Effects of extended-release eprinomectin on productivity measures in cow–calf systems and subsequent feedlot performance and carcass characteristics of calves

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Abstract

The objective of this study was to estimate the impact of a single injection of extended-release eprinomectin on economically relevant production variables in beef cows and calves as well as subsequent feedlot health, performance, and carcass traits of calves compared with a traditional, short duration anthelmintic. Animals from 13 cooperator herds across seven states were stratified within herd and assigned to one of two treatments; injectable doramectin (DOR; Dectomax; $n = 828$) or injectable eprinomection (EPR; Longrange; $n = 832$). Fecal samples were randomly collected from a subset of cows at both treatment and the end of grazing to evaluate fecal egg count (FEC). Continuous and categorical data were analyzed using the MIXED and GLIMMIX procedures of SAS, respectively. Cow treatment body weight (BW) and final BW were not different ($P \geq 0.40$) between treatments. There were no differences ($P \geq 0.12$) between treatments in cow ADG, change in BW, or body condition scores during the grazing season. While FEC at treatment did not differ ($P = 0.18$), cows treated with EPR had lower final FEC at the end of the grazing season ($P = 0.02$) and a greater reduction of FEC over the grazing season ($P = 0.01$). Calf treatment BW, weaning BW, and ADG did not differ between treatments ($P \geq 0.34$). Incidence of pinkeye tended to be less ($P = 0.06$) for cows treated with EPR but was not different for calves ($P = 0.43$). Conception to AI, overall pregnancy rates, and calving interval were not different between treatments ($P \geq 0.45$). A subset of calves from each herd was sent to Tri-County Steer Carcass Futurity (TCSCF) feedlot for the finishing phase. Calf BW did not differ at initiation of feeding ($P = 0.20$). While EPR calves tended to be heavier at reimplantation ($P = 0.07$), final BW and overall ADG were not different between treatments ($P \geq 0.13$). Health records indicated lower morbidity for EPR calves ($P = 0.05$). Carcass performance including HCW, dressing percent, backfat, KPH, REA, YG, were not different between treatment groups ($P \geq 0.12$). However, EPR calves had a greater marbling score, greater average quality grade ($P < 0.01$), and higher proportion of calves that graded average choice or greater ($P = 0.03$). Results of this study indicate no difference in cow or preweaning calf performance, however, carcass quality in the feedlot phase was improved. Thus, economic analysis indicates opportunities for return on investment if animals treated with EPR have improved health status and/or carcass quality during the feeding phase.

Keywords

anthelmintic, deworm, economics, fecal egg count, feedlot, pregnancy

Disciplines

Agricultural Economics | Animal Sciences | Large or Food Animal and Equine Medicine | Veterinary Preventive Medicine, Epidemiology, and Public Health

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Effects of extended-release eprinomectin on productivity measures in cow–calf systems and subsequent feedlot performance and carcass characteristics of calves

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ABSTRACT: The objective of this study was to estimate the impact of a single injection of extended-release eprinomectin on economically relevant production variables in beef cows and calves as well as subsequent feedlot health, performance, and carcass traits of calves compared with a traditional, short duration anthelmintic. Animals from 13 cooperator herds across seven states were stratified within herd and assigned to one of two treatments; injectable doramectin (DOR; Dectomax; n = 828) or injectable eprinomection (EPR; Longrange; n = 832). Fecal samples were randomly collected from a subset of cows at both treatment and the end of grazing to evaluate fecal egg count (FEC). Continuous and categorical data were analyzed using the MIXED and GLIMMIX procedures of SAS, respectively. Cow treatment body weight (BW) and final BW were not different ($P \geq 0.40$) between treatments. There were no differences ($P \geq 0.12$) between treatments in cow ADG, change in BW, or body condition scores during the grazing season. While FEC at treatment did not differ ($P = 0.18$), cows treated with EPR had lower final FEC at the end of the grazing season ($P = 0.02$) and a greater reduction of FEC over the grazing season ($P = 0.01$). Calf treatment BW, weaning BW, and ADG did not differ between treatments ($P \geq 0.34$). Incidence of pinkeye tended to be less ($P = 0.06$) for cows treated with EPR but was not different for calves ($P = 0.43$). Conception to AI, overall pregnancy rates, and calving interval were not different between treatments ($P \geq 0.45$). A subset of calves from each herd was sent to Tri-County Steer Carcass Futurity (TCSCF) feedlot for the finishing phase. Calf BW did not differ at initiation of feeding ($P = 0.20$). While EPR calves tended to be heavier at reimplantation ($P = 0.07$), final BW and overall ADG were not different between treatments ($P \geq 0.13$). Health records indicated lower morbidity for EPR calves ($P = 0.05$). Carcass performance including HCW, dressing percent, backfat, KPH, REA, YG, were not different between treatment groups ($P \geq 0.12$). However, EPR calves had a greater marbling score, greater average quality grade ($P < 0.01$), and higher proportion of calves that graded average choice or greater ($P = 0.03$). Results of this study indicate no difference in cow or preweaning calf performance, however, carcass quality in the feedlot phase was improved. Thus, economic analysis indicates opportunities for return on investment if animals treated with EPR have improved health status and/or carcass quality during the feeding phase.

Key words: anthelmintic, deworm, economics, fecal egg count, feedlot, pregnancy

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INTRODUCTION

It has been well documented that gastrointestinal parasites can be detrimental to cattle health and performance. Production parameters impacted by parasitic infection include weight gain, reproductive efficiency, health, feedlot performance, and carcass quality (Hawkins, 1993). Since the 1960's, anthelmintic treatment has been a staple in ruminant production systems to mitigate production losses caused by helminth infection. In cow–calf production, anthelmintic treatment has been shown to improve cow BW and body condition scores (BCS), increase overall breeding season pregnancy rates, and improve calf performance (Stuedemann et al., 1989; Wohlgemuth et al., 1990; Stromberg et al., 1997; Hersom et al., 2011). The effects of anthelmintic treatment during the feeding phase have been shown to improve ADG, feed to gain (F:G), daily dry matter intake, and final BW (Smith et al., 2000). Furthermore, studies have linked calfhood deworming treatment to improved lifetime performance including growth, reproduction, and health (Mejia et al., 1999; Stacey et al., 1999; Clark et al., 2015).

