This publication shares publicly available resources pertaining to short-horned grasshoppers, with a focus on their damage, management, and behavior.

Short-Horned Grasshoppers

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Acrididae - an economically damaging insect family:

Short-horned grasshoppers are in the Acrididae family in the order Orthoptera. At least 400 grasshopper species are native to the western U.S. with 13 species being economically damaging to range and croplands of Montana (Zhang et al. 2019) ***(Fig. 1, Table 1)***. Outbreak events are sporadic but tend to occur in areas with consecutive years of drought conditions, hot weather, and warm falls.

Grasshoppers in the News:

Every fall, the USDA releases the Grasshopper Hazard Forecast Map featuring Arizona, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. These annual reports are shared by news outlets, USDA personnel, Extension agents, and the public to help spread information about the impending hazard risk, and to establish management strategies (Gamboa 2024).

Table 1. *Major economically damaging Acrididae grasshoppers of Montana.*

Species name	Common name
Ageneotettix deorum	White-whiskered grasshopper
Aulocara elliotti	Big-headed grasshopper
Camnula pellucida	Clear-winged grasshopper
Melanoplus bivittatus	Two-striped grasshopper
Melanoplus dawsoni	Dawson grasshopper
Melanoplus differentialis	Differential grasshopper
Melanoplus femurrubrum	Red-legged grasshopper
Melanoplus infantilis	Little spur-throated grasshopper
Melanoplus sanguinipes	Migratory grasshopper
Opeia obscura	Obscure grasshopper
Phlibostroma quadrimaculatum	Four-spotted grasshopper
Phoetaliotes nebrascensis	Large-headed grasshopper
Trachyrhachys kiowa	Kiowa grasshopper

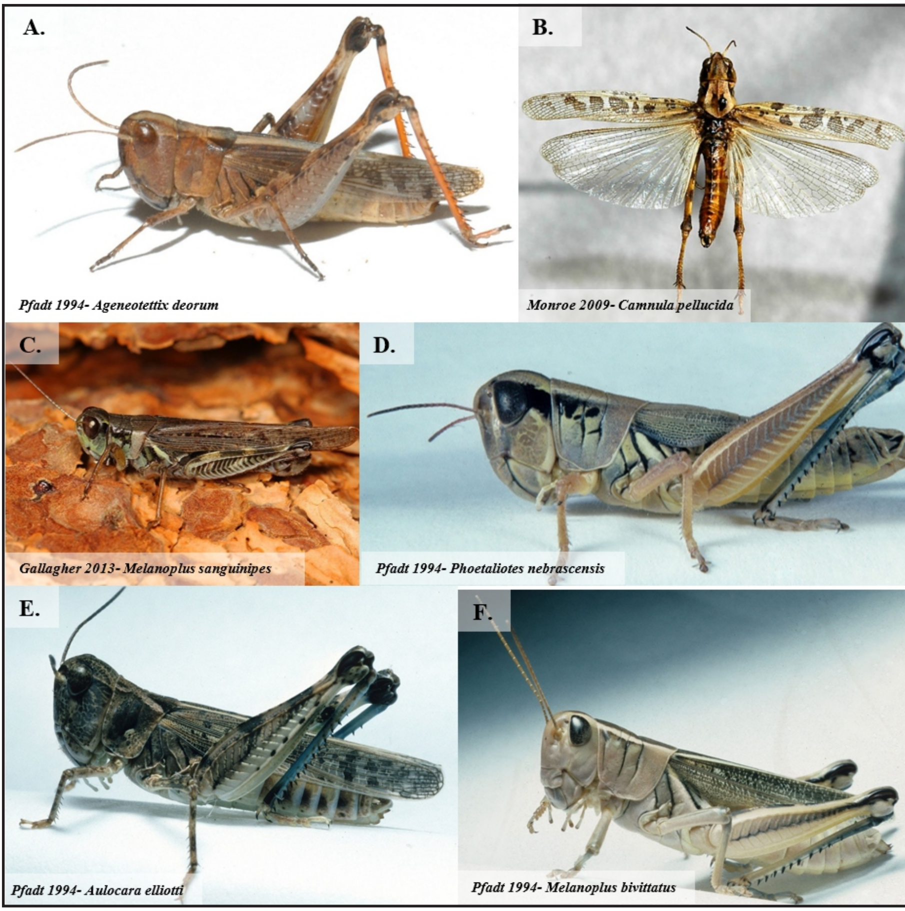
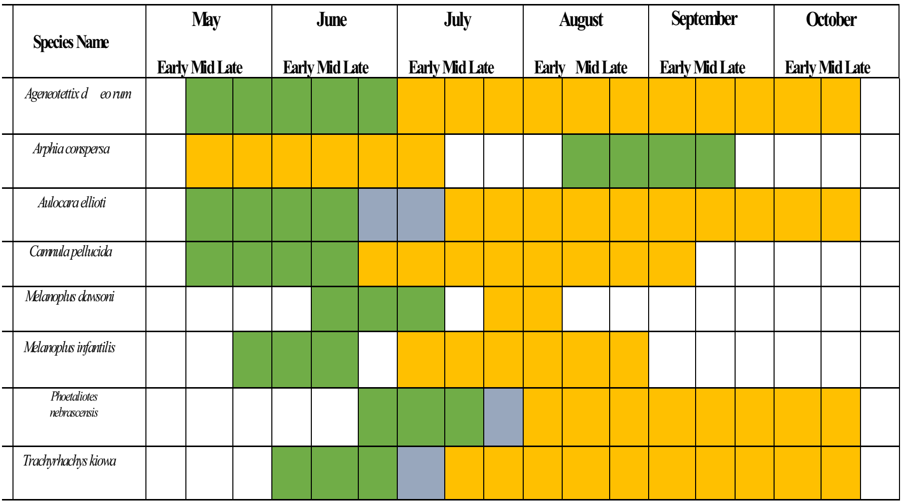


