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Impact of Grasshopper Control on Forage Quality and Availability in Western Nebraska

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On the Ground

- Grasshopper outbreaks in Nebraska have resulted in losses over $2 million per year due to lost forage for livestock. As much as 23% of western U.S. forage is consumed by grasshoppers annually.
- Controlling grasshoppers reduced grasshopper numbers without negatively impacting beneficial insects.
- In 2011, 29 more 318 kg steers could have grazed a 1000 hectare pasture for a 5 month growing season due to grasshopper suppression. In 2012 (a drought year), 54 more steers could have been grazed if grasshoppers were controlled. Grasshopper infestation can result in significant reduction in livestock grazing capacity especially in dry conditions.

Keywords: grasshoppers, AUMs, insecticide, cattle, grazing.

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More than 100 species of grasshoppers have been documented in Nebraska.[1] Roughly 10 of these species are considered “outbreak species” that periodically cause substantial losses to planted forages and rangelands in western Nebraska. The western two-thirds of Nebraska are largely pasture and rangeland, mainly due to low annual precipitation and highly erodible topography. As a result, this region is predominately devoted to cattle production. Additionally, many acres of marginal crop ground in the Nebraska Panhandle have been converted to introduced, cool season forage pastures to increase the amount of forage available for cattle. In recent years, grasshoppers have been a major agricultural pest within this region of Nebraska. Grasshopper outbreaks in Nebraska have resulted in losses of over $2 million per year as a result of lost forage for livestock.[2] Grasshoppers have been reported to consume 1.25 to 2.5 times more forge than mammalian herbivores in areas of the Great Plains[3] making them a serious threat for cattle production on forage in the western United States. Grasshopper infestation has a more negative impact when it occurs along with drought. The value of grass increases when less is available for livestock grazing and controlling pests becomes a bigger issue. Determining whether to employ a method of controlling grasshopper infestation is dependent upon the economic threshold, which can be a moving target. The price of cattle, the price of grass lease, and the price of grasshopper control all impact the economic threshold. As much as 23% of forage in the western United States is consumed by grasshoppers annually, and although chemical control programs have successfully reduced both costs and environmental impacts of treatment, some control tactics and strategies remain challenging to grasshopper management.

The most common insecticides for treatment of forage and rangeland grasshopper infestations are carbaryl (Sevin), diflubenzuron (Dimilin), and malathion.[4] These chemicals can be applied using several treatment options, most of which involve using reduced agent-area treatments (RAATs). By using RAATs, alternating strips of pasture or rangeland are sprayed, thereby reducing the treated area by one-half. This treatment program has reduced treatment costs and conserves beneficial insects.[4,5] Additionally, this may be a way to control grasshoppers in rugged or expansive rangeland. A widely adopted chemical, diflubenzuron (Dimilin), acts as an insect growth regulator and efficiently suppresses grasshopper populations. Malathion and carbaryl (Sevin) are also effective in treatment of forage grasshopper infestation. Unfortunately, carbaryl,[6] malathion, and diflubenzuron[7] have negative impacts on beneficial or endangered species. Additionally, repetitive treatment with nonselective insecticides has been shown to increase the intensity of grasshopper outbreaks.[8] Thus, a chemical control strategy with a potentially reduced effect on nontargeted insects would be desirable.

Insecticides with systemic properties (compounds that are taken up by plants and require ingestion by insects) may serve as a more targeted control tool (i.e., they target herbivores).

One compound tested in this study, Prevathon, is a xylem mobile anthranilic diamide, which has been shown to be highly selective toward insect rather than mammalian ryanodine receptors.[9] Although forage loss and insecticide efficacy have been given substantial attention, little has been done to quantify the impact of grasshopper management on forage quality and subsequent grazing management decisions following insecticide treatment. Therefore, our objectives were to evaluate a compound that uses a new class of chemical and mode of action as an insecticide for grasshopper control in crested wheatgrass pastures and to evaluate the effects of grasshopper control on biomass, digestibility, and crude protein of crested wheatgrass pasture (*Agropyron cristatum*).