In 2012, Merial, Inc. released an extended-release version of the anthelmintic drug, eprinomectin. This product label claims 100–150 d of parasite protection with one injection. Evaluation of concentration of eprinomectin shows effective plasma concentrations up to 150 d postadministration (Solls et al., 2013). Studies with stocker cattle have proven that extended-release eprinomectin effectively reduces worm burdens and improves weight gains in this class of cattle (Rehbein et al., 2013a, 2013b, Clark et al., 2014). However, to date, little research has been published regarding the effects of extended-release eprinomectin on cow–calf performance. Therefore, the objective of this study was to assess economically relevant performance parameters in cow herds following administration of extended-release eprinomectin at the start of the grazing season and to assess subsequent feedlot performance of progeny. We hypothesized that treatment of cows and calves with extended-release eprinomectin would improve cow performance and reproductive success and positively impact progeny performance compared to a short duration anthelmintic.

MATERIALS AND METHODS

All procedures and protocols were approved by the Iowa State University Institutional Animal Care and Use Committee (3-16-8209-B).

Survey

Because one of the study goals was to follow progeny through the feedlot phase to assess health and performance, Tri-County Steer Carcass Futurity (TCSCF) cooperators were identified as cooperators for this study because of the retained ownership platform (Reinhardt et al., 2009).

In May 2015, a Qualtrics survey (Qualtrics, Provo, UT) was administered by TCSCF and Iowa State University to screen potential cooperator herds. Survey questions were aimed at identifying management styles, record keeping, and herd health protocols. Questions inquired about current parasite control programs including if a parasite control program was in place, what type of dewormer was used (i.e., pour-on or injectable), which classes of cattle were commonly dewormed in the operation (i.e., cows, calves, or both), and postweaning parasite management of calves. Other questions identified common production practices such as if and when body weights were typically recorded, if and when BCS were recorded, when calving season typically began and ended, if calving data were recorded, and if pregnancy checks were conducted.

In order to qualify for participation in the study, producers must have had a parasite control program in place as part of a herd health protocol and be able to provide accurate visual ID records for both cows and calves. Birth records, including birth date, sex, and birth weight, for both the year of initial treatment (2016) and the subsequent calving season (2017) must have been available. Producers must have had the ability to collect timely and accurate measurements including cow and calf BW and cow BCS at the time of treatment and at weaning. Necessary reproduction data included pregnancy checks for both spring- and fall-calving herds with fetal aging if possible, AI dates (if applicable) as well as length of bull exposure. Producers that met minimum requirements were then selected for participation in the study. It is important to note that producers participating in this study were not required to have any history of parasitic infection within their herd nor were they required to identify the level of parasitic infection prior to the initiation of the study.

Experimental Design

Twelve cooperator herds located in seven states (Iowa, Missouri, Indiana, Kentucky, Tennessee, Ohio, and Georgia) participated in the study. The total number of animals enrolled in the trial was 1,768 cow–calf pairs and included both spring- and fall-calving herds. Animals were stratified within herd by cow age, calf birth date, calf birth BW, and calf sex and assigned to one of two treatments;

injectable doramectin (DOR; Dectomax, Zoetis, Animal Health, Parsippany, NJ; n = 879) or injectable eprinomection (EPR; LongRange, Merial, Duluth, GA; n = 889) at a rate of 1 mL/50 kg. Treatments were administered in the spring of 2016 during pasture turnout (Table 1). Average pasture turn-out date for participating herds was 16 May 2016. On average, treatments were administered on 9 May 2016 with a treatment range of March 23rd to June 15th. Individual and overall herd characteristics at the time of treatment are presented in Table 1. Overall, at treatment administration, cows averaged 5 ± 3.0 yr of age, weighed 568 ± 92 kg with an average BCS of 5.4 ± 0.9, and were 69 ± 33 d postpartum (DPP). One hundred and eight pairs (n = 51 DOR; n = 57 EPR) were removed from the trial due to nontreatment-related issues including mortality, morbidity, or culling during the grazing season.

The study consisted of two different treatment tiers. In tier one, only cows were treated. Following treatment, EPR cows were managed on similar but separate pastures from DOR cows and treatments were not comingled at any time between treatment and weaning. Moreover, cows were not grazed in pastures where the opposite treatment had grazed previously during the grazing season. In tier two, EPR cows and DOR cows were comingled from the start of the trial. At approximately 90 d of age, per label instructions, calves were treated with the identical product as their dams. Both dams and calves only received a single dose of their respective anthelmentic throughout the duration trial. The two-tier design implemented in this study allowed for unique evaluation of both parasite burden and performance response. In order to maintain separate parasite burdens relative to treatment, tier one was implemented. This design prevents EPR cows from potentially diminishing parasite loads that DOR may otherwise have been exposed to. However, because reproductive variables were of interest in this study, tier two was implemented in order to evenly apply variables, such as natural service sires, between treatment groups. Although forage data including quality and type were not collected, tier two allowed for mitigation of forage type and quality variables that often confound results in replicated grazing studies. It is important to note that previous studies have successfully detected performance and parasite load differences between anthelmintic treatments that were comingled in a grazing environment (Clark et al., 2013; Watson, 2016).