Figure 1. *(A) Female adult white-whiskered grasshopper (Ageneotettix deorum), (B) clear-winged grasshopper (Camnula pellucida), (C) migratory grasshopper (Melanoplus sanguinipes), (D) large-headed grasshopper (Phoetaliotes nebrascensis), (E) big-headed grasshopper (Aulocara elliotti), and (F) two-striped grasshopper (Melanoplus bivittatus). Image Credit: Erika Rodbell*

Life Cycle:

Grasshoppers undergo incomplete metamorphosis with most species having one generation a year. Incomplete metamorphosis consists of three general life stages: egg, nymph, and adult ***(Fig. 2, Table 2)***. Most grasshoppers lay their eggs in the late summer/early fall, in bare, dry ground such as stubble fields, ditches or weedy pastures. Nymphs generally molt through five instar stages, growing incrementally larger, until they are adults.

Table 2. *Timing of Montana grasshopper species by month. Green represents nymphal emergence or egg hatch, yellow represents the adult life stage, and blue represents the overlap of these two life stages. Speckle-winged grasshoppers over winter as adults meaning that nymphal emergence occurs in the late summer.*



Appearance:

Grasshoppers are large insects easily seen with the naked eye. One can identify a grasshopper from other insects by their jumping hind legs with large femurs. Short-horned grasshoppers can be distinguished from other closely related insects, like crickets and katydids, by their comparatively short antennae ***(Fig. 1.)*** (Capinera et al. 2004).

Grasshoppers have an incomplete lifecycle, which means nymphs and adults are similar in their appearance. Adult grasshoppers can be

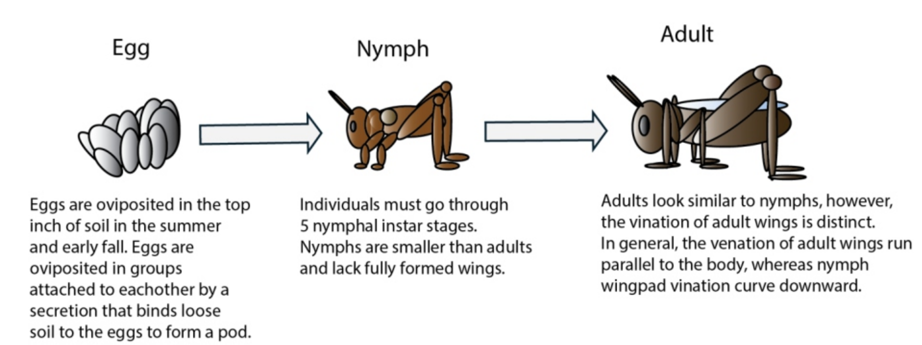


Figure 2. *The grasshopper life cycle is an incomplete life cycle featuring egg, nymph, and adult life stages. Image Credit: Erika Rodbell*

significantly larger than nymphs and have fully developed wings that sit along their abdomen. Nymphs do not have fully developed wings, but rather have wing pads ***(Figs. 2 & 3)***.

