

I.8 Natural Enemies Attacking Grasshopper Nymphs and Adults

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Introduction

There are 548 recognized species of North American grasshoppers, with about 400 of these occurring on the 650 million acres of rangeland in the 17 Western States (Pfadt 1988). Around two dozen of these are considered potential agricultural pests. Several species may be considered beneficial because of their preference for weeds, and the remainder are either harmless, cause only minor damage, or are beneficial as food sources for wildlife. Along with mammals, grasshoppers are the most significant grazers in the world's temperate grasslands, where people produce most of their food.

This large and diverse group of extremely successful insects occupies many habitats worldwide. Grasshoppers are a food source for equally large and diverse groups of parasites and predators—insects, spiders, and other animals collectively referred to as “natural enemies.” These complex animal groups maintain a continual pressure, although variable in degree, on grasshoppers throughout their range. Natural enemies significantly affect grasshopper populations and present the first line of defense before outbreak events. Natural enemies should be factored into regulatory strategies with efforts to conserve them when resorting to chemical control operations.

Decisionmakers need to consider the impact on nontarget and beneficial insects of chemical insecticides and application rates used to control rangeland grasshoppers. The effect of economically and politically expedient chemical control programs should be monitored constantly through the “window of natural enemies” in the process of regulation.

This chapter presents a brief review of life histories, occurrence, and distribution and briefly details facts relating to some of the more important arthropod natural enemies of grasshoppers in western North America.

Grasshopper Parasites and Predators

Order Diptera (flies).—

Family Anthomyiidae.—Members of the family Anthomyiidae are medium in size, about a quarter-inch (6 mm) long and closely resemble the common housefly.

Adults are often characterized by slender, dark-colored bodies and rarely possess any metallic coloration or noticeable “bristles” on their body (Cole 1969). Some species are of economic importance, but very few are true parasites. This family occurs worldwide with more than 550 species known in North America, and many are quite common (Borror and DeLong 1971). One species is reported to parasitize grasshoppers, and two species have been reported as egg predators of grasshoppers, although the validity of these reports has been challenged (Rees 1973).

Acridomyia canadensis Snyder is the only species in North America known to parasitize grasshoppers. It has been classified as an “important” parasite in Canada and mentioned as “occurring” in Montana and Idaho (Rees 1973). This fly is known to parasitize at least 16 species of grasshoppers within all 3 grasshopper subfamilies of the family Acrididae, the slantfaced, the spurthroated, and the bandwinged grasshoppers. *Melanoplus bivittatus* and *M. packardii* are reported as this parasite's preferred host species.

Details of the life history of this species are summarized by Rees (1973). Pupae overwinter in the soil, and adults emerge during June, July, and early August. *A. canadensis* typically has one generation per year; however, some adults do not emerge until the second year. Mating occurs upon emergence. After a short but unspecified gestation period, the female flies begin stalking hosts. Upon selection of a suitable host, the female uses its rasping mouthparts to penetrate the host's body and then feeds upon the body fluids. After feeding, the female inserts her ovipositor into the feeding wound and lays eggs in the body cavity. The ovipositor is barbed, which prevents the host from escaping once penetration has occurred. Up to 70 eggs are deposited in each host, and they hatch within 48 hours. Larvae (20–70 per host) develop simultaneously and complete three instars in about 16 to 20 days. Mature larvae then emerge from the host, enter the soil, and pupate. Death of the host usually precedes emergence of the larvae.

Two species of this family have been reported as predators of grasshopper eggs: *Hylemya angustifrons* (Meigen) and *H. platura* (Meigen) = *Delia platura* (Meigen). *H. angustifrons* was reported as a predator

only of *M. spretus* eggs. *D. platura*, the seedcorn maggot, may have been incorrectly associated with grasshopper eggs and confused with *Acridomyia canadensis*, which it closely resembles (Rees 1973). These assertions of predation recorded in the early literature should be viewed with caution in light of current systematic knowledge of this group.

Family Calliphoridae.—This is a common group occurring worldwide and well known as blow flies. Adults, about the size of the common housefly, are recognized by their abdomen. Adults of different species have abdomens of different colors—usually a variation of metallic blue or green. Most members of this group are scavengers that live in carrion and excrement. They are similar to flesh flies, family Sarcophagidae, which are important parasites of grasshoppers in North America.