Plot Design

Field plots were laid out in a completely randomized experimental plot design at the High Plains Agricultural Laboratory in Sidney, Nebraska on predominately crested wheatgrass (*Agropyron cristatum*) pasture (about 95%), which also included some buffalograss (*Bouteloua dactyloides*) and blue grama (*Bouteloua gracilis*). The study location was fenced within an approximately 3.93 ha. The study location was subdivided into 16,929 m^2 experimental units, each separated by 15.2 m from each other. Each experimental unit was then subdivided into a 30.5 x 10.7 m area to receive treatment. This experimental design was developed to minimize drift and plot interference from grasshopper movement (adult grasshoppers will move about 2 m/d).

Chemical Treatments

The treatments in 2011 were: Coragen (146 mL/ha, formulated chlorantraniliprole), Dimilin (146 mL/ha, formulated diflubenzeron), Prevathon (570 mL/ha, formulated chlorantraniliprole), Prevathon (994 mL/ha) formulated chlorantraniliprole), and Control (no treatment). The treatments in 2012 were: Belt (146 mL/ha, formulated flubendiamide), Dimilin (146 mL/ha), Prevathon (731 mL/ha), Prevathon (1,023mL/ha), and Control (no treatment). To fit within the study location, chemical treatments were applied to 3 replicates, and 4 replicates were reserved for the untreated control. The low and high rates of Prevathon were increased in 2012 to reflect the commercialized application rate (the commercial rates were not known for rangeland in 2011). Applications were made with a water carrier at 215 L/ha. Two spray passes were necessary to reach the target rates. Chemical applications were made immediately following the first sweep samples taken on the first sample data of each year (22 June 2011 and 18 May 2012).

Grasshopper Evaluation

Plots were evaluated by taking 50 low and fast sweeps with a 38-cm diameter, heavy muslin net. For each sweep, the net was moved through a 180° arc with the top of the net at the approximate top of the vegetation. Flags were set at the center of each plot and were used as guides such that the samples were taken from the center of the plots. Plots were sampled on six dates in 2011 (22 June, 27 June, 5 July, 11 July, 18 July, and 25 July) and eight dates in 2012 (18 May, 30 May, 11 June, 26 June, 3 July, 17 July, 24 July, and 1 August). Sample dates and trial initiation in each year corresponded with regionally reported grasshopper counts. Grasshopper egg hatch began much earlier in 2012 relative to 2011. Plots were not sampled later in the season, as the cool season crested wheatgrass was already mature. Samples were brought back into the lab and total grasshoppers of all life stages were counted. Mean grasshopper numbers were compared with SAS 9.2 software using the PROC MIXED function. Weather data were collected for each year from a permanent weather station located near the study sites at the University of Nebraska High Plains Agricultural Laboratory. Beneficial or nontarget arthropods were sampled the same as for grasshoppers. The sampled beneficial taxa included: Araneae, Braconidae, and Coccinelidae. Each beneficial taxa was analyzed separately by year and as a seasonal average with sample date used as repeated measures using SAS 9.2 software using the PROC MIXED function with AR(1) covariate structure.

Forage Quality for Livestock

For vegetation characteristic estimates, plots were randomly sampled each year by harvesting all available biomass from four 0.5 m^2 quadrats per plot. Samples were submitted to the ruminant nutrition lab at the University of Nebraska-Lincoln for *in vitro* dry matter disappearance (IVDMD) and crude protein (CP) analyses. Data were analyzed with SigmaPlot 12 Software using a one-way ANOVA and Dunnett's test post hoc to determine differences between treatments and controls. Biomass (kg/ha) dry matter was converted to air dry (90% dry matter), which was used to calculate AUM/ha. In this system, 1 animal unit (AU) is 454 kg, and 354-kg air dried forage is 1 AUM. The AUM available for a 5-month grazing season was calculated for the biomass available in each treatment and the number of 318-kg steers (0.7 AUM per steer) that could appropriately (taking 25% of the biomass available) graze 1,000 ha for 5 months to show the potential grazing impact of the treatments.