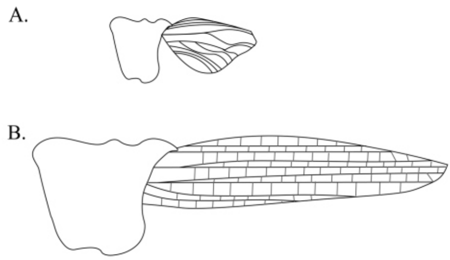


Figure 3. *Lateral view of the basic venation of an acridid wing. "A" represents the basic venation of a fifth instar wing pad. "B" represents the basic venation of an adult wing. Please note, the nymphal wing pad venation curves downward while the adult wing venation runs parallel to the body. Image Credit: Erika Rodbell*

Damage:

Although acridids can feed on grain, the main source of crop damage is through defoliation. Grasshoppers either feed on foliage or clip the plant and/or leaves at the stem. This means that, although they may be consuming their weight in biomass every day, the damage caused by their feeding is much greater because of the clipped foliage that is lost (Pfadt 1994). On average, a mixture of economically damaging grasshopper species can cause more than 50% loss of rangeland grass foliage and 30% loss of forage over the course of the season (Hemken 2019), making grasshoppers the most economically damaging rangeland defoliating insect family (Zhang et al. 2019, Dakhel et al. 2020).

Monitoring:

As grasshoppers are ectotherms, they are more active under warm and sunny conditions, which may influence the number of grasshoppers counted when scouting. Therefore, it is best practice to scout on clear sunny days when temperatures are above 70°F. Grasshopper nymphs do not fly and may hunker down in the lower portions of the stand instead of jumping, so this scouting method may be more accurate for adults. Monitoring for grasshoppers is recommended both outside and within the crop field, because grasshoppers first feed in habitats exterior to the field and then invade (UNL 2015). Generally, grasshopper populations are higher outside of the field, so scouting methods are slightly different between the field margin and the field interior (UNL 2015).

Scouting: Field Margin

Grasshopper monitoring along the field margin is best done through the square-foot method. The square foot method involves randomly selecting an area one square foot in size that is several feet from your position. As you walk towards this area count the number of grasshoppers jumping into and out of the one square foot space. Do this 18 times at different locations within the field margin and divide the total value by two. The generated value will be the estimated number of grasshoppers per square yard (i.e., 9 square feet) (UNL 2015).

Scouting: Field Interior

Grasshopper monitoring within the field is done through the square yard method, due to lower population densities. Visualize one square yard at a distance of a few feet from your position. As you walk towards the one square yard area count the number of grasshoppers jumping into and out of the space. Do this 18 times at different locations in the field and average the value to generate the average number of grasshoppers per square yard (UNL 2015).

Economic Thresholds for Grasshoppers:

Economic thresholds are pest densities that signify that management strategies should be implemented to mitigate continued populational growth and to avoid economic injury (Pedigo et al. 2021). In the U.S., the general economic threshold in rangeland systems is eight individuals per square yard, with economic injury occurring at 15 individuals per square yard.

In cropping systems, the economic threshold for grasshoppers within the field margin is higher than the field interior, at 50-75 nymphs or 30-45 adults per square yard. The economic threshold for grasshoppers within the field is 30-45 nymphs or 8-14 adults per square yard (NDSU 2024; Table 3). Severe outbreak events may occur when nymph populations exceed 100 per square yard in the field margin or 60 per square yard within the field. For adults, severe outbreaks can be diagnosed when populations reach 41 per square yard within the field margin, or 15 per square yard within the field (NDSU 2024; ***Table 3***).

Management in Crops:

Biological Control:

Biological control agents of grasshoppers include bacteria, fungi, microsporidia, nematodes, predators, and viruses. However, they are not consistently efficacious, thus economic injury can still occur (Dakhel et al. 2020). One can enhance concentrations of entomopathogenic fungi,

Table 3. *Grasshopper populational densities per square yard. Ranging from low to very severe densities for nymphs and adults based on their location (i.e., along the margin of the field or within the field). Highlighted is the economic threshold for each of these categories.*

Severity Rating	Nymphs- per square yard		Adults- per square yard	
	Margin	*Field*	*Margin*	*Field*
Low	25-35	15-25	10-20	3-7
Threatening i.e., Economic Threshold	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	>200	>120	>80	>28

** This table was provided by North Dakota State University Extension 2024*

Nosema locusta, by using Nolo Bait® which is effective at controlling grasshopper nymphs but is cost prohibitive for large scale applications. Over the last few years, however, Nolo Bait® has been out of stock, and may not be available for use in future seasons.

