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Abstract

Dung beetles (*Scarabaeinae*) provide essential services which promote the health and productivity of grasslands across the globe. The beetles move manure and dig tunnels, activities which improve soil drainage, aeration, and nutrient distribution.. In addition, dung beetles can also assist in managing insect pest species such as flies. Studies evaluating the effect of fire on dung beetle communities show mixed results and are often dependent on the geographic location of the study and the species of beetles present. This study aimed to determine if the season of prescribed burning impacted dung beetle communities on pastures grazed by cattle in the Flint Hills.

Introduction

True dung beetles are a family of specialized beetles which feed on manure and use it for larval rearing. Through the tunnels they excavate and the redistribution of manure into the tunnels, dung beetles improve soil drainage, aeration, and nutrient distribution (Nichols et al., 2008). In addition, dung beetles can also assist in managing insect pest species like face and horn flies (*Musca autumnalis* and *Haematobia irritans irritans* (Linnaeus), respectively). Both fly species require fresh intact bovine manure for larval development and studies have shown that dung beetles can reduce fly populations by 74% (Nichols et al., 2008). Horn flies are obligate blood feeding ectoparasites which cause significant stress in animals and production losses (Brewer et al., 2021). With increasing levels of pesticide resistance in multiple fly species in Kansas, non-pesticidal biological control options such as dung beetles can reduce selective pressure on fly populations by reducing the need for pesticide use. Three functional types of dung beetles (known as guilds) fill different niches in the ecosystem. Rollers build a compact ball of manure (brood balls), and roll it away from beetle competition at the manure pat. Tunnelers excavate soil below and adjacent to manure and bury it in the tunnels. The remnants of tunnelers can often be seen underneath a manure pat where small tunnels extend below the ground surface. Rollers and tunnelers are considered the most effective manure distributors (Nervo et al., 2014; Menéndez et al., 2016). Dwellers remain within the manure pat itself and larval development also occurs within the pat instead of in a brood ball below ground.

Prescribed burning is a practice used by many producers in the Great Plains involving the intentional burning of grassland to remove unwanted weeds and allowing the native

grasses to grow back healthier (Prescribed Burning, 1999). The effect of burning on arthropod communities is often overlooked despite their major role in maintenance of healthy prairie landscapes. Studies evaluating the effect of fire on dung beetles often produces conflicting data. In the Mediterranean, dung beetle abundance (how many beetles are present) can be negatively affected by fire, but species diversity (which species are present) generally is not affected by burning (Palusci et al., 2021). In Brazil, rain forest beetles were negatively affected by fire (França et al., 2020) but not savannah (Nunes et al., 2019) and it is possible that dung beetles in fire-adapted landscapes are more tolerant of the effects of fire. A study conducted in Texas representing the Southern Great Plains showed no effect of burning on dung beetle populations (Smith et al., 2019). The Texas study carried out beetle collection one month after spring burning in March, so the effects of burning may not have been fully captured due to naturally occurring seasonal variation in species.

Like most insects, dung beetles undergo a dormant period over the winter and a reproductive period occurring during warmer months. Burning when beetles are most active could significantly impact beetle populations and should therefore be avoided. Populations of ticks and insects exist together in complex ecosystems. Fire treatment of Flint Hills warm season grassland significantly reduced the tick populations and should be considered as a method of reducing tick burdens without the need for pesticides. Spring burning was shown to reduce tick populations most effectively in our recent study (Salazar et al., 2024) and if tick control is a priority, spring burning should be performed. However, the effect of burn season on dung beetle populations is unknown. As dung beetles aid in horn fly control, without knowing seasonal burn effects on beetles, selecting spring burning for tick control could potentially negatively impact beetle populations. This study aimed to determine if the season of prescribed burning impacted dung beetle abundance on native warm season grassland in the Flint Hills

Experimental Procedures

This study was carried out over the 2023 grazing season from May 8 until August 15 at the Kansas State University Beef Stocker Unit. The facility has 1,120 acres divided into 18 pastures. Pastures were blocked with six pastures each burned in the spring (April), summer (August), and fall (October). Pastures have been burned annually for four consecutive years. Over the study period, pastures were grazed at an equal stocking density (246 lb/acre) ensuring equal availability of manure resources for beetles in each burn treatment area.

