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White grubs vary in size depending on species and stage of development, but all are generally C-shaped with white bodies and tan head capsules.

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Down and dirty with WHITE GRUBS

A look at May/June beetle biology and how knowledge about the identity, distribution and age structure of white grubs allows for better control.

By most accounts, white grubs are the leading insect pest of managed turfgrass in the United States. The term "white grub" is used to describe the immature stage (larva) of a complex of scarab beetles that includes masked chafers (Northern and Southern), May/June beetles (Phyllophaga species), European chafer, Oriental beetle, Japanese beetle, Asiatic garden beetle and green June beetle.

Adult beetles of these species are not turf pests, although some feed on leaves of various woody plants and can be serious pests of ornamental gardens. May/June beetles are the nickel-sized, brown-black beetles that are attracted to lights around maintenance buildings at night, and make that loud "crunch" in the morning when stepped on by golf course personnel. Larvae, however, live underground and feed on the roots of most turfgrasses and other plants. White grubs are key pests of turf because they cause direct injury by consuming root tissue and are responsible for collateral injury caused by vertebrate predators, including skunks, moles and armadillos, which tear up the turf to devour them.

White grub control is a challenge for turf managers because a grub infestation may include numerous species that have complicated life cycles. The life cycle of any white grub includes an egg, three larval instars (stages), a pupa and the adult beetle. Many species (collectively referred to as annual white grubs) complete their life cycle in one year; these include masked chafers and Japanese beetles. Others, particularly May/June beetles, may take two or even three years to complete development, spending the majority of that time below the soil surface as third-instar grubs. The length of the life cycle depends on the species of beetle and where they occur geographically. May/June beetles living in the southern U.S. may take one or two years to complete development, while the same species may take two or three years in northern states.

Several years ago, investigators in the Department of Entomology and Plant Pathology at Oklahoma State University began to evaluate insecticides for white grub control.

We soon discovered that unlike most places in the U.S. that are typically infested with annual white grubs, Oklahoma turf typically is infested with a mixed population of southern masked chafer and May/June beetle grubs, or in some cases a preponderance of the latter. We also discovered that we didn't know which species of May/June beetle grubs were turf pests in our state. It turns out that more than 70 species of May/June beetles call Oklahoma home. We can identify adult beetles to species rather easily by examining distinct physical characteristics that differ among them. In contrast, larvae are very difficult to identify to species because differences in physical traits among grubs are not so readily apparent. Their correct identity can only be assured by someone with special training and experience in using the keys for identification of these larvae.

While we were addressing these challenges, several new classes of insecticides were being registered for control of white grubs. These products control white grubs over a fairly long time period (treatment window) during the summer. Yet, we also know that they're more effective at controlling young grubs (first and second instars), and are less effective at controlling larger, older grubs (third instars). In addition, most treatment recommendations suggest that applications coincide with egg hatch of masked chafers, which commonly occurs about two weeks after oviposition (egg laying). While this recommendation seemed to work most of the time, we occasionally received reports from turf managers of "poor control" with products that had previously provided good control. In nearly all of those cases, the "problem grubs" turned out to be May/June beetle grubs.

We soon realized that to effectively manage white grubs, we needed to answer several questions:

- What species of May/June beetles infest turf?
- What are their life cycles, and when do adult beetles emerge and lay eggs?
- How are white grubs physically distributed in turf?
- What insecticide products effectively control white grubs of May/June beetles?

In 2005, we initiated a research project to begin answering these questions. To answer the first two questions, we worked with several golf courses and sod farms that were located in different areas of Oklahoma and we collected beetles and larvae throughout the summers of 2005-2006.

QUESTION 1: WHAT SPECIES OF MAY/JUNE BEETLES INFEST TURF?

We collected white grubs that were feeding on turf at bermudagrass sod farms to identify the predominant species occurring in different regions of Oklahoma. Since OSU currently lacks a reliable expert in identification of larval white grubs we decided to use the "CSI" approach and compare DNA from correctly identified adult beetles with the DNA from unknown larvae. This method works because the DNA fingerprint doesn't change from larval to adult form. To accomplish our goal, we froze specimens in liquid nitrogen, ground up a leg from both beetles and larvae, and sequenced a small fraction of the DNA contained within the leg tissue. Once the DNA was processed, we "matched" the DNA sequence from an identified beetle with an unidentified larva to determine the identity of the latter (see Figure 1 for a hypothetical example).

