Field Guide to Grasshoppers

of Economic Importance in Nevada

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Field Guide to Grasshoppers

of Economic Importance in Nevada

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Sponsored by

University of Nevada Cooperative Extension
Nevada Department of Agriculture

Funded by

Renewable Resources Extension Account

Text adapted with permission from

Field Guide to Common Western Grasshoppers, Bulletin 912–September 1994 by Robert E. Pfadt, University of Wyoming, USDA-APHIS–Wyoming Agricultural Experiment Station.

Our sincere appreciation to Dr. Pfadt for allowing us to use his photos.
For additional photos and information see Dr. Pfadt's fact sheets on the web at:
http://www.sidney.ars.usda.gov/grasshopper/ID_Tools/F_Sheets/index.htm

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Introduction

Of the 400 species of grasshoppers known to inhabit the 17 western states, 118 are found in Nevada, and less than 10 of those species are economically important. This field guide is designed to help people identify those species of economic importance at stages when management strategies are most effective. Knowing the identity of the grasshoppers is the first step in determining whether or not a threat exists. Then, an economic threshold can be established, and an effective, economical, and integrated pest management strategy can be developed, if necessary.

All grasshoppers are not pests. Some are beneficial depending on their food habits. Others are migratory and may pose a threat to distant crops. Outbreaks often occur over large areas (Figure 1, next page). Life cycles, including period of hatch, development, and reproduction, vary by species. These variables must be considered when choosing control measures for grasshopper pests. Cost effective, successful integrated pest management depends on appropriate choice and accurate timing of biological, mechanical, cultural, and chemical treatments during the most vulnerable life stages of the grasshoppers.

Grasshoppers and Mormon crickets eat plants and organic material, such as plant litter, dung, and dead insects. Large populations devastate valuable range plants and crops. A grasshopper can consume up to one-half its weight in green forage in one day. In the western United States, they consume up to 25 percent of the available rangeland forage, thus affecting wildlife and domestic grazing. Impacts on wildlife are not well documented; but impacts on agricultural production have been researched and documented. Consumption of forage resources by grasshoppers limits grazing and reduces the pounds of meat produced by the livestock industry. Their consumption of crops reduces production and profitability. Outbreaks have occurred where entire grazing allotments, pastures, or crop areas have been consumed, severely reducing the profitability and sustainability of the production resources.

This guide is designed to simplify identification of economically damaging grasshopper species for ranchers, farmers, agency personnel, and other land managers. It includes color pictures, drawings, and descriptions of the distinguishing characteristics, seasonal life stages, feeding and reproductive behavior, and habitat preferences of grasshopper pests in Nevada. The integrated management of range, crop, and garden grasshoppers is also discussed.

The species identified in this guide are responsible for most of the grasshopper damage to Nevada's range plants, but they also injure crops, fruits, vegetables, and landscape ornamentals in the state. Learn about their distinguishing features, when to expect them, their life cycle, what kind of feeding damage they do, and what plants they prefer to eat. This will help in managing them, particularly in years when populations are average and damage is routine. Outbreak periods, when numbers are high and damage is great, usually call for extra control efforts.

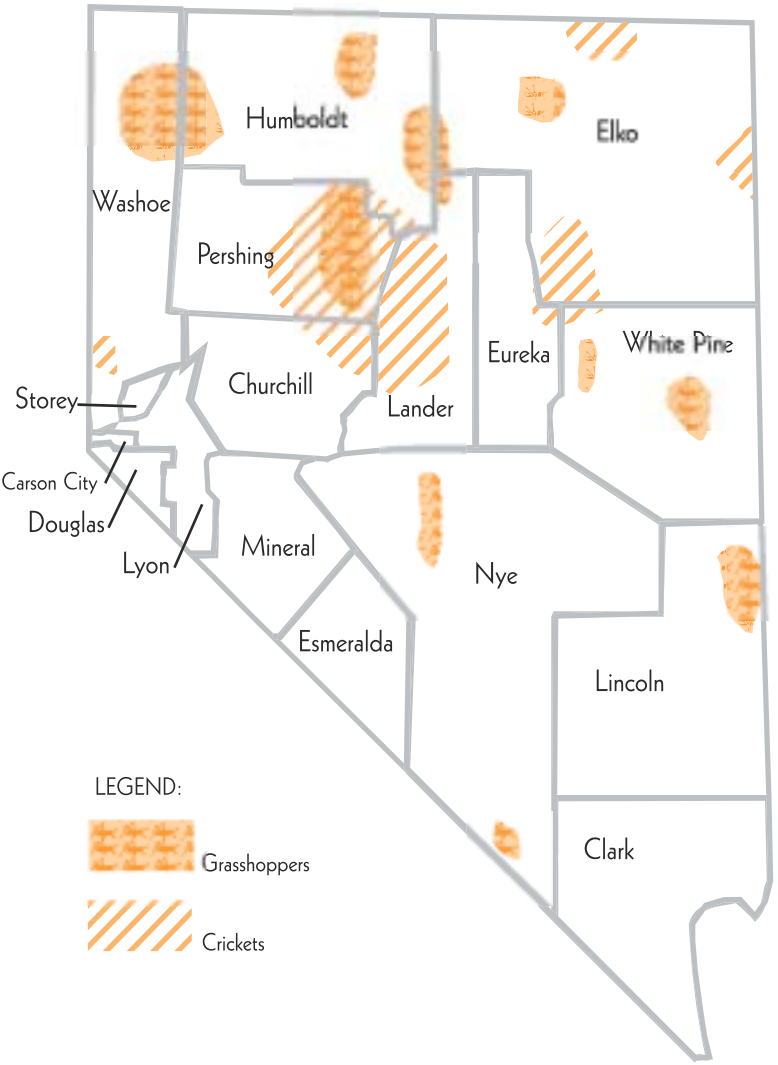

Figure 1. Areas of historical infestation are shown above, although grasshoppers and Mormon crickets can be found throughout Nevada.

Identification and Anatomy

Accurate identification: An accurate identification of a pest is always the first step in pest management. It is crucial to be able to identify the early stages of the three or four species of grasshoppers that are most economically damaging in Nevada. This guide describes the major distinguishing characteristics of each species. This information should only be used as a preliminary guide. Before a major control program is undertaken, confirm the species identification by contacting the Entomologist for the Nevada Department of Agriculture, (775) 688-1182, Extension 245. Send sample specimens for identification to 350 Capitol Hill Avenue, Reno, Nevada 89502.

Grasshoppers have three body regions. The **head** has chewing mouthparts, compound eyes, and antennae. The **thorax** has a saddle-shaped top (pronotum), three pairs of legs, and two pairs of wings. The segmented **abdomen** houses small appendages on the sides of the last abdominal segment whose shape is often unique to each species of grasshopper (spiracles and cerci).

The important identifying characteristics of the head region are: color patterns of the antennae; coloration of the eyes and face; and the shape of the small depressions between the eyes (lateral foveolae). Identifiers of the thorax include: color patterns of the disk (top) of the pronotum; and the presence, size, and color of the front (tegmina) and hind wings. Grasshoppers have two pairs of wings as adults; Mormon crickets are wingless. Identification of immature grasshoppers is more difficult because they have wing pads instead of wings. The color of the large section (femur) and thin section (tibia), often with many tiny spines, of the hind leg differs among species. The identifiers for the abdomen are: presence and shape of the egg laying structure (ovipositor) on females and the shape and size of the cerci on males. An additional characteristic of the abdomen is the shape of the bottom section of the last segment (subgenital plate) of the adult male grasshopper.

Adult males make the best specimens for identification purposes. A 10X-magnifying lens may be needed to clearly see some grasshopper characteristics.

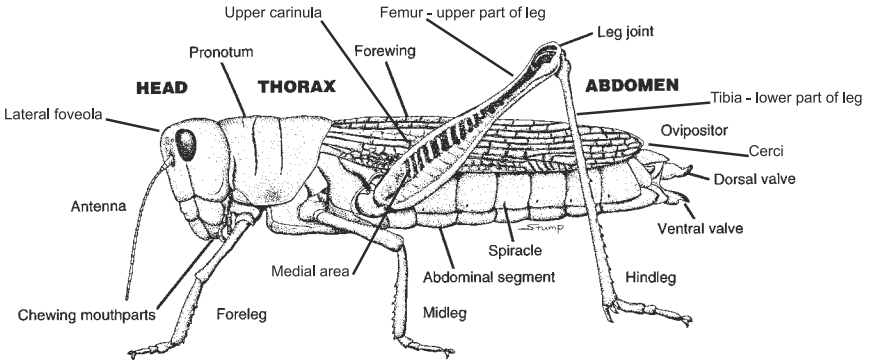

Figure 2. The external characteristics of a female grasshopper. Modeled after *Melanoplus bivittatus* (Say, 1973).

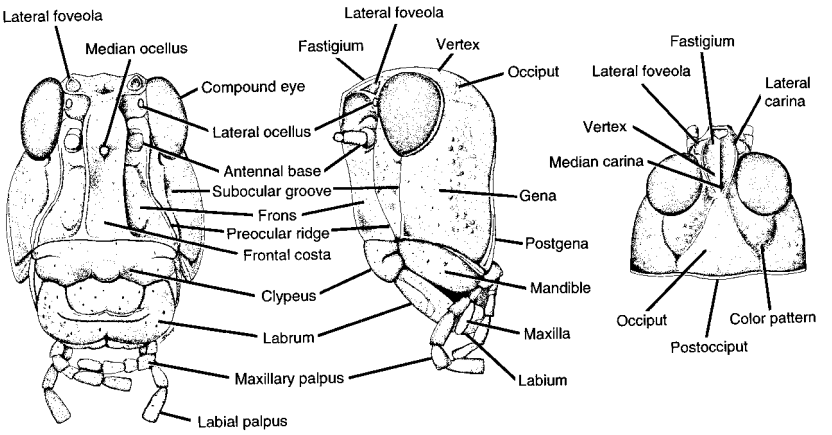

Figure 3. Grasshopper head, front, side, and top views. Modeled after *Trimerotropis pallidipennis* (Burmeister).