Production Measures

Performance. Cow body weights (BW) and body condition scores (BCS; 1–9; Wagner et al., 1988) were taken at the time of treatment and again at the end of the trial. The end of the trial was differentially determined based on calving season. For spring-calving cows, end of trial was considered

Table 1. Age, calving date, birth weight, treatment date, days postpartum, BW, and BCS of cows from cooperating herds enrolled in the study

Herd[1]	n	Mean age, years (range)	Julian calving date, mean and range	Calf birth weight, mean and range	Dam treatment date[2], mean and range	Days postpartum[3], mean and range	Mean BW, kg (range)	Mean BCS[4], (range)
1	75	5.4 (2–13)	56 (16–97)	36 (25–49)	160 (160–161)	104 (63–144)	576 (431–750)	5.5 (4.0–9.0)
2	51	4.8 (2–11)	58 (23–101)	---	124 (121–128)	69 (27–105)	582 (452–716)	6.0 (4.0–8.0)
3	40	5.1 (3–10)	90 (12–201)	---	91 (---)	0.6 (−110–79)	591 (448–740)	6.2 (4.0–8.0
4	164	4.9 (2–13)	23 (−2–57)	33 (21–49)	89 (81–104)	67 (26–93)	541 (350–769)	5.8 (4.0–8.0)
5	194	4.8 (2–12)	18 (−18–109)	---	139 (122–153)	120 (44–166)	621 (376–858)	4.3 (3.0–6.0)
6	67	4.2 (2.0–11)	72 (125–136)	---	128 (125–136)	56 (19–91)	658 (372–803)	4.3 (3.0–6.0)
7	402	5.7 (2–14)	127 (16–290)	37 (18–52)	150 (116–166)	69 (31–143)	522 (306–796)	5.7 (3.3–8.0)
8	129	5.2 (2–15)	142 (19–291)	39 (23–56)	140 (126–147)	60 (14–128)	621 (495–782)	5.4 (4.0–7.3)
9	188	6.2 (2–14)	109 (51–268)	37 (27–45)	131 (130–133)	49 (7–79)	602 (413–759)	5.4 (4.3–7.3)
10	118	4.3 (2–16)	85 (45–148)	34 (20–49)	127 (126–132)	43 (−22–87)	566 (395–744)	5.5 (4.0–7.5)
11	90	3.9 (2–10)	81 (57–112)	33 (21–43)	126 (---)	45 (14–69)	537 (372–779)	5.7 (4.0–8.0)
12	248	5.8 (2–15)	110 (79–167)	35 (16–51)	---	---	---	---
Overall	1,766	5.3 (2–16)	89 (−19–291)	36 (16–56)	133 (81–166)	70 (−110–166)	568 (306–858)	5.4 (2.0–9.0)

[1]Herds were located in seven different states.

[2]Julian date of treatment within a herd.

[3]Days postpartum at anthelmintic administration.

[4]Body condition score on 1 to 9 scale (1 = emaciated and 9 = obese; Wagner et al., 1988).

as time of weaning. For fall-calving herds, end of the trial was considered when pairs were removed from pasture. Calves that were in tier two of the trial were weighed at the time of treatment (*n* = 543 DOR; n=543). All calves in the study were weighed at the time of weaning (*n* = 828 DOR; *n* = 832 EPR). Birth weights of fall calves (*n* = 79 DOR; 73 EPR) were evaluated as a response variable to anthelmintic treatment. It is well established that nutritional status during gestation plays a crucial role in fetal development and postnatal progeny performance. Undernutrition, such as often seen during a parasitic infection, can be detrimental to development and lifetime performance of an animal by decreasing birth weight, impacting development during gestation, and ultimately altering postnatal metabolism and performance (Funston et al., 2009; Canton and Hess, 2010). Forty-four calves were removed from final analysis due to administration of the incorrect anthelmintic treatment (*n* = 21 DOR; *n* = 23 EPR).

Fecal samples. Fecal samples were taken from a subset of five herds. Approximately 15 cows per treatment were randomly selected at each location and were sampled at the start (*n* = 75 DOR; *n* = 69 EPR) and end (*n* = 70 DOR; *n* = 65 EPR) of the trial to measure initial and final fecal egg counts (FEC). Samples collected included both spring- and fall-calving herds as well as herds from both experimental tiers. All fecal samples were shipped to Texas A&M Diagnostic Lab for analysis of FEC as well as coproculture if warranted.

Health outcomes. Available herd health records were used to analyze incidence of pinkeye over the course of the grazing season. Health records were submitted from two herds and both indicated treatment records for pinkeye for cows (*n* = 323 DOR; *n* = 325 EPR) and calves (*n* = 312 DOR; *n* = 308 EPR). In July, fly counts were conducted on a subset of five herds to evaluate fly burden. Herds included in the analysis consisted of both experimental tiers as well as both spring- and fall-calving herds. Live fly counts were evaluated in the pastures (*n* = 151 DOR; 150 EPR) in mid-July. Within a pasture, animals were selected at random and fly burdens were estimated from a single side of the animal and included face, shoulders, back, and legs. Flies were counted individually until the number exceeded 25, and then counted in groups of 5 (Steelman et al., 1997). Estimations from a single side were then doubled to obtain a full body estimate of fly burden. At the time of live evaluation, pictures (*n* = 133 DOR; *n* = 134 EPR) were taken of the side used in the live analysis for fly count confirmation.

Reproduction end points. For all herds, overall breeding season pregnancy rates were collected for both spring and fall herds (*n* = 828 DOR; *n* = 832 EPR). Of participating herds, six producers implemented AI protocol. Where applicable, conception rates to AI were analyzed (*n* = 334 DOR; *n* = 327 EPR). Calving distribution for the 2017 calving season was evaluated as well as calving interval between 2016 and 2017 calving for all spring-calving herds (*n* = 610 DOR; *n* = 611 EPR).

Feedlot and carcass data. After weaning, calves were managed at individual cooperating locations per the standard operating procedure of each farm. Although postweaning management of calves was not controlled as part of the study, requirements established by TCSCF for calves entering the program ensured comparable health management between producers. To qualify for TCSCF, calves must be weaned for a minimum of 30 d, be castrated and dehorned, and treated for internal and external parasites. Calves must also have been administered two doses of the following vaccinations: infectious Bovine rhinotracheitis (IBR), Bovine viral diarrhea virus (two types; BVD), parainfluenza (PI3), Bovine respiratory syncytial virus (BRSV), and seven-way blackleg.

A subset of calves from each herd at the discretion of the cooperator was then sent to a TCSCF feedlot for the finishing phase. Calves arrived at the feedlot between 16 October and 22 December 2016 (*n* = 238 DOR; *n* = 259 EPR). Upon arrival, calves were vaccinated with a five-way and seven-way. Calves were also administered a dewormer, implanted, tagged, and weighed. Cattle were transitioned to an 80% concentrate diet over a 28-d period. While at TCSCF, feedlot performance and health were monitored. Finished cattle were harvested between 21 March and 6 July 2017. Following slaughter, carcass data were collected. Thus, feedlot performance, morbidity, and carcass parameters were analyzed.

