III.3 Impact of Control Programs on Nontarget Arthropods

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Introduction

Grasshopper control programs potentially can have a large impact on the rangeland ecosystem. Of particular concern are the effects of large-scale control programs on natural enemies of grasshoppers, pollinators of seed crops and endangered plant species, endangered species of vertebrates, and general biodiversity of grasslands. Here, I will be addressing two main questions: (1) What are the immediate and more long-term effects of grasshopper control treatments on nontarget species? and (2) Does the disruption in communities of nontarget arthropods affect the population dynamics of grasshoppers and the potential for outbreaks?

Effect of Grasshopper Control Treatments on Nontarget Arthropods

There is very little information on the effects of grasshopper control treatments on beneficial and other nontarget arthropods (animals with exoskeletons, such as insects, spiders, and crayfish). Insecticidal sprays can cause high mortality of grasshoppers, so it should be assumed that sprays can cause large reductions in other arthropod populations as well. The potential for a significant impact on nontarget arthropods is large because they are often very active when grasshopper control treatments are typically applied. For example, Quinn et al. (1993) showed a relationship between the presence of nymphal grasshoppers, the stage usually treated in control programs, and the activities of some groups of nontarget arthropods, such as ants, ground beetles, wolf spiders, sphecid wasps, and robber flies.

As part of the Grasshopper Integrated Pest Management (GHIPM) Project work in South Dakota, Quinn et al. (1990, 1991, 1993) studied the effects of large-scale aerial applications of bran bait containing 5 percent active ingredient (AI) carbaryl at 1.5 lb/acre (1.68 kg/ha), and ultralow-volume (ULV) malathion (91 percent AI) at 0.58 lb AI/acre (0.65 kg/ha) on nontarget arthropods of mixed-grass rangeland. Table III.3–1 lists the groups of nontargets that my colleagues and I collected with malaise (aerial) and pitfall (ground) traps before treatments were applied. Of all the groups of nontargets collected in malaise traps, only two are considered predators of grasshoppers—sphecid wasps (15 percent) and robber flies (3 percent). Both of these groups feed on a variety of insects and not just grasshoppers. The most abundant groups collected in malaise traps were ichneumonid wasps (32 percent) and moths (27 percent). Most of the ichneumonid wasps collected were Lepidoptera parasites.

Most of the groups of nontarget arthropods collected in the pitfall traps were grasshopper predators. The two most abundant groups were blister beetles (36 percent) and ants (31 percent). Blister beetle larvae may be significant predators of grasshopper egg pods (Parker and Wakeland 1957, Rees 1973). Ants feed on molting grasshoppers. Other abundant groups of nontarget arthropods were darkling beetles (11 percent), wolf spiders (8 percent), and ground beetles (7 percent).

Some groups of nontarget arthropods were affected by both the insecticidal bait and spray treatments (table III.3–2). Activities of darkling beetles, ground beetles, and field crickets were reduced by 49 percent to 89 percent after 1 week in plots treated with either the insecticidal bait or spray. The dominant species of darkling beetles and ground beetles were similarly reduced by the two treatments (Quinn et al. 1990, 1991). Populations of these groups did not change in the control plots over the same time period. These groups were most likely affected by the insecticidal bait because they either consumed the bait directly or because they fed on infected grasshoppers. Other groups were affected by the insecticidal spray, but not the bait. For example, activities of blister beetles and ichneumonid wasps were reduced by 59 percent and 56 percent, respectively, in the malathion spray plots but did not change in the bran bait or untreated (control) plots. Activities of two species of ground beetles, *Cratacanthus dubius* and *Discoderus parallelus*, were reduced by 81 percent and 66 percent, respectively, in the insecticidal bait plots but did not seem to be affected by the insecticidal spray.

Pfadt et al. (1985) conducted a study to determine the effects of ULV malathion at 8 fluid oz/acre (0.58 lb AI/acre) on nontarget organisms of shortgrass rangeland in Wyoming. Pfadt's team concluded that (1) aerial applications of insecticidal sprays are not likely to have a large impact on nontargets because most species are protected (in nests, soil, and plants), and (2) the only arthropods likely to be affected are those that inhabit

Table III.3–1—Relative abundance (percent) of nontarget arthropods collected with malaise and pitfall traps, July 2–8, 1986, at mixed-grass rangeland plots, Butte County, SD (adapted from Quinn et al. 1993)