Calliphorids and sarcophagids can be separated visually by structural differences of the antenna and thorax. It is uncertain whether differentiating *Calliphora vicina* Robineau-Desvoidy, the only species ever associated with grasshoppers in North America and collected by Riley (1877), from the now extinct Rocky Mountain locust, *Melanoplus spretus* (Walsh), was an error. Cole (1969) reported that Packard and Thomas, two other entomologists of that era, also recorded *C. vicina* as parasitic on *M. spretus* and indicated that reproduction was by paedogenesis (reproduction in the larval stage), suggesting to Cole that erroneous observations had been made.

Family Asilidae.—Members of the Asilidae are known as robber flies. These raptors of the insect world are strong fliers noted for their voracious appetites and predatory behavior toward flying insects (Rees and Onsager 1985). There are 856 species of Asilidae in North America; 26 are reported as predators of grasshoppers (fig. I.8–1). Six species exhibit a definite preference for grasshoppers (Rees 1973).

Asilids display a variety of identifying structural characters. Those that prey on grasshoppers are large with elongated, tapering bodies and long legs. Bright colors are rare in this group. Most species exhibit gray to silvery coloration, and nearly all are bearded and bristly (Cole 1969). Life cycles range from 1 to 3 years. The adults are very territorial and cannibalistic.



Figure I.8–1—Unidentified robber fly (Family Asilidae) feeding on a fifth-instar *Camnula pellucida*, Twin Buttes, Owyhee County, ID. (This photograph and all others in this chapter were taken by D. L. Hostetter of the U.S. Department of Agriculture’s Agricultural Research Service.)

A 6-year study in Wyoming by Lavigne and Pfadt (1966) documented that three species, *Stenopogon coyote* Bromely, *S. neglectus* Bromley, and *S. picticornis* Loew, feed primarily on rangeland grasshoppers. These authors concluded that these species, along with 9 others associated with grasshoppers in Wyoming, can reduce grasshopper populations by 11 to 15 percent.

Family Sarcophagidae.—Most sarcophagids or flesh flies are scavengers as larvae, but some are parasites of insects. This family is distributed almost worldwide with more than 2,000 described species, most of which occur in tropical to warm temperate areas (Shewell 1987). There are about 21 to 23 species that are parasites of grasshoppers in North America. Sarcophagidae are without exception ovoviviparous, meaning that their eggs hatch within the uterus and the female deposits a live larva on the host (Shewell 1987).

The five most prominent North American species are *Acridophaga aculeata* (Aldrich), *Kellymyia kellyi* (Aldrich) = *Blaesoxipha kellyi* (Aldrich), *Opsophyto opifera* (Coquillett) = *Blaesoxipha opifera* (Coquillett), *Protodexia hunteri* (Hough) = *Blaesoxipha hunteri*, and *Protodexia reversa* (Aldrich) = *Blaesoxipha reversa* (Aldrich).

“Larviposition” by *A. aculeata* and *K. kellyi* occurs during flight of the fly with the selected grasshopper. This airborne interception often knocks the targeted grasshopper to the ground. The flies attack during natural flight or when the host has been flushed by livestock or otherwise disturbed. *Opsophyto opifera*, *P. hunteri*, and *P. reversa* all stalk grasshoppers on the ground. When within striking range, the female flips a larva from the tip of her abdomen onto the grasshopper. The larva quickly penetrates the host’s body through an intersegmental space and begins feeding on the body fluids and tissue (fig. I.8–2). One species, *Servaisia falciformis* (Aldrich) = *Protodexia* = *Sarcophaga falciformis* (Aldrich), possesses a sharp ovipositor that is used to insert a larva into the large muscle of the hind leg of the grasshopper. The larva begins to feed in the leg and eventually migrates into the body cavity, where it continues feeding until mature (Middlekauff 1959).

Sarcophagid larvae complete three instars (growth stages) in 6 to 9 days within the host before reaching maturity. The mature larva exits through a hole in the grasshopper body wall and pupates in the soil. One to three generations are possible, depending on the species, number of suitable hosts available, and environmental conditions. These flies target last-stage nymphs and adults and are generally considered the most effective group of grasshopper parasites (Rees 1973).