Results of Grasshopper Control Treatments

A significant reduction in grasshopper numbers was measured following the initial application of all chemical applications (Fig. 1). For both years, all treatments were significantly different from the controls (Fig. 2) with the exception of Belt (146 mL/ha) in 2012. The most effective treatments in 2011 were Coragen (146 mL/ha^{-}) and the high rate of Prevathon (994 mL/ha) with a mean grasshopper capture of 1.0 and 1.1, respectively. Mean grasshopper capture in the control was significantly higher at 10.3 grasshoppers per 50 sweeps. In 2012, the low rate of Prevathon (731 mL/ha) resulted in the best grasshopper suppression with a mean capture of 2.0 compared with the control with a mean of 9.4 grasshoppers. Beneficial insect numbers were not significantly

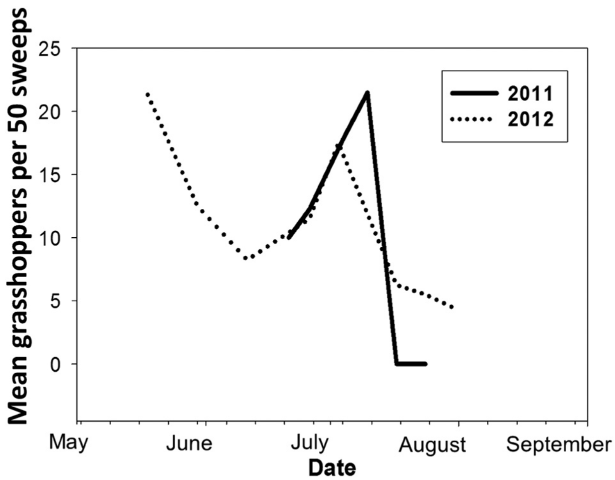

Figure 1. Mean number of rangeland grasshoppers captured by sweep net from the control plots during the 2011 and 2012 sampling season.

different across treatments, with the exception of Braconidae in 2011 (Table 1).

Insecticide treated plots exhibited a numerical trend toward greater available biomass (Table 2) compared with the control. However, only the low rate of Prevathon (1,023 mL/ha) in 2012 was statistically different from the control (P = 0.029). Additionally, no differences were detected in forage quality (IVDMD) or CP (Table 2).

Discussion of Grasshopper Suppression

The United States Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) conducts annual surveys of rangeland grasshoppers throughout Nebraska. The adult grasshopper survey of this region of Nebraska (Cheyenne County) conducted by the USDA-APHIS-PPQ Rangeland Grasshopper and Mormon Cricket Suppression Program showed mean grasshopper numbers of 20.8/m^2 in 2011 and 15.2/m^2 in 2012. The APHIS-PPQ numbers indicated that the lower economic threshold of eight adult grasshoppers per 8 m^2 (the economic threshold for rangeland grasshoppers ranges from 9.6–47.8 grasshoppers/m^2) had been reached and that treatment in the study area would have been warranted. This economic threshold reflects the approximate carrying capacity of several grasshopper species.[10] However, economic thresholds are not constant for nymphal and adult density estimations,[11] and determination of site-specific economic thresholds will impact the success of suppression efforts.[12]

Finding grasshopper control with minimal impact on beneficial insects could be positive for range management. Applying pesticides has both economic and ecological costs. However, if treatment is not applied prior to economic damage, the possibility exists of monetary loss as a result of forage reduction for cattle. Previous research[13] has reported grasshopper density reduced biomass by 50% and 85% in ungrazed and early grazed pastures, respectively. Thus, a chemical control tool that has improved selectivity toward insect herbivores (e.g., a product containing a plant-systemic insecticide) would be desirable. In this particular study, no statistical differences were detected in beneficial insect numbers. However, Prevathon may be a strong candidate for further study focused on nontarget impacts.

