Final Project Report to the NYS IPM Program, Agricultural IPM 2003-2004

Title:
Impact of Scarab Grub Management Tactics on Non-Target Soil Fauna

Project Leader:
Daniel Peck, Dept. Entomology, NYSAES, Geneva, NY

Cooperators:
Nancy Consolie, Paul Robbins, Shirley Lewis, Katie Straight (Dept. Entomology, NYSAES, Cornell Univ., Geneva, NY); Leslie Allee (Dept. Entomology, Cornell Univ., Ithaca, NY); Dianne Black (Freeville, NY)

Type of grant:
Pheromones; biorationals; microbials; conventional pesticides

Project location(s):
Application: throughout the Northeast. Research site: Crittenden Farm, NYSAES, Geneva, NY.

Abstract:
We are conducting a five-year study to assess the effects of control tactics on non-target microarthropod communities. Our focus is on white grub control in home lawns, which represents the major pest complex in one of the most extensive and expanding components of our urban and rural landscape. Although microarthropods are attributed a large role in certain soil processes such as decomposition, our understanding of this major component of soil fauna is quite limited. In order to gauge the benevolence of pesticides used in lawn care, we are conducting field trials to test their effects on the abundance, diversity and function of non-target arthropods, particularly those that are "out-of-sight, out-of-mind" without the aid of a microscope. Do these common lawn care products have an effect on non-target fauna (such as mites and springtails) and is this relevant to soil processes (such as decomposition)? Turf stands developed at NYSAES, Geneva, NY were treated with three standard chemical insecticides, a biological control agent, and a plant nutrient in 2000, 2001, 2002 and 2003. Here we present an initial analysis of certain data obtained over 2001 and 2002. A several year study of this issue is important because effects on non-target soil fauna may be cumulative. In the future, this work will allow for more informed choices about pest management decisions in turfgrass ecosystems by lawn care professionals as well as homeowners.

Background and justification:
Accelerating urbanization of the U.S. population has resulted in increasingly larger areas of green space being utilized for recreation both communally in the form of parks, golf courses and natural areas, and personally in the form of home lawns. The average town of 170,000 people has 1,338 acres of turf in parks, cemeteries, factories, school and churchyards and about 3,500 acres around single family dwellings. All of these areas require decision-making strategies to maintain them for their intended uses. Although much research has been conducted on efficacy of various control strategies for the target species, comparatively little research has been conducted on the effects of these control strategies on non-target organisms. Knowledge about the effects of these strategies on non-target soil organisms will provide extremely useful information to area IPM educators in that it will yield a benevolence index of treatment effects on soil-dwelling beneficials and non-target organisms. This information can be communicated to IPM stakeholders to aid in choosing environmentally friendly yet efficacious control tactics. This may prove to be particularly important and useful information for

homeowners whose use of lawn care products is regulated mainly by their desire to use them or not, and whose advice comes mainly from the companies selling the products they wish the homeowners to purchase for use.

This research project is justified because: (a) homelawns (turfgrass) are one of the most extensive and expanding components of our urban and rural landscape, (b) pesticides are highly available for homeowner use, (c) many studies on non-target effects are limited to short-term experiments, (d) many studies on non-target effects are limited to abundance effects (versus diversity, species composition, ecological function), (e) little is known about the role of microarthropods in soil processes such as nutrient cycling, decomposition, and overall turfgrass health, and (f) in the near future we will have transgenic turfgrass varieties released and deployed, whose impact on the environment will have to be assessed.

Are approach is to (a) conduct a 5-year study to examine cumulative effects, (b) focus on alternative strategies used to manage one major pest complex, and (c) move beyond abundance effects to consider diversity, species composition and ecological function. We namely sought to answer: Do these common lawn care products have an effect on non-target fauna, and is this relevant to soil processes and turfgrass health?

Objectives:
1   Compare the effects of white grub control practices on non-target organisms in turfgrass
2   Compare repeated yearly applications to gauge longer-term cumulative effects on non-target organisms
3   Establish an initial foundation on the identity, abundance, diversity and role of micro and macro fauna associated with homelawns
4   Generate specific information about treatment effects on soil-dwelling beneficials and non-target organisms to support decision making by IPM educators and homeowners

Very little is known about the impact that treatment decisions for soil insect pest management have on non-target soil organisms. The results of our study will measure specific direct and indirect effects of common lawn care products on the abundance, diversity and function of non-target predators and decomposers in the soil and turfgrass community. They will lead to general information on the diversity of soil invertebrates associated with turfgrass. And as a multiple-year experiment, this study will also gauge the short-term and cumulative long-term effects of lawn care products on scarab pests, beneficials and other non-target fauna.

