

4Evaluation of the terminal implant at time of final BW collection on d 200.
APPLICATIONS

Use of multiple implants (reimplantation) during the finishing phase via the product sequence described previously improved ADG by 3.7 to 8.1% over 200 DOF compared with a single implant for both steers and heifers. In addition, final d-200 BW were improved in feedlot steers reimplanted compared with those that received a single implant; however, final d-200 BW were not statistically improved for feedlot heifers that received reimplantation. There were no differences between any of the 3 reimplant regiments adopted in this study (Choice-Choice, Choice-Plus, and Choice-One) for either ADG or final BW. Local reactions at the reimplant site were rarely detected across treatment regimens and sex, at a maximum of 0.7%. There were minimal differences among treatments on implant site retention, with the exception of the single-implant treatment (Choice-Sham) not having any terminal implants present as expected per study design. Reimplant did not affect the prevalence of mortalities or removals nor affect the prevalence of bullers in feedlot steers, supporting the overall field safety of reimplant. Synovex Choice as an initial implant followed by terminal implantation with Synovex Choice, Synovex Plus, or Synovex ONE Feedlot 60 to 120 d later is effective and safe for use in improving rate of weight gain in growing beef steers and heifers fed in confinement for up to 200 days. J. Anim. Sci. 90:5056–5066. https://doi.org/10.2527/jas.2012-5091.

ACKNOWLEDGMENTS

This research study was funded by Zoetis Inc., Veterinary Medicine Research and Development, in Kalamazoo, Michigan. The authors thank study personnel at each site for their efforts in conduct of the study and management of the study cattle.

LITERATURE CITED


FDA. 2014b. SYNOVEX CHOICE Freedom of Information Summary in Feedlot Heifers. NADA 141-043. US Food and Drug Administration, Rockville, MD.


Table 7. Summary of the percentage of deads and removals in steers and heifers and the incidence of bullers in steers over a 200-d feeding period where cattle were implanted with Synovex Choice (Zoetis Inc.) on d 0 followed by terminal reimplantation on either d 60 or 120

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment¹</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Choice-Sham</td>
<td>Choice-Choice</td>
</tr>
<tr>
<td><strong>Steers</strong></td>
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<tr>
<td>Deads and removals, %</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Bullers, %</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Heifers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deads and removals, %</td>
<td>3.3</td>
<td>4.0</td>
</tr>
</tbody>
</table>

¹Choice-Sham = Synovex Choice administered on d 0 followed by reimplantation with a sham implant (empty needle) on d 60 or 120; Choice-Choice = Synovex Choice administered on d 0 followed by reimplantation with Synovex Choice administered on d 60 or 120; Choice-Plus = Synovex Choice administered on d 0 followed by reimplantation with Synovex Plus (Zoetis Inc.) administered on d 60 or 120; and Choice-One = Synovex Choice administered on d 0 followed by reimplantation with Synovex ONE Feedlot (Zoetis Inc.) administered on d 60 or 120.
Ball et al.: Reimplant strategies improve growth


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