USGA Sponsored

Research *You Can Use*

The Search for Biological Control of White Grubs

In hopes of using the information to protect golf courses, University of Kentucky scientists analyze how Mother Nature limits the number of beetle larvae.

BY CARL T. REDMOND AND DANIEL A. POTTER

Tiphia pygidialis is a wasp that lays its eggs on masked chafer grubs. Upon hatching, the larvae consume the victims. *Tiphia pygidialis* was the most abundant parasite, killing 0% to 33% of the grubs at a given site.

OBJECTIVES

- Determine identity and incidence of microbial pathogens and parasitoids of Japanese beetle and masked chafer grubs on golf courses across Kentucky, the first such study in the transition zone.
- Quantify site characteristics associated with particular grub species and natural enemy incidence.
- Evaluate how grass species, mowing height, and golf course pesticides affect incidence of pathogen infection and parasitism of naturally occurring white grubs in the field, and determine if the impact of naturally occurring pathogens can be enhanced.
- Test the hypothesis that natural enemy load on Japanese beetle grub populations on golf courses is greater in geographical regions where populations have stabilized than in regions into which the pest has more recently spread.

Start Date: 2007 (current cycle)
Project Duration: Three years
Total Funding: $60,000

White grubs, the immature stage of stout-bodied beetles called scarabs, are the most destructive insect pests on golf courses in the cool-season and transitional climatic zones.[4] Grubs cause turf damage in two ways: by chewing off the roots, resulting in

Kentucky superintendents sampled for white grubs in their most affected sites. Grubs occurred in a wide range of Kentucky soils and pH ranges, with no particular relationship between soil type and the predominant grub species.

dead patches that can be lifted or rolled back like a carpet, and by attracting skunks, raccoons, armadillos, and other varmints that dig up the turf to eat the grubs. Golf courses often sustain both types of injury. Many millions of dollars are spent each year to control white grubs in home lawns and on golf courses in the United States.

Golf course superintendents now rely almost exclusively on synthetic insecticides for grub control, applying a long-residual soil insecticide before egg hatch to intercept newly hatched grubs, or spot-treating larger grubs in late summer if and when grub damage appears. Insecticides, however, are expensive and must be reapplied every year, and their overuse can impact the beneficial insects that help to buffer pest outbreaks.

Sole reliance on insecticides, especially of the same chemical class, can also lead to pesticide resistance. Resistance to pyrethroids was recently documented in annual bluegrass weevil populations on New England golf courses and for southern chinch bugs on St. Augustinegrass lawns in Florida. Because societal pressures to reduce use of synthetic insecticides, even reduced-risk products, likely will intensify, it is prudent to explore other approaches that can be used to help reduce reliance on the lone chemical strategy.

Integrated pest management (IPM) uses a combination of tactics to keep pests below damaging levels while minimizing undesirable side effects. Although synthetic insecticides will likely remain essential IPM tools for golf courses for the foreseeable future, integrating non-chemical controls into the management plan can help reduce pesticide dependence, as well as labor and costs. Integrating non-chemical controls also helps reduce the likelihood of pests developing resistance to insecticides.

Biological control, including use of microbial insecticides and conservation of natural enemies of pest species, is well suited to perennial systems such as golf courses. At present, however, microbial insecticides constitute only a minuscule fraction of the turf insecticide market,[2] and not enough is known about predators, parasites, and pathogens of white grubs to effectively enlist their aid.

This project seeks new knowledge about the natural enemies of white

Nematodes found infecting white grubs were given wax worms to infect. The color of the cadavers aids in identifying the nematode strains. One of the nematode strains was noticeably larger than commercial strains and may have potential as a new bio-insecticide especially suited for white grubs in the transition zone.

Scientists at the University of Kentucky continue to explore methods of biological control of white grubs, the larvae of scarab beetles. Part of this investigation included conducting a sampling survey with 33 golf course superintendents throughout Kentucky to assess what parasites and bacterial, fungal, or nematode pathogens were present on the sampled grubs in an effort to identify new potential biological control agents.

grubs on golf courses in the transitional climatic zone. It includes the first survey of pathogens of masked chafers (*Cyclocephala* spp.), the most widespread and destructive native grub pests in the United States. We seek new control agents with potential as bioinsecticides for turf pests, and better understanding of how site characteristics affect these agents for natural suppression of grub populations.

Grub survey kits were sent to 34 golf course superintendents throughout Kentucky in late summer, asking them to collect 30 grubs and a soil sample from their worst non-treated grub site. Samples were returned via overnight mail. Six additional Lexington-area golf courses were intensively sampled in late August, mid-September, and early October to track natural enemy incidence over time.

