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Growth and Reproductive Performance of Rangeland Beef-Cattle as Influenced by Controlled and Uncontrolled Populations of Horn Flies (Diptera: Muscidae)

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Abstract

A 4-yr study was conducted on native rangeland to assess the growth and reproductive performance of cows (*Bos taurus*) infested with naturally occurring seasonal populations of horn flies (*Haematobia irritans*). One hundred five Angus × Hereford cow-calf pairs were evaluated as a randomized complete block that was replicated across 4 yr. Cows were approximately 39 d postpartum at the beginning of each yearly trial and were randomly allocated to either an untreated control (UTC) or an insecticide-treated (TRT) herd. Horn fly populations were monitored throughout each yearly replication and blood serum progesterone levels were used to estimate postpartum interval lengths and days to pregnancy. Initial body weights of cows were collected in May with final body weights and calf weaning weights acquired in October of each year. Monthly horn fly control ranged from 85.55 to 99.57% throughout the 4 yr. Cows within UTC herds maintained on average 530.10 ± 94.74 more ($P = 0.0015$) flies per animal than TRT. However, no differences were detected between treatment groups for any of the reproductive parameters evaluated ($P > 0.05$). Despite a lack of difference in the reproductive parameters measured, TRT cows gained more ($P = 0.0492$) weight throughout the fly seasons when compared to UTC cattle. Furthermore, calves paired with insecticide-treated cows tended ($P = 0.0680$) to wean 16.28 ± 8.04 kg heavier than calves paired with cows exposed to naturally occurring horn fly populations.

Key words: *Haematobia irritans*, *Bos taurus*, postpartum, weaning, progesterone

Animal health is essential to maximizing rangeland animal performance. Ectoparasites pose a substantial threat to animal welfare and often jeopardize profit margins for producers. Previous research regarding the production impacts on cattle (*Bos taurus*) infested with horn flies (*Haematobia irritans*) has established this pest as one of the most influential ectoparasites of rangeland cattle (Byford et al. 1992). In fact, substantial monetary returns can be seen when successful control of this pest is achieved (Drummond 1981, Kunz et al. 1984, DeRouen et al. 2003). The economic impacts of the horn fly are typically observed as decreased growth performance of infested animals. For instance, it has been documented that growth performance of yearling steers and heifers is negatively impacted by the presence of horn flies (Kinzer et al. 1984, DeRouen et al. 2003). Furthermore, impaired growth performance of calves paired with horn fly-infested cows can be expected (Campbell 1976, Cocke et al. 1989). Despite clear evidence of loss through growth performance, the full extent of horn fly-induced stress effects on cattle has yet to be determined.

The performance responses of horn fly-infested cattle are economically impactful but other stressors have been shown to impact performance similarly. For example, both heat and nutritionally stressed yearling steers and calves gain less weight and wean lighter, respectively, when compared to their unstressed counterparts (Houghton et al. 1990, Blackshaw and Blackshaw 1994). Furthermore, heat-stressed cows produce less milk and consume less feed when compared to unstressed counterparts (Hahn et al. 1974, West 2003). In addition to the observed commonalities of responses observed in stressed cattle, alternative stress sources elicit a variety of reproductive consequences that have yet to be evaluated in horn fly-infested cattle.

Reproductive efficiency in rangeland cattle is arguably one of the most influential and economically important performance parameters and source of economic hardship for producers. Heat-stressed cattle exhibit longer postpartum intervals (PPI) and decreased conception rates when compared to unstressed cattle (Jordan 2003, Morton et al. 2007). Similarly, limited energy intake during the postpartum period lengthens PPI in rangeland cattle (Yavas and Walton 2000). Minimizing PPI and subsequent days to pregnancy (DPP) helps maximize reproductive performance in rangeland cattle leading to successful management programs and consistent producer returns.