Dung beetle traps were set in three pastures from each burn treatment group and sampled biweekly from June 8 to August 15 resulting in a total of six trapping dates. One pitfall trap was placed in each pasture and traps placed a sufficient distance apart to not cause competition. Areas for trap deployment were selected to ensure similar topography, elevation, and overall vegetation structure. Dung beetles can fly long distances to search for manure (Smith et al., 2019), but we did not expect much travel between the pastures because manure supply was adequate.

Pitfall traps were constructed from clear 16-oz plastic drinking cups. Each trap was constructed using two cups with the outer cup containing a drainage hole drilled into the bottom. Matching holes were drilled on the sides of both cups to allow any rain-water to escape from the inside cup and prevent the trap from overflowing. Holes were

dug in the ground deep enough for the stacked cups to be flush with the ground surface to allow beetles to crawl into the cup. Traps were baited with a 2.5 oz ball of swine manure wrapped in cheesecloth and attached to the inner cup rim with a binder clip. Swine manure is very attractive to dung beetles and provides a stronger attractant than any cattle manure in the surrounding area. Cups contained 3.4 oz. of water, 1 teaspoon of salt, and a drop of unscented dish soap to break the water surface tension. A visible post with a bright-colored ribbon was placed directly next to the trap for relocation. Traps were baited in the morning, and allowed to collect beetles for 24 hours, after which they were collected. Collected beetles were cleaned with water and identified using entomological dichotomous keys. Where possible, specimens were identified to the species but in some cases, genus level identifications were made.

The number of beetles collected from each burn treatment group were compared by one-way ANOVA and Tukey's HSD post hoc comparison tests. A collection point was considered to be different from the others if $P < 0.05$. All tests were performed using GraphPad Prism (Version 10 for Windows, GraphPad Software, Boston, MA). Weather data were retrieved from Kansas Mesonet Systems provided by Kansas State University.

Results and Discussion

A total number of 8,646 beetles were collected from nine traps representing at least eight *Scarabaeinae* species (Table 1). *Onthophagus* beetles were identified to the genus level, as some of the identifying characteristics were lost through sample degradation. Some Hister beetles were collected ($n = 313$) and although these are dung-associated dwelling beetles, they are not members of the *Scarabaeinae* family and were not included in the analysis. *Onthophagus* beetles were the most abundant species collected from all three burn treatment areas, representing over 85% of beetles caught. Although the most numerous, these beetles are also the smallest and not the most effective at manure removal compared to the other larger beetles (Nichols et al., 2018).

The largest numbers of beetles were collected from fall burned pastures (Figure 1) although this is due to the high number of *Onthophagus* beetles. Peak beetle numbers were found two weeks earlier following burning in spring pastures than in fall and summer. Critically, larger beetles from the roller and tunneler guilds were not different ($P > 0.05$) between spring, summer, or fall burned pastures. Season of fire treatment did not significantly impact the number of beetles or dung beetle species collected and choice of burn time can be made on other grounds without impacting beneficial beetles. Interestingly, there was a trend of more beetles being caught on days where the average precipitation for the preceding five days was higher (Figure 2). Further research should be carried out to determine the impact of abiotic climate conditions on dung beetle activity.

Implications

Burning in spring, summer, or fall did not impact dung beetle populations collected on native Flint Hills pasture. Time of burn can be chosen based on other desired outcomes without impacting the size of dung beetle populations.

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Table 1. Number of dung beetles¹ collected from three pastures from each spring, summer, or fall burn treatment group

Species	Summer		Spring		Fall		Guild
	Average	SD ²	Average	SD	Average	SD	
<i>Canthon chalcites</i>	23.8	5.8	22.9	5.8	17.2.0	4.3	Roller
<i>Canthon viridis</i>	1.0	0.0	1.0	0.0	1.0	0.0	Roller
<i>Copris fricator</i>	9.0	6.0	1.7	0.6	3.0	1.0	Tunneler
<i>Dichotomius carolinus</i>	1.7	0.3	1.0	0.0	2.0	0.3	Roller
<i>Melanocanthon nigricornis</i>	6.0	0.0	2.0	0.0	1.0	0.0	Roller
<i>Onthophagus spp.</i>	90.0	40.0	129.0	40.0	168.0	38.0	Tunneler
<i>Phanaeus triangularis</i>	2.0	1.0	1.0	0.0	1.2	1.0	Roller
<i>Phanaeus vindex</i>	2.5	0.5	2.2	0.6	1.6	0.3	Roller
<i>Pseudocanthon perplexus</i>	0.0	0.0	1.0	0.0	0.0	0.0	Roller

¹ Average caught in each trap.