Grubs were identified, incubated for 30 days, and dissected to assess mortality from bacterial, fungal, or protozoan pathogens. Masked chafers and Japanese beetles accounted for 64% and 30%, respectively, of grubs sent in by superintendents. Masked chafers also predominated on Lexington courses. Grub populations declined from about 18 per 0.1 m^2 in late August to about 5 per 0.1 m^2 in October and 2 per 0.1 m^2 the following spring owing to natural mortality agents. *Tiphia* wasps, *Serratia* (amber disease), *Metarhizium* fungus, and *Paenibacillus* (milky disease) bacteria, and entomopathogenic nematodes (nematodes that attack and produce disease in insects) infected 2%, 5%, 8%, 20%, and 18% of the masked chafer grubs, and 0%, 3%, 5%, 12%, and 19% of the Japanese beetle grubs sent in by superintendents.

Ovavesicula, a protozoan that causes debilitating disease in adult Japanese beetles, was uncommon in Kentucky, but gregarines (*Stichtospora*) infected 26% of Japanese beetle grubs in the spring. The latter two pathogens were absent or uncommon in masked chafer

CONNECTING THE DOTS

An interview with Carl Redmond, *research analyst and Ph.D. candidate, and* Dr. Dan Potter *regarding the work at the University of Kentucky to develop biological controls for white grubs.*

Q: *Please compare and contrast the use of microbial insecticides with conventional pesticides.*

A: Biological insecticides currently make up only an estimated 1⁄10 of 1% of the overall turf insecticide market. Biological pesticides traditionally have been more costly, specific to particular pest species, less reliable and consistent, and slower acting than chemicals. On the upside, biological insecticides tend to pose little hazard to people or the environment, and once established, can provide long-term control. Given the ever-growing pressure to reduce pesticide inputs, and new technologies for producing microbial insecticides, insect-pathogenic nematodes, viruses, and other organisms doubtless will play a bigger role in the future. And, naturally occurring enemies (pathogens and parasitic and predatory insects) present on every golf course are the reasons why insect outbreaks are the exception rather than the rule. If we can learn to conserve these buffers, the need for chemical inputs can be reduced.

Q: *Since most golf course superintendents use insecticides to manage their major insect pests, such biological control strategies would need to fit into an overall IPM program, which may include the use of insecticides. To what extent are various biological control strategies compatible with insecticide use?*

A: Most of the new insecticides are relatively selective; that is, they tend to be more active against target pests than against beneficial species. So, a product like halofenozide (MACH 2), which causes lethal premature molting in pest insects, is relatively non-toxic to predatory insects that do not consume grass. Parasitic *Tiphia* wasps that can reduce Japanese beetle grub populations by 40% or more, are active mainly in April, so postponing preventive grub control until late May or June allows a superintendent to work with them, rather than against them. That's an example of so-called "conservation biological control." Finally, most modern insecticides have low toxicity to insect pathogens such as nematodes and milky disease bacteria.

Q: *Your data showed that none of the white grub pathogens or parasites accounted for more than 20% mortality by themselves, but white grub mortality rates rose to 33% for Japanese beetles and 48% for masked chafers when all potential biological controls were considered collectively. Do you believe that an effective biological control strategy would include applications of perhaps several white grub pathogens or parasites, rather than a single component?*

A: Yes, if a portfolio of effective agents were commercially available, but there is still too much that we don't understand about why natural enemies are effective in some situations and not in others.

Q: *Your survey results also revealed grub densities that vary significantly, depending on the grass species (cool-season versus warm-season grasses) and mowing height (i.e., fairway versus rough). Would you please comment on these results and the subsequent skunk damage in light of turfgrass species and height of cut?*

A: We did see different densities and proportions of Japanese beetle and masked chafer grubs, depending on grass species and mowing height, but we don't at this point know why. Our plot ratings suggested that skunks are less inclined to dig in taller, deeper-rooted grass, or in relatively wiry grasses like bermuda and zoysiagrass, despite those grasses having plenty of grubs. In contrast, they caused significant damage to closely mowed perennial ryegrass. It may come down to how hard they have to work to get at the grubs. Understanding why grubs and skunks tend to hammer some sites and seemingly avoid others could help to focus control efforts.

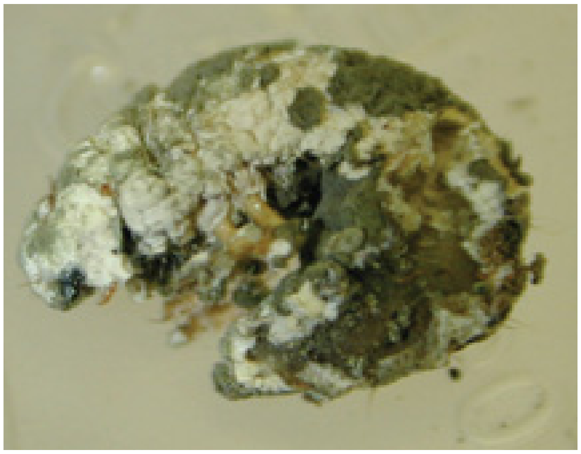
Q: *Does your work with Japanese beetle grubs yet suggest that natural populations of grub parasitoids and pathogens increase the longer that Japanese beetles have been in those areas? If so, do you think using applications of these parasitoids and pathogens in areas recently invaded by Japanese beetles (e.g., Midwestern and Great Plains states) could help stabilize populations of Japanese beetles faster than what could occur naturally?*

A: Our national survey, and some recent work by Dave Smitley, do suggest that it takes a while for the Japanese beetle's full complement of natural enemies to "catch up" when the pest spreads into new areas as it is now doing in the Great Plains and Ozarks regions. That may explain why the expanding beetle population tends to outbreak at first, and then decline and stabilize over time. But there also is much local variation in pathogen load on white grubs, even across different sites on the same golf course. At this point, we don't know enough to say if releasing natural enemies on golf courses where Japanese beetles have recently spread would accelerate natural suppression of grub populations.