Economic Analysis

Extended-release eprinomectin (EPR) is marketed as offering novel performance response and has a label-claim for lengthened protection. However, the cost of this product is in an added out-of-pocket expense to producers compared to conventional parasite control products. Therefore, an economic analysis evaluating production responses to anthelmintic treatment and thus, economic impact on producers, was conducted. The goal of this analysis was to evaluate the initial cost of treatment and the differential performance needed for producers to make up the increased cost of EPR compared to a conventional parasite control product like DOR.

The economic model used for the cow–calf enterprise analysis was a partial budget (Texas Cooperative Extension, 2002). For this analysis, a treatment herd was standardized to 100 cow–calf pairs. Margin over cost was set at 0% to determine breakeven prices and labor was considered equal between the two treatment groups. A standard weaned calf percentage of 90% was used for both treatments. An average weaning weight of 238 kg was used for both the treatments. In addition to the baseline analysis, alternative scenarios were analyzed by increasing or decreasing calf prices by 20% while holding all other variables constant.

An enterprise budget was used for the analysis of the feedlot data (Ag Decision Maker, 2017). Budgets for each treatment group were created using actual records and prices reported by TCSCF.

Statistical Analysis

Cow–calf analysis. Performance data and calving interval were analyzed using the MIXED procedure of SAS 9.4. Conception to AI, overall breeding season pregnancy rates, calving distribution, and health outcomes were analyzed using the GLIMMIX procedure of SAS 9.4. Cow, or calf when appropriate, was the experimental unit for the analysis. The model included fixed effects of treatment, season, tier, calf sex when appropriate, and included the random effect of pasture nested within location to account for variation within and across herds relative to management and weather.

Feedlot performance and carcass quality analysis. Feedlot and carcass performance were analyzed using the MIXED procedure of SAS 9.4. Quality grade distribution and morbidity were analyzed using the GLIMMIX procedure of SAS 9.4. Calf was the experimental unit for the analysis. The model included fixed effect of treatment, tier, season, a covariate of calf sex, and included the random effect of pasture nested within producer to account for variation in management.

Tier and season were tested as main effects and for interaction and removed if no interaction was detected. Significance was declared at $P \leq 0.05$ and tendencies $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

The objective of this study was to measure a multitude of standard, economically relevant production variables of beef cows and calves as well as subsequent feedlot health, performance, and carcass traits of those calves from herds that were administered extended-release eprinomectin compared to dectomax 1% injectable at the labeled dose rate.

Cow Performance

Cow performance data are presented in Table 2. Initial and final BW did not differ due to treatment ($P \geq 0.32$). In addition, change in BW over the course of the trial was not different and there was no difference in change in BW as a percent of initial BW which correlated into no differences in ADG ($P \geq 0.12$). Subsequently, there were no differences in either initial or final BCS ($P \geq 0.23$) as a result of treatment. While previous literature has found weight differences (Ciordia et al. 1982; Stuedemann et al. 1989), comparisons have predominately been made between dewormed groups and nontreated controls. However, the present study compares differences between two groups treated with anthelmintics that differ in duration of efficacy. Results from a similar study (Backes et al., 2016) have reached comparable conclusions showing no overall weight difference between groups treated with a conventional short duration oral oxfendazole or extended-release eprinomectin. However, Myers (1988) has suggested that increased performance in the form of improved milk production or reproductive success following anthelmintic treatment may confound cow weights so that weights may not be a meaningful production parameter when studying parasite control in cow–calf production.

Health Outcomes

Previous studies have indicated some level of fly control associated with treatment with extended-release eprinomectin in grazing environments (Vesco et al., 2015; Trehal et al., 2017). Anecdotal evidence has found reduced fly burdens with lower incidence of pinkeye in grazing cattle that were treated with extended-release eprinomectin. While extended-release eprinomectin is not labeled for fly control, one of the objectives of the current study was to evaluate claims of reduced fly burden and incidence of pinkeye. An evaluation of fly burden in the current study indicated no differences between

EPR and DOR treated cows ($P \geq 0.62$; Table 3). These results are similar to those reported by Watson (2016), where there were no differences in fly counts between control, combination treatment of oxfendazole and moxidectin, or extended-release eprinomectin-treated calves comingled during a 100-d stocker period. Interestingly, EPR cows in the current study tended to have a lower incidence of pinkeye as reported by treatment records (DOR = 8.4%; EPR = 4.6%; $P = 0.06$), however, this reduction is not explained by differences in fly burden. When evaluating incidence of pinkeye in calves, there was no difference in pinkeye treatment between treatment groups ($P = 0.43$).

There has been speculation that the fly control associated with extended-release eprinomectin is correlated with the reduction in pinkeye within treated herds. Fly control following treatment with extended-release eprinomectin is believed to be a result of residue in manure pats that disrupt egg and larval development of fly species that use the manure to procreate, in a manner similar to an insect-growth regulator (IGR). While treatment with extended-release eprinomectin has been shown to reduce horn fly burdens in grazing stocker cattle (Trehal et al., 2017), there is no data on its effectiveness on face flies, the main transmitters of pinkeye within a grazing herd. Furthermore, face flies can travel long distances and spend minimal time on an animal, making control of these pests difficult with products such as IGR (Antonelli and Ramsay, 2014). Therefore, it is hard to identify a causal relationship between fly control and pinkeye with this product. More research is necessary to verify and determine the relationship, if one exists, between these two variables.

Table 2. Performance of cows treated with different anthelmintic treatments during the grazing season

Item	Treatment[1] DOR	EPR	SEM	*P*-value[3]
BW, kg				
Treatment	577	578	11.4	0.85
Weaning	587	590	10.8	0.40
Change in[4], kg	9	12	4.7	0.13
Change in[4], %	1.95	2.67	0.81	0.12
Performance				
ADG[4], kg	0.05	0.08	0.04	0.23
BCS				
Treatment	5.57	5.57	0.07	0.99
Weaning	5.58	5.60	0.09	0.59
Change in	0.00	0.02	0.08	0.67

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Larger SEM presented ($n = 828$ DOR; $n = 832$ EPR).