Biology and Life Cycles

Life cycles vary by species. Each species has a particular set of ecological and physiological adaptations that allow it to grow, survive, and reproduce within an environment. Specific life cycles will be treated in the discussion for each species.

Grasshoppers develop from eggs, into nymphs, then adults. Eggs are laid in pods, usually in or on the soil. The egg pods of species vary in the number of eggs they contain and in their size, shape, and structure. They develop if exposed to favorable incubation temperatures. Warm temperatures can speed up the process of development. Cold temperatures may slow or end this process, and eggs may enter a dormant period. The number of dormant eggs that hatch the following spring can be greatly reduced by cold spring temperatures. Late spring or early summer cold weather can also significantly reduce grasshopper populations, especially when moisture is present. Some species hatch the same summer they are laid. When ground temperatures warm above 50°F to 55°F, the eggs begin to develop. Consequently, elevation impacts the timing of egg development, and eggs hatch at different times in Nevada, from early spring to late summer.

Egg masses are usually laid in undisturbed sites (ditches, weedy areas, waysides, rangeland, etc.) in late summer and fall. Grasshoppers lay their eggs in pods of two to 120 eggs cemented together with a froth that hardens. A female lays an average of 200 eggs in her lifetime. With adequate food and dry, warm conditions, a female may lay 400 eggs. Laid in the soil, eggs can survive very harsh environments, including Nevada's winters. Eggs begin hatching in April and May and peak in mid-June. Cool and extremely dry springs may delay the hatch until June and July.

Depending on the species, hatching may occur over a period of three to four weeks. Nymphs may develop for eight to 10 weeks and become adults nine to 11 weeks after hatching. Nymphs and adults may be present all year, with some species overwintering in the late nymphal stages. However, most species overwinter as eggs in the soil. Because of variations in the stages of life cycles and individual species development, active feeding by grasshoppers may occur over an entire growing season.

Hatchlings emerge from the pod one after another. They are not mobile until they completely shed the egg membrane and are susceptible to predation during emergence. As they grow, they molt, changing structure and form and shedding their outer shell (exoskeleton). The nymph looks like the adult but is smaller, lacks wings, has fewer antennal segments, and has only rudimentary genitalia. Grasshoppers may molt four to six times, depending on the species. Each molted nymph is called an instar.

A new adult has functioning wings but is not immediately capable of reproduction. It takes a new female adult one to two weeks of development to be ready to deposit eggs. She deposits eggs throughout her life, producing up to three pods per week.

Land managers should use this guide (Table 1) for determining which species live in their management area. Keeping good records from year to year aids in species identification. Identifying which species occupy particular locations and knowing the dates of their first appearance and how they develop through various instars are critical parts of the puzzle necessary in planning their management.

Species are categorized by seasonal cycles arranged into groups:

1. Very early occurring nymph and adult
2. Very early hatching
3. Early hatching
4. Intermediate hatching
5. Late hatching

Table 1

The relative time of hatching for grasshoppers in Nevada varies with annual weather patterns.

Very Early Spring	Early Spring	Mid-spring	Late Spring
Twostriped *Melanoplus bivattatus*	Bandwing *Trimerotropis pallidipennis*	Bigheaded *Aulocara elliotii*	Redlegged *Melanoplus femurrubrum*
Mormon Cricket *Anabrus simplex*	Nevada Sage *Melanoplus rugglesi*	Clearwinged *Camnula pellucida*	
	Packard *Melanoplus packardii*	Migratory *Melanoplus sanguinipes*	
	Valley *Oedaleonotus enigma*	Jerusalem Cricket *Stenopelmatus fuscus*	

Behavior

A response to the environment: Grasshopper behavior responds to fluctuations in the environment to improve chance of survival. The jumping/flying response helps them flee enemies that may parasitize or feed on them. Their reactions to cold differ across species.

Some grasshoppers spend cool nights under litter or in grasses, while others stay on bare ground, needing little protection. Still others hide in bushes at various heights in the canopy. With favorable weather and temperatures, grasshoppers may feed at night and start their day at dawn, warming themselves in the early sun. Because they are cold-blooded, it may take a couple of hours of basking in the sun before a grasshopper becomes active. Cold, overcast, or rainy weather interrupts normal activities, causing them to seek shelter and remain inactive. Prolonged, severe cold, moist conditions often devastate a population.

During warm, sunny weather, most grasshoppers feed in the morning and in late afternoon. Some species climb a host plant, feeding on leaves, petals, buds, or soft seeds. Others are ground foragers, searching for seeds, dead insects, and clippings (stems and leaves) felled by plant-climbing grasshoppers.

Grasshoppers are careful in their food selection. They sample potential food sources before choosing one over another. They choose plants that are important nutritionally, supplying them with specific sugars, phospholipids, amino acids, and vitamins. They prefer young, green leaves. Preferred host plants are listed under individual species.

Grasshoppers communicate with each other both visually and acoustically to attract or recognize mates, to scare off unwanted suitors, and to protect a territory or food source. Some make clicking sounds when they fly and others do not.

A female determines where to lay her eggs by probing the soil with her ovipositor. By doing so, she senses the physical and chemical properties of the soil (temperature, moisture content, acidity or alkalinity, and salt content). Adults fly out of deteriorating habitats affected by drought or forage depletion to seek food and shelter elsewhere. They may also leave for other reasons, such as changes in the climate.

Treatment Thresholds

What represents a damaging number of grasshoppers per acre or square yard? That depends on what is considered damage. A rancher might ask, "How much forage can be lost before my animals lose enough weight to make it cost-effective for me to take measures to treat for the grasshoppers?" A wildlife manager might want to know the level of forage loss that will reduce large game animal survival over winter or if the nesting of a particular bird species is compromised because of grasshopper feeding. On the other hand, a homeowner may consider a different population of grasshoppers devastating to a vegetable garden or ornamental landscape.

Some people have zero tolerance for grasshoppers. Emotionally they "can't stand them!" Tolerance levels or treatment thresholds for an infestation differ from case to case. Each threshold must be considered important and the benefits of treatment weighed against the costs of control and potential environmental losses. In addition, the coverage of the outbreak area is important. Is the area of infestation a backyard or tens of thousands of acres of rangeland? Also evaluate if a single application will suffice or if multiple applications will be required to control the outbreak.

Ranch and Rangeland Thresholds

Rangeland tolerances have been established over years of research and experience. (Branson and Redlin, 2001; Glogoza and Weiss, 1997). Most are based upon an economic threshold at which forage and crops are threatened. Growers ask, "Where, in a field, should the counts be taken? Is it profitable to treat and when?" The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has established the action threshold for pest grasshoppers on rangelands of eight adults per square yard (Table 2).

It is important to determine this threshold early in a season because many treatments are most effective during the third instar before the grasshopper can fly, escape treatment, and move greater distances to find food.

With practice, accurately counting one to five grasshoppers per square foot will become easy. Five grasshoppers per square foot equates to 45 grasshoppers per square yard, which far exceeds the action threshold of eight per square yard. It's important to remember that those eight must be pest species or no economic benefits will occur from implementing an expensive management strategy.

Home and Garden Thresholds

Resources are generally more available for pest control in gardens and landscapes. Expectations for success in production of produce and maintaining a beautiful environment are much higher than those associated with wild lands. Likewise, the thresholds for damage are much lower. Aesthetic and emotional thresholds often override the economic considerations for pest control and may be only one to a few grasshoppers per square yard.

Table 2

Rangeland grasshopper infestation ratings based on the number of adult grasshoppers per square yard.

	Adults per square yard	
Rating	Margin of Field Crops	Fields and Rangelands[a]
Non-economic	5 to 10	0 to 2
Light	11 to 20	3 to 7
Threatening	21 to 40	8 to 14
Severe	41 to 80	15 to 28
Very Severe	80	28+

[a] Counts from both rangelands and field crops are to be made randomly inside and away from the margins of the area or field.

Grasshopper Outbreak Dynamics

Grasshopper population dynamics are cyclic. Over several years, the population of a species, or more likely several species, increases and then with favorable conditions, an outbreak occurs. Everyone asks, "Where did they all come from?" or "Why are there so many?" Weather affects the growth and explosion of grasshopper populations. Hot, dry summers, warm autumns and mild springs over several years usually precede an outbreak.

Predation by birds, mammals, and invertebrates reduces the population of grasshoppers each year, as do parasites that attack eggs and nymphs. Grasshoppers do contribute to the food chain.

Although grasshopper populations may decrease significantly due to weather, disease, or predation, an outbreak still may occur.

For example, one pair of grasshoppers can produce 400 eggs. If half of those are lost to weather, parasites, and predators, that still leaves 200 grasshoppers, nearly a 100-fold increase in the population. It is surprising that outbreaks do not occur more often in Nevada.

Grasshopper damage depends upon the species, their density (the total number of grasshoppers per square yard or acre), and their feeding behavior. Some consume green forage directly from the plant, while others clip it and eat it later. Clipping can account for 50 percent of forage loss. Ground-dwelling species may eat the clipped pieces. Although there are 118 species of grasshoppers in Nevada, only a few cause significant damage to warrant the time and money for their control. If sufficient numbers of damaging species are present, control measures may be warranted.

Surveying and Collecting Samples

Many factors influence grasshopper densities. Several species of grasshoppers may live together in the same habitat, usually with one dominant species comprising more than 50 percent of the population. Occasionally, there are codominant species. Because of weather, predators, parasites, disease, and insecticide treatments, the densities of grasshoppers within a site can change over time. Often, the more abundant species dominate for years. Soil, vegetation, topography, moisture levels, and the use of the habitat by other animals and humans also influence grasshopper densities in a region.

Species composition within a habitat usually remains constant year after year. Knowing which species were prevalent in past years aids in the identification of the current year's population.

APHIS, Agricultural Research Service (ARS), state, and university researchers have developed scouting procedures for identifying species, and for counting egg and grasshopper densities (Branson and Redlin, 2001; Glogoza and Weiss, 1997).

Sampling for eggs should be done in early spring (March and April). Two inches of soil from a square foot of soil should be sifted through a six-mesh screen. Take three to five samples per site to calculate more accurately the average number of eggs per square foot. As mentioned earlier, five grasshoppers per square foot, equates to 45 per square yard. Economic crop damage is likely if there is either an average of 17 or more eggs per square yard in the field or 120 or more eggs per square yard outside but adjacent to the field or both (Table 3). In this case, an early seeding of small grains with a higher seeding rate at the edges of the field should be made rather than a planting of a more susceptible crop.

