Reducing Tick Populations Through Prescribed Burning

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Abstract
Ticks are one of the most important obligatory blood-feeding ectoparasites of livestock and humans. High tick burdens on cattle can result in decreased production, anemia, skin irritations, pruritus, and stress. In addition, ticks can transmit a wide variety of pathogens such as bacteria, protozoa, and parasites, which cause diseases in animals and humans. Tick control is difficult to achieve because a large proportion of the pest's life is spent off the animal host. Prescribed burning of grasslands has been suggested as a potential method to reduce tick abundance; however, the efficacy of prescribed burning as a mechanism for tick control in the Flint Hills is unknown. This study aimed to explore the effect of seasonal prescribed burning on the tick population in the Kansas Flint Hills. Ticks were collected from three pastures of each prescribed burn treatment: spring (April), summer (August), or fall (September), and non-burned pasture as a control treatment. All areas were burned annually for four years and grazed at an equal stocking density. Ticks were collected every other week from March to August using cloth dragging and baiting with dry ice. Ticks were identified morphologically utilizing a microscope and published keys of tick anatomy. Fewer ticks ($P < 0.0001$) were collected from fire-treated areas compared to unburned areas. Additionally, the season of the burn can potentially further impact tick populations with lower tick populations ($P = 0.0403$) observed in spring burned versus fall burned areas. The results of this study suggest that annual burning of grazing areas could be an effective method to effectively reduce tick abundance in cattle pastures.

Introduction
Worldwide, 80% of the cattle population is infected or at risk of tick-borne pathogens (Rochlin and Toledo, 2020; De Castro et al., 1997). In the U.S., ticks on livestock can cause devastating economic losses. According to the U.S. Department of Agriculture, the economic impact from an extended tick outbreak could be more than $1.2 billion, including control costs. Tick control has largely relied on the use of on-animal acaricides; however, chemical control has significant deleterious effects, including the generation of pesticide resistance, high levels of mammalian and environmental toxicity, and the killing of non-target organisms (Polito et al., 2013; De la Fuente et al., 2007). Alternative effective non-chemical methods for tick control are urgently needed. Prescribed burning of grazing areas has been suggested as an alternative method of tick control (Polito et al., 2013; Davidson et al., 1994). Long-term fire treatment can also significantly reduce tick abundance and could impact tick-borne pathogen prevalence (Gleim et al., 2019).

The efficacy of prescribed burning for tick control in different management systems and geographic regions needs to be further evaluated. Importantly, in areas where prescribed burning is already undertaken for other ecosystem benefits such as weed suppression and grass improvement, the season of burn becomes important. This study explored the effect of prescribed burning on the tick populations on native warm season grassland in the Kansas Flint Hills.

Experimental Procedures

This research project was conducted in the Kansas State University Beef Stocker Unit located west of Manhattan, KS. The grazing area was divided into 18 pastures with six pastures assigned to either a spring, summer, or fall burn. All pastures had been burned for four consecutive years (Figure 1). Spring pastures were burned in April, summer in August, and fall in September. Cattle were grazed between May and August and stocked at equal density. Three pastures in each burn treatment were selected for tick sampling and unburned sections that had not received any fire treatment. Ticks were collected every other week beginning in April and ending in August.

On every tick sampling day, humidity and temperature values were measured using a digital thermometer. Tick collections were performed each day between 8:30 a.m. to 12:00 p.m. Permanent sampling locations were selected to reduce microhabitat variation as a sampling bias. Drag and dry ice bait sampling methods were used to collect ticks in all life stages. For drag sampling procedures, flannel cloths measuring 39.4 × 39.4-in were pinned to a 47.24-in long, 1-in diameter wooden dowel on one side. The dowel was then tied at each end to approximately 59 inches of twine. The fabric flag was dragged as close to the ground as the vegetation would allow. The cloth was dragged over a 50 × 50 ft^2 area using a single pass. All ticks were removed from the fabric and stored in secured tubes. After dragging, dry ice (2.5 lb) was placed on a 39.4 × 39.4-in flannel cloth and left to sublime for 1 hour (Barré et al., 1997; Koch and McNew, 1981; Petry et al., 2010; Zimmerman et al., 1987) in the corner of the square close to trees for approximately an hour. Any ticks collected from the fabric, along with ticks collected from dragging, were stored at -4°F for a minimum of 24 hours to kill ticks. Ticks were counted and identified to species and life stage using microscopically identifiable features. All ticks were identified morphologically utilizing a microscope and published keys. Specimens were stored in microcentrifuge tubes at -4°F.

