I.9 Mites and Nematode Parasites of Grasshoppers

G. E. Belovsky, D. Branson, J. Chase, J. Barker, and G. Hammond

Very little is known about the nonfungal, nonbacterial, and nonprotozoan pathogens (macroparasites) of grasshoppers. Two major groups of macroparasites for grasshoppers are mites (Acarina) and roundworms (Nematoda). In some instances, the different species of these natural enemies of grasshoppers have not even been identified, let alone studied for their impacts upon grasshopper populations. Therefore, macroparasites are a largely unexploited set of biocontrol agents that might be used to manage grasshopper populations.

Mites

Mites provide an excellent example of the potential opportunity for pest managers to exploit macroparasites in grasshopper control, as well as exemplifying the general lack of understanding about the ecology of parasites that prevents pest managers from using them.

At least two mite species are known to parasitize grasshoppers. The most common is the red mite *(Eutrombidium locustarum)* found on the wings of grasshoppers; another red mite is found on the legs and antennae of grasshoppers and has not yet been formally named. These mites have complex life cycles, going through at least three stages of development (larvae, nymph, and adult), and the complete life cycle requires from 2 months to a year (Rees 1973). Larvae of both mite species attach to the external surface (are ectoparasites) of grasshoppers and suck their blood (hemolymph). In addition, at least the wing mite as a nymph and adult also preys upon grasshopper eggs.

Little is known about the egg predation by mites because this occurs in the soil. However, based upon the mites' consumption needs (Rees 1973), their predatory depression of grasshopper egg survival could be substantial. Each mite nymph requires more than two grasshopper eggs to become an adult. Adult males require three eggs to be able to reproduce and adult females require seven to eight eggs to reproduce. Furthermore, each female mite deposits up to 4,000 eggs (Rees 1973), providing mite populations the potential to increase rapidly and substantially as grasshopper population numbers increase.

When studied in the laboratory, the ectoparasitic effects of larval mites were thought to be of no consequence to grasshopper survival or reproduction (Huggans and Blickenstaff 1966). This conclusion is not unexpected because the grasshoppers had greater quantities of high-quality food than they could consume and were maintained at near optimal temperatures and humidities. Unlike the laboratory studies, our field investigations indicate that larval mites can reduce grasshopper survival and reproduction dramatically.

In western Montana, we have studied the survival and reproduction of *Melanoplus sanguinipes* in cages that were placed over field vegetation and that maintained field temperature and moisture conditions. We have found that the grasshopper densities attained in the cages were comparable to field densities and were food limited (Belovsky and Slade 1994). In another set of experiments conducted in the same fashion, we stocked cages with grasshoppers that either had no wing mites on them, or had one or more wing mites on them.

When we compared the survival of grasshoppers with and without mites in the cages, we found that mites reduced the survival of grasshopper nymphs and adults by an average of 29 percent, and female reproductive output was reduced by an average of 47 percent (fig. I.9–1). Rather than an inconsequential effect, the ectoparasitism by wing mites reduced the grasshopper population's overall egg production by 62 percent.

The effect of ectoparasites in reducing the grasshopper population's egg production becomes stronger when grasshoppers experience greater intraspecific competition for food (higher densities). For example, cages initially stocked with 4 adults exhibited only a 45-percent reduction in total egg production, while cages initially stocked with 10 adults exhibited a much greater reduction, 69 percent. Therefore, the loss of hemolymph to wing mites must be considered in the context of environmental conditions, and the judgment that mite ectoparasitism is unimportant from laboratory studies is of little value. Similar results for the leg mite and the grasshopper *Ageneotettix deorum* were observed with total egg production being reduced by 41 percent (fig. I.9–1).