Table 3
Relationship between egg numbers per square yard in fields or roadsides and borders and a potential grasshopper infestation.

	Number of eggs per square yard	
Infestation Level	Roadsides & Borders	Fields & Rangelands
Light	40-120	6-8
Threatening	121-300	9-17
Severe	301-600	18-33
Very Severe	600	33

After Glogoza and Weiss, 1997

After the eggs have hatched, use a sweep net across an area to:

1. Identify the grasshoppers present by species.
2. Determine the proportion of each species in an infestation.
3. Learn their stage of growth and which instar is present.

To determine which grasshopper is present, collect several specimens. Often many species of grasshoppers will be present at one location. The best method of collecting grasshoppers is to use a light net, although any method that will allow an uncrushed specimen to be caught will work. If the specimens need to be submitted for identification, they should be killed in a simple killing jar containing potassium cyanide or ethyl acetate-saturated plaster of paris (Figure 4) or frozen. If these methods of preserving are not available, collect and ship specimens in 70 percent rubbing alcohol. This works, but the colors needed for an accurate identification of the insect may be affected.

Carefully pack the specimen to protect it, and ship it dry to: Nevada Department of Agriculture, 350 Capitol Hill Ave., Reno, Nevada, 89502. Include the following data: location, county, date collected, type of crop or habitat where the grasshoppers were collected, number per square yard, collector's name, phone and fax numbers, mail or e-mail address for sending a report of the results. E-mail is preferred. The phone number for the entomology laboratory is (775) 688-1182 Ext. 245. The e-mail address is jknight@govmail.state.nv.us.

Once a grasshopper specimen is identified as a species that may be damaging, it is necessary to determine how many grasshoppers are present per unit area and whether the treatment is necessary.

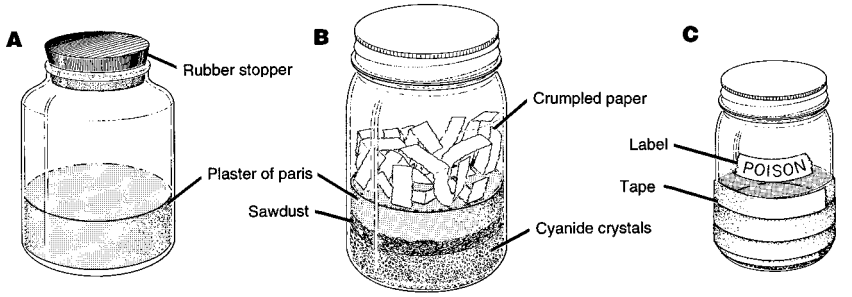

Figure 4. Killing jars: A. Plaster of paris saturated with ethyl acetate. B. Crystals of potassium cyanide under sawdust and plaster of paris. C. Protect glass jars from breaking with electrical or duct tape and label "**poison**." Do not use wood, plastic or metal containers for killing containers.

Grasshopper population counts are based on the numbers of grasshoppers per square yard. A count can be achieved in two ways. Federal agencies use a method where scouts count the grasshoppers hopping in 18 to 27 one-square-foot areas. Scouts walk randomly along a path looking about six feet ahead. Each count is taken several paces from the last. The sum of 18 is then divided by two or the sum of 27 is divided by three, and the result is grasshoppers per square yard.

For example:

Sample counts per square foot:
2+1+2+0+0+1+1+1+2+1+2+1+2+1+2+1+0+1 = 21
21 ÷ 2 = 10.5 grasshoppers per square yard.

Several paths should be counted in different locations of the infested area and an average number of grasshoppers per square yard calculated for the area.

A person learns to easily count less than five grasshoppers per square foot, although first and second instars are small and may be difficult to distinguish from leafhoppers. Leafhoppers have wings; nymphal grasshoppers are wingless. In this case, the scout may have to crouch or kneel to be certain grasshoppers are present and moving within or out of the area. Accurate counts greater than five per square foot are not necessary for making management decisions. At five per square foot, there are 45 grasshoppers per square yard, which exceeds the recommended action threshold of eight per square yard.

Another method is simply to count the grasshoppers in a visually approximated 3 feet by 3 feet area. Several of these areas should be counted throughout the infested area and then the totals should be averaged.

If the population is mixed with damaging and nondamaging species, count only the damaging grasshoppers. Either of these methods will give reliable results. Some find it easiest to count the grasshoppers in a square foot. The results can then be compared to economic thresholds for the given crop or habitat. Weather can have an important impact on survey results.

Grasshoppers, being cold-blooded invertebrates, will be much less active during cool weather. Wind may also cause results to be lower than expected. Grasshoppers are less active during windy times. Take counts from midmorning on and before the winds pick up.

When the grasshoppers that were counted were mostly first to third instar, (wingless and generally less than ½-inch long), divide the total number of grasshoppers counted by three to arrive at the adult-equivalent total. Generally about 50 percent or less of all the early instars found on rangelands will become adults. Count the fourth-instar nymphs and older as adults. Sometimes changes in weather, predation and parasitism cause a big population of nymphs to crash. That is why repeated sampling throughout the season is necessary for managing grasshoppers. Usually if controls are initiated between the third and fifth instars, forage is saved and the potential for the grasshopper population to recover the following year is eliminated.

Early detection and treatment are important because:

1. Smaller grasshoppers (early nymphs) are more susceptible to insecticide so less is needed to obtain control.
2. Early treatment prevents winged adults from migrating to uninfested areas and laying eggs.
3. Fewer acres have to be treated.
4. Less crop damage results.
5. Preventing egg laying reduces potential grasshopper threats in subsequent years.

Control measures can begin while grasshoppers are nymphs in the hatching sites (roadsides, fence rows, etc.) when land managers scout for them in early spring (March and April).

USDA Grasshopper Survey
Square-foot Method

Determine the number of nymphs or adult grasshoppers per square yard (density). Count the number of grasshoppers that hop or move within nine square-foot areas of infested land.

- Visualize a square foot area about six feet in front of you. From that distance, you can observe the grasshoppers without frightening them away and affecting the count.
- Move slowly toward the area and count the grasshoppers in or jumping out of the area. Stoop or crouch to see small nymphs early in the season.
- Walk 10 to 15 paces (be consistent each time) away from the counted area. Keep the sun in front of you so that your shadow does not scare away the grasshoppers in the upcoming counting square.
- Visualize the next square foot area and count the grasshoppers in the area. Repeat this process nine times and add up the total for the number of grasshoppers per square yard.

Grasshoppers are not uniformly distributed. Repeat this counting per square yard at least three times (27 square foot areas counted); then calculate the average for the number of grasshoppers per square yard in the area.

Integrated Pest Management

Definition: Integrated pest management (IPM) is understanding the pest, the hosts infested, the environmental conditions affecting both, the available pest control methods, and then using this information to implement a timely, cost-effective plan to prevent unacceptable pest damage with the least hazard posed to people, property, and the environment.

Although emphasis is given to integrated management of grasshoppers for range management in this guide, consideration for their management in yards and gardens is given when techniques may be appropriate and realistic. For example, barriers to exclude grasshoppers may be cost effective around a high-value vegetable garden or ornamentals, but impractical for rangeland use.

A basic tenet of IPM is that healthy, vigorous rangeland ecosystems and home landscapes are the most permanent solutions to grasshopper problems in the long term. In such environments, plants have greater potential to ward off or survive pest attacks. There are also inherent factors within the system that limit pest damage: weather, predators, parasites, exposure, plant resistance, etc.

Grasshopper Integrated Pest Management Resources

Much information is available for private and public use on grasshopper integrated pest management (GHIPM). The federal government has supported GHIPM research in the western United States since the 1980s and information from that work is now available. See the reference section for sources of GHIPM information.

IPM Techniques

Integrated grasshopper management incorporates mechanical, physical, cultural, biological, and chemical techniques to suppress an infestation in the most efficient, economical, and environmentally sound manner.

Traditionally, for range managers, pesticides were the most cost-effective way to suppress grasshoppers. More recently, cultural practices, a wide variety of predators and parasites, and growth regulators that arrest insect development are being used.

Since gardens and landscapes are a smaller management area, more resources and thus a greater variety of control tactics, are generally available for control purposes than are available for range management.

Physical and Mechanical Strategies

Ranch and rangeland: Rangeland fire, whether natural or man-made, kills grasshoppers but does not usually destroy egg pods in the soil. However, newly hatched nymphs may die for lack of food, if few plants germinate the next spring. Fire is not generally effective at helping to control grasshoppers because it often occurs at the wrong time. Early fires that could kill the first instars are rare because the vegetation is too green and moist to carry wildfire well over a large area. Most fires occur late in the season when vegetation is dry, but unfortunately, by then most grasshopper damage has occurred and the eggs have been laid.

Disking or plowing ground that is full of egg pods reduces the hatch the next spring. Unfortunately, rangeland returns usually do not allow this type of expense. Only limited cropland in Nevada can justify such expenditures and then only as part of a crop rotation or renovation plan.

Home and garden: Grasshoppers are cold-blooded animals and are least active early in the morning before temperatures rise. This is the best time to catch and destroy them. Use a sweep net or catch grasshoppers by hand to remove them from vegetable and flower gardens, ground cover plantings, and the general landscape. Dispose of them in a closed container in the trash or in a fire, or crush them to kill them.

Digging and cultivating in early spring, and leaving the soil exposed makes the eggs available for predators and exposes them to adverse freezing, thawing, and dehydrating conditions.

Tilling cropland and vacant land in mid- to late summer reduces potential egg-laying sites because grasshoppers prefer undisturbed areas for egg laying. However, consider that this will also increase soil dehydration and soil erosion in windy areas. Tillage is most practical if it is part of the normal management proposed for the cropping of the land.

Keeping waste areas, fence rows, roadsides, and other egg-laying ground free of weeds through cultivation or chemical treatment, or fallow during the mid- to late summer, may discourage egg laying. Eggs are laid where nymphs are most likely to find food readily available the following year.