The other anticipated results of this long-term study include (a) establishment of improved protocols for monitoring and assessing the soil arthropod community in turfgrass, (b) identification of potential indicator species that should be targeted in future studies due to their susceptibility to specific treatments, (c) strengthened understanding of the soil arthropod community and undesirable effects of common lawn care practices for communication to stakeholders, and (d) improvement of the experimental turfgrass stand at NYSAES for future use in research and demonstration projects.

Procedures:
Turfgrass plots (10 x 10 m) were established at NYSAES, Geneva in 2000 and managed for a higher density grass stand through overseeding and fertilizing. Plots were replicated four times in a completely randomized design for a total of 24 test plots with a 10-m buffer zone separating test plots on all sides. The abundance and composition of target and non-target organism populations was evaluated through a variety of sampling techniques on each of four dates (July, August, September, October). Data were compared across the six experimental treatments and to data collected in previous years (2000 – 2003).

Treatments were applied at the same rate and to the same plots as in previous years. The six treatments were (1) the organophosphate insecticide trichlorfon (Dylox) as the late season curative or "traditional" chemical control, (2) the chloronicotinyl insecticide imidacloprid (Merit) as the early season or "modern" chemical control, (3) the insect growth regulator halofenozide (Mach 2) as the "alternative" control, (4) the entomopathogenic nematode *Heterorhabditis bacteriophora* (Heteromask) as a "biological control", (5) a dispersible, granular form of elemental sulfur fertilizer (SulFer95) as a plant nutrient with putative insect control benefits, and (6) an untreated control (Table 1). Following a recommended application program, Merit and Mach 2 were applied once each year after the July sampling date; Dylox and nematodes were applied once each year after the August sampling date; and Sulfer was applied twice each year after the July and August sampling dates.

Table 1. Description of treatments.

Common name	Trade name	Class	Description
Trichlorfon	Dylox	Organophosphate	Traditional chemical control (late season curative)
Imidacloprid	Merit	Chloronicotinyl	Modern chemical control (early season preventive)
Halofenozide	Mach 2	Insect growth regulator	Alternative chemical control (insect growth regulator)
Sulfer	SulFer95	Plant nutrient	Experimental control (plant nutrient with putative insect control benefits)
Nematodes	Heteromask	Biological	Biological control (entomopathogenic nematode, *Heterorhabditis bacteriophora*)
Control	NA	NA	Untreated

Sampling methods were identical to previous years. The abundance of organisms was calculated from soil cores, pitfall traps and tuna traps. For microfauna, organisms were collected from that were dug using a 4-inch diameter cup cutter. Fauna was extracted with modified Tullgren funnels that featured a light and moisture gradient to force mobile invertebrates into capture cups at the bottom of a funnel. Organisms were separated from debris using a salt-flotation technique and sorted under the stereoscope.

Pitfall traps (6-inch diameter x 4-inch depth) with screened bottoms (for draining precipitation) were placed in the cup cuts and monitored after 24 hours. Tuna traps were 1-ml plastic micro centrifuge tubes with a small amount of canned tuna placed in the bottom third of the tube. The tubes were pressed into the soil with the top at ground level and monitored after 24 hours. On each of the four sampling dates five soil cores, five pitfall traps and ten tuna traps were deployed in each treatment plot. Invertebrates collected from soil cores, pitfall traps, and tuna traps were processed, preserved and classified to different taxonomic groups.

Subsamples were not combined; each soil core, pitfall and tuna trap was processed and analyzed individually to obtain information on dispersion patterns and to guide future sampling schemes. Thus far, invertebrates have been classified to broad taxonomic groups including ants, beetle larvae, centipedes, diplurans, earthworms, fly larvae, ground beetles, leaf beetles, millipedes, mites, pillbugs, root aphids, rove beetles, sowbugs, springtails, symphylans, weevils and wolf spiders,.

Extraction and enumeration techniques were developed for managing the microarthropods associated with the soil samples. The three major challenges were extracting microarthropods and other soil organisms from the soil sample, separating them from other contaminants in the extracted sample, and counting the vast number of organisms captured. To overcome these challenges, standardized protocols were established to (a) extract organisms from individual soil samples in modified Tullgren funnels that used light and humidity gradients to force them into vials of alcohol, (b) separate organisms from residual organic and mineral materials by floating and decanting using a saturated salt solution, and (c) plate specimens onto counting trays to systematically quantify and classify each individual. Because of the sheer numbers of organisms associated with the soil cores, the analysis of each sample required 1-2 hours.