[3]*P*-value: Significant $P \leq 0.05$; Tendency $0.05 < P \leq 0.10$.

[4]Calculations based on weight changes from treatment to weaning/end of grazing season.

Table 3. Health and reproductive success of cows treated with different anthelmintic treatments during the grazing season

Item	Treatment[1] DOR	EPR	SEM	P-Value[3]
FEC				
Initial	2.07	2.97	0.49	0.18
Final	1.76	0.71	0.34	0.02
Change in	−0.30	−2.12	0.60	0.01
Health				
Cow Pinkeye, %	8.4	4.6	---	0.06
Live Fly Counts	62	60	11.3	0.62
Picture Fly Counts	50	58	11.8	0.69
Reproduction, % (no./no.)				
Conception to AI	47 (157/334)	50 (164/327)	---	0.51
Pregnancy Rate[4]	88 (729/828)	88 (733/832)	---	0.45
Calving Interval[5], days	371	370	2.1	0.72

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Larger SEM presented (n = 828 DOR; n = 832 EPR).

[3]*P*-value: Significant $P \leq 0.05$; Tendency $0.05 < P \leq 0.10$.

[4]Pregnancy rate for 2016.

[5]Calving interval from 2016 to 2017 calving.

Reproduction

Marked improvement in reproductive success of both mature cow herds and developing heifers have been noted following administration of anthelmintic treatment when compared to nontreated controls (Stuedemann et al., 1989; Larson et al., 1995; Stromberg et al., 1997; Loyacano et al., 2002; Andresen et al., 2017). Improved conception rates that have been previously reported have frequently been in conjunction with increases in BW and BCS indicating an improvement in the nutritional status of the animal. Given the low priority of function of reproductive processes such as cyclicity and initiation of pregnancy (Short and Adams, 1988), it is plausible that the improved nutritional status often associated with anthelmintic treatment could improve reproductive function, especially during early lactation when nutritional demands are increased. The extended days of parasite protection claimed by extended-release eprinomectin allows the possibility to improve nutritional status for a longer period before reinfection with GIN during a critical time when a cow is nursing and trying to conceive. When evaluating reproductive success of cow herds in the current study (Table 3), there were no differences in conception to AI (DOR = 47%; EPR = 50%; P = 0.51) or overall breeding season pregnancy rates (DOR = 88%; EPR = 88%; P = 0.45). Contrarily, Backes (2016) reported dams treated with oral oxfendazole tended to have higher overall conception rates when compared to cows treated with EPR. However, neither the current study nor Backes (2016) reported differences in ADG or BW over the course of the grazing season, indicating nutritional status was not greatly improved between the short duration group and the extended protection groups in these studies. Evaluation of calving distribution in the calving season following treatment indicated no differences in the number of calves born in the first 21 d as a result of treatment (P = 0.98). Analysis of subsequent 21-d intervals showed no differences between treatment in the number of calves born in each interval ($P \geq 0.33$). As expected, with no differences in calving distribution, there was also no difference in calving interval between the 2016 and 2017 calving season (DOR = 371 d; EPR = 370 d; P = 0.72).

Fecal Egg Counts

Fecal samples were collected from a subset of five cooperator herds at the start and end of the grazing season for evaluation of FEC as well as coproculture if warranted. Of the five herds sampled, three DOR and four EPR groups warranted coprocultures from samples collected at the start of the grazing season, which identified the percent of each roundworm species found in the fecal sample. Species identified in DOR groups were predominantly comprised of *Cooperia* (100%, 81%, and 76%) and *Haemonchus* (0%, 19%, and 24%). Similarly, EPR groups consisted primarily of *Cooperia* (100%, 100%, 82%, and 55%) followed by *Haemonchus* (0%, 0%, 18%, and 12%). Other species detected in the EPR group were *Oesophagostomum* (0%, 0%, 0%, and 12%) and 18% of larvae cultured were too damaged to identify. No coprocultures were warranted for fecal samples taken at the end of the grazing season.

Fecal egg count data are reported in Table 3. Efficacy is most commonly measured using fecal egg reduction tests (FECRT), which compares FEC before and after treatment with an anthelmintic to measure the reduction in or elimination of fecal egg shedding (Taylor et al., 2002; Coles et al., 2006). While initial FEC were not different between treatment groups in this study (P = 0.89), final FEC were lower (P = 0.02) in EPR cows compared to DOR cows. Subsequently, EPR cows had a greater overall reduction in FEC compared to DOR cows (P = 0.01). However, FEC of both treatments at both treatment and at final performance measurement were far below a threshold that would be indicative of clinical parasitism (Bagley et al., 1998). We believe that a lack of parasitic infection during the grazing season may have resulted in a lack of performance differences in this study. Low FEC may be a reflection of the types of herds that were selected to participate in this study. Because of the stringent requirements to qualify for participation, herds selected were uncommonly well-managed which likely contributed to low overall FEC. In similar studies, consisting of treatments that included positive control groups and comingled treatments, both Pfeifer et al. (1999) and Ward et al. (1991) saw similar FEC during the course of the respective trials and reported no performance differences following anthelmintic treatment. This indicates, in agreeance with previous work, the level of parasitic infection in the current study may not have been high enough to elicit a production response. However, it should be noted that Clark et al. (2013) was able to detect significant differences in performance between commingled ivermectin and extended-release eprinomectin-treated stocker calved that had FEC of 5.14 and 0.90, respectively.