Cultural Control:

Cultural control tactics for grasshoppers in cropping systems include changing seeding strategies, crop rotations, and being aware of crop locations. Early spring seeding allows for seeded plants to develop longer so they are better able to withstand grasshopper feeding. In winter wheat, delayed fall seeding may be helpful, unless there is a late frost. In years where high grasshopper numbers are anticipated, doubling the seeding rate along field borders may slow grasshopper migration into crops. Crop rotation can be beneficial as late maturing crops or green plant cover that persists into the late summer and fall are more attractive to adult grasshoppers who are also looking for a place to lay eggs. So, the subsequent year those fields may have more egg pods than fields seeded with early maturing crops (NDSU 2024). By not seeding fields previously planted with a late-maturing crop or fields near late maturing crops, one can avoid crop damage caused by planting in a field harboring greater densities of grasshopper eggs (NDSU 2024).

Mechanical Control:

Tillage in the fall and/or early spring can reduce the number of eggs that survive until nymphal emergence (Spawn 1945). Tillage can bury the eggs so deeply that the emerging nymphs cannot crawl to the soil surface, or it can bring eggs to the surface exposing them to desiccation (Severin and Gilbertson 1931). Additionally, fallowed fields attract reproductive female adults, forming a temporary trap crop, thus enhancing the number of egg pods oviposited in these sites. By terminating the fallowed field with a spring tillage, one can expect reduced nymphal emergence (NDSU 2024). However, tillage can decrease soil moisture.

Chemical Control in Crops:

Chemical control tactics include products with the active ingredients, carbaryl (e.g., Sevin), chlorantraniliprole (e.g., Vantacor), diflubenzuron (e.g., Dimilin, organic insecticide), malathion (e.g., Cythion and Fyfanon), and pyrethroids (e.g., Warrior II and Mustang Maxx) (Dakhel et al. 2020). Diflubenzuron, registered for use in both range and crop land, is an insect growth regulator and is only effective when applied at the nymphal life stage. Within cropping systems, diflubenzuron has a two-week residual so application of this control tactic should be applied early within nymphal development. If applying Dimilin when both life stages (nymphs and adults) are present, mixing Dimilin with a knockdown insecticide (e.g., Mustang Maxx) may provide enhanced control.

Seed treatments are another method of chemical control. Seed treatments with the active ingredient imidacloprid or bran baits treated with Sevin can also be an effective strategy. Treated seeds planted along the field margin, can help mitigate the movement of grasshoppers further into the field interior. Bran baits are only attractive to insects that feed on bran, and when the material is consumed, the insect is exposed to the toxin.

Management in Rangeland:

Reduced Stocking Rates:

Grasshoppers oviposit in patches of bare ground between plant crowns, so increasing plant densities can reduce oviposition rates within rangeland systems. A traditional approach to increasing plant densities is to decrease stock rates (Redfearn and Bidwell 2024).

Grazing Rotations:

Season long grazing can result in greater grasshopper population densities, but grazing twice each growing season can limit grasshopper populations. Grazing rotations allow for increased plant densities and includes two grazing periods consisting of 3-6 pastures with rotational grazing dates. By rotating dates, one can coordinate grazing with specific growth stages of the prevailing plant species, which can result in increased forage tillering. Coordinated grazing can remove approximately 25-33% of the above ground biomass, leaving the lower portions of the stand, often too close to the ground for cattle to access, for grasshopper feeding (Onsager 2000).

Chemical Control:

Insecticide applications registered for the control of grasshoppers in rangeland systems include products with the active ingredients malathion, carbaryl, and diflubenzuron which can help manage endemic populations (Dakhel et al. 2020). However, such applications are most effective early in grasshopper development. As grasshoppers generally hatch between May and July it is important to ensure continuous scouting and to apply insecticides only when populations reach the economic threshold ***(Table 3)***.

USDA-Grasshopper Management Programs:

Starting in the mid-20th century, the USDA-APHIS conducted an annual large-scale application of insecticides in western grasslands of 17 states as part of their grasshopper and Mormon cricket suppression program (USDA-APHIS 2021). The first quarter of every year, the USDA-APHIS opens enrollment in their suppression program. The predominant insecticide applied in this program is diflubenzuron (i.e., Dimilin®) (USDA-APHIS 2021). Often, these applications occur in 10,000-acre swaths. In 2021, this program treated more than a million acres in Montana (APHIS 2023).