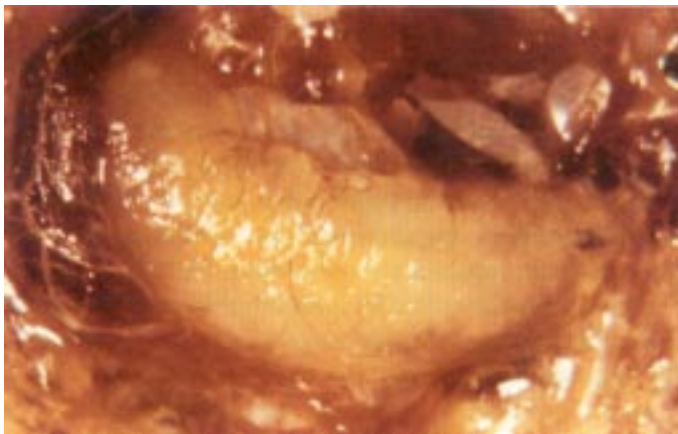


Figure I.8–2—Mature third-instar *Sarcophagidae* sp. larva prior to emergence from an adult *Melanoplus sanguinipes* (magnification 1.6×).

Reports documenting the incidence of parasitization in grasshoppers in the Northern United States and Western Canada vary from less than 1 percent to 50 percent (Middlekauff 1959, Lavigne and Pfadt 1966, Rees 1973). A detailed compilation of the North American species of Sarcophagidae associated with grasshoppers, preferred hosts, geographic distribution, and life histories and habits is presented in Rees (1973).

Family Tachinidae.—Tachinid flies also occur worldwide and represent the second largest family in the order Diptera with nearly 1,300 North American species (Borror and DeLong 1971). The larvae are primarily parasites of caterpillars in the order Lepidoptera. Most tachinids deposit their eggs directly on the surface of the host. Upon hatching, the larva burrows into the host and feeds internally on body fluids and tissue. The larva completes three instars feeding within the caterpillar. The host dies prior to emergence of the larva, which then pupates and overwinters in the soil. Six species have been reported from grasshoppers, but only the following three are considered important parasites in the United States and Canada (Smith 1958, Rees 1973).

Acemyia tibialis is the principal tachinid parasite of grasshoppers and has been reported from *Melanoplus bivittatus* and *M. sanguinipes*. Canadian reports indicate parasitism ranges between 16 and 65 percent (Rees 1973). *Ceracia dentata* (Coquillett) and *Hemithrixion oestriforme* Brauer and Bergenstamm have been reported from grasshoppers collected in the United States and Canada with parasitism rates ranging between 1 and 5 percent (Rees 1973).

Family Nemestrinidae.—Members of this cosmopolitan family are commonly known as tangle-veined flies. They are medium-sized, stout-bodied, fast fliers that can hover persistently. There are only six North American species. Two, *Neorhynchocephalus sackenii* (Will.) and *Trichopsidea* (= *Parasymmictus*) *clausa* (Osten Sacken) (Smith 1958) are parasites of grasshoppers. *N. sackenii* is the smaller of the two species and is readily distinguished from *T. clausa* by having an elongated proboscis.

Nemestrinids have only one generation a year. They overwinter in the soil as mature larvae, pupate in the spring, and emerge as adults from late May through

mid-July (Smith 1958). Females deposit as many as 4,700 eggs in crevices or holes in dead weeds, fenceposts, and other similar structures at elevations ranging from 3 to 40 feet. Eggs hatch in 8 to 10 days, producing a small (0.5-mm) cream-colored larva. Larvae are thought to be distributed by the wind, a scenario enhanced by the fact that females prefer to lay their eggs on elevated sites (Prescott 1955). Contact with a host is thought to be a random event facilitated by the ability of larvae to survive up to 14 days in the free-living state.

When a suitable grasshopper host (fourth- and fifth-stage nymphs or adults) is contacted, penetration of the body wall occurs within 30 minutes. Once inside the host, the nemestrinid constructs an elongated, spiral respiratory tube attached internally to the body wall of the host (fig. I.8-3). The small end of the tube opens at the surface of the body wall and is the source of air for the larva. The larger end of the tube forms a respiratory sleeve, which fits snugly over the breathing spiracles on the rear of the larva. The larva feeds on the host's fat and reproductive tissue and completes four instars before emerging from the host (fig. I.8-4). The larva emerges just prior to death of the grasshopper and burrows into the soil, where it overwinters as a larva (Prescott 1955).