Nontarget group		Feeding habits	Relative abundance
			Percent
Malaise traps			
Ichneumonidae	Ichneumonid wasps	Mostly moth parasites	31.6
Lepidoptera	Moths	Plant feeders (as larvae)	26.6
Sphecidae	Sphecid wasps	General predators*	14.7
Odonata	Damsel flies	General predators	9.4
Mutillidae/ Tiphiidae	Velvet ants/ tephiid wasps	Wasp, bee, and beetle parasites	9.3
Pompilidae	Spider wasps	Spider predators	5.8
Asilidae	Robber flies	General predators*	3.0
Chrysididae	Cuckoo wasps	Wasp and bee parasites	1.8
Halictidae	Halictid bees	Pollen feeders/bee parasites	1.4
Others			1.8
Pitfall traps			
Meloidae	Blister beetles	Pollen feeders/grasshopper egg predators*	35.9
Formicidae	Ants	Seed and plant feeders/general predators*	31.0
Tenebrionidae	Darkling beetles	General scavengers/detritus feeders	10.9
Lycosidae	Wolf spiders	General predators*	7.8
Carabidae	Ground beetles	General predators/plant feeders*	6.9
Gryllidae	Field crickets	General predators/plant feeders*	2.6
Buprestidae	Metallic wood-boring beetles	Plant feeders	1.6
Other spiders		General predators*	1.1
Others			2.2

*Feed on grasshoppers

Table III.3–2—Effect of carbaryl bran bait and malathion ULV spray on change in activities of nontarget arthropods between the pretreatment and 1 week posttreatment sampling intervals, Butte County, SD

Nontarget group	Trap	Treatment	% change ($\bar{x} \pm$ SEM[1])	n
Blister beetles	Pitfall	Bran bait	–10.1 ± 13.6	10
		Malathion	–58.5 ± 6.4	10
		Control	–35.1 ± 15.9	9
Ants	Pitfall	Bran bait	32.6 ± 43.6	7
		Malathion	–39.6 ± 3.0	9
		Control	509.3 ± 447.6	5
Darkling beetles	Pitfall	Bran bait	–89.3 ± 4.2	10
		Malathion	–80.9 ± 9.5	10
		Control	210.2 ± 132.4	8
Wolf spiders	Pitfall	Bran bait	–80.5 ± 4.9	10
		Malathion	–76.1 ± 4.1	10
		Control	–61.6 ± 13.2	9
Ground beetles[2]	Pitfall	Bran bait	–88.0 ± 4.6	10
		Malathion	–53.0 ± 8.4	9
		Control	41.8 ± 37.8	9
Field crickets	Pitfall	Bran bait	–82.5 ± 0.1	9
		Malathion	–49.3 ± 14.6	9
		Control	24.4 ± 64.2	6
Ichneumonid wasps	Malaise	Bran bait	143.9 ± 68.7	10
		Malathion	–56.1 ± 6.9	10
		Control	71.1 ± 35.6	8
Sphecid wasps	Malaise	Bran bait	0.1 ± 18.1	10
		Malathion	–17.5 ± 13.7	10
		Control	32.8 ± 61.9	8
Spider wasps	Malaise	Bran bait	–1.8 ± 24.4	10
		Malathion	–9.9 ± 39.7	10
		Control	50.0 ± 57.5	8
Robber flies	Malaise	Bran bait	39.8 ± 27.7	10
		Malathion	–29.5 ± 30.2	9
		Control	–44.9 ± 13.3	7

[1]Standard error of the mean.

[2]Does not include *Amara impuncticollis*, which was not present in traps before treatments but was present after treatments.

foliage during the day. For example, this study showed that the ant *Formica obtusopilosa*, which is commonly found foraging on flowers, was affected by the insecticides. However, colonies of all ant species were not affected. Pfadt's results also indicated that immature Ephemeroptera (mayflies) and Odonata (dragonflies and damselflies) in ponds may have been affected by the malathion.

Swain (1986 unpubl.) conducted a study on desert grassland in New Mexico to determine the effects of malathion ULV (8 oz/acre–0.58 lb AI/acre), carbaryl (0.54 lb AI/acre), and 2 percent (AI) carbaryl bran bait (1.5 lb/acre) on nontarget arthropods. Her study showed that mean abundance of most groups of nontargets declined immediately after treatments. In particular, all treatments seemed to affect populations of ants and only the insecticidal sprays affected populations of spiders.

Swain (1986) and Quinn et al. (1990, 1991, 1993) found that large-scale application of insecticidal sprays and baits had little long-term impact on the groups of nontargets examined. For example, my team found that activities of four dominant species of ground beetles and three dominant species of darkling beetles rebounded to the pretreatment levels 1 year after treatment. Only one species of darkling beetle, *Eleodes tricostatus*, may have been affected 1 year after treatment. Quinn et al. (1993) also found that field crickets, ichneumonid wasps, and blister beetles, as groups, rebounded to or above the pretreatment levels 1 year after treatment.