To date, soil core samples have been assessed and analyzed through 2002. All other assessments and analyses are temporarily delayed until additional funding is secured. The phases remaining in this five-year study include analysis of the 2003 field samples, conducting the 2004 field season, analyzing the 2004 field samples, conducting the descriptive and statistical analysis of all five years, and writing and reporting research results. Additional funding is being sought so we can successfully complete this five year study.

Results and discussion:

In 2001 and 2002, 187,239 and 112,964 individuals were collected, counted and classified from the soil cores using the protocols outlined above (soil cores were not conducted in 2000, the first year of the study). There was a mean of 390 and 234 individuals per cup cut, or an extraction rate of approximately 49,656 and 29,793 individuals/m^2 of turf and associated topsoil.

In order of greatest to lowest abundance, the major taxa present in soil core samples were mites (66.2% of total individuals), springtails (17.1%), ants (6.3%) and thrips (1.1%). Other taxa collected included millipedes, centipedes, sowbugs, pillbugs, earthworms, snails, spiders, immature Coleoptera and Lepidoptera, Hemiptera, rove beetles, leaf beetles, click beetles, weevils, symphylans and diplurans. Six classes of arthropods were collected: Arachnida, Hexapoda, Chilopoda, Malacostraca, Symphyla, Diplopoda (Fig. 1). Ten orders of hexapods were collected: Collembola, Hymenoptera, Heteroptera, Thysanoptera, Coleoptera, Diptera, Protura, Lepidoptera, Diplura and Orthoptera (Fig. 1). Nine taxonomic groups were analyzed in more detail because they each comprised >0.5% of the total individuals recovered (Fig. 2).
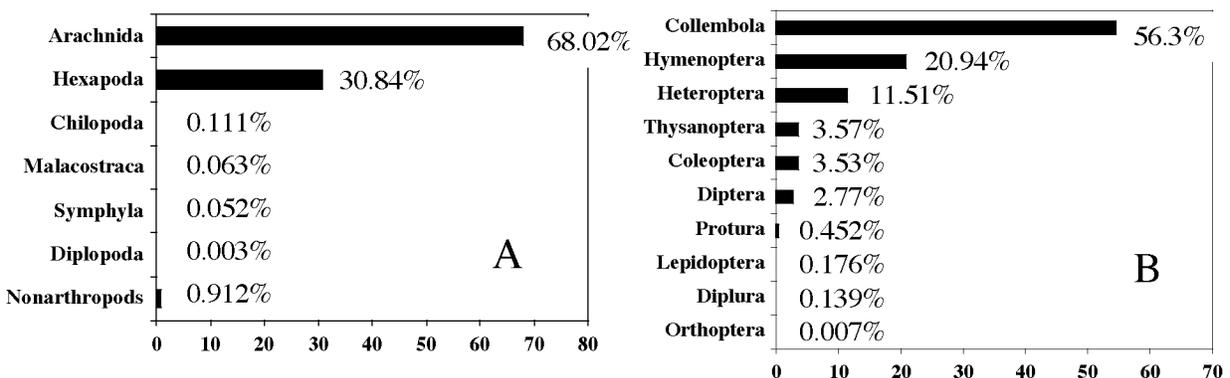

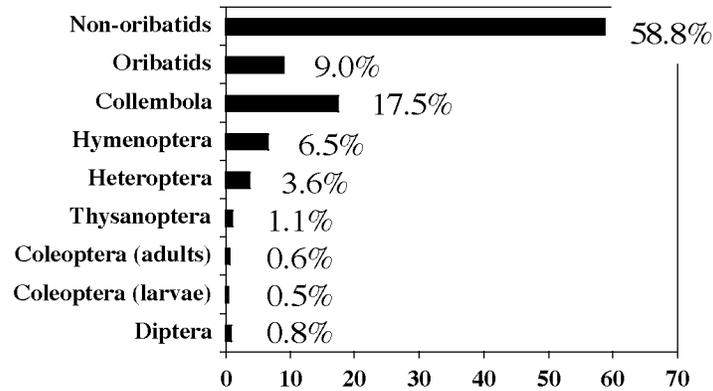Fig. 1. Arthropod class (A) and hexapod order (B) composition of soil core samples.

Fig. 2. Most represented groups from soil core samples (>0.5% of total individuals recovered).

Seasonal fluctuations in the populations of these groups was revealed by plotting abundance versus eight sampling dates (July, August, September and October over 2001 and 2002).