Grasshopper nymphs and Mormon crickets hop from place to place, but they usually do not jump high, unless startled. Consequently, simple 2-feet tall barriers can do much to keep them out of a vegetable garden. However, barriers must have a smooth surface because grasshoppers and crickets are great climbers. A chicken wire fence draped with sheet plastic pulled taut makes a great barrier early in the year. Angle the fence to bend out away from the area it is protecting. This makes it more difficult to climb. Secure the base of the plastic with soil so that there are no entrance holes into the garden.

Floating row covers can be used to protect vegetables and ornamentals. Care must be taken to secure them well so that there are no entrance holes where they meet

the soil. Unfortunately, many products are so lightweight that some grasshoppers can chew through them to damage the plants underneath.

Grasshoppers are attracted to yellow. Long, sticky, yellow tape and sticky, yellow plastic squares are available to trap pests. Yellow plastic can be floated on or suspended over water dams, ponds, and even children's wading pools to attract the grasshoppers to the water where they will drown or be eaten by fish.

Jars, shallow pans, and buckets filled with a ten percent solution of molasses and water can also be used to trap grasshoppers. Cover the containers with a film of canola oil to deter bees and mosquitoes from getting into them. The grasshoppers will be attracted to the sweet solution and the canola oil. Bury the containers so that the rims are at ground level for best results. Remove the dead grasshoppers daily. Clean the trap and renew the bait as necessary.

Cultural Strategies

Ranch and rangeland: Changing rangeland cultural practices centers around grazing management. Studies in the Great Plains (Flaherty, 1995; Onsager, 2000) demonstrated that using twice-over rotational grazing during the season rather than employing season-long grazing delays the development of nymphs and reduces their survival rates, leading to significantly fewer adults later in the season. The average number of grasshopper species was 3.3 times higher under season-long grazing than rotational grazing. Localized outbreaks that occurred under season-long grazing did not occur with rotational grazing. As a result, much forage was saved under rotational grazing. Among nine major grasshopper species, none were significantly more abundant in the rotationally grazed areas compared to the sites grazed season-long. The three species that caused the outbreaks under season-long grazing remained innocuous under rotational grazing. Twice-over rotational grazing appears to suppress grasshopper outbreaks in rangelands.

Home and garden: Summer weed control in fallow fields, waste areas, fence rows, ditches, etc., accomplishes two objectives:

1. If eggs are already in the field, there will be nothing for small nymphs to feed on when the eggs hatch, and
2. Fields will not be attractive to egg-laying adults since there is nothing on which to feed.

Eliminate tall grass and weeds from around the vegetation you wish to protect. This not only makes these areas less attractive for egg laying, it reduces food sources so grasshoppers are not attracted to these areas. It also exposes grasshoppers to greater predation from birds, lizards, etc.

Fallow ground, burned rangeland, and bare ground do not favor grasshoppers. Females do not lay eggs in barren soil because the nymphs will not have anything to eat. Also, if the soil where eggs are laid is disturbed and the egg pods are exposed to the elements over the winter, they die. Disking and cultivation usually reduce chance of survival for grasshoppers. Grasshoppers need undisturbed egg-laying sites with available food to flourish. Without a food source, outbreaks are reduced.

Biological Strategies

Ranch and rangeland: Predators and parasites of grasshoppers are numerous. They suppress grasshopper outbreaks and reduce

grasshopper population densities. Several species of flies and wasps are parasites of grasshopper eggs, nymphs, and adults. Predators, such as birds, rodents, lizards, snakes, and many arthropods are often more effective than parasites in reducing grasshopper numbers. Arthropod predators include ground and blister beetles, spiders, robber flies, assassin bugs, sphecid wasps, and ants. Birds are known to reduce grasshopper densities 30 percent to 50 percent and egg-pod predation runs about 19 percent (occasionally 100 percent locally), while parasitism reduction rates do not usually exceed 10 percent. Unfortunately, weather that favors grasshoppers may cause a population increase that overwhelms natural controls and leads to a grasshopper outbreak.

The fungus, *Entomophus grylli*, is a naturally occurring control for grasshoppers under most conditions. It spreads by direct contact. This fungus causes infected grasshoppers to climb to the top of grass stems or brush limbs and die with their heads pointing upwards. The cadavers remain in this position until wind or rain knocks them off. Unfortunately, high humidity is required for this fungus to be effective, and in arid regions and where overgrazing has occurred, *E. grylli* is less effective as a biological control agent. *Beauvaria bassiana* is another effective fungal pathogen of grasshoppers that is commercially produced.

The protozoan, *Nosema locustae,* formulated on bran bait at one billion spores per pound of bran, is marketed as Nosema® or "Nolo Bait®. It is applied at 1 pound of bran per acre. After ingestion, it multiplies in the grasshopper, and then causes diarrhea, dehydration, and eventually death. Cannibalistic grasshoppers that eat the diseased, dead grasshoppers spread the protozoan *Nosema* through the population. The product, Nosema®, is slow acting and usually is not very effective the year of application, but may cost-effectively reduce the following year's population of grasshoppers. Neither young nor old grasshoppers effectively spread *Nosema locustae*, so timing of application is important. Apply the bait during the third instar stage to spread the disease and reduce grasshopper numbers. *Nosema locustae* overwinters on egg pods laid by infected females, in overwintering nymphs, and in the soil. Grasshoppers that do not eat bran are not directly infected, but may become infected through cannibalism. Nosema® is target specific to grasshoppers and crickets; it does not harm beneficial insects and other nontarget organisms.

Other bioagents may become available in the near future. For example, GREEN MUSCLE®, the pathogenic fungus *Metarhizium anisopliae* var. *acridium*, is an effective biological control of locust in Africa that is commercially available on that continent. Whether or not it will kill western grasshopper pests must be examined.

Growth regulators are another possible biological control. A chitin inhibitor for grasshopper control is currently being sold as Dimilin® for registered sites. Chitin is the material that provides structure for the insect's exoskeleton. Dimilin® inhibits hardening of the exoskeleton after a molt, causing the insect to dehydrate and die. It may interfere with egg production because the eggshell is also made of chitin.

Dimilin® can be applied aerially mixed with water or oil, or in a bran bait. Like Nosema® and Sevin®, an insecticide discussed later, Dimilin® is only effective on those grasshoppers attracted to bran baits. An important attribute of Dimilin® is that it is not toxic to adult insects (pollinating bees and predators), birds, and mammals. However, Dimilin® is persistent in the environment and

toxic to immature aquatic insects. In tests, Dimilin® was found to be as effective as the pesticide Sevin® which is toxic to pollinators and predators. Dimilin® works fairly rapidly, with the majority of the kill occurring within seven days of application.

Home and garden: Develop a garden that attracts birds of all kinds by planting trees and shrubs for nesting and food. Attach bird-nesting boxes to poles and provide bird-baths in the landscape. Allowing turkeys, domestic geese, and chickens to roam free around a homestead or within a fenced-in vegetable garden, once the plants are established, will keep grasshoppers at bay. Birds feed on egg pods, nymphs, and adults.

As discussed previously, a fungus, *Entomophus grylli,* often causes high mortality under warm, humid conditions. In arid regions it is much less effective.

The protozoan mentioned earlier, *Nosema locustae*, is normally present naturally, to some extent, in grasshopper populations, but generally does not cause significant mortality. *N. locustae* spores incorporated on bran baits, sold under such names as Semaspore®, Nolo Bait®, or Grasshopper Attack® , kill some nymphs but virtually no adults. However, infected adults lay fewer eggs. *N. locustae* baits act too slowly and kill too few grasshoppers to be of much value when the need for control is immediate.

Nematodes called hairworms commonly infest adult grasshoppers. They reduce the vigor of grasshoppers, but do not cause significant mortality. Insects that feed on grasshoppers include the larvae of blister beetles (predators of the eggs), bee flies (parasites of eggs), robber flies, ground beetles, flesh flies, and tangle-veined flies. Birds (quail, turkey, larks, etc.) and mammals consume grasshoppers, but have little impact in outbreak years.

Chemical Strategies

Ranch and rangeland: Chemical control of rangeland grasshoppers currently involves the use of aerially applied malathion, carbaryl (trade name Sevin®, both as a liquid and bran bait), or acephate (trade name Orthene®). Carbaryl baits are occasionally applied from the ground. These same products are recommended for grasshopper control in crops and in the landscape. The principle source of mortality to grasshoppers is through ingestion, though the chemicals also kill by body contact. These chemicals interfere with the insect's nervous system, resulting in death.

These insecticides are fast acting. When applied at recommended rates under optimal conditions, they can reduce grasshopper populations within 24 hours to 72 hours. Control rates of 80 percent to 85 percent are common. These chemicals are applied at low volumes when used as sprays, and malathion is used at ultra-low volumes, (ULV—8 fluid ounces per acre). Optimal conditions include low moisture (to prevent dilution of the insecticide), cool temperatures (so heat rising from the ground does not prevent the chemical from reaching the ground), and little or preferably no wind (to prevent drift from the target area). These conditions usually restrict aerial application to early morning, from sunrise until ground temperature reaches approximately 75°F to 80°F and before wind speeds exceed 10 miles per hour.

A disadvantage of using chemicals as liquids is that they are less target specific; they kill insects that are beneficial such as ants, honeybees, parasites, and predators. The chemicals are also toxic to aquatic insects such as mayflies, caddisflies, and stoneflies. Additionally, when these products effectively reduce the number of grasshoppers, other

animals that depend on them as food may decline or have to move elsewhere to survive. All of these chemicals may have some toxic effect on birds and mammals (including humans) if used improperly. Therefore, the application rates and other warnings listed on the labels should be read and followed in order to avoid direct hazards to nontarget species. The label is the law.

The Reduced Agent and Area Treatments (RAATS) program is recommended for integrated control of rangeland grasshoppers (Lockwood, 2000; Foster, *et al.*, 2001). The rate of insecticides applied is reduced compared to traditional recommendations and untreated swaths (refuges) are alternated with treated swaths. By using this procedure, 60 percent to 75 percent less pesticide is used. Although pesticides are only applied to kill grasshoppers in the treated swaths, the grasshoppers that move out of the untreated swaths into the treated areas to feed are also killed. This allows predators and parasites to be preserved in the untreated swaths to suppress the grasshoppers that remain there. Organisms within the refuges that move slowly are not exposed to pesticides and even those that move into the treated swaths may not be affected if they do not forage. Refuges protect biocontrol agents of grasshoppers and weeds.