Discussion of Insect Control on Forage Biomass

In this study vegetative biomass numerically increased with insecticide treatment, suggesting a reduction in grasshoppers and insect herbivory. Precipitation has an especially important impact on forage quality and quantity in dryland agriculture. In 2011, the study area experienced much more moisture

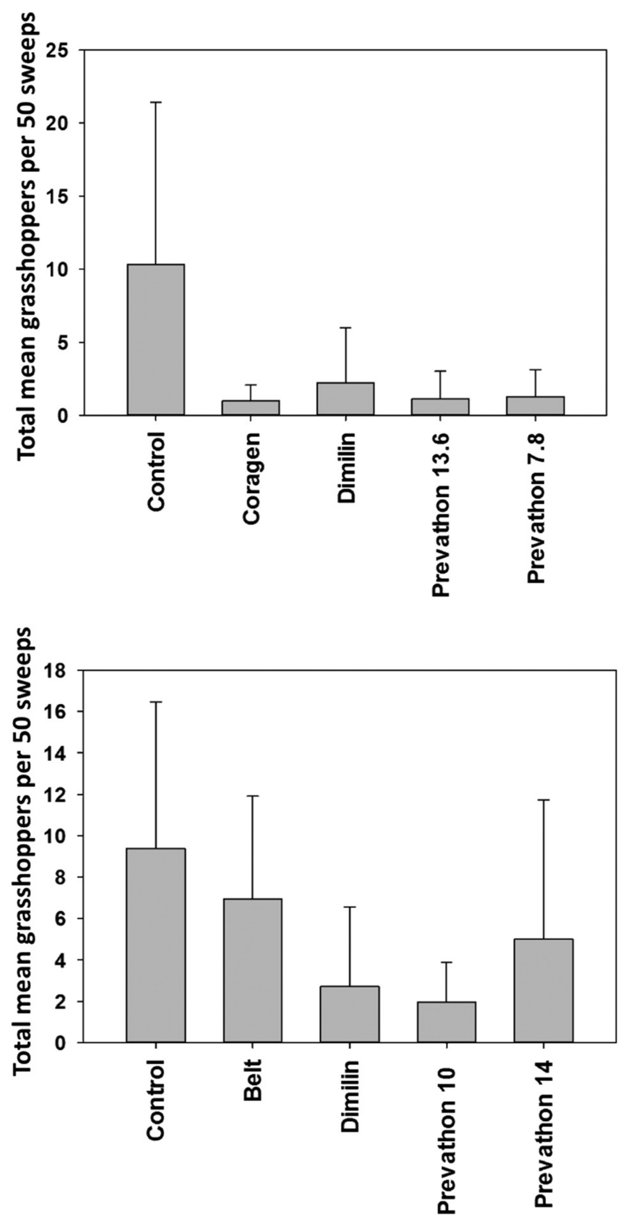

Figure 2. Mean ± standard error of the mean number of grasshoppers sampled in 2011 (top panel) and 2012 (bottom panel). All treatments were significantly different from the control ($P < 0.05$) with the exception of Belt in 2012 (P = 0.204).

Table 1. Mean ± SEM of beneficial or nontarget arthropods per 50 sweeps per sample date

Treatment	Braconidae	Araneae	Coccinelidae
2011 Nontarget/beneficial insects			
Prevathon 13.6	2.01 ± 0.77	3.91 ± 0.69	6.60 ± 3.63
Prevathon 7.8	*3.83 ± 1.27	3.91 ± 0.75	1.67 ± 3.63
Dimilin	2.07 ± 0.76	5.67 ± 1.05	2.80 ± 4.29
Coragen	1.92 ± 0.67	2.88 ± 0.60	2.27 ± 3.63
Check	1.33 ± 0.48	4.52 ± 0.68	9.55 ± 3.14
2012 Nontarget/beneficial insects			
Prevathon 14	7.81 ± 8.33	3.38 ± 0.64	0.15 ± 0.12
Prevathon 10	10.31 ± 10.66	1.66 ± 0.44	0.05 ± 0.12
Dimilin	6.02 ± 6.29	1.83 ± 0.46	0.20 ± 0.12
Belt	7.23 ± 7.52	2.00 ± 0.48	0.24 ± 0.12
Check	8.41 ± 7.78	2.33 ± 0.48	0.11 ± 0.10

SEM indicates standard error of the mean.
* Significantly different than all treatments ($P = 0.0363$).