² Standard deviation.

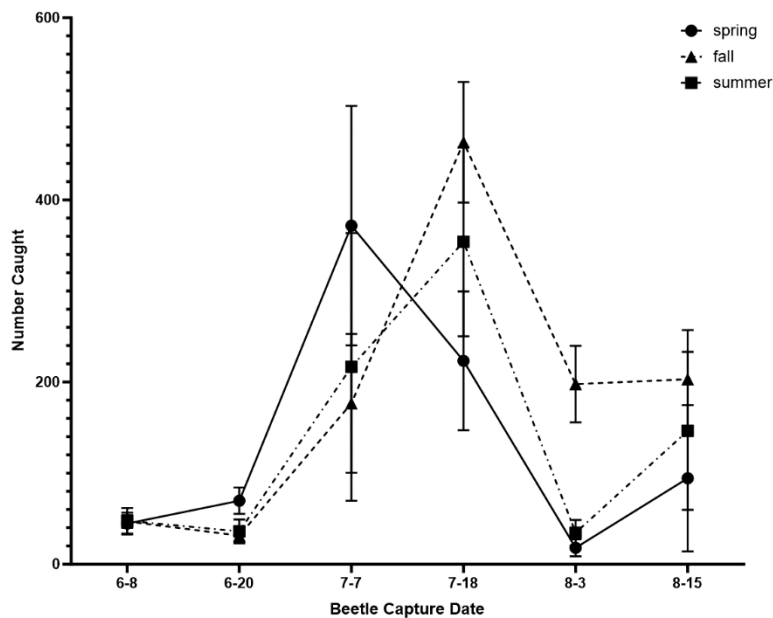


Figure 1. Average number of dung beetles caught on each sampling date with no differences ($P > 0.05$) between spring, summer, or fall treatments.

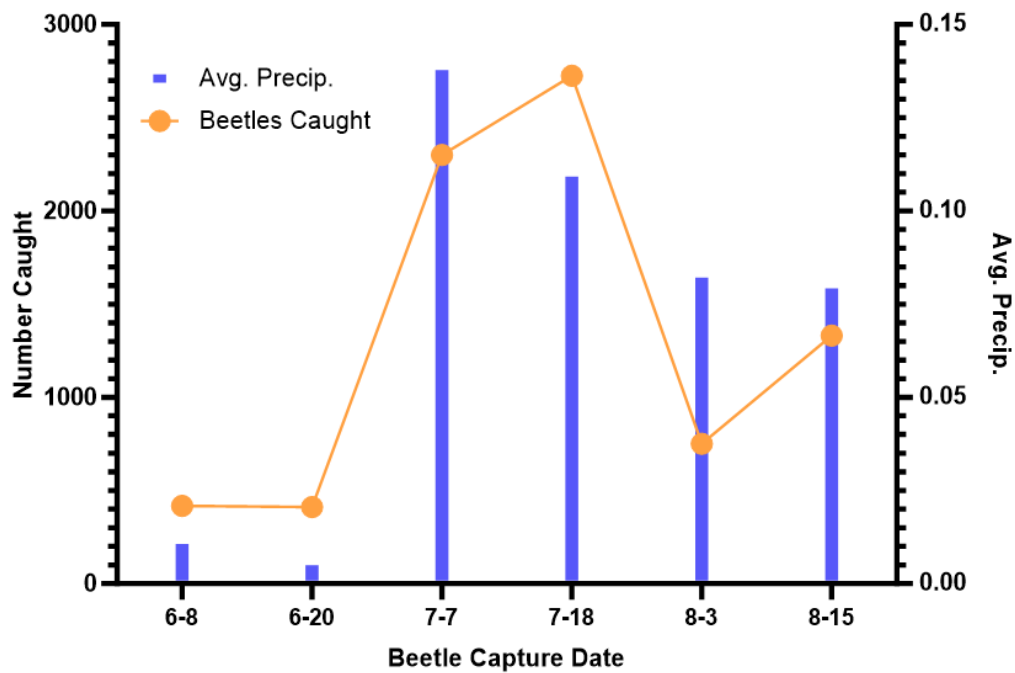


Figure 2. Average precipitation the week prior to beetle collection potentially influences the number of beetles caught.