Reduced Agent and Area Treatments:

To reduce the cost and potential environmental impact of such large-scale insecticide applications, the Reduced Agent and Area Treatments (RAATs) strategy program was developed by the University of Wyoming in 1997. Since 1997, the RAATs program has been adopted by land managers and USDA personnel across the western U.S. (Dakhel et al. 2020). As the name implies, the goal of the program is to reduce the quantity of insecticides applied and acreages treated. The recommendation from this program is to treat every other swath (5 to 30- meters wide) with an insecticide. Meaning that the total acreage treated is reduced by half and the annual cost for grasshopper management would similarly decrease (Dakhel et al. 2020, Schell 2024). This program is effective because grasshoppers are highly mobile, thus they can be exposed to the treated plant materials as they move through the field. To increase the likelihood of grasshopper exposure, adding canola oil as an adjuvant can attract and retain grasshoppers within the treated strips. Canola oil contains vital fatty acids that grasshoppers need to ingest. By using canola oil as an adjuvant, one can increase the efficacy of their RAATs strategy (Hemken 2019). In general, this program provides approximately 80% control and reduces the cost by as much as 60% (Schell 2024).

Management in Non-Crop Areas: Yards and Gardens

Scouting:

Scouting your garden or yard for grasshoppers is important to find the hotspots for grasshopper activity. Often the populational densities of the previous summer and fall provides some insight as to the degree of grasshopper populational densities for the coming spring. When using insecticide treated baits, knowing where in your yard grasshoppers tend to be can help determine where to broadcast this material (Cranshaw and Hammon 2024). Scouting additionally can help inform you of when or if it is appropriate to apply an insecticide.

Baits:

Although costly, baits can be a useful tool for grasshopper management in small spaces like flowerbeds. Baits contain bran and an insecticide, often carbaryl (i.e., Sevin®), and need to be replaced after rain events (Cranshaw and Hammon 2024). As baits must be consumed to be effective, the impact of this form of grasshopper control on non-target insects is limited. Bran baits work best when deployed for the control of grasshopper nymphs early in the spring when food sources are more limited, and at densities of 10-25 grasshoppers per square yard. There is an alternative bait (i.e., Nolo Bait®) treated with the biocontrol agent, Nosema locusta, and is effective in grasshopper oviposit sites. However, Nosema locusta is only effective on nymphal grasshoppers and Nolo Bait® is out of stock and may not be available for future seasons (Cranshaw and Hammon 2024).

Insecticides:

Organic control options include Neem oil (e.g., AzaGuard®), pyrethrins (e.g., PyGanic®), and Nosema locustae (e.g., Nolo Bait®). Non-organic control options include acephate (e.g., Orthene, not labeled for crops or pasture), pyrethroids (e.g., Ortho Home Defense Insect Killer for Lawns and Landscape®; Ortho Bug B Gon Insect Killer for Lawns and Gardens®; Bioadvanced Complete Insect Killer®) and carbaryl (Eco Bran® bait or Sevin®). However, it is important to note that one must check the insecticide label to determine where, when, and how it is appropriate to apply this material.

Summary:

- Grasshoppers are native to North America and are sporadic pests of range and croplands of the United States.
- Of the 400 species in Montana, 13 are economically damaging.
- The USDA releases Rangeland Grasshopper Hazard Map every fall.
- There are chemical, mechanical, and biological control options for the management of grasshoppers in croplands, rangelands, yards, and gardens.

Any mention of products in this publication does not constitute endorsement by Montana State University Extension. It is a violation of Federal laws to use insecticides in a manner inconsistent with their labeling.

Additional Resources:

2024 Rangeland Grasshopper Hazard Map:
https://www.aphis.usda.gov/plant_health/plant_pest_info/grasshopper/downloads/hazard.pdf

Grasshopper Management: https://www.ars.usda.gov/plains-area/sidney-mt/northern-plains-agricultural-research-laboratory/pest-management-research/pmru-docs/grasshoppers-their-biology-identification-and-management/management/management-information/

Grasshopper Integrated Pest Management User Handbook:
https://www.ars.usda.gov/plains-area/sidney-mt/northern-plains-agricultural-research-laboratory/pest-management-research/pmru-docs/grasshoppers-their-biology-identification-and-management/ipm-handbook/ipm-handbook-overview/

Grasshopper Species Fact Sheets: https://www.ars.usda.gov/plains-area/sidney-mt/northern-plains-agricultural-research-laboratory/pest-management-research/pmru-docs/grasshoppers-their-biology-identification-and-management/ipm-handbook/grasshopper-species-fact-sheets-scientific-name/