Very little is known about the reproductive consequences associated with horn fly-induced stress. One study, despite significant weight gain advantages, observed no effects on first service conception rates of replacement heifers with and without horn fly stress (DeRouen et al. 2003). To our knowledge, the reproductive performance of mature rangeland cows in response to horn fly-induced stress has yet to be evaluated. Expanding our understanding of this parasitic interaction to specifically include the potential reproductive consequences associated with horn fly-induced stress on cattle is essential to properly develop and implement integrated pest management programs aimed at alleviating economic losses associated with this pest. Therefore, we hypothesized that horn fly infestations would extend cattle anestrous and negatively affect growth performance in both the cow and calf. The objectives of this study were to assess the postpartum responses of nursing rangeland beef cows to seasonal horn fly populations as measured by cow and calf growth performance, PPI, and days to pregnancy.

Materials and Methods

This study was conducted at the Corona Range and Livestock Research Center of New Mexico State University (CRLRC) from the months of May to October across 4 yr beginning in 2013. Animals were maintained in accordance with the standard operating procedures of CRLRC management and the university's Institutional Animal Care and Use Committee at NMSU (Approval #0229_001).

One hundred five (year 1 = 18; year 2 = 40; year 3 = 25; year 4 = 22) Angus × Hereford cow/calf pairs were stratified by postpartum status (PPS; days) at the initiation of each yearly trial using the previous calving date. Animals used on a yearly basis were subject to availability and considered independent from one another. Each year animals were equally and randomly allocated to one of two treatment groups; 1) untreated control (UTC) and 2) insecticide-treated (TRT) herd, with the exception of year 3 in which there were 12 and 13 animals assigned to the TRT and UTC, respectively. Untreated control animals remained insecticide-free throughout the duration of each year, while cows within the TRT group received insecticidal treatment at the initiation of each study year (May) and anytime horn fly populations rose above an average of 10 flies per animal. The insecticide treatment regimen for TRT cows included a commercially available insecticide impregnated ear tag (XP-820; 8% Abamectin, Y-Tex Corporation, Cody, WY) followed by commercially available pour-on (Brute Pour-on; 10% Permethrin, Y-Tex Corporation, Cody, WY) application when appropriate. Calves were not treated with insecticides and treatment herds were maintained in separate but similar pastures sharing a common fence line and a single water source. Animal groups were randomly assigned to pastures each year resulting in the East pasture holding UTC groups during 2013 and 2014 and the TRT group during 2015 and 2016.

Horn Fly Population Estimates

Horn fly population estimates were taken anytime animals were gathered for blood collection or weighing procedures. Therefore, weekly and twice-weekly horn fly population estimates were conducted on individual cows during the first three yearly trials and every other week during year 4. Individual population estimations were made using procedures similar to those described by Smythe et al. (2017). In brief, individual horn fly counts were estimated by enumerating horn flies on both sides of the animal from a distance of 1–3 m using a handheld tally counter. All counts were made between the hours of 10:00 and 12:00 h. Pretreatment horn fly counts were taken immediately prior to treatment application each year and are presented descriptively. Individual population estimates were averaged to represent mean herd populations within each group. Following individual fly counts, general population estimates on both herds were visually estimated to the nearest 100 flies on a subset of cows to ensure insecticide treatment regime described above was followed until weaning in October of each year (data not included). No control estimates were developed on general population estimations collected later in the fly season. Monthly horn fly control was estimated as the percent reduction in average horn fly counts obtained between TRT and UTC cows for each month in which individual population estimates were made.

Growth Performance Evaluations

Mature cows were weighed in May and October of each year to obtain initial and final body weights, respectively. Total weight gain throughout the course of each trial was calculated as the difference between final and initial weight and was used to develop average daily gain (ADG, kg) for each yearly replication. Duration of each yearly replication ranged from 151 to 153 d. Calves (64 females and 41 males) with UTC and TRT herds were 38.37 ± 1.20 and 39.31 ± 1.20 d old when trials were initiated, respectively. Consistent management and breeding practices employed by the CRLRC ensured similar calf attributes across both treatment groups. Calves were weighed once at weaning each year in mid-October. A total of five cows and two calves were not located during weighing procedures and subsequently excluded from analysis.