One-way ANOVA and Tukey's HSD post hoc comparison tests were performed on the number of ticks collected from each treatment area with a significance level of 0.05 ($P < 0.05$). Statistical analyses and plots were generated using GraphPad Prims (GraphPad Software, San Diego, CA).

Results and Discussion

A total of 341 adult ticks, 1,392 nymph ticks, and 234 larva ticks were collected from all study areas (Table 1). Three different tick species were identified: the lone star tick (*Amblyomma americanum*), the American dog tick (*Dermacentor variabilis*), and the Gulf Coast tick (*Amblyomma maculatum*). Lone star ticks are widely distributed across the eastern U.S. from central Texas, Oklahoma, and Kansas, and along the Atlantic coast north to Maine (Raghavan et al., 2019; Centers for Disease Control and Prevention, 2019). The American dog ticks display a broad distribution across the central and eastern U.S. and can also be found in regions of California (Centers for Disease

Control and Prevention, 2019; Boorgula et al., 2020). Gulf Coast ticks are mostly found in the southern states such as southeast Kansas and Oklahoma (Centers for Disease Control and Prevention, 2019). Cumulatively, these ticks can transmit pathogens such as *Rickettsia* spp., *Ehrlichia* spp., *Francisella tularensis*, *Anaplasma marginale*, Bourbon virus, and Heartland virus that affect animals and humans (Hecht et al., 2019; Guizzo et al., 2022; Higuita et al., 2021). In states where these ticks predominate as significant vectors of human and animal pathogens, tick control methods are important in reducing the economic losses in beef production sectors.

In this study, ticks were collected from three individual pastures in each treatment group to form three biological replicates. There was no difference among the three pastures burned in spring ($P = 0.4133$) or fall ($P > 0.05$); however, ticks counts in three pastures burned in summer were different ($P = 0.0038$) from each other with one pasture supporting higher tick populations. This was likely due to the vegetation composition in the outlier, which had more wooded areas that are associated with increased presence of ticks. Characteristics observed in wooded habitats including higher humidity, less direct sunlight, and more vertebrate diversity promote tick survival, compared to prairie habitats with lesser woody plant populations (Polito et al., 2013; Bourdin et al., 2023).

Fewer ticks ($P < 0.0001$) were collected from fire-treated areas compared to non-burned control areas during the five months of sampling (Figure 2A). Studies suggest that the reduction of leaf litter cover in post-burned pastures reduces tick abundance (Gallagher et al., 2022; Allan, 2009). The decrease in plant litter may translate to lower soil temperature affecting the survival of ticks over winter (Gallagher et al., 2022). Fire treatment can also reduce environmental humidity and induce high temperatures which cause tick desiccation during dry periods (Gallagher et al., 2022). Together, changes in abiotic and biotic elements caused by prescribed burns, with direct killing of ticks, reduces tick populations.

Among seasonally burned areas, tick counts in fall pastures were higher ($P = 0.0403$) than summer and spring pastures, indicating that the time when fire was performed has an effect on the number of ticks (Figure 2B). The abundance of tick species was lower ($P = 0.0331$) in spring fire treatment areas compared to fall fire treatment. According to a study from areas in Missouri (Bouzek et al., 2013), the *A. americanum* life cycle takes a minimum of two years to complete. Overwintering adults and nymphs emerge in early March (spring), adults start laying eggs in late April, nymphal activity is observed from April to September, while larval activity begins in July until October. When correlating our population counts with the life cycle of *A. americanum*, spring-prescribed burning may be most effective for tick control because ticks are still undergoing overwintering stages and are within leaf litter and relatively immobile. In contrast, the tick counts were higher in summer and fall burned pastures because nymph and larvae stages feeding on small mammals can escape from fire effects. Strategically timing the prescribed fires to align with conditions that specifically target certain tick species at vulnerable periods during their life cycle is important to maximize the effects of prescribed burning for tick control.