Calf Performance

Results for calf growth and performance are reported in Table 4. There were no differences in birth BW for calves regardless of tier or calving season (P = 0.57). Because fall-calving herds were treated in the spring while cows were pregnant, birth weights of fall calves were analyzed as possible fetal programing response to treatment. However, analysis of birth weights of fall calves indicated no difference between treatments (P = 0.43; data not shown). Calf BW at the time of treatment for calves in tier two was not different (P = 0.50). Likewise, weaning weights were not different between the two treatment groups regardless of tier or calving season (P = 0.75), although as expected there was a season effect ($P \leq 0.01$) where fall calves were lighter at weaning than spring calves. Subsequently, ADG between time of treatment and weaning was not different (P = 0.28), and overall preweaning ADG did not differ due to treatment (P = 0.57). While little comparable literature exists for evaluation of a short duration and extended-release anthelmintic, Backes (2016) found increased weaning weight for calves from dams treated with oral oxfendazole compared with calves from dams treated with extended-release

Table 4. Performance and health of calves who were treated with different anthelmintic treatments during the grazing season

	Treatment[1]			
Item	DOR	EPR	SEM	P-Value
BW, kg				
Birth	35	35	0.6	0.57
Treatment	142	141	7.4	0.50
Weaning[4]	231	232	5.5	0.75
Performance, kg				
Treatment ADG[5]	1.02	1.04	0.04	0.34
Weaning ADG[6]	1.05	1.05	0.02	0.66
Health, %				
Pinkeye	18.6	21.1	---	0.43

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Larger SEM presented (n = 807 DOR; n = 809 EPR).

[3]P-value: Tendency $0.05 < P \leq 0.10$.

[4]Actual weaning weight.

[5]Calculation based on weight change from time of anthelmintic treatment to weaning.

[6]Calculation based on weight change from birth to weaning.

eprinomectin. While milk production has been previously implicated in improved performance of preweaned calves (Frechette and Lamothe, 1981; Ciordia et al., 1982; Stromberg et al., 1997), a lack of performance differences in calves makes it an unlikely mechanism in the present study. Likewise, low FEC found in cows suggest low worm burdens, possibly a result of well managed pastures, which may have correlated to low levels of parasitic infection in calves. However, preweaning anthelmintic treatment may have implications for improved performance later in both stocker and feedlot phases. Stacey et al. (1999) found that preweaning treatment with a sustained-release ivermectin bolus improved stocker weight gains compared to calves treated with a conventional ivermectin pour-on. Clark et al. (2015) found that calves entering the feedlot with a higher worm burden had reduced growth, compromised immunocompetency, and altered carcass composition compared to steers with low FEC even though both groups were treated upon feedlot arrival. Furthermore, Clark et al. (2015) suggest that not only do calves with a lesser parasite burden have improved preweaning performance, but that early parasite protection may improve lifetime production.

Feedlot Performance and Carcass Characteristics

Feedlot performance and carcass measurements are presented in Table 5. There was no difference in BW between DOR and EPR calves at initiation of

Table 5. Feedlot and carcass characteristics of calves that were treated with different, preweaning anthelmintic treatments

	Treatment[1]			
Item	DOR	EPR	SEM[2]	*P*-value[3]
BW, kg				
Initial	347	354	9.1	0.23
Reimplant	432	443	7.6	0.08
Final	545	550	6.8	0.27
Performance, kg				
ADG	1.53	1.53	0.15	0.91
Health				
Treated, %	22.4	13.6	---	0.06
Carcass Quality				
HCW[5], kg	341	343	4.4	0.43
Dress[6], %	61.5	61.8	0.00	0.20
Backfat, cm.	1.37	1.35	0.05	0.72
KPH[7], %	2.29	2.22	0.05	0.06
Ribeye area[8], cm.[2]	81.76	82.15	0.94	0.58
Yield grade[9]	2.49	2.55	0.08	0.35
Marbling score[10]	1083	1097	9.23	0.13
Quality grade[11]	12.30	12.52	0.10	0.03
% QG Distribution[12]				
Avg choice or Higher	40.38	51.43	---	0.03
Low choice	47.31	41.43	---	0.63
Select and lower	12.31	7.14	---	0.37

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Larger SEM presented (n = 238 DOR; n = 259 EPR).

[3]P-value: Significant $P \leq 0.05$; Tendency $0.05 < P \leq 0.10$.

[4]Hot carcass weight.

[5]Dressing percent.

[6]Kidney, pelvic, heart fat.

[7]Marbling score: small: $1{,}000^0$, modest: $1{,}100^0$, moderate: $1{,}200^0$, etc.

[8]USDA quality grade: 12: Choice^-, 13: Choice^0, 14: Choice^+, etc.

[9]Percentage of steers in each treatment by quality grade, within treatment total is 100%.

the feeding period (P = 0.20). Subsequent BW taken at reimplantation approximately 50 d after initiation of feeding showed a tendency for EPR treated calves to weigh more (P = 0.07). While not statistically different (P = 0.13), EPR-treated calves did finish with a slight weight advantage compared with DOR calves. Although EPR calves finished with slightly heavier weights throughout the feeding period, this did not correlate into differences in ADG ($P \geq 0.31$) between treatments. However, when evaluating health of calves in the feedlot, EPR calves were treated for various health issues fewer times compared with DOR calves (P = 0.05) indicating improved health status. While all essential components of the immune system are present at birth, full functionality of immunity is not possibly until 2–4 wk of age and may continue to develop through puberty (Wilson et al., 1996; Chase et al., 2008). Because DOR calves were protected from parasitic infection for a shorter period of the grazing season, as were their dams, exposure to parasites may have occurred. Because parasites can impair or even inhibit immune response (Gomez-Munoz et al., 2004), an infection during this critical stage of development may have resulted in impaired development of the immune system thus impacting lifetime immunocompetency. Although FEC in this study were low, calves are more susceptible to parasites, and although immediate performance was not impacted, disruption of immune development may have been occurred resulting in higher feedlot morbidity.

Subsequent carcass measurements showed no differences due to treatment including hot carcass weight (HCW), backfat (BF; $P \geq 0.22$). Likewise, ribeye area (REA) and yield grade (YG) were similar ($P \geq 0.60$) between treatments. Calves treated with EPR tended to have a lower kidney, pelvic, and heart fat (KPH; $P = 0.06$). While there was no difference ($P = 0.13$) in marbling score, there was a difference in quality grade distribution where EPR calves had a greater percentage of carcasses grade average choice or higher compared to DOR (38.4% DOR; 49.7% EPR; $P = 0.03$). However, there were no differences in the number of carcasses that graded low choice or select and lower ($P \geq 0.37$). Gardner et al. (1999) reported that feedlot morbidity results in a reduction in quality grade, with a higher percentage of steers identified as sick grading Standard. Therefore, reduced morbidity and improved quality grade create potential for a greater return on initial anthelmintic treatment. The results of this study are in agreeance with those of Gardner et al. (1999) where DOR calves had a higher incidence of morbidity, resulting in an increased health cost, and had a lower average quality grade as well as fewer calves grading average choice or higher compared with healthier EPR calves.