Reproductive Performance Evaluations

Weekly blood samples acquired during 2013 proved to be insufficient for determining PPI and DPP. Therefore, blood samples were collected twice-weekly during 2014 and 2015 via coccygeal venipuncture (Corvac Integrated Serum Separator Tube, Covidien, Minneapolis, MN). Samplings began in May and continued for a minimum of 8 wk. Blood samples were stored on ice for shipment to the laboratory where they were centrifuged at 1,850 × *g* for 30 min. Serum was decanted into 10 ml plastic freezer vials and stored at −25°C until assayed. Serum progesterone concentrations were assayed in duplicate using solid-phase RIA kits (Schneider and Hallford 1996). Intra- and inter-assay coefficient of variations were 7.5 and 4.9%, respectively.

The postpartum anestrous period was estimated to begin using the dam's previous calving date and end when blood serum progesterone (P4) concentrations were elevated above 1 ng/ml for two consecutive sampling periods. Days to pregnancy was estimated when serum P4 concentrations failed to fall below 1 ng/ml throughout blood sampling period. Calving dates were collected the following year and used to estimate calving intervals.

Statistical Analysis

Percent control was estimated for each month in which individual horn fly population estimates were taken and reported descriptively. Weekly horn fly counts were analyzed using the PROC MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC, 2014) to determine differences between treatment groups. Fixed effects corresponded to treatment while treatment within year, animal within treatment by year, and month within treatment by year were treated as random effects in the model. Residual effects with separate variance components were estimated for both treatment groups specific to year, animal within year, and month within year. Mean comparisons of fixed effects were conducted using least square means (LSM) test ($\alpha = 0.05$).

Growth and reproductive variables were analyzed as a randomized complete block design with subsampling where year was the blocking factor and the individual cow the subsampling unit using the PROC MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC, 2014). Fixed effects corresponded to treatment and year main effects with a random effect corresponding to treatment by year. One-tail tests were used to compare differences between treatment groups based on our original hypothesis. Treatment effects were considered to be significant when $P \leq 0.05$ and tendencies were discussed when $P \leq 0.10$.

Results

Horn Fly Population Estimates

Insecticidal horn fly control was successful and reduced ($F_{1,6} = 30.11$, $P = 0.0015$) TRT populations throughout the four trial years (Table 1). Pretreatment horn fly population estimates in 2013, 2014, and 2016 were below the recommended economic threshold of 200 flies per animal (Schreiber et al. 1987). In 2015, pretreatment horn fly population estimates were on average 481.58 flies per cow.

Table 1. Average horn fly populations and percent control across a 3-yr study conducted at the Corona Range and Livestock Research Center in New Mexico

	Population estimates (SEM)[a]		
	UTC	TRT	Percent control[b]
2013			
May	131.88 (12.88)	3.89 (0.87)	97.05
June	211.29 (22.39)	30.54 (7.02)	85.55
2014			
May	224.79 (19.81)	19.80 (3.98)	91.19
June	881.95 (20.67)	6.17 (0.98)	99.30
July	744.85 (18.04)	3.98 (0.53)	99.46
Aug.	529.25 (13.10)	2.27 (0.44)	99.57
2015			
May	446.54 (24.08)	5.80 (0.64)	98.70
June	528.67 (14.17)	5.76 (0.37)	98.91
July	607.02 (18.36)	6.04 (0.68)	99.00
Aug.	624.51 (18.06)	6.59 (0.52)	98.94
Sept.	645.38 (22.41)	4.92 (0.98)	99.24
2016			
May	442.27 (40.16)	7.91 (1.59)	98.21
June	426.76 (43.47)	38.48 (13.23)	90.98
July	672.13 (49.33)	3.20 (0.85)	99.52
Aug.	1033.00 (85.52)	8.04 (1.04)	99.22
Sept.	814.68 (49.05)	8.09 (0.91)	99.01
Total[c]	530.10 (94.74)[a]	10.00 (2.55)[b]	97.93

[a]Data presented as raw means and respective SEMs of horn fly population estimations taken from two herds; UTC = untreated control herd; TRT = insecticide-treated herd.