Data were analyzed to see whether individual treatment applications suppressed arthropod groups. This effect was tested by determining the significance of the interaction term in an analysis of variance where least squared means of the before treatment populations were compared with post treatment populations. In the case of oribatid mites, for instance, results show that despite an apparent decline in Dylox- and Merit-treated populations relative to the control, the effect was not significant for any date in 2001 or 2002 (Fig. 3). In fact, no effect of single applications of Dylox, Merit or the other treatments were detected for any of the nine target groups.
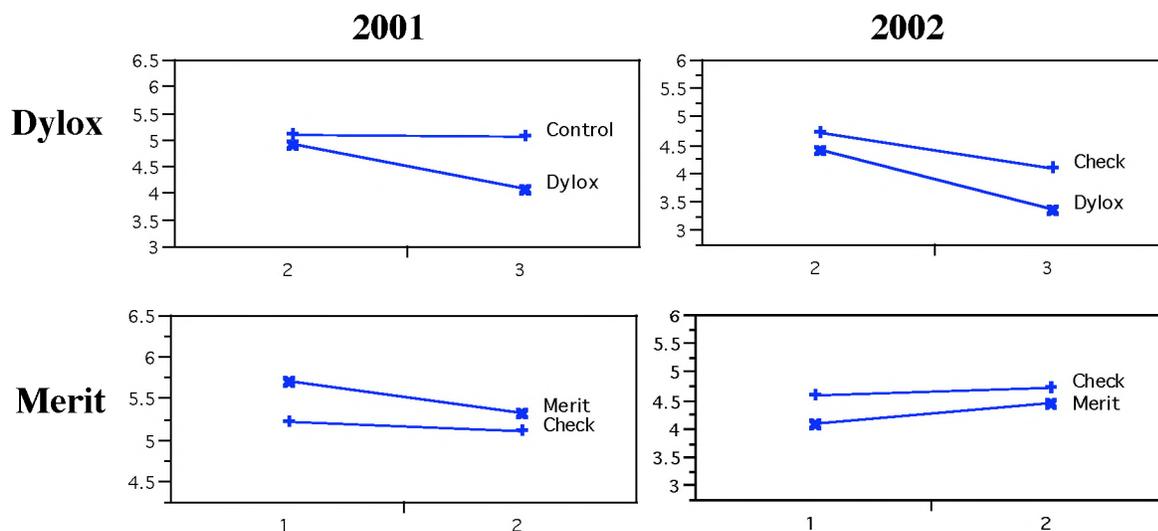

Fig. 3. Interaction plots for oribatid mites comparing pre- and post-treatment populations.

Data were then analyzed to see whether repeated treatments led to differences in arthropod populations. This effect was tested with repeated measures analysis of variance where multiple measures in the same plot over time were taken into account, i.e. eight measures across 2001 and 2002. Again, there was no overall effect of Dylox. In the case of Merit, however, a

significant effect was detected for total hexapods (P<0.004), springtails (P<0.001) adult beetles (P<0.02) and thrips (P<0.02), i.e. in the mid-term Merit significantly reduced populations of these arthropod groups (Fig. 4). Springtails, thrips and beetle adults were 2.6, 3.4 and 1.7 times more abundant in the control versus Merit (Table 2).
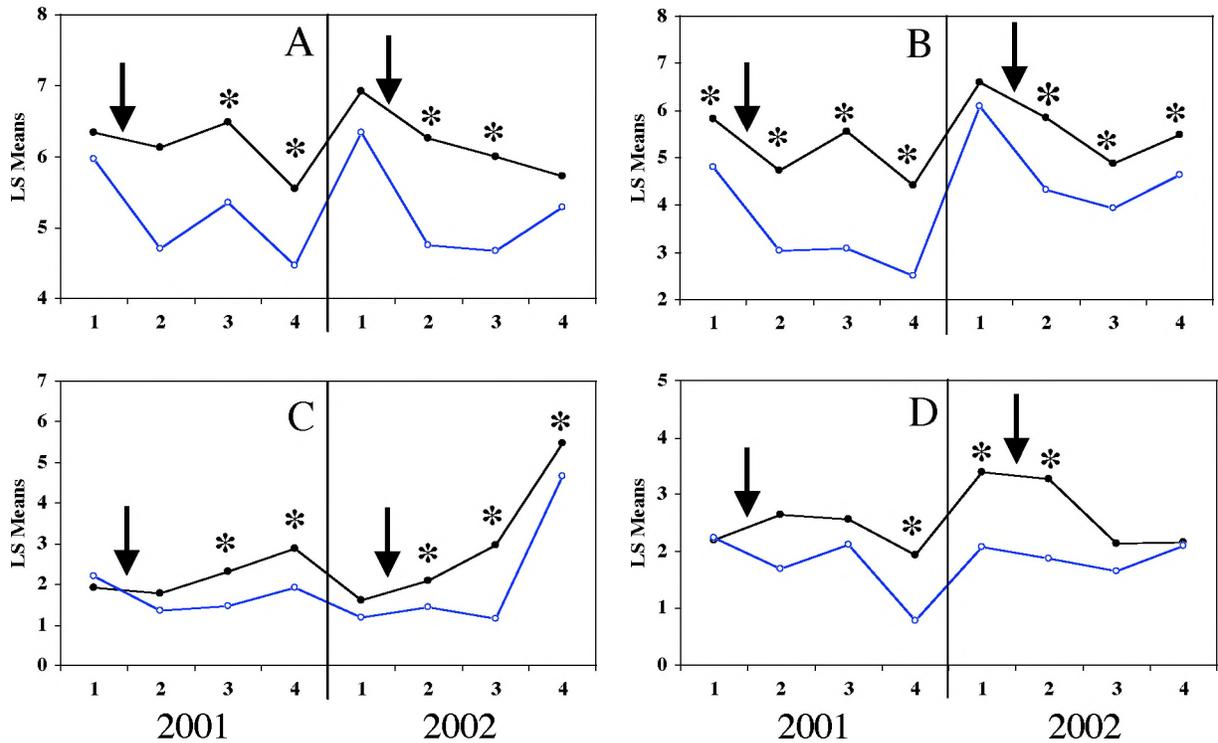