The predators and parasites from the refuges will rapidly recolonize the treated swaths as the pesticides dissipate.

The RAATS treatment is 80 percent to 95 percent as effective as the traditional treatments for grasshoppers. Those that remain do not lead to an outbreak the following year. However, swath treatments can reduce the control cost and amount of insecticide used by more than 50 percent compared to conventional broad coverage. The USDA cost-share program to control grasshoppers has ended and subsidies by Nevada are limited. This makes RAATS the best alternative to a traditional program because the costs of traditional management without subsidies exceed the benefits to rangelands. Just as important, using less pesticide protects native species (fish, birds, wildlife, microorganisms), beneficial organisms (predators and parasites), water quality, and humans from toxic products.

The National Grasshopper Management Board recommends using one of the following RAATS procedures to economically manage grasshoppers in rangelands:

1. Apply carbaryl (Sevin XLR®) at 8 fluid ounces per acre. This is 280 grams of active ingredient, added to an equal volume of water at pH 7. Apply the 1:1 diluted product and water in 100-foot swaths, alternating with 100-foot untreated swaths (Figure 5). The traditional application would use 16 fluid ounces of pesticide per acre over the entire area, rather than 8 fluid ounces per acre in alternating 100-foot wide strips.

2. Apply diflubenzuron (Dimilin 2L®) to the 100-foot treatment swaths at a rate of 0.75 fluid ounces per acre. This is 5.3 grams of active ingredient, mixed with 8 fluid ounces of water and 4 fluid ounces of canola oil. Use canola rather than crop oil because canola is an attractant for many grasshopper species that may stimulate feeding, thus exposing the grasshoppers to more pesticide. If the majority of the grasshoppers to be treated are late instars, the vegetation is dense, the terrain is rough, and it is hot, increase the application rate or total volume of Dimilin® applied up to the traditional level of 1 fluid ounce per acre in 30

fluid ounces of carrier (20 fluid ounces of water and 10 fluid ounces of canola or crop oil).

❸ Apply malathion (Fyfanon®) at 4 fluid ounces per acre (This is 342 grams of active ingredient) in 100-foot swaths, alternating with 25-foot untreated swaths. The traditional application of malathion calls for 8 fluid ounces per acre. Good results, (80 percent to 85 percent mortality, unless there were high population densities of late instars and adults present) were achieved using 100-foot swaths at the following rates and coverage: 5 fluid ounces per acre with 33-foot untreated swaths, 5 fluid ounces with 50-foot untreated swaths or 7 fluid ounces with 100-foot untreated swaths.

Consider the following for success when using RAATS: use Micronaire nozzles or turn conventional nozzles at a 45-degree angle into the wind to enhance the distribution and coverage of the application at these low volumes of product.

With all chemicals higher rates or coverages may be needed if grasshopper densities are extreme (more than 50 per square yard), the forage cover is tall or dense, the terrain is rough, or operational conditions are poor.

Apply products under cool conditions (ground temperatures, measured with a soil thermometer, below air temperatures, measured at three feet off the ground) whenever possible. Do not apply products when the air temperature exceeds the ground temperature by 10°F to 20°F. Grasshopper mortality was 90 percent using Dimilin®

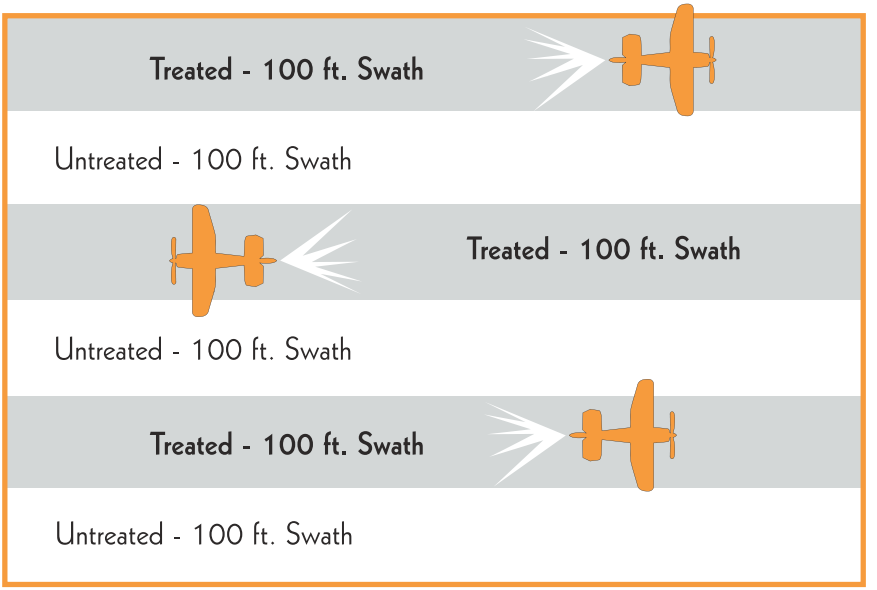

Figure 5. Rangeland RAATS application with 50-percent coverage. Pesticides are only applied in the treated swaths allowing predators and parasites to be preserved in the untreated swaths and using less chemical.

under these range of conditions. Thermals, rising air, may interrupt the deposition of pesticides unless cross winds between four miles and 10 miles per hour are present.

In all cases, pesticides must be applied according to the label directions. It is against the law to do otherwise and is contrary to good common sense. Following the label directions reduces the risk to plants, animals, and the environment.

Home and garden: Many suitable insecticides are available for grasshopper control around the home for crops and garden use (Tables 4 and 5). Multiple insecticide applications may be required to protect gardens, trees, and crops, especially if the grasshoppers' normal weed and grass food plants have been eaten or have begun to dry out.

Table 4

Insecticides labeled for grasshopper control on various crops. [a]

Insecticide	Alfalfa	Alfalfa Seed	Corn	Wheat	Barley	Mint	Potatoes
Asana XL®	+(21)						+(28)
Baythroid 2®	+(7)		+(0)[b]				
Dimethoate 4E,4C®	+(10)		+(14)	+(35)			+(21)
Furadan 4F®	+7	+0	+(30)				+(21)
Lorsban 4E®	+(7-14)		+(35)				+(28)
Lorsban 4E SG®				+(28)			
Malathion 57 EC®	+(0)			+(7)			
Malathion ULV®	+(0)		+(5)	+(7)		+(7)	+(7)
Penncap-M®	+(15)		+(12)	+(15)			+(20)
Scout X-TRA®							+(21)
Sevin 4F, 50W XLR[c], 80S®	+(7)		+(18)	+(21)			+(21)

[a] Preharvest interval days are in parentheses.

[b] Sweet corn only.

[c] The Sevin XLR® label has directions for making wheat bran bait.

+ = Labeled for specific crop indicated.

Brand names are used for illustration purposes only and do not constitute an endorsement by University of Nevada Cooperative Extension.

Table 5

Insecticides labeled for grasshopper control at various sites[a].

Insecticides	Trees & Shrubs	Garden	Range	Noncropland
Asana XL®				+
Diazinon	+	+		+
Dimethoate	+			
Lorsban 4E®	+b			
Malathion+®	+	+	+	
Malathion ULV®			+	+
Penncap M®			+	
Sevin 4 Oil®			+	+
Sevin®	+	+	+	+

[a] Carefully read label for preharvest and pregrazing intervals, phytotoxicity, and other precautions.

[b] Christmas tree nurseries and plantations only.

After Patrick, 1998

Brand names are used for illustration purposes only and do not constitute an endorsement by University of Nevada Cooperative Extension.

Summary

Integrated pest management for grasshoppers can be effective, but because grasshopper infestations know no boundaries, it is imperative that all levels of government and the private sector come together to manage grasshoppers cooperatively. It takes everyone working together and pooling resources to successfully combat grasshopper pests, especially when the management expenditures exceed the economic benefits to the private sector.

Species of Economic Importance in Nevada

This section includes an alphabetical listing by common name, with the species name shown in *italic*. It includes color pictures, drawings, and descriptions of the distinguishing characteristics, seasonal life stages, feeding and reproductive behavior, and habitat preferences of grasshopper pests in Nevada.

Bandwing Grasshopper

Pallidwinged Grasshopper: *Trimerotropis pallidipennis*

Identification

The bandwing group of grasshoppers is one of the more noticeable encountered in the Great Basin. Many are quite large with yellow, red, or blue hindwings. The adults make clicking noises as they fly. The most common bandwing species in Nevada is the pallidwinged grasshopper (*Trimerotropis pallidipennis*). Although these grasshoppers are quite large they are rarely of economic importance. Species are commonly differentiated by the color and banding of the hindwing, coloration of the front wings, and shape and color of the pronotum. Accurate identification requires determination by an expert.

The colorful hindwings serve to attract mates and to escape predators. A predator keys in on the wing color. When the grasshopper lands, the wing color changes as the grasshopper folds its wings, camouflaging the grasshopper.

Hatching

Two generations per year may be produced, although in most Nevada climate zones the bandwing overwinters in the soil, in the egg stage, producing only one generation per year. Hatching occurs in early spring with adults found from late June until early September. Eggs are pale yellow with 18 per pod. Average egg length is 5 millimeters with an average diameter of 1 millimeter. Pods are delicate with a thin layer of froth over the eggs.

Habitat

This grasshopper is one of the most widely distributed in the arid areas of the west. Its habitat includes dry grasslands, western prairies, desert grasslands, and desert scrublands. Most often this species is found in lower elevations, in areas with thin soils and sparse vegetation. However, it has been documented at elevations exceeding 10,000 feet. It has considerable flight capability and may be found at a number of locations in a short period of time. In addition, due to its habit of dispersing at night, it can be found near lighted areas such as city streets and parks — areas not normally inhabited by this species.

Food

Bandwings feed on a wide variety of species within western, native plant communities. They feed on cultivated crops especially vegetables, alfalfa, and barley. They also eat cheatgrass, tumblemustard, bluebunch wheatgrass, timothy, and wooly Indianwheat. Most often they will focus their feeding efforts on grasses located within their habitat area. They are rarely abundant enough to damage rangelands except in conjunction with other grasshoppers.