[b]Percent control is calculated as the percent reduction in TRT fly populations as compared to UTC populations.

[c]Letters compare treatment groups within rows; model-based estimates followed by the same letter are not significantly different ($F_{1,6} = 30.11$, $P = 0.0015$).

The percent control of horn flies following insecticidal application ranged between 85.55 and 99.57% between the months of May and September. Visual herd estimates following individual counts on UTC herds indicated populations gradually declined until late September while TRT populations were maintained well below the economic threshold. No population estimates in October of any year were above 100 flies per cow.

Growth Performance Evaluations

Initial body weights of cows differed ($F_{3,3} = 9.26$, $P = 0.0501$) between year regardless of treatment assignment. Initial body weights of cows participating in 2015 maintained a numerical advantage of 80.31 ± 16.48, 54.81 ± 13.66, and 56.52 ± 15.99 kg, when compared to cows used in 2013, 2014, and 2016, respectively (Table 2). Initial body weights with regard to treatment assignment across all four yearly trials for UTC and TRT cows were similar ($F_{1,3} = 1.25$, $P = 0.3445$) averaging 459.61 and 471.43 kg, respectively (Table 2).

Final body weights for cows from the TRT herd were 27.66 ± 12.08 kg heavier ($F_{1,3} = 5.24$, $P = 0.0530$) when compared to UTC cows. In fact, TRT cows gained 15.44 ± 6.51 kg more than UTC counterparts across all years ($F_{1,3} = 5.63$, $P = 0.0492$; Table 3). Additionally, year effects ($F_{3,3} = 37.02$, $P = 0.0072$) were observed for weight gain. On a yearly basis, raw data average weight gains were consistently and numerically higher for TRT cows in comparison to UTC cows. However, cows gained numerically less weight during 2015 than any other trial years regardless of treatment assignment by a range of 53.41 ± 8.55 to 72.51 ± 7.04 kg (Table 2).

Calf weaning weights tended to vary ($F_{1,3} = 6.59$, $P = 0.0779$) between years with the lowest and highest average weights of

Table 2. Average initial weights and weight gain of cows with weaning weights of calves for untreated and insecticide-treated animal herds for each yearly trial

	UTC[a]	TRT[a]	
Variable[b]	Mean (SEM)	Mean (SEM)	Average (SEM)[c]
Initial weight (kg)			
2013	441.92 (14.89)	424.75 (16.21)	433.33 (12.57)b
2014	451.48 (15.96)	465.57 (12.72)	458.55 (8.54)b
2015	502.76 (12.06)	524.36 (12.90)	513.36 (10.67)a
2016	446.18 (11.14)	467.50 (18.69)	456.84 (11.92)b
P-value			0.0501
Weight gain (kg)			
2013	69.03 (10.23)	85.35 (7.93)	77.37 (6.59)b
2014	87.92 (8.72)	107.11 (9.41)	96.47 (4.47)a
2015	15.49 (6.96)	32.68 (9.74)	23.95 (5.44)c
2016	79.04 (6.25)	83.64 (9.15)	81.49 (6.24)b
P-value			0.0072
Weaning weight (kg)			
2013	205.55 (14.30)	211.06 (6.71)	208.31 (8.80)b
2014	245.11 (5.59)	270.11 (6.36)	257.61 (7.13)a
2015	236.01 (8.19)	234.66 (8.17)	235.53 (8.00)a
2016	230.58 (11.38)	264.65 (7.38)	247.08 (8.54)a
P-value			0.0779

[a]Data presented as raw means and respective SEMs; UTC = untreated control herd; TRT = insecticide-treated herd.