We recovered eight species of May/June beetle grubs that infest turf; five of these were common, each accounting for at least 12 percent of the total specimens collected (Table 1). We also found that in general we collected more May/June beetle grubs than Southern masked chafer grubs from the sod farms.

Table 1. White grubs collected from seven sod farms in Oklahoma, 2005-2006.

Species	# Locations found	% of Total white grubs collected
P. bipartita	4	13.8
P. calceata	5	12.2
P. congrua	3	14.6
P. crassissima	6	20.3
P. crinita	2	15.4
P. ephilida	2	2.4
P. submucida	4	8.9
P. torta	3	7.3
Southern masked chafer	7	0.8

QUESTION 2: WHAT ARE THEIR LIFE CYCLES, AND WHEN DO ADULT BEETLES EMERGE AND LAY EGGS?

Once we identified the turf-infesting May/June beetles, we were able to look at the flight patterns of those species that we collected in our adult traps. We learned that instead of calling them May/June beetles, we could just as easily call them "April beetles," "July beetles" or "August beetles" because, depending on the species, they emerge and take flight from early spring through early fall. In addition, it appears that their peak flight activity ranges from April through July.

Since there is flight activity throughout the summer, it shows how critical it is to apply an insecticide for grub control at the optimal time to avoid having to make multiple applications. A preventive insecticide applied too early might not provide good control of the grubs that hatch later in the summer. If applied too late, some of the early-hatching grubs could escape control, especially if the insecticide is applied at the lowest rate. We think a sod producer, golf course superintendent or lawn care professional would benefit most from an application made from mid-June to July 1.

QUESTION 3: HOW ARE WHITE GRUBS PHYSICALLY DISTRIBUTED IN TURF?

Left: Mixed populations of white grub species infesting a bermudagrass fairway. Above: Armadillos and other vertebrate predators can cause "collateral" damage to turf as they dig for white grub prey.

Insects can be distributed across a habitat in three distinct patterns: uniform, random or clumped. A uniform distribution means that individuals are spread evenly across the landscape. This pattern is rare in nature. More commonly we see clumped, or aggregated, distributions of insects. Clumped distributions usually occur when individuals are drawn to a high-quality resource; visualize zebra gathered around a watering hole in the dry African savannah. Random distributions are also common and are at least partially explained by the heterogeneous nature of habitats. The distribution pattern of an insect is affected by availability of necessary resources, such as food, shelter and reproduction or nesting sites. For species that have overlapping distributions, competition within and among them may influence their physical distribution.

From an ecological standpoint, we are interested in the distribution of white grubs in turf because it may help us understand how different species of May/June beetles that overlap in time and space are able to "share" the turfgrass resource and interact with one another. We wouldn't expect to see two or more species sharing a resource peacefully, so the distribution of each species may be influenced by competition with other species.

From a practical standpoint, knowing the distribution of white grubs in turf might allow us to target insecticide applications as spot treatments rather than broadcast applications. Broadcast applications for white grub control tend to be a waste of time, labor and money unless the infestation is widespread. They also place biological poisons in the environment where they are not needed, which goes against the philosophy of Integrated Pest Management (IPM). Circumstantial observations suggest that white grub infestations in turf occur in concentrated patches of damage in fairways and lawns (clumped). Therefore, knowledge about where white grub infestations are present (or not present) helps build a more time- and money-efficient, and effective IPM program.

We're studying the distribution of white grubs at several Oklahoma sod farms by recording GPS coordinates for each specimen collected in the field over time. We'll use these coordinates to create distribution maps for each species to help us visualize overlapping species distribution patterns. Observing these maps over time will reveal how these distributions change throughout the season. We're also classifying the development stage of the white grubs by measuring their head capsule size; with the largest measurements corresponding to third instar (oldest) white grubs. Remember that larger white grubs are not as easily controlled with many insecticides and must be treated with Dylox, Sevin or Arena.

QUESTION 4: WHAT INSECTICIDE PRODUCTS EFFECTIVELY CONTROL WHITE GRUBS OF MAY/JUNE BEETLES?