Bandwing Grasshopper

Pallidwinged Grasshopper: *Trimerotropis pallidipennis*

Figure 6. Diversity of bandwing colors.

Figure 7. Diversity of bandwing colors.

Figure 8. Diversity of bandwing colors.

Figure 9. Diversity of bandwing colors.

Dispersal and Migration

The pallidwinged bandwing is a strong flier and disperses at night. Adults migrate in June and July. It can cause injury to crops in migration. In communities and around homes, it can be annoying because it is attracted to lights at night.

Figure 10. Adult.

Bigheaded Grasshopper

Aulocara elliottii

Identification

Adults possess relatively large heads, justifying the common name "Bigheaded" grasshopper. The upper surface of the pronotum is distinctively marked with light lines that give the appearance of an "X." The hind femur has two black bars and the tibia is medium blue.

The head of the nymph has the lateral foveolae (pits) (Figure 13) in a triangular pattern that are visible from above. Nymphal antennae are flattened. The face of the nymph is moderately slanted. The pronotum are the same color as that of the adults. On the nymph the hind femur has two dark bars on the upper part of the medial area, up to seven dark spots on the lower carinula and the hind tibia is blue with three dark rings. The general body color of the nymph is drab gray and tan with reddish markings.

Hatching

The shallow depths at which summer eggs are laid exposes developing eggs to warming spring temperatures. This allows bigheaded grasshoppers to hatch midspring the following year when the soil is moist. Eggs in any particular pod hatch within seconds of each other. However, this shallow egg depth may subject eggs not only to dessication, which they are able to survive, but also to predators and can result in a reduction in egg density of 54 percent.

Habitat

Large populations can be found in the following Nevada areas: desert, mixed grasses, short grass, and bunch grass sites. High densities destroy forages needed for livestock production and wildlife habitat. Consumption of all available plant species on a site will leave the site open to soil erosion. This species is found throughout Nevada.

Food

Bigheaded grasshoppers depend largely on green leaves of grasses and sedges. They attack plants by feeding on a leaf, chewing it from the tip down. Often the leaf is cut and falls to the ground where feeding continues. They will feed on ground litter containing leaves, seeds, bran, and other dead grasshoppers, eating most anything that is available. In Nevada, they consume western wheatgrass, needle and thread grasses, thread-leaf sedge, needle-leaf sedge and crested wheatgrass. Crested wheatgrass is a sought out preferred host.

Dispersal and Migration

Often the dominant species in rangeland outbreaks, bigheaded grasshoppers have fully developed wings and fly to evade predators, disperse, and migrate. They have been observed flying distances up to seven miles. Dispersal is not the norm. These grasshoppers usually remain where the nymphs hatch and develop.

Bigheaded Grasshopper

Aulocara elliottii

Figure 11. First instar.

Figure 12. Fourth instar.

Figure 13. Adult male.

Figure 14. Adult female.

Figure 15. Dorsal view, pattern variations of pronotal disk.

Clearwinged Grasshopper

Camnula pellucida

Identification

Adults are medium sized, yellow to brown, and have mottled forewings and transparent hindwings (Figure 19). The forewings have a light angular line that converges to form a 'V' in the resting grasshopper. Males are much smaller than females.

First instar nymphs are strikingly colored cream, tan, and black (Figure 16). Their heads have triangular lateral foveolae (pits) (Figure 20) and have a dark band crossing under the eyes and extending to each side of the front of the head. The pronotum has clearly defined lateral ridges.

The color of the hind tibia ranges from reddish–brown in early instars to tan in the older nymphs. The clearwinged grasshopper is commonly found in wet pasture habitats. It is one of Nevada's economically detrimental species and may cause significant damage.

Hatching

Clearwinged grasshoppers hatch in midspring. After a summer warming period following egg deposition, a winter chilling at 41°F for a minimum of 70 days, and another warming period, eggs are ready to hatch. This occurs as soil temperatures in the spring following egg deposition rise above a threshold of 55°F. Hatch occurs when soil temperatures reach 80°F. A warm spring and favorable soil moisture shorten the period of hatch for an entire egg bed. Although hatching of all individuals in a pod may occur within one day, it is also common for this to take two days to four days per pod. The entire process of hatch can occur within 12 days. Cool, dry weather may delay the hatch for a month. Usually the hatch takes place between 9 a.m. and noon.

Habitat

Clearwings are a severe pest throughout Nevada rangelands. Hatching and feeding sites can be found in all counties and in a variety of habitats from mountain meadows to desert riparian areas. During periods of infestation this pest will also be found in urban and agricultural settings.

Food

Clearwing feeding habits focus on all grasses, including western wheatgrass, reed canarygrass, fescues, bluegrasses, wheatgrasses, bromes, and slenderhair grass; and small grains, such as wheat and barley. Outbreaks in rangelands may devastate grasses and forages in areas as large as 1.3 million acres. During outbreak periods, clearwings will also feed on crops in agricultural lands and on ornamentals and home gardens in urban settings.

Figure 16. First instar.

Figure 17. Fourth instar.

Clearwinged Grasshopper

Camnula pellucida

Figure 18. Adult female.

Dispersal and Migration

Clearwinged grasshoppers can occupy a wide variety of grasslands across North America. They may remain unseen for five to 10 years, increase gradually over three to four years, and reach population peaks the following two to three years. Populations may spread more than 2,000 square miles over these increase years. Egg beds of clearwinged grasshoppers may contain as many as 3,000 to 100,000 eggs per square foot. This creates large populations of young grasshoppers that deplete food sources. Migration occurs rapidly as nymphs disperse seeking green vegetation. Dispersal continues all through the nymphal stage. Older stages of nymphs travel in cohesive bands.

On hot, sunny afternoons, masses of adult clearwinged grasshoppers will take off into the wind, migrating distances of 100 yards to several hundred yards. They may fly at low or high altitudes. Although migration ceases when egg-laying starts, females continue to fly from feeding grounds to egg laying beds, moving to egg beds during the hottest part of the day to deposit eggs.

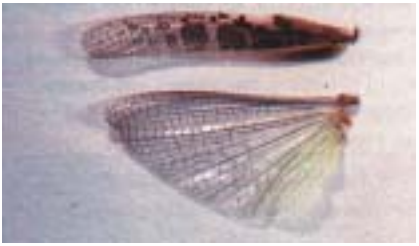

Figure 19. Forewing (tegmen) and hindwing.

Figure 20. Note lateral foveola on head and carinae on pronotum.

Not all populations of clearwinged grasshoppers migrate. Optimum conditions for larger populations include above-normal spring and summer temperatures and enough precipitation to maintain green host plants.

Migratory Grasshopper

Melanoplus sanguinipes

Identification

The adult male migratory grasshopper can be easily identified by the shape of the cercus, the notch of the subgenital plate (Figure 25), and the node or bump between the middle legs. The females have similar color patterns to the males. The hind tibiae are blue-green or red. This is the most common destructive grasshopper in Nevada. It occurs in or near agricultural habitats throughout the state. As the name implies, this species does migrate.

The nymphs have spotted compound eyes and a yellow, crescent-shaped band below the eyes that extends to the first section of the thorax. The hind femur's black band is broken by a light stripe in the middle and has light areas at each end. The hind tibia, for the most part, is blue-green or red. The nymphs are generally gray or light green.

Dispersal and Migration

Migratory grasshopper adults, and occasionally nymphs, swarm. This is variable among populations, based on food availability. The least degree of migration occurs where vegetation is lush. They are highly migratory in the prereproductive phase. Swarming begins in late morning and ends in the afternoon for feeding and resting. It occurs on clear days with temperatures approaching 80°F, and when gentle, intermittent winds allow them to fly at speeds of 10 miles per hour to 12 miles per hour. Individuals may fly on the average from five miles to 30 miles a day, at heights ranging from just above the ground to 8,000 feet to 9,000 feet.

Hatching

This is a midspring hatching species with the duration and timing of the hatch being influenced by soil temperature and moisture. Hatching begins along warm, open, south-facing slopes with little vegetative cover and sandy soils. Heavy clay soils and tall vegetation that shades the ground retard hatching. The hatch may be completed in three to six weeks depending on air and soil temperature. Complete egg development requires 527 day-degrees (Add the minimum and maximum daily temperatures and divide by two; ie. If this were to total 60°F, 60°F – 50°F = 10. That is 10 day-degrees) with above 50°F soil temperature. Eighty percent of development occurs during the summer the eggs are laid, and 20 percent occurs the following spring. The length of time necessary for embryonic development is greatly influenced by the climate of the area.

Figure 21. First instar.

Figure 22. Fourth instar.

Migratory Grasshopper

Melanoplus sanguinipes

Figure 23. Adult male.

Habitat

The migratory grasshopper is a serious pest to both crop and grassland areas. It is distributed widely across North America and lives in many habitats. It is a common inhabitant of grasslands and meadows with host plants including many kinds of forbs and grasses. This species causes more damage to crops than any other species currently found in the United States.

Figure 24. Side view of end of male abdomen.

Figure 25. End view of male abdomen, showing notch in the subgenital plate.

Food

Food sources for this species are often distributed across an array of plants within the habitat area. While the main feeding focus is on grasses and forbs, severe damage to wheat, barley, oats, alfalfa, clover, corn, vegetables, ornamentals, vines, bushes, trees, and ground litter has been noted. During periods of outbreaks, this species will migrate in massive swarms and cause damage to vegetation in areas miles away from its hatching sites.

Nevada Sage Grasshopper

Melanoplus rugglesi

Identification

The identifying characteristics of the Nevada sage grasshopper are the bright orange inner and lower areas of the hind femur, the tan upper and middle areas of the femur that have three dark bars, and the blue hind tibia. The male's cercus is quite large and square to rectangular. There is a solitary phase and migratory phase of this grasshopper. During the migratory phase, it tends to have more orange markings on the body.

The nymph's compound eyes have a dark, diagonal bar with white margins. The side of the head has a white or cream–colored, crescent–shaped band that extends into the pronotum (Figure 28).