[b]Initial weights of cattle acquired in May of each study year; weight gain was calculated as final body weight minus initial body weights; final body weights and weaning weights taken in October of each year.

[c]Letters compare yearly averages within columns for each variable; model-based estimates and respective SEMs followed by the same letter are not significantly different (LSM; $\alpha = 0.05$, $F_{3,3}$).

Table 3. Average weights and reproductive variables of cows with weaning weights of calves for untreated and insecticide-treated animal herds

	Weight (SEM)[a]		
Variable[b]	UTC	TRT	P-value[c]
Final weight (kg)	524.24 (8.73)	552.08 (8.79)	0.0530
Weight gain (kg)	62.40 (4.72)	77.83 (4.73)	0.0492
Weaning weight (kg)	228.99 (5.66)	245.27 (5.78)	0.0680
Postpartum interval (d)	69.13 (3.57)	66.41 (3.57)	0.3425
Days to pregnancy (d)	76.20 (1.63)	74.16 (1.61)	0.2635
Calving interval (d)	352.37 (2.92)	354.80 (2.95)	0.3070

[a]Data are presented as mixed model estimates and respective SEMs within treatment groups; UTC = untreated control herd, TRT = insecticide-treated herd.

[b]Multiple variables were assessed; mature animal final weights and weight gain, along with weaning weights of calves all reported in kilograms.

[c]Comparisons were made between treatment groups for each weight variable (one-tail; LSM $\alpha = 0.05$; $F_{1,3}$), postpartum interval and days to pregnancy (one-tail; LSM $\alpha = 0.05$; $F_{1,1}$), and calving interval (one-tail; LSM $\alpha = 0.05$; $F_{1,2}$).

208.31 ± 8.80 to 257.61 ± 7.13 kg being observed during 2013 and 2014, respectively (Table 2). Regardless of year effects, calves paired with insecticide-treated cows tended ($F_{1,3} = 4.10$, $P = 0.0680$) to wean heavier than calves paired with UTC cows by 16.28 ± 8.04 kg (Table 3). Most notably, an average numerical advantage of 25.00 and 34.07 kg in favor of TRT paired calves was observed during 2014 and 2016, respectively.

Reproductive Performance Evaluations

Pregnancy rates for UTC and TRT cows were 88.1 and 87.8%, respectively. Progesterone concentrations failed to exceed 1 ng/ml for weekly blood samples collected in 2013 and as such, were insufficient for PPI and DPP estimations limited data collection in the present study. However, no differences of model-based estimates for PPI ($F_{1,1} = 0.61$, $P = 0.5787$) or DPP ($F_{1,1} = 0.18$, $P = 0.7453$) between treatment groups were observed during 2014 and 2015. Similarly, calving interval was not affected ($F_{1,2} = 0.31$, $P = 0.6328$) by treatment which averaged 352.64 and 354.52 d for UTC and TRT, respectively (Table 3).

Discussion

Horn fly control efforts specific to the TRT animal herds were highly effective as indicated by the percent reduction from UTC horn fly estimates. The substantial control observed in this study was expected as the insecticide treatment regime was highly aggressive. Naturally occurring horn fly populations appeared to be minimal in mid-May during 2013, 2014, and 2016. However, pretreatment horn fly population estimates in May 2015 were well above the established economic threshold of 200 flies per cow (Schrieber et al. 1987). Conversely, individual- and herd-based populations in 2013 minimally exceeded the economic threshold throughout the entire fly season. Inconsistent fly populations from year to year may be the product of multiple environmental factors such as temperature and humidity fluctuations that can affect horn fly population growth and expansion (Lysyk 1992).

Traditionally, field-based assessments of product efficacy against horn flies utilize spatial separation of the animal herds in question within a given fly season to avoid product carryover and unintended control. Our treatment groups shared a common fence line with untreated counterparts and treated animals received the same insecticide treatment regime from year to year. No indication of product carryover was observed as supported by UTC population estimates and associated percent control calculations. However, numerical fluctuations in UTC populations were observed across and within yearly trials (Table 1). Assessing environmental influences as they relate to population expansion or reduction throughout the fly season was not an objective in the current study. However, further detailing the environmental influences of desert rangeland scenarios to help explain New Mexico horn fly population dynamics would be warranted.