Implications

Over time, annual burning of grazing areas can significantly reduce tick populations especially if burned in spring (April) and burning can offer an effective method for non-chemical tick control. Special attention needs to be paid to wooded areas as these areas act as refuges for ticks.

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Table 1. Number of *Amblyomma americanum*, *Dermacentor variabilis,* and *Amblyomma maculatum* ticks found following prescribed fire season and identified by life stages

	Number of larvae		Number of nymphs		Number of adults		
Prescribed fire season	*A. americanum*	*D. variabilis*	*A. americanum*	*D. variabilis*	*A. americanum*	*D. variabilis*	*A. maculatum*
Spring	0	0	4	0	2	1	0
Summer	0	0	33	0	27	1	0
Fall	0	0	86	0	26	4	1
Unburned	234	0	1269	0	245	35	1

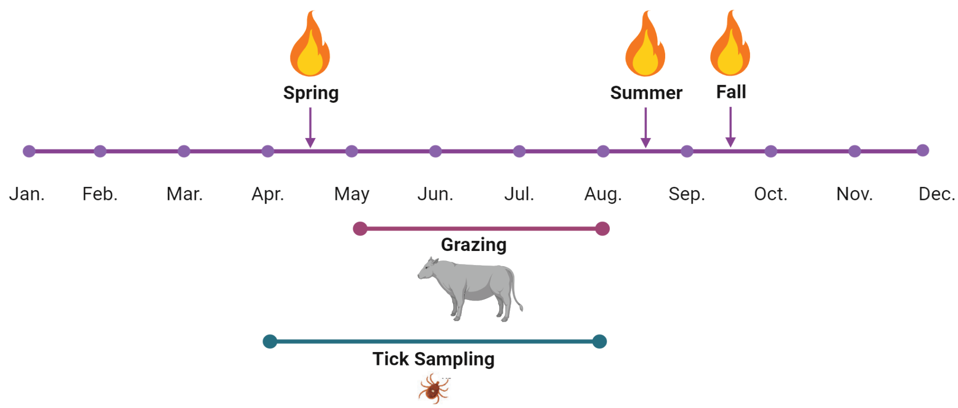

Figure 1. Schematic timeline of prescribed fire timing, cattle grazing period, and tick collection.

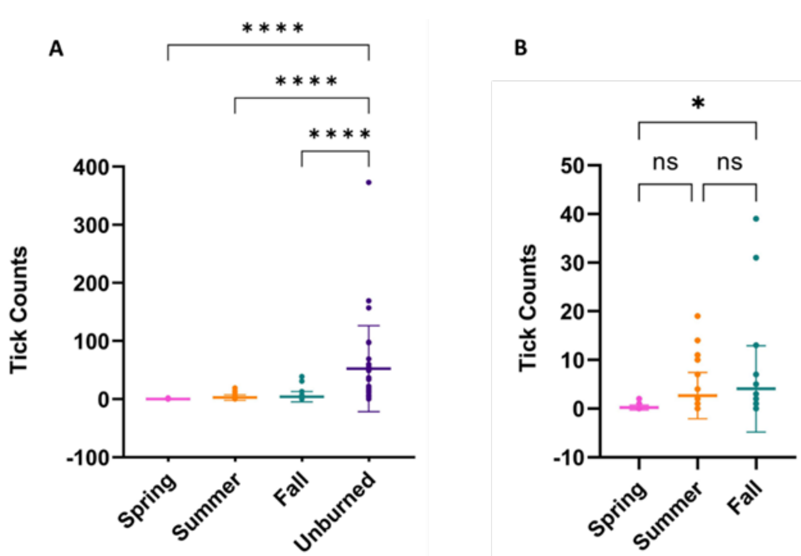

Figure 2. Effects of prescribed fire season treatments (spring, summer, fall, and unburned control) on tick counts.

A) Comparison between ticks collected from prescribed burned and unburned areas from each collection event. B) Comparison between the seasonal time of prescribed burn with relation to tick counts. Each dot represents the total number of ticks collected on each sampling day.

*$P < 0.05$. ****$P < 0.0001$. ns = not significant. Error bars show standard deviation.