The femur of the nymph has three light and dark bars and the hind tibias are mostly gray. The bodies of the nymphs have black stripes with cream and tan patches. This grasshopper occasionally occurs locally in high numbers.

Dispersal and Migration

Young nymphs may move erratically. Older nymphs move as a coherent band. Nevada sage grasshoppers spend most of their time on the ground. However, adult Nevada sage grasshoppers are extremely migratory traveling two miles to four miles per day and 40 miles to 75 miles per season. Conditions favorable for flight are clear skies, minimum air temperatures of 70°F, soil temperatures of 85°F, and air currents of two miles per hour. Grasshoppers can be transported greater distances when caught by strong winds while they are aloft. Young adults fly intermittently with periods of crawling and resting. As they age, within a few days, they gain greater ability to swarm. They can fly up to a few hundred feet off the ground.

Hatching

The Nevada sage grasshopper hatches in years of normal weather in early spring, usually April. Below normal temperatures may delay the hatch up to 20 days. The hatching period ranges from two to three weeks.

Habitat

Habitat for this species includes the deserts of the far west, mostly in the states of Nevada and Utah, but it is also found in adjacent states and British Columbia. Cold desert shrub sites with an understory of forbs and grasses are preferred.

Nevada Sage Grasshopper

Melanoplus rugglesi

Figure 26. First instar.

Figure 27. Fourth instar.

Figure 28. Migratory male.

Figure 29. Solitary male.

Food

Feeding is mainly focused on the shrub component of a site. The most preferred shrubs include big sagebrush, black sagebrush, Douglas rabbitbrush, spiny hopsage, and shadscale. Feeding will also occur on silver sagebrush, bud sagebrush, littleleaf horsebrush, antelope bitterbrush and gray rabbitbrush. Heavy feeding has also been observed on downy brome. During outbreaks, this species will denude most vegetation available including ornamentals, gardens, and alfalfa fields. Minor damage to grain fields also has been documented.

Figure 30. Migratory female.

Packard Grasshopper

Melanoplus packardii

Identification

This grasshopper is another large species, nearly the size of the twostriped grasshopper. The adults are tan, brown, and yellow in color. Two conspicuous light tan stripes extend from the head through the pronotum (Figure 34). The hind tibiae are red or blue. The male cerci are spatulate and lack any projections (Figure 35). This characteristic allows you to separate it from the twostriped grasshopper, which is similarly colored.

The nymphs are greenish–tan to green depending on their age (Figure 32). Each antennal segment is ringed in pale yellow. The femurs of nymphs have several rows of dark spots. Their hind tibiae are usually green. This species is found in the same habitats as the twostriped grasshopper in Nevada.

Hatching

Packard grasshoppers are considered an early spring hatching species. Like other grasshoppers, the timing of egg hatch depends on soil temperature and moisture varying from late April to early June.

Habitat

This species is found widely across western North America, including Nevada. It is primarily a rangeland species, inhabiting tallgrass, shortgrass, mixed grass, bunchgrass, and desert grass sites. The Packard grasshopper can be found at elevations as high as 9,000 feet and is recognized as an important cropland grasshopper for the damage it causes. Although it usually occurs in low densities, it is sometimes the second most populous species found in rangeland environments. Through periods of outbreaks, this species may be the dominant species and comprise more than 50 percent of the total grasshopper population in a given area.

Food

Since this grasshopper prefers poor forage plants of little economic value, in its natural habitat, it generally causes little damage. However, in years of high populations, severe damage can occur from feedings on small grains and alfalfa.

Packard Grasshopper

Melanoplus packardii

Figure 31. First instar.

Figure 32. Fourth instar.

Figure 33. Adult male.

Figure 34. Dorsal view of head and pronotum of a female.

Dispersal and Migration

Primarily a rangeland species, Packard grasshoppers are strong fliers and may disperse a minimum of 10 miles in a season. They are rarely of economic importance, although in combination with migratory and twostripped grasshoppers, they may cause crop or forage damage.

Packard grasshoppers spend most of their time on the ground becoming active as soil temperatures rise to 80°F and air temperatures to 70°F. They cease activity when temperatures rise above 90°F.

Figure 35. End of male abdomen showing cercus and supraanal and subgenital plates.

Redlegged Grasshopper

Melanoplus femurrubrum

Identification

Adult redlegged grasshoppers are medium sized, have a bright yellow underside and bright red hind tibia. Rarely, the hind tibia is colored yellowish–green or blue. The male has a bulbous subgenital plate and a uniquely shaped cercus (Figure 40).

The nymphs are strikingly marked yellow and black (Figure 37). They have brown to burgundy eyes with light yellow or tan spots. There are no dark bands on the eyes. The front of the head has a dark, vertical band with light stripes on each side that join on the lower section of the head.

The nymphs have a white, crescent–shaped stripe extending from the head to the abdomen along their sides (Figure 36). Their hind femur has a solid black stripe in the upper half. The hind tibia is yellow or gray, with the spines tipped in black.

Hatching

With a scattered pattern of egg laying throughout its habitat, the redlegged grasshopper's eggs develop under a wide range of soil temperatures and moisture conditions allowing the hatch to persist for about 52 days. With this extended period of hatching, nymphs can be found nearly all summer. The redlegged grasshopper's hatch occurs in late spring after the twostriped and migratory grasshopper's hatch. There is one generation annually. Normal rainfall and low temperatures in spring and summer can keep populations low.

Habitat

The redlegged grasshopper is found throughout most of Nevada, excluding high mountains and very cold areas. Its habitat includes tall vegetation, grasslands, meadows, crop borders, reverted fields, idle croplands, and roadsides. Habitats also include moist, weedy areas.

Food

This species will feed on alfalfa, clover, and small grains. They are also pests to corn and other vegetables. Large numbers can develop in meadows, damaging forage grasses and forbs of all types.

Dispersal and Migration

Redlegged grasshoppers, having the capability of flight distances of 30 feet to 40 feet, readily disperse into new habitats. In drought years, adults develop longer wings and fly more, often accompanying the migratory grasshopper. Adults are active during the day, feeding in the early morning and coming to roost in vegetation in early evenings. Even though dispersal flights do occur, most adults stay close to their hatching area. Populations respond well to reduced summer rainfall and warmer temperatures of spring and summer and may increase to outbreak numbers within one to two years, reaching densities of 200 to 500 nymphs per square yard.

Redlegged Grasshopper

Melanoplus femurrubrum

Figure 36. First instar.

Figure 37. Fourth instar.

Figure 38. Adult male.

Figure 39. Adult female.

Figure 40. Side view end of male abdomen.

Twostriped Grasshopper

Melanoplus bivittatus

Identification

The twostriped grasshopper is Nevada's largest species in the genus *Melanoplus*. The nymphs are identified by the brown compound eye with many tan spots and no dark stripes; the tan or green front of the head with a line of dark spots on each frontal ridge. There is no light crescent below the eyes. The pronotum has a light, horizontal stripe across the side, just below a dark stripe. The upper half of the hind femur is almost entirely black. The hind tibia is green or buff, with black spines. Adults have two distinctive light yellow stripes running down the dorsum of the head, pronotum, and tegmina. The stripes come together forming a triangle. The adult male is easily identified by the shape of the cercus (Figure 45).

The nymphs are usually tan or green in color (Figure 42).

Hatching

This is a very early spring hatching species, being one of the first to appear in roadside and field border habitats. The twostriped grasshopper starts to hatch as soil temperatures warm in the spring. Eggs may hatch eight to 10 days ahead of the migratory grasshopper's eggs and hatching may last from four to six weeks. There may be more than one hatch a season following rain and warm temperatures. It takes about 40 days for nymphs to reach the adult stage, but because of extended hatch periods, nymphs may be present in the habitat for up to 75 days.

Habitat

This pest is found in the less arid parts of Nevada, mostly around tall, lush herbaceous vegetation. These grasshoppers are commonly found in cropland habitats, including crop borders, ditch and canal banks, roadsides, and wet meadows, habitats found in every Nevada county.

Food

Twostriped grasshoppers are a major crop pest, causing damage to small grains, alfalfa, and corn. They feed on many kinds of plants in a given site. During outbreaks they adjust their feeding toward the most available plant species and eat even dead ground litter.

Dispersal and Migration

A major crop pest that may completely destroy crops, twostriped grasshoppers may migrate both as nymphs and as adults with nymphal populations reaching densities as great as 500 per square yard. When skies are clear and temperatures are about 75°F, nymphal migration begins and lasts until early evening. Movement is not influenced by wind. Adults begin flying at temperatures of 86°F to 90°F and may fly as high as 600 feet to 1,400 feet. They are able to travel long distances. At high population densities, twostriped grasshoppers develop longer wings and more slender bodies, making them more adapted for flight.

Twostriped Grasshopper

Melanoplus bivittatus

Figure 41. First instar.

Figure 42. Fourth instar.

Figure 43. Adult male.

Figure 44. Dorsal view of twostriped grasshopper.

Figure 45. Side view end of male abdomen.

Valley Grasshopper

Oedaleonotus enigma

Identification

The tegmina (forewings) may be short in valley grasshoppers, only as long or slightly longer than the pronotum (first section of the thorax). The individuals with short wings cannot fly and resemble large nymphs. Those with normal wings can fly. The adults and later instars have a distinct white collar on the front edge of the thorax (Figure 49). The cercus of the male is broad at the base with a finger-like tip (Figure 50). The hind femur has reddish areas that are marked with V–shaped, light lines. The femur also has some orange coloration on the end attaching to the body and the lower margin. The hind tibiae are blue (Figure 48).

Nymphs have slightly slanted heads with the first two segments of the antennae being lighter than the rest. Compound eyes, generally brown, have many cream–colored spots and a relatively large dark spot near the center of the eye. The top of the thorax has a light stripe down the middle, extending from the top of the head to the abdomen (Figure 47). The femur of the nymph is similar to the adult femur in coloration and the tibia is light gray. The nymphs are light tan with darker spots.

Hatching

Valley grasshoppers usually hatch in April in Nevada. The hatch continues for about a month. Eggs generally hatch in the morning with air temperatures between 45°F and 90°F and soil temperatures are between 76°F and 98°F.