Calf growth performance observed in this study coincides with previously reported impacts of horn flies on rangeland calves (Campbell 1976; Cocke et al. 1989). Direct inferences on decreases in milk production in response to horn fly infestations have been criticized for inappropriate methodologies and study designs (Jonsson and Mayer 1999). More indirect inferences, specifically nursing calf growth performance, have been attributed to decreased milk production of dams infested with horn flies (Campbell 1976). More information regarding the cow-calf interaction under horn fly-induced stress along with more direct measurements of milk production under these scenarios would be needed to understand the effects of horn fly-induced stress on milk production in grazing cattle.

In general, mature cow body weight changes as a result of horn fly-induced stress have garnered much less attention than the more monetarily valuable weaning weights of calves. In the present study, differences were observed between treatments regarding weight gain of mature cows. However, a strong year effect was present most likely due to high starting weights of cows used in 2015. Subsequently, weight gains for this year were relatively limited. Despite limited growth observed during 2015, ADG of TRT cows throughout the 4-yr trail was 0.11 kg greater than UTC cows. Comparatively, ADG advantages of 0.16 kg by yearling steers in New Mexico have been reported (Kinzer et al. 1984). Weight gain in younger more rapidly growing animals can be expected and therefore more profound weight gain effects may be observed during horn fly-induced stress. This may help explain the differences in weight gains observed between these two studies. Regardless, increases in mature body weight gains during the late postpartum and early gestational periods, which coincides with the natural horn fly seasons observed in this study, may hold some biological significance and insight on how offspring performance is affected due to maternal exposure of horn flies particularly in spring calving systems.

It should be noted that inconsistencies between trial years were observed for multiple variables. For instance, high initial body weights of cows during the 2015 trial provided little room for mature body growth and most likely accounted for the low weight gains of these animals during the same year. Furthermore, weaning weight advantages differed numerically from year to year. Nevertheless, in all years TRT calves outperformed UTC calves specific to weaning weight. It is plausible that the low horn fly populations observed throughout 2013 accounted for relatively marginal weaning weight advantages during the same year. However, the discrepancy observed in 2015 is harder to explain. Initial body weights of cows during 2015 would indicate increased nutritional status of the animals which may have facilitated higher milk production and availability to calves irrespective of horn fly stress (Buckley et al. 2003). Similarly, one study in Florida suggested that ample forage availability may have offset expected decreases in weight gain of cattle despite maintaining horn fly populations above the economic threshold (Hogsette et al. 1991). Future research regarding the effects of horn flies across varying nutritional statuses of cows is warranted.

Our results would indicate that the presence of horn flies has no impact on PPI or DPP for rangeland cows in New Mexico. This is supported with observed yearly calving intervals which produced no statistical differences between treatment groups. However, problems with once weekly sampling protocols used in identifying PPI and DPP through blood serum progesterone during 2013 limited data collection and subsequent inferences specific to these variables. Improved blood sampling protocols similar to those used during 2014 and 2015 are encouraged for future assessments of reproductive impacts associated with horn fly-infested cows.

Cows maintaining a favorable prepartum body condition, indicative of sufficient gestational nutrient availability, may negate potential increases in postpartum anestrous lengths despite low nutrient availability during the postpartum period (Yavas and Walton 2000). Cows in this study were all in moderate body condition (body condition score ≥ 4; 1 to 9 scale) during treatment assignment and study initiation. Irregular summer and winter precipitation (>22 cm/yr) may have provided ample forage growth and subsequently favorable body conditions of mature cows included in this study. More research concerning the postpartum and early gestational effects of horn fly-infested cows under more restrictive diets is needed.

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