Q: *What would you tell superintendents across the country about how biological control of insects would fit into their golf course management programs?*

A: Practice conservation biological control. Insecticides, like human medicines, are powerful tools, but their overuse can sometimes have adverse side effects. Golf courses are patrolled by billions of beneficial insects that help buffer the turf against pest outbreaks. Last week a student in my lab found a heretofore unknown wasp parasitizing cutworm eggs on golf courses. Use reduced-risk insecticides, and apply them at the proper times. Scout and keep records of past infestations to better focus preventive treatments where they are needed. Diversify out-of-play areas with flowering plants and trees, because many of the predatory and parasitic insects that help to suppress pests require the nectar, pollen, or other resources that such plants provide. Keep an open mind, because biological control and biological insecticides will play greater roles in the future.

Jeff Nuss, Ph.D., *manager, USGA Green Section Research.*



Grub killed by greenish *Metarrhizium* fungus.

grubs. Additional *Stichospora*-infected grubs were reared to determine their fate, which has not previously been studied. Such grubs emerged as adults, although their maturation was slightly delayed. Eighty nematode strains, 40 each from masked chafer and Japanese beetle grubs, are being processed for PCR identification.

In 2007, kits were sent to 33 golf superintendents throughout Kentucky who were asked to collect a sample of 30 grubs and soil during September from the worst, non-treated grub site on their courses.

Superintendents placed the white grubs in individual cups of peat moss and returned the kits to the University of Kentucky by overnight mail. Grub samples were identified to species and examined for parasites and disease symptoms.

Replicated stands of irrigated turfs used in fairways or roughs of transition zone golf courses were sampled for grub species preference and incidence of parasitoids and pathogens. Plots maintained at fairway height (⅝") consisted of creeping bentgrass, perennial ryegrass, zoysiagrass, and bermudagrass. Plots at rough height (2.5") consisted of turf-type tall fescue, Kentucky bluegrass, perennial ryegrass, or a tall fescue/Kentucky bluegrass mix. Of the fairway-height grasses, zoysiagrass and bermudagrass had the highest incidence of masked chafer grubs. Masked chafers were most numerous in creeping bentgrass, whereas Japanese beetles favored perennial ryegrass. Japanese beetle populations were highest in rough-height grasses, outnumbering masked chafers by two to four times. Skunk damage was greatest in creeping bentgrass and perennial ryegrass at fairway height. There was little skunk digging in fairway-height zoysiagrass or bermudagrass, or in rough-height grasses. Parasitism by *Tiphia* wasps occurred in all grasses but was greatest in zoysiagrass.

Grub collection kits were sent to cooperators in 22 states to survey natural enemy load in Japanese beetle populations throughout the species range in the USA. Collected grubs are being analyzed for pathogens to test whether the impact of particular agents is associated with how long Japanese beetles have been established in a given area.

> Sole reliance on insecticides, especially of the same chemical class, can lead to pesticide resistance. This project seeks new knowledge about the natural enemies of white grubs on golf courses in the transitional climatic zone. We seek new control agents with potential as bioinsecticides for turf pests, and better understanding of how site characteristics affect these agents for natural suppression of grub populations.

SUMMARY POINTS

- Grub species and associated pathogens and parasitoids were surveyed on 27 Kentucky golf courses, the first such study in the transitional climatic zone. Masked chafers and Japanese beetle grubs accounted for about 66% and 30% of the grub infestations, respectively. Insect-pathogenic nematodes, *Tiphia* wasps, milky disease, and other pathogens account for moderate to high natural mortality at some sites.
- Nematodes isolated from masked chafer and Japanese beetle grubs are currently being identified.
- Turfgrass species and mowing height influence incidence of grubs and natural enemies.
- Pathogens of Japanese beetle grubs are being surveyed across the eastern and central United States to determine if natural enemy load can predict area-wide cycles of decline of grub populations.

RELATED INFORMATION

http://usgatero.msu.edu/v08/n08.pdf
http://turf.lib.msu.edu/tero/v01/n08.pdf
http://turf.lib.msu.edu/ressum/2008/7.pdf
http://turf.lib.msu.edu/ressum/2007/9.pdf
http://turf.lib.msu.edu/ressum/2006/13.pdf
http://turf.lib.msu.edu/ressuml/274.pdf

Carl T. Redmond, *research analyst and Ph.D. candidate; and* Daniel A. Potter, *Ph.D., Bobby C. Pass professor of entomology; Department of Entomology, University of Kentucky, Lexington, Ky.*