Much of our recent research involves evaluating efficacy of new insecticides for controlling May/June beetle white grubs. Before we discuss the results of our trials, let's first talk about strategies for chemical control of white grubs: preventive, curative and rescue applications. Preventive applications are made in anticipation of a pest problem, usually in response to repeat infestations of a pest insect at a particular location. Most systemic insecticides are used preventively and are applied in advance of white grub activity. Curative treatments are made when white grubs are actively feeding but not causing visual damage to the turf. Their presence may be detected by monitoring or collateral damage to turf caused by vertebrate predators. Rescue treatments are similar except they're made when turf is showing damage symptoms and needs to be rescued immediately.

Monitoring is recommended for areas that historically have been infested with white grubs. Effective management often depends on estimating population density (e.g., number per square foot) and treating when grub densities reach a damaging level. Grub counts are made by cutting and peeling back several 1-square-foot patches of turf and looking for the C-shaped larvae in the root zone. Enough patches are observed to get a representative number of samples for estimating grub density in the area of interest. Treatment recommendations vary by geographic area and host plant, but in Oklahoma we recommend treating for white grubs of May/June beetles when their populations exceed four grubs per square foot.

Knowing when to treat is important, but we also need to choose the right insecticides for the job. We conducted two trials in 2008 at a teaching golf course on the campus of OSU-Oklahoma City. These trials were performed on bermudagrass to evaluate Arena, Merit and a new product, Acelepryn,

FROM LEFT: TOM A. ROYER; DAMON L. SMITH

as preventive and curative treatments (Figure 2). All products worked well against a mixed population of May/June beetle species and southern masked chafer compared to plots not treated with insecticide. Even though average grub densities in untreated plots were below the recommended treatment threshold, preventive and curative strategies were effective at reducing white grub densities using the products tested.

Acelepryn is of particular interest because it's the newest insecticide registered for white grub control on golf courses in most states. Acelepryn controls grubs with a single application and can be applied effectively at low rates. Based on our results and those at other universities, the treatment window for using Acelepryn is wide ranging because it's effective as a preventive or curative application. This is probably due, in part, to the chemical nature of the active ingredient, chlorantraniliprole, which belongs to a novel class of insecticides known as the anthranilic diamides (Group 28 Insecticide). However, we recommend that Acelepryn should be rotated with insecticides from other chemical classes to avoid/delay the onset of resistance in white grub populations.

SUMMARY

Not all golf courses are equal in terms of the complex of white grub species they harbor. As G.I. Joe used to say, knowing is half the battle. Knowledge about the identity, distribution and age structure of white grubs allows for better selection of insecticides, treatment windows and target sites. Our research strives to improve white grub management while saving money and reducing the adverse environmental impacts of chemical control. **GCI**

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IMPACT ON THE BUSINESS

War on white grubs

A superintendent at an Army-owned, public golf course combats June beetles with preventive insecticide treatments. **BY MARISA PALMIERI**

At the Army-owned Ruggles Golf Course in Aberdeen Proving Ground, Md., golf course superintendent Mark Burk is now winning the battle with green June beetles, which he's fought in the white grub stage for years.

Two years ago, Burk hit a wall in his grub control program, as the grubs' tunneling was raising the turf up and creating mounds everywhere. Additionally, skunks and other animals were causing damage of their own, digging for their favorite snacks.

"Combined, they were creating a real mess on the fairways and tees," Burk says.

Until 2007, Burk was spraying the ryegrass fairways and tees with Dylox. Though he says it worked well as a clean-up product, the result was a sea of dead grubs baking in the hot August sun, which caused a noticeably foul odor.

"We were definitely looking to spray preventively to avoid clean-up work," he says.

At that time, Burk tried Arena. The first season, he sprayed preventively on the fairways, but since he was working with a new product, he didn't spray the tees.

The preventive application in the fairway worked very well, but come August, Burk had grub activity in the tees. A vendor recommended he try Arena in its granular form as a curative measure.

"I broadcast the granular and watered it in, and literally had success the next morning," he says. "There were dead grubs on top of the turf – I was pleasantly surprised with the quick knockdown."

Burk's pleased to report he only had to use the curative method one season. Since then, he's preventively sprayed fairways and tees around June 1.

"We usually see the June beetles' eggs hatching the first week of August, so we like to have the active ingredient down so the timing is such that we get them just as the eggs hatch," Burk says.

He spends about $3,500 a season on grub control, and as a superintendent who maintains 27 holes with about a $500,000 budget and nine part-time staffers, he's pleased with making a single application.

"One application is getting the job done," he says. "And it's also more environmentally friendly, because there's much less insecticide hitting the ground." **GCI**