Habitat

This grasshopper is a rangeland species associated with the semiarid/sagebrush-grass areas of the western United States. This is a very common grasshopper in Nevada. It usually occurs in relatively high numbers on old burns in foothills and valleys.

Food

This species is primarily a forb and shrub feeder and may be considered beneficial when numbers are low. During outbreaks feeding habits will also include alfalfa, cotton, grain crops, and vegetables.

Valley Grasshopper

Oedaleonotus enigma

Figure 46. First instar.

Figure 47. Fifth instar. White stripe from head to abdomen.

Figure 48. Male. Blue hind tibia.

Figure 49. Female. White collar on thorax.

Dispersal and Migration

Length and height of valley grasshopper flights have not been adequately studied. It is not known if individuals disperse or if dispersal takes place in small or large groups. Dispersal of older nymphs and adults appears to be slow and to occur daily. During peak population periods, nymphs have been observed migrating in bands of 20 to 30 per square yard. Although some adults disperse from nymphal habitats, others remain in those habitats and reproduce. Densities may climb to more than 20 adults per square yard. Dispersal and migration become survival mechanisms during drought as food sources brown and dry.

Figure 50. Side view end of male abdomen showing shape of cercus.

Mormon Cricket

Anabrus simplex

Identification

Although the Mormon cricket is neither a grasshopper nor a cricket, we have included it in this manual due to its importance and wide occurrence in Nevada.

Adults and nymphs of Mormon crickets have long antennae, and smooth, shiny exoskeleton with a variety of color patterns. The adult female has a long ovipositor with a gentle upward curve (Figure 54). The male cercus has two large teeth (Figure 55). Adults are 1½ to 2 inches long.

First instar nymphs are about ¼ inch long and tend to be black with a white stripe (Figure 51). Older nymphs vary in color from black to various shades of brown, orange, and green (Figures 52, 53). Mormon crickets are commonly found from the foothills to the mountaintops in northern Nevada.

Hatching

Eggs are laid in summer and go dormant through winter. Mormon crickets emerge in early spring when soil temperatures reach 40°F. At higher elevations eggs may incubate an additional year.

Habitat

Large populations of this species develop in the open sagebrush-grass areas of the Great Basin and Intermountain West, mostly in rangeland areas dominated by sagebrush and forbs. Resident populations in the Western United States occur from rangeland sites in the Great Basin to elevations of 11,000 feet in the Rocky Mountains.

Food

The Mormon cricket feeds on more than 400 species of plants, yet the food of choice is succulent forbs. Migrating bands damage forage plants and crops, including sugar beets, small grains, alfalfa, and garden vegetables.

Dispersal and Migration

Mormon crickets have a migratory habit, staying at one site only three or four days. Migrating bands of either nymphs or adults may destroy crops. They are flightless; instead they crawl and hop. During the first four instars they are mobile, moving around extensively for short distances to seek food and shelter. In later stages, they move together in bands in one direction. They may travel 25 miles to 50 miles per season; moving mainly during the day when skies are clear and temperatures range from 65°F to 95°F. Separate bands may join into a larger band or flow through each other, each continuing its established course. Extensive migration occurs when populations reach outbreak proportions. High population densities have lasted five to 21 years.

Mormon Cricket

Anabrus simplex

Figure 51. First instar.

Figure 52. Fourth instar.

Figure 53. Adult male.

Figure 54. Female with ovipositor and spermatophore.

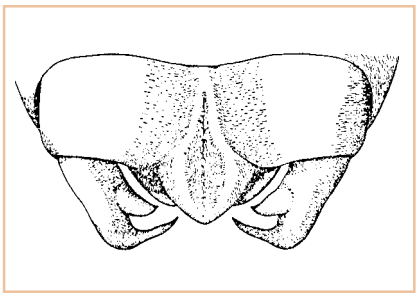

Figure 55. Paired cerci of male Mormon cricket, dorsal view. (Drawing by Ashley B. Gurey)

Jerusalem Cricket

Stenopelmatus fuscus

Identification

The Jerusalem cricket (Figure 56) is not a cricket nor is it a grasshopper, but it is included here due to the number of identification requests received yearly at the state entomologist's office and University of Nevada Cooperative Extension offices. Jerusalem crickets are bizarre looking insects. They are fairly easy to recognize, having large reddish-brown to orange heads with long antennae. The thorax is about the same color as the head. The abdomen generally is black and white striped with the striping going around the body. This coloration may vary from almost completely white to very dark. The legs of this insect are armed with large spines, primarily for digging and burrowing. Jerusalem crickets do not have wings.

Figure 56. An adult Jerusalem cricket.

Hatching

Jerusalem crickets lay small clusters of relatively large eggs in soil pockets. The eggs hatch in midspring, developing to adults by fall. Their complete life cycle may extend three years or more.

Habitat

These insects are commonly found west of the Rocky Mountains, occurring most often along the Pacific Coast from British Columbia to Mexico. They are found throughout Nevada, although not in great numbers. Jerusalem crickets may be found under rocks in open grassy pastures during the winter, spring, and fall. They become inactive during the fall and hide for protection. They can also be found and dug out of manure heaps and damp places.

Food

The Jerusalem cricket will eat a variety of foods. Bread, grass roots, vegetables, including slices of potato, and a variety of fruits may be consumed. They relish meat and small insects. Only rarely have there been enough Jerusalem crickets in one location to cause economic crop losses. On occasion, they have been pests in commercial potato fields. They are not a problem in home gardens in Nevada. In fact, they may help reduce the numbers of other soil-borne pests. Not enough is known about them and their activity to declare them a pest or a beneficial insect.

Dispersal and Migration

Jerusalem crickets live most of their lives underground. When they do move about on the ground it is usually at night or in the early morning and evening. Only rarely do they travel about during the day. They are usually discovered during ground preparation for planting.

Glossary

Abdomen. The hind region of the insect body consisting of nine apparent, ringlike flexible segments in the grasshopper.

Antenna. (pl., antennae). Pair of segmented appendages (feelers) located on head and sensory in function.

Arthropoda. A group of animals that have segmented bodies, exoskeletons, and jointed legs.

Bandwinged grasshoppers. A subfamily of grasshoppers, the Oedipodinae, that usually have a submarginal dark band on the hindwings.

Brood. All the individuals that hatch at about the same time from eggs laid by one series of parents and normally mature at about the same time; a group of individuals of a species that have hatched into young or have become adult at approximately the same time, live together in a defined and limited area, and may be of different generations.

Carina. (pl., carinae). An external ridge on the skin.

Cercus. (pl., cerci). An appendage of the 10th abdominal segment, usually triangular and short in grasshoppers.

Compound eye. An eye made up of many individual eye elements each represented externally by a corneal facet.

Day-degrees. The degrees each day that the average daily temperature is above a threshold temperature needed to complete a stage of development. These degrees are totaled to yield the day-degrees required to complete a development stage or process, such as egg incubation or nymphal development.

Disk of pronotum. Central upper surface of pronotum.

Distribution. The location of all habitats in which the species lives and reproduces; the area in which the species has been recorded.

Dorsal. Pertaining to the top surface of the body.

Egg pod. A case made of grasshopper gluelike secretions and soil particles enclosing a clutch of grasshopper eggs.

Exoskeleton. The outer skin or exterior skeleton.

Femur. (pl., femora). A segment of the insect leg; the stout segment of the grasshopper's hindleg.

Forb. Broad-leaved herbaceous plant (e.g., dandelion).

Foveola. (pl., foveolae). A small depression in the exterior skin (integument).

Genitalia. The external reproductive structures.

Geographic range. The area where a species is or can be found.

Hindwings. The fan-shaped, membranous second pair of wings of grasshoppers.

Instar. The immature insect between two successive molts.

Integument. Skin.

Larva. (pl., larvae). The immature insect that has hatched from the egg, but has not yet reached the pupal stage in orders with complete metamorphosis, e.g., a caterpillar.

Lateral foveolae. A pair of small depressions on the top of the head at the side or front between the compound eyes.

Lateral lobe. The vertical sides of the pronotum.

Medial. Situated in or closest to the middle.

Molt. Process of shedding outer layers of the integument.

Nymph. An immature insect of a species with gradual metamorphosis.

Ovipositor. In grasshoppers the paired digging and egg-laying structures at the end of the female abdomen.

Pronotum. The saddle-shaped top of the first thoracic segment.

Prothorax. The front segment of the thorax.

Pupa. (pl., pupae). The stage between the larva and the adult stages in insects with complete metamorphosis; a nonfeeding stage in which adult structures develop and grow.

Seasonal cycle. The timing of the periods of egg hatch, nymphal development, adulthood, and reproduction.

Slantfaced grasshoppers. A subfamily of grasshoppers, the Gomphocerinae.

Spur. A spinelike portion of the exterior skin connected by a joint.

Subgenital plate. In the male grasshopper the terminal ventral plate underlying the genitalia.

Tegmen. (pl., tegmina). The leathery, narrow, nearly parallel-sided forewings of grasshoppers.

Thorax. The middle body region of an insect, between the head and abdomen.

Threshold. The temperature or level of hormone concentration that must be reached before development or growth can begin.

Truncate. Cut off squarely at end.

Ventral. Pertaining to the undersurface of the body.

Wing pads. The developing wings found on nymphs.

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http://www.sidney.ars.usda.gov/grasshopper/ID_Tools/F_Guide/behavior.htm

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CHEMTREC Pesticide Accident Hotline (material safety information, spills, leaks, etc.)	(800) 424-9300
American Association of Poison Control Centers	(800) 222-1222

Pesticide Safety And Information

University of Nevada Cooperative Extension www.unce.unr.edu	(775) 784-1931

Nevada Department of Agriculture

agri.state.nv.us

Elko	(775) 738-8076
Las Vegas	(702) 486-4690
Reno	(775) 688-1182
Winnemucca	(775) 623-6502

United States Department of Agricultural Pesticide Record Keeping (for information and forms for restricted use chemical applications)	(703) 330-7826
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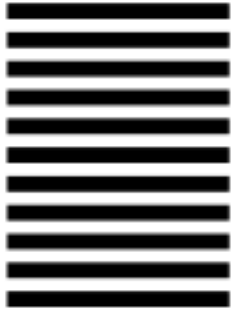

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