Pollinators, such as honey bees and solitary bees, are important components of rangeland and adjacent cropping systems. Although the effects of large-scale control treatments on bees have not been examined thoroughly, insecticidal sprays should be presumed to exert a serious impact on bee populations because they are particularly susceptible to commonly used insecticides (carbaryl, malathion). The effects of insecticides on native bees and rare rangeland plants are reviewed in chapters III.4 and III.5 in this section of the User Handbook.

In summary, large-scale applications of nonselective insecticidal sprays can cause large reductions in populations of nontarget species of arthropods immediately after treatment. Species that are active during treatments or that feed on infected grasshoppers are particularly susceptible. These include ground beetles, darkling beetles, blister beetles, spiders (especially wolf spiders), field crickets, foraging bees, and ants. In contrast, insecticidal baits affect only species that consume the baits directly or prey that have consumed the baits. These species include darkling beetles, ground beetles, field crickets, and ants.

Although reductions in nontarget arthropods can last throughout the year of application, there is little evidence that grasshopper control treatments cause any long-term effects on nontargets. Besides the resiliency of populations, there may be numerous other explanations for this lack of evidence of long-term treatment effects. Inadequate sample sizes and large population variability inevitably lead to a conclusion that treatments have no effect, when in fact, one may exist. No studies of nontarget arthropods have examined the possibility of making such an error (by conducting a statistical power analysis). An additional problem with existing studies is that they frequently assess effects on whole families and not species. When lumping of species is done, species emerging after treatments can dilute the effects of treatments and cause one to find no treatment effect when one actually exists (Quinn et al. 1993). Thus, these studies must be viewed with caution.

Effect of Control Treatments on Grasshopper Outbreaks

In general, nonselective insecticides can cause pest resurgence when they disrupt populations of natural enemies. Similarly, large-scale grasshopper control programs can potentially *enhance* grasshopper outbreaks by killing off grasshopper predators and parasites or by affecting their behavior. Although it seems clear that insecticide applications can affect natural enemies of grasshoppers, at least in the short term, it is less clear that reductions in natural enemies automatically affect grasshopper population dynamics.

Several chapters in this User Handbook address the effects of natural enemies on grasshoppers. Results from studies summarized in these chapters indicate that grasshoppers are attacked by a wide variety of predators and parasites and that grasshopper mortality can be quite high, at least on a local level. For example, birds can reduce grasshopper densities by 30 to 50 percent (see chapter I.10 on “Birds and Wildlife as Grasshopper Predators”). Parker and Wakeland (1957) estimated that an average of 19 percent of grasshopper egg pods were destroyed by predators but that at the local level, mortality may be as high as 100 percent. Parasitism rates of grasshoppers can also be quite high at the local level (exceeding 50 percent), although they do not usually exceed 10 percent (Lavigne and Pfadt 1966, Rees 1973). As discussed by Capinera (1987), the collective effects of all the different mortality factors may add up to an overall large effect on grasshoppers. It seems clear that we should not underestimate the effects of grasshopper natural enemies and that we should work to preserve these organisms.

There is some evidence that grasshopper populations are regulated by natural enemies (particularly birds) under certain conditions (see chapter VII.14 on “Grasshopper Population Regulation”). In effect, natural enemies may be responsible for keeping grasshopper populations at low levels. Once the natural enemies are removed (for example, by nonselective insecticides), then grasshopper populations can no longer be regulated and outbreaks can occur. Once grasshoppers reach high densities, natural enemies are no longer able to suppress their populations. Unfortunately, few studies have examined the role of natural-enemy reductions, caused by nonselective insecticides, on subsequent grasshopper outbreaks.

In a review of grasshopper population dynamics over several years, Lockwood et al. (1988) found that the duration and stability of grasshopper outbreaks were greater in northern Wyoming, compared with southern Montana, and suggested that the more intensive grasshopper control programs in Wyoming may have contributed to this. In a study of the effects of an insecticidal spray (malathion) and bait (carbaryl on bran) on grasshopper and nontarget arthropod populations, Quinn et al. (1989, 1991, 1993) found that populations of most dominant grasshopper species, four species of ground beetles, and numbers of other nontargets rebounded to or above pretreatment levels a year after treatment. An exception was *Ageneotettix deorum*. Densities of this species remained low a year after treatment. These results indicate that some nontarget arthropods and grasshopper species are very resilient. Clearly, until more is known about the effects of natural enemies on grasshopper population dynamics and the effects of grasshopper control programs on resiliency of natural enemies, scientists and land managers should act to preserve these communities.

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