These results are in line with the previous studies. Clark et al. (2013) found that calves treated with extended-release eprinomectin did not have improved feedlot performance or carcass characteristics. Likewise, Backes (2016) saw no difference in HCW, marbling score, backfat, KPH, YG, or quality grade distribution between calves treated with extended-release eprinomectin or oral oxfendazole at weaning. Again, low FEC at initiation of the present study may have resulted in a lack of performance throughout all phases of production.

Economic Impact, Herd Level

Cow–calf. Performance responses were evaluated for differences in economic value between treatment groups (Beef Cattle Decision Aids, 2002). Variables considered as economically relevant in the cow–calf analysis include cow BW, overall breeding season pregnancy rates, calving interval, calving distribution, and calf weaning BW. As seen by production measurements presented in Tables 1 and 2, little variation exists between treatment groups. Overall breeding season pregnancy rates were not different indicating a lack of evidence for increased return on investment through increased calf crop. Likewise, calving interval and calving distribution were not different, and there were no differences in calf performance.

A lack of differences in the current study provides little opportunity for EPR cows to recoup the increased cost of treatment during the preweaning phase. Therefore, the cow–calf analysis sought to determine increased production, in kilograms of calf weaned, necessary for the respective treatments to be indifferent. Because treating with DOR is considered a conventional practice, the improved performance needed by EPR calves in order to negate the cost difference between treatments was also evaluated.

The partial budget for this analysis is organized into two categories—expenses and income associated with the change. In the present study, this considers a change from DOR to EPR treatment.

Expenses. Because expenses such as forage, feed, labor, and reproduction were the same irrespective of treatment, only costs associated with differences in anthelmintic treatment were considered. Based on drug prices at the time of treatment, DOR costs \$0.32/cc and EPR costs \$1.38/cc. The average amount of medicine administered for cows and calves was 12cc and 3cc, respectively, for both the treatments. This resulted in a cost of \$5.01 per cow–calf pair treated with DOR and a cost of \$21.39 per cow–calf pair treated with EPR. Cost difference between EPR and DOR treatments was \$16.38/pair.

Income. Income was determined by evaluating pounds of calf weaned at the market price on the average date of weaning for cooperating herds. A market price of \$3.40/kg (Iowa auction average for Sept. 2016) was used (USDA-AMS, 2016).

Results from the economic analysis are reported in Table 6. This analysis indicates that EPR cows would need to wean calves with a 4.8 kg weight advantage over DOR calves in order to eliminate the difference in cost between treatments. For producers to recoup the cost of the specific anthelmintic in cow–calf production, DOR and EPR

Table 6. Economic analysis and breakeven weight for calves and cull cows treated with different anthelmintic treatments during preweaning

	Treatment[1]		
	DOR	EPR	Difference[2]
Herd size[3]	100	100	---
Cost of Treatment	$5.01	$21.39	$16.38
Average WW, kg	238	238	---
Breakeven weight needed[4], kg			
$2.73/kg	1.8	7.9	6.0
$3.40/kg[5]	1.5	6.3	4.8
$4.06/kg	1.2	5.3	4.0
Average cull cow weight, kg.	577	571	6
Cull cow value[6], $/hd	$902.41	$893.78	$9.23

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Cost difference that must be made up by EPR calves in order to breakeven with a conventional treatment.

[3]Budget utilized from Beef Cattle Decision Aids (2002).

[4]Added weaning weight necessary above the average for treatments to breakeven at various market prices.

[5]Weighted average market price of medium to large, frame 1, 227–249 kg fed calves for Iowa auctions on September 2016.

[6]Value calculated based on October 2016 Boning cow 544–907 kg prices reported from Sioux Falls, SD.

calves would need to add 1.5 and 6.3 kg by weaning, respectively. The sensitivity of kilograms of weaned calf required to pay for the cost of anthelmintic treatment at alternative calf prices are reported in Table 6. Results of the sensitivity analysis indicate, as expected, that the added weight necessary for a producer to recoup the cost of anthelmintic treatment was highly variable depending on the market price.

While it may not be efficient to retain open females in a herd, attention to management and marketing of cull cows can impact profitability. Cull cows can represent up to 10–20% of total revenue within the cow–calf enterprise (Peel and Doye, 2008). While marketing is important, management strategies alone can increase cull cow value by 25–45% (Peel and Doye, 2008). Increasing pounds of animal sold can result in increased revenue at comparable prices. Therefore, the use of a specific anthelmintic could improve cow–calf returns through increased cull cow values. While there were no differences in cow BW at weaning, evaluation of BW differences between open cows in each treatment group were analyzed for opportunities for increased cull cow value. Analysis shows a slight weight advantage for open DOR cows compared to open EPR cows (577 kg DOR; 571 kg EPR; data not shown) (Table 4). This slight weight advantages creates an opportunity for producers to realize a greater return, on average, from cull animals treated with DOR. With an average cull cow price of $1.56/kg from October 2016 (Sioux Fall, SD) (USDA-AMS, 2016), DOR cows had the potential to have an increased return of $9.23/head (Table 6). It is also important to note the reduction in incidence of pinkeye in EPR cows. This also provides an opportunity, through reduced health and labor costs, to increase returns on the initial cost of anthelmintic treatment. Thus, improved performance in the form of added weight for either weaned calves or cull cows and improved herd health have the potential to improve return on investment for preweaning anthelmintic treatment for the cow–calf enterprise.

While not evident in the current study, performance increases necessary to offset cost of treatment during the preweaning phase may be possible in alternative environments such as those with higher levels of parasitic infections. Data evaluating the use of extended-release eprinomectin compared to a conventional ivermectin injectable in fall-calving beef herds has shown improvements in conception to AI as well as overall breeding season pregnancy rates (Andresen et al., 2018). Therefore, improvements in reproductive efficiency manifested as greater overall season pregnancy rates following anthelmintic treatment may provide opportunities for a greater return on investment.