Fig. 4. Effect of Merit (MANOVA P<0.05) on suppressing total hexapod (A), springtail (B), adult beetle (C), and thrips (D) populations, recovered from soil cores, relative to the control. Open circles indicate Merit; closed circles indicate control; arrows indicate application period; asterisks indicate significant differences at specific sampling dates (P<0.05).

Table 2. Magnitude of abundance effects (least squares mean, 2001 and 2002) after three years of applying Merit.

Group	Control	Merit	Difference
Springtails (order Collembola)	9719	3787	2.6
Thrips (order Thysanoptera)	552	161	3.4
Beetle adults (order Coleoptera)	385	228	1.7
- Rove beetles (family Staphylinidae	134	56	2.4
- Ground beetles (family Carabidae)	171	18	9.5
- Leaf beetles (family Chrysomelidae)	51	49	1.0
- Weevils (family Curculionidae)	21	33	0.6

In the short-term (i.e. before and after results of a single application) we did not detect any direct effects for Dylox, Merit, or any of the other experimental treatments on the abundance of arthropods recovered from soil cores. In the mid-term, however, (i.e. the cumulative results of three or more consecutive applications to the same plot over time) Merit significantly reduced the populations of certain arthropod groups. Based on these results we suggest that many non-target effects may be cumulative and not detectable in short-term experiments. These same

analyses will be conducted for the results from the baited ant traps and the pitfall traps to gauge whether macrofauna respond to Merit in the same way.

These data show evidence for a possible indirect effect on predators mediated by reduced prey populations. Four beetle families were sorted from the adult beetles recovered from core samples. The two families of predaceous beetles, the rove beetles and ground beetles, were 2.4 and 9.5 times more abundant in the control versus Merit (Table 2). On the other hand, the two families of phytophagous beetles, the leaf beetles and weevils, were unaffected (1.0 and 0.6 times more abundant). Predator populations may have been impacted by reduced prey (springtail) populations under Merit.

Because of their abundance and significant response to one of the treatments, we intend to examine the springtails in more detail. Springtails are a diverse group that have at least four families represented; classification to family, genus or species would help explore any treatment effects in higher resolution. This target group may help us answer the question of how relevant is their population suppression: Do 2.6 times more springtails influence ecological processes such as thatch decomposition, or the abundance of generalist natural enemies? In addition, we intend to examine the species composition of the springtails and gauge how the composition might or might not change over the five years of the experiment. There were 4.5 times more springtails in control versus Merit in 2001, and 2.1 in 2002. If this difference continues to decrease, it would be interesting to determine if this response is due to (a) population recovery by the original species, or (b) a species-level response through selection of different species.

Finally, these initial results have implications for white grub control. Merit is usually used as a preventive since grubs are hard to scout while they are still most susceptible as first and second instars. It may be, therefore, that control programs based on Merit harbor significant changes to the microarthropod fauna associated with turfgrass. It is not known what other non-target effects of Merit are reported in the literature.

Our future directions will include (a) analyzing the results of the additional baited ant trap and pitfall surveys, (b) exploring the use of "bait-lamina" to measure springtail activity and detect differences among treatments, (c) examining long-term effects on abundance and species recovery over five years, (d) calculating diversity indices and relation to treatment and time, and (e) exploring the effect of springtail suppression on thatch decomposition.