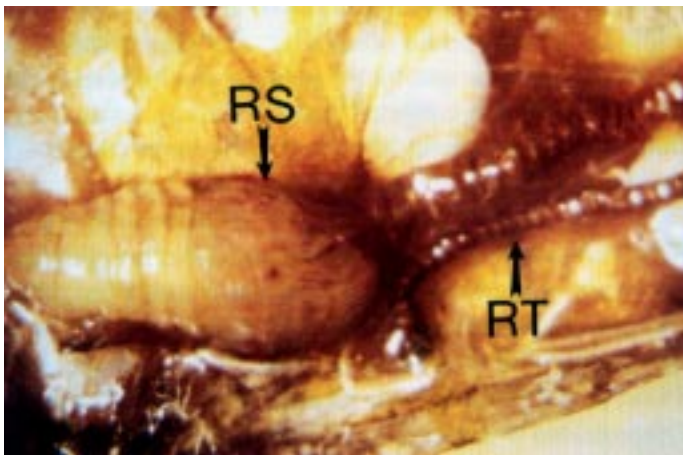


Figure I.8-3—Second-instar *Neorhynchocephalus sackenii* (Family Nemestrinidae) in adult *Oedaleonotus enigma*. Note the respiratory sleeve (RS) and respiratory tube (RT) attached to body wall (magnification 1.6×).



Figure I.8-4—Mature *Neorhynchocephalus sackenii* larva emerging between head and pronotum of mature brachypterous *Oedaleonotus enigma*.

Nemestrinids favor rangeland and “idle acres” habitats and those grasshoppers with similar habitat preferences. The flies are seldom found in cultivated areas or cropland (Prescott 1960). *Ageneotettix deorum* (Scudder), *Camnula pellucida* (Scudder), *Metator pardalinus* (Sausser), and *Aeropedellus clavatus* (Thomas) are preferred hosts of *N. sackenii* with parasitization rates between 30 and 95 percent (Prescott 1955). *Oedaleonotus enigma* (Scudder) is a preferred host of *N. sackenii* in south-central Idaho (Hostetter et al. 1991 unpubl.).

Order Hymenoptera.—

Family Formicidae.—This family consists of the ants, a large and very successful group found worldwide in almost every habitat. Ants can be formidable predators of hatchling grasshoppers if they are found in an ant colony's territory. Ants are localized, general predators and have little effect on grasshopper populations. Four species have been observed as predators of rangeland grasshoppers: *Formica rufa obscuripes* Forel, *F. obtusopilosa* Emery, *Myrmica sabuletti americana* Weber, and *Solenopsis molesta validiuscula* Emery (Lavigne and Pfadt 1966).

Family Sphecidae.—This is a large family of solitary wasps consisting of eight subfamilies, most of which nest in wood, construct mud cells, or burrow in the soil.

Twenty-nine species are recorded as parasitizing grasshoppers in Canada and the United States (Rees 1973). Female “digger wasps” prefer grasshoppers as provisions for their nests and are sometimes mentioned as efficient grasshopper predators (Lavigne and Pfadt 1966). A typical species of this group, *Prionyx parkeri* Bohart and Menke, requires about 1 hour to capture, cache, and lay an egg on an adult grasshopper. Upon hatching, the wasp larva begins to consume the live grasshopper, which remains paralyzed. These wasps are generally rare in most grasshopper habitats, but there is a report in Idaho (Newton 1956) of three *Tachysphex* spp. reducing a population of *Oedaleonotus enigma* (Scudder) by 84 percent.

Order Arachnida.—

Family Araneidae.—The spiders are probably the least studied of the grasshopper predators. Nine species of spiders have been reported as predators of grasshoppers, but the list is known to be incomplete and undoubtedly is much longer (Lavigne and Pfadt 1966, Rees 1973). The wolf spider, *Schizocosa minnesotensis* Gertsch, and a jumping spider, *Pellenes* sp., are two species of nonweb-builders that are often quite abundant on rangeland and are reported (Lavigne and Pfadt 1966) as predatory on various rangeland grasshopper species. The black widow spider, *Latrodectus mactans* (F.), is also a common rangeland predator of grasshoppers in Wyoming and Idaho (Lavigne and Pfadt 1966, and my own personal observations).