(627.4 total mm) than in 2012 (302.5 total mm), likely impacting both grasshopper abundance (increasing) and plant communities and biomass (decreasing). The inverse relationship between biomass and IVDMD would be expected if grasshopper feeding stimulates plant regrowth. Crude protein was not different between treatments and all treatments were barely adequate to supply nitrogen for rumen function.[14] While this study did not result in nitrogen differences, others[13] did report lower nitrogen content in grasshopper density treatments compared with controls. Similarly, other researchers[15] reported locus outbreaks in Asia to have a preference for lower nitrogen forages. The apparent relationship between insecticide usage, plant response, and forage quality deserves more intensive study in light of these findings.

Table 2. Biomass, *in vitro* dry matter disappearance (IVDMD), and crude protein (CP) in crested wheatgrass by insecticide treatment

Treatment	Biomass (kg/ha)	SE	IVDMD	SE	CP	SE
2011 Biomass, IVDMD, CP						
Prevathon 13.6	1,662	128.2	49.5	1.22	7.61	0.45
Prevathon 7.8	1,369	128.2	49.1	1.22	7.39	0.45
Dimilin	1,589	128.2	50.5	1.22	7.37	0.45
Coragen	1,421	128.2	49.8	1.22	7.44	0.45
Control	1,350	148.1	52.3	1.06	7.16	0.39
2012 Biomass, IVDMD, CP						
Prevathon 14	1,428*	113.6	42.0	1.93	5.94	0.36
Prevathon 10	1,169	113.6	45.8	1.93	5.77	0.36
Dimilin	1,191	113.6	43.6	1.93	5.42	0.36
Belt	996	113.6	44.6	1.93	6.75	0.36
Control	893	98.4	43.7	1.67	5.81	0.31

SE indicates standard error.
* Significantly different than the control ($P = 0.029$).

Table 3. Animal unit months (AUM) available per hectare for a 5-month grazing season and the number of 318-kg yearlings that could graze on 1,000 hectares for 5 months

Treatment	AUM for 5 months	# of 318-kg steers grazing 1,000 ha for 5 months
2011		
Control	0.85	242
Coragen	0.89	255
Dimilin	1.0	285
Prevathon 7.8	0.86	246
Prevathon 13	1.04	298
2012		
Control	0.56	160
Belt	0.62	179
Dimilin	0.75	214
Prevathon 10	0.73	210
Prevathon 14	0.90	256

Grasshoppers are known to feed preferentially,[16] with the ability to compensate for any nutrient shortage by feeding on a plant high in a limiting nutrient.[17] That being said, plant quality may have little effect on grasshopper population dynamics.[17] Grasshopper densities may be more dependent on temperature than plant nutrient content.[18]

Impacts of Grasshopper Control on Available AUMs

In 2011 the AUM/ha were 0.85 for the control and 0.95 for the treated (average of all treatments) (Table 3). This was a 10% reduction in available forage. If a rancher had 1,000 ha of this forage and wanted to graze it for 5 months, with insecticide treatment it could be stocked with 271 head of yearlings that averaged 318 kg over that time period. Without treatment, only 242 head could be stocked. In 2012, the AUM/ha for the control was 0.56 and 0.75 for the treated, which is a 25% reduction in available forage. More substantially, in 2012, the untreated control would support 160 318-kg steers, while the average of the treated pastures would have supported 215. Previously reported research[19] indicated that hot dry conditions tended to coincide with increased grasshopper numbers. This also tends to be a condition in which less forage is produced for livestock grazing as well. Considering drought is a common occurrence in western Nebraska, and the fact that in 2012 there was less available forage for both grasshoppers and cattle, insecticide treatment would have increased the grazing capacity substantially. Given that 0.99 AUM/ha is considered a good forage condition for this region of the High Plains,[8] treatment of grasshoppers appeared to improve forage quantity.

Implications

Results of this study suggest administering grasshopper control can effectively reduce grasshopper populations compared with an untreated control without negatively impacting beneficial insect numbers. While IVDMD and CP appear to be unaffected by insecticide treatment, available biomass was significantly improved by Prevathon (high) in 2012. Additionally, it appears insecticide treatment could save AUM particularly in drought years, when forage resources are already limited.

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