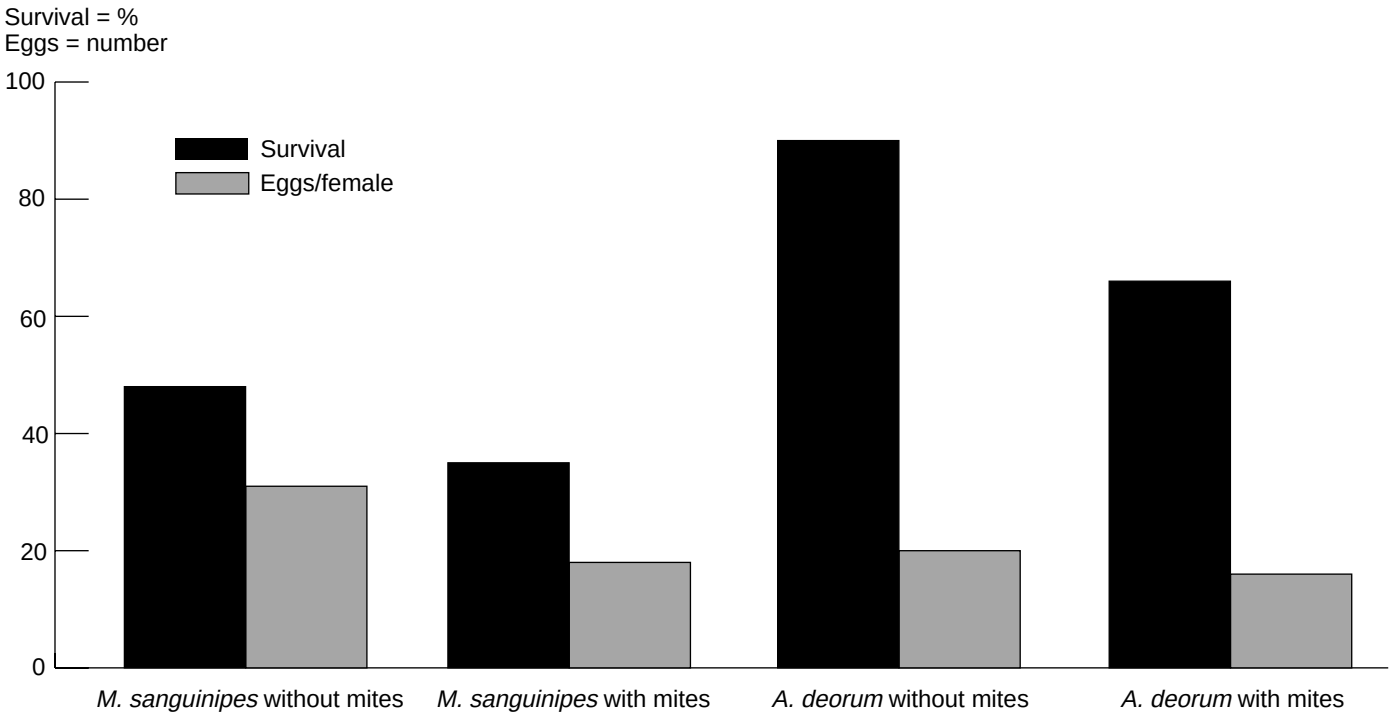

Figure I.9–1—Comparison of the survival and reproduction for two grasshopper species with and without mite infections. Results are statistically significant, and the values represent the means of at least 10 caged populations for each treatment.

The importance of egg predation by nymphal and adult mites and ectoparasitism by larval mites in controlling grasshopper numbers depends upon the abundance of mites. Predation and ectoparasitism effects will be of little importance if there are not large enough numbers of mites relative to grasshopper numbers.

In our field experiments, the grasshoppers that were infected had an average of 3.5 mites. Samples from grasshopper populations in different habitats in western Montana showed that from 0 to 75 percent of the grasshoppers were infected (average = 20.5 percent) at a site, and the individuals that were infected had an average of 2.5 mites. Extending our experimental results on ectoparasitism to field grasshopper populations indicates that larval mites may reduce overall egg production on average by 9 percent, with the effect varying from 0 to 33 percent in different populations.

The predicted natural reductions in total egg production by mites are not adequate in many instances to serve as a viable control method. However, the impact of ectoparasitism by mites could potentially help control grasshopper numbers if the percentage of grasshoppers infected can be increased.

We compared the percentage of grasshoppers infected by mites at different sites in western Montana with environmental characteristics (average daily air temperature, average solar radiation, average soil surface temperature, average soil temperature at less than an inch to almost 2 inches (2–5 cm), average relative humidity, percent cover by vegetation, soil moisture, and the rate of water passing through the soil). We found that infection increased with the rate of water passing through the soil, indicating that mite abundance may be limited by the soil's drainage (the poorer the drainage the fewer the

mites). Because the egg, nymphal, and adult stages of the mites live in the soil, we suspect that survival of these stages, rather than survival of the ectoparasitic larval stage, is reduced in soils with poor drainage.

Consequently, to take advantage of the mites' efficiency in controlling grasshopper egg production, a pest manager would need to counteract the local environmental conditions that lead to poor drainage. This type of habitat management may be difficult. Pest managers may be able to raise mites in large numbers and release them into the environment to overcome the poor survival of mite eggs, nymphs, and/or adults in the soil. Raising large numbers of mites in the laboratory is difficult because of the mites' complex life cycle and varied needs for survival and reproduction.

Nematodes

Nematodes are parasites that live within the grasshopper's body (endoparasites), and they are even less well understood than mites. Two species, *Mermis nigrescens* and *Agamermis decaudata,* are important parasites of grasshoppers. These species are even more difficult to identify taxonomically than the mites. These roundworms have a 2- to 3-year life cycle. The larval stages live in the hemolymph of grasshoppers and are considered parasites because they obtain nourishment by absorbing nutrients from the hemolymph. Nematodes are considered parasites rather than parasitoids because parasitoids would consume the grasshopper's body and nematodes do not.

Grasshoppers become infected with *Mermis nigrescens* when they ingest the nematode's eggs, which have been deposited on vegetation. Grasshoppers become infected with *Agamermis decaudata* when the newly hatched larvae penetrate a grasshopper's body (Streett and McGuire 1990). The infection generally lasts for 1 to 3 months and usually results in the death of the grasshopper when the adult nematode(s) exits from the grasshopper's body. The remainder of the nematode's life is largely spent in the soil except when adult females emerge for egg deposition.

In western Montana, we have found, by dissecting large numbers of *M. sanguinipes* in different years and habitats, that nematodes infected less than 10 percent of the grasshoppers at most sites in most years. The highest infestation level we observed at one site in a single year was more than 90 percent. We also found that nematode-infected female grasshoppers still produced eggs, but egg production was reduced by 85 percent.

Nematodes have the potential to be used as a biological control agent if pest managers could enhance nematode numbers by improving survival in the soil or by supplementing their numbers by releases. However, nematode ecology is even more poorly understood than that of mites, and in nature, nematode numbers are usually even lower than mite numbers.

Future Prospects

Employing mites and nematodes actively as biological control agents will require a better understanding of these parasites' natural histories and their ecological impacts on grasshoppers. Also, nobody knows if these parasites can be raised economically in the laboratory. Scientists may be able to take advantage of these natural grasshopper enemies through habitat manipulation that increases their populations or by adding to their natural populations. Mites and nematodes are native enemies of our grasshoppers and may potentially provide an environmentally "friendly" control strategy that can be sustainable for longer periods of time with less attention by pest managers.

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