The feeding habits and preferences of spiders in the rangeland ecosystem are largely unknown and difficult to measure. Most species are generalists and opportunistic feeders on grasshopper nymphs and adults.

Family Trombididae.—This is the most important of three known families of mites that have been reported as parasites of grasshoppers and locusts. Red mites have been universally observed attached to the wings of their host (Uvarov 1928). The most thorough biological studies of the commonly observed North American species

Eutrombidium locustarum (= *trigonum*) Walsh were by L. O. Howard (1918) and H. C. Severin (1944).

Adult mites appear early in the spring and begin searching for grasshopper egg-pods. Mites remain in the pods feeding on individual eggs until the mites become sexually mature. Mating takes place in the egg-pod, but eggs are laid in cells (300–700 per cell) in the soil. Larvae emerge after 28 to 30 days and actively seek a suitable host. Larvae usually attach at the base of the wings on adults. Feeding continues until the larva is engorged; it then drops off the host, burrows into the soil, and transforms into a “nymph,” an eight-legged immature mite that closely resembles the adult. Nymphs leave the grasshopper toward the end of the summer, when fresh egg pods become available for additional feeding. After more feeding on eggs, the nymph transforms into the adult and overwinters in the soil.

The value of these mites as regulators of the grasshopper is not significant, but they are minor factors in the grasshopper life cycle. Mites belonging to the genus *Gonothrombium* were collected from grasshoppers in Wyoming in 1963 (Lavigne and Pfadt 1966). The investigators reported that 21 of 35 species of grasshoppers (adults) collected during studies in Wyoming between 1959 and 1962 were infested with mites. Conversely, only 8 of 454 grasshopper nymphs collected during the same period were infested with mites. Numbers of mites per individual grasshopper ranged from 1 to 41 with 2 the most common number. No attempt was made to determine detrimental effects, but Lavigne and Pfadt concluded that the mites had little if any effect on the grasshopper hosts.

Order Nematoda.—

Family Mermithidae.—Three species of nematodes belonging to this family are parasitic on grasshoppers: *Agamermis decaudata* Cobb, Stienen, and Christie, *Agamospirura melanopli* Christie, and *Mermis subnigrescens* Cobb (Rees 1973). A *Hexamermis* sp. has also been recovered from the greenstriped grasshopper, *Chortophaga viridifasciata* (DeGeer), in Missouri (Blickenstaff and Sharifullah 1962, Puttler and Thewke 1971).

Nematodes are long-lived animals with from 2 to 4 years required for each generation (Rees 1973). Spring rains and moist soil force the pregnant females from the soil to the vegetation. Eggs are deposited on foliage, where they remain alive for most of the summer. Grasshopper nymphs eat vegetation contaminated with these eggs. The infective nematode larva is released from the egg during the digestive process. The larva eventually penetrates through the host's gut wall into the body cavity, where it remains for 4 to 10 weeks. The mature larva exits the host (usually killing it) late in the summer and overwinters in the soil. The final molt, resulting in the adult, occurs in the spring.

Known North American distribution is limited to the upper Midwest, Northeast, and small, restricted areas in the Western United States. Moisture in the microhabitat, probably in the form of free water, is required for successful development of nematodes. When the required conditions occur, the incidence of infestation in localized areas can exceed 60 percent (Rees 1973).

Family Gordiacea.—Members of this class of roundworms (Nematomorpha) are known as horsehair worms or Gordian worms. They closely resemble nematodes in general body features (Hegner and Engemann 1968). Adults are free living and aquatic. Larvae are parasitic in crustaceans, grasshoppers, crickets, and beetles. Females lay thousands of eggs in long, gelatinous strings in water.

Upon hatching, larvae seek an immature form of aquatic insect as the primary host. Later the larvae become terrestrial and seek a secondary host (usually a cricket, grasshopper, or beetle), where they feed and continue to develop. The mature larva exits the host (causing death) and returns to an aquatic habitat (ponds, animal watering troughs, intermittent pools, streams, or similar area), where it reaches sexual maturity. Roundworms are opportunists that attack many hosts and are considered incidental parasites of grasshoppers and Mormon crickets (Rees 1973).

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