The same study also found reduced calving interval and a shift in calving distribution in the calving season following initial anthelmintic treatment for cows treated with EPR, as well as increased weaning weights for their calves. Thus, a reduced calving interval and a shift in calving distribution following anthelmintic administration may improve the probability of weaning heavier calves. Data from Funston et al. (2010) show that steers and heifers born in the first 21-day calving period perform better than cohorts born in later calving periods. Shifting calving distribution may also improve cow pregnancy rates by increasing the postpartum recovery time. This may result in a larger calf crop as well as increased pounds of calf weaned per cow. These data indicate alternative conditions to the ones in the current study have the potential to generate a greater return on investment following treatment with EPR. However, it is important to note that improvements in returns based on improved performance will be highly dependent on the economic conditions at the time calves are marketed.

It is also important to note that estimates from this analysis are likely conservative. The comparison in the current study was made between extended-release eprinomectin and a single treatment of a short duration anthelmintic. Because the goal of this study was not to compare the effectiveness of deworming, no comparison was made using a short duration anthelmintic multiple times throughout the grazing season to create an equal number of protected days as EPR, which would have increased initial treatment costs for DOR. The goal of the current study was to evaluate extended-release eprinomectin compared to conventional dewormers in common production settings where deworming typically occurs once during the grazing season which was also the basis of the economic analysis conducted.

Feedlot. The enterprise budget for this analysis used actual income and expense records for each treatment group and prices reported by TCSCF.

Expense. Costs including feed, interest, death loss, and yardage were assumed equal between treatment groups as these costs were accrued regardless of anthelmintic treatment. Because there were no differences in weaning weight, placement cost at the time of delivery was the same for each group ($2.60/kg) based off reported market price at the time of delivery by TCSCF. Records obtained through TCSCF allowed for individual animal health records including how many times a calf was treated and the cost of health treatments throughout the feeding period. Calves treated with DOR preweaning had a greater number of health issues (Table 5) throughout the feedlot phase resulting in higher health costs of $6.00 per animal.

Income. Fed cattle prices used were the average price received by producers in this study as reported by TCSCF. Average final BW was used to determine the live value of animals within each treatment group. This price accounted for premiums and discounts that were paid for various quality, yield, and weight characteristics. Although quality grade distribution presented in Table 5 indicates a larger number of carcasses grading average choice or greater for EPR-treated calves, premiums for YG, CAB, and prime were consistent between the two treatment groups. This may have been a result of variability in marketing time as market dates for finished cattle ranged from 21 March 2017 to 18 July 2017. While fed cattle price was not different between treatment groups ($2.87/kg), EPR calves did finish the feedlot phase with a slight weight advantage over DOR calves (550 kg DOR; 557 kg EPR) resulting in a slight increase in income on a live weight basis.

Results of the feedlot budget analysis are reported in Table 7. The culminating effect of both healthier and heavier EPR calves resulted in a lower breakeven price ($1.10 DOR vs. $1.08 EPR) and an opportunity for slightly higher profits ($200.11 DOR; $227.22 EPR) per animal.

Retained Ownership

As seen by slightly higher returns for EPR calves in the feedlot, administering EPR preweaning may be able to make up the cost difference between the two anthelmintic treatments.

For producers operating on a retained ownership platform, like cooperating herds in this study, opportunities to capitalize on a higher calfhood deworming investment are much greater. While a lack of differences in the cow–calf portion of this study indicated little potential for improved returns for cow–calf production alone, improved immunocompetency and higher final BW of EPR calves may allow producers to realize a return on investment of the original treatment given preweaning.

While, on average, participating cooperator herds anecdotally noted returns on the added cost of extended-release eprinomectin, variability in market conditions over time will greatly impact economic outcomes for environments outside of the current study. Returns realized by implementing a value-added practice will be highly impacted

Table 7. Economic analysis and breakeven prices for feedlot animals treated with different anthelmintic treatments preweaning

	Treatment[1]		
$/steer[2]	DOR	EPR	Difference[2]
Total costs	$1,375.49	$1,369.18	$6.31
Income	$1,576	$1,596	$21
Profit	$200.11	$227.19	$27.08
Breakeven selling price, ($/kg)			
For variable costs	$2.43	$2.38	$0.05
For all costs	$2.49	$2.45	$0.04

[1]Treatment: DOR = doramectin (Dectomax; Zoetis Animal Health, Parsippany); EPR = eprinomectin (LongRange; Merial, Duluth, GA).

[2]Budget utilized from Iowa State University Extension and Outreach (Ag Decision Maker, B1-21). All market prices were average of actual market values obtained through Tri-County Steer Carcass Futurity (TCSCF) records.

by differences in cattle prices at key marketing times including weaning, backgrounding, or finishing. While retained ownership may increase price risk due to delayed marketing and potentially added price volatility, cow–calf producers have opportunities to mitigate some production risk through value added practices such as preventative health protocols that reduce performance variability (White et al., 2007).

CONCLUSION

To our knowledge, this is one of the two studies published to date that evaluates the effect of extended-release eprinomectin on cow–calf production and feedlot performance of progeny compared to a conventional, short duration anthelmintic. The results of this study show no difference in cow performance or reproductive success over the course of the grazing season. Likewise, there were no improvements in calf preweaning performance or feedlot performance. While carcass characteristics were largely unchanged due to treatment, there was an improvement in quality grade for EPR-treated calves. Improved immunocompetency via extended parasite protection during the preweaning phase may have had long-term impacts on feedlot morbidity resulting in improved quality grade measurements. This was evident by a lower percent of illness during the feeding phase, increased marbling score, a higher average quality grade, and a higher percent of EPR calves grading average choice or higher, presenting a chance to increased returns to producers by have more animals qualify for value-added programs.

It is important to note that FEC counts were very low in this study and may have provided very little opportunity for performance improvement following anthelmintic treatment in both treatment groups. Thus, more research is needed in populations carrying greater parasitic burdens to evaluate the effect of extended-release eprinomectin on cow–calf production.

Conflict of interest statement. The authors declare no conflict of interest.

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