Android and iPhone Apps for Grasshopper Identification:
https://www.ars.usda.gov/plains-area/sidney-mt/northern-plains-agricultural-research-laboratory/pest-management-research/pmru-docs/grasshoppers-their-biology-identification-and-management/id-tools-apps/android-iphone-id-apps/android-and-iphone-id-apps/

Grasshoppers, Grasshoppers, They're Everywhere:
https://agresearch.montana.edu/wtarc/producerinfo/entomology-insect-ecology/Grasshoppers/MSUGrasshoppers.pdf

Grasshoppers in the Yard and Garden:
https://urbanipm.montana.edu/entomology/resources/fact-sheets/grasshoppers-in-the-yard-and-garden.html#:~:text=Bifenthrin%20%26%20zeta%2Dcypermethrin%20(products,Eco%20Bran%20bait%20or%20Sevin).

References

Animal and Plant Health Inspection Service (APHIS). 2023. Environmental assessment rangeland grasshopper and Mormon cricket suppression program. Available from: https://www.aphis.usda.gov/sites/default/files/mt-1-2023-28.pdf.

Capinera JL, Scott RD, Walker TJ. 2004. Field guide to grasshoppers, crickets, and katydids of the United States. Ithaca, NY: Cornell University Press. 249p.

Cranshaw WS, Hammon R. 2024. Grasshopper control in gardens and small acreages. Available from: https://extension.colostate.edu/topic-areas/insects/grasshopper-control-in-gardens-small-acreages-5-536/.

Dakhel WH, Jaronski ST, Schell S. 2020. Control of pest grasshoppers in North America. Insects. (11):1-18. DOI:10.3390/insects11090566.

Gamboa R. 2024. Montana Ag Network: USDA issues grasshopper forecast. Available from: https://www.krtv.com/news/montana-ag-network/montana-ag-network-usda-issues-grasshopper-forecast.

Hemken M. 2019. Beating back the grasshopper hordes. Available from: https://www.farmprogress.com/crops/beating-back-the-grasshopper-hordes.

North Dakota State University (NDSU). 2024. North Dakota field crop insect management guide. Available from: https://www.ndsu.edu/agriculture/sites/default/files/2024-01/229706_Insect_Orig-web_colorCV.pdf.

Onsager JA. 2000. Suppression of grasshoppers in the Great Plains through grazing management. J. Range Manage. 53: 592-602. DOI: 10.2307/4003152.

Pedigo, L.P., M.E. Rice, and R.K. Krell. 2021. Entomology and pest management, 7th ed. Waveland Press Inc., Long Grove, IL.

Pfadt RE. 1994. Western Grasshoppers, 3rd eds. Wyoming Agr. Exp. Sta. Bul. 912. Laramie, WY.

Redfearn DD, Bidwell TC. 2024. Stocking rate: the key to successful livestock production. Available from: https://pods.okstate.edu/fact-sheets/PSS-2871pod.pdf.

Schell S. 2024. Reduced Agent and Area Treatments (RAATs). Available from: https://www.uwyo.edu/entomology/grasshoppers/raat/index.html.

Severin HC, Gilbertson GI. 1931. Destroy the grasshopper eggs. SD Agric. Exp. Sta. Bul. 267.

Spawn GB. 1945. Tillage methods in grasshopper control. Agricultural Experiment Station South Dakota State College of Agriculture and Mechanic Arts Bul. 379. Brookings, SD.

United States Department of Agriculture- Animal & Plant Health Inspection Service (USDA-APHIS). 2020. IPM Handbook. Sourced from: https://www.ars.usda.gov/plains-area/sidney-mt/northern-plains-agricultural-research-laboratory/pest-management-research/pmru-docs/grasshoppers-their-biology-identification-and-management/ipm-handbook/.

United States Department of Agriculture- Animal & Plant Health Inspection Service (USDA-APHIS). 2021. Protecting U.S. Rangeland from grasshoppers and Mormon crickets. Sourced from: https://www.aphis.usda.gov/sites/default/files/fs-grasshoppers-mormon-crickets.pdf.

University of Nebraska Lincoln (UNL). 2015. Monitoring grasshoppers. Available from: https://cropwatch.unl.edu/monitoring-grasshoppers.

Zhang L, Lecoq M, Latchininsky A, Hunter D. 2019. Locust and grasshopper management. Annu. Rev. Entomol. 64:15-34. https://doi.org/10.1146/annurev-ento-011118-112500.