PACE INSIGHTS June, 1998 Volume 4 Number 6

All Worms Are NOT Created Equal: A Look at Earthworms, Black Cutworms and Stem Nematodes

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The word "worm", defined by Webster's Dictionary as "any of numerous relatively small elongated usually naked and soft-bodied animals", is used to refer to many of the pests that plague turf managers. Yet although they share a common body shape, organisms commonly referred to as worms -- including earthworms, caterpillars and nematodes -- are not closely related to one another, and are managed in very different ways. In this issue of *PACE Insights*, we will review the biology of some of the key "worm" pests on golf courses, and present some new strategies for their management.

Earthworms: a surprising pest

Although superficially similar to insects such as caterpillars in appearance, earthworms differ from insects in several important respects, including the lack of segmented appendages (including legs), the lack of a protective chitinous exoskeleton, and very different respiratory, circulatory and excretory systems. They can range in length from a fraction of an inch to several feet in length, though most of the species we are familiar with in the U.S. are only a few inches long. Most of the world's 1800 species of earthworms have the amazing ability to regenerate large portions of their bodies -- a handy survival skill when one of your chief predators are birds that like to peck and tear you into small pieces. And unlike most insects, earthworms live for relatively long periods -- up to 2 years under field conditions.

The seemingly insignificant earthworm has received a great deal of attention from biologists throughout the ages -- from the likes of Aristotle (who called them "the intestines of the earth") to Charles Darwin (who stated that "earthworms have played a most important part in the history of the world"). No doubt it is their well-known benefits -- including decomposition of plant and organic matter, improved soil structure via the formation of water stable aggregates, and soil aeration -- that these famous scientists stood so in awe of. Yet despite their well known positive contributions, earthworms can also cause problems -- on golf courses and in agriculture.

Castings, a combination of soil and fecal material that certain earthworms excrete at the soil surface, are the source of the damage that earthworms cause on golf courses. These mounds (usually no more than 2 inches across, although some tropical earthworms produce casts that are 10 inches high and weigh 3.5 pounds!) cause uneven playing surfaces, smearing and slipperiness, and lack of turf growth where they are deposited. Earthworms produce casts on all types of turf, but the greatest problems have been reported on tees and fairways, rather than on greens. And although casting behavior is not well understood, it appears that earthworms deposit their casts on the turf surface only under certain conditions (hint: this is an important point to remember in the discussion of earthworm management below).

Earthworms: a new problem?

Most golf courses play host to several different earthworms. Two common earthworm species -- the night crawler (*Lumbricus terrestris*) and the red earthworm (*Lumbricus rubellus*) occur in many locations across the U.S. However, each region also appears to have its own unique grouping of other species as well.

In the past five years, superintendent complaints about earthworms appear to have increased -- across the United States, and in Europe as well. This may be partly due to the gradual switch we have made away from broad spectrum insecticides and fungicides (chlordane, diazinon, arsenic, copper sulphate) which are highly toxic to earthworms, to more specific products that pose little or no hazard to earthworms. This theory is partly backed up by the fact that golf courses reported serious problems with earthworms from the 1900s to the 1950s (before the introduction of many synthetic pesticides), but few problems were reported from the 1950s to the 1980s -- the heyday of broad spectrum pesticides.

Another factor contributing to the increased incidence of earthworms on golf courses may ironically be our improved cultivation techniques, particularly on fairways. Although earthworms can survive under a wide variety of soil conditions, their numbers are highest in light and medium loams that are well aerated (Table 1) -- exactly the type of environment where turf grows best. But here is where the story gets more complex. Because although well aerated soils may promote the growth of more earthworms, it is probable that the worms don't produce as many casts under these conditions. This is because it is primarily in heavier, clay soils, where oxygen is limited and movement is more difficult, where earthworms are more likely to come to the surface to deposit their casts. This is borne out by our observation that most earthworm problems -- in other words most casting problems -- occur in areas of the golf course that are wet because they are in low spots, or because of poor drainage and

heavy soils.

Table 1. Relations of soil type to earthworm populations (from Edwards, 1972)

Soil type	Number earthworms per meter^2
light loam	63
light sandy	57
medium loam	56
alluvium	44
clay	40
gravely loam	36
peaty acid soil	14
shallow acid peat	6

Chemical vs. cultural control

As more and more golf courses report problems with earthworms, two very different philosophies have emerged regarding their management. The most direct strategy relies on killing the earthworm itself, via the use of pesticides. In contrast, a more indirect approach relies on manipulation of the environment, via cultural practices, to discourage earthworms from producing casts on the turf surface. The plusses and minuses of each of these strategies is discussed below.

Chemical control: There are a variety of fungicides and insecticides which have been shown to be toxic to earthworms (Table 2). In the United Kingdom, where earthworms have been a perennial problem on golf courses, products based on thiophanate-methyl (known as "Castaway" and "Mildothane") and carbaryl (known as "Cavalier") are actually labeled for earthworm management, and have been used successfully. However, in the U.S., none of these products is registered for use against earthworms (although several are registered for use on golf courses), making their use against earthworms illegal in this country. In addition, we would like to try to avoid additional pesticide applications wherever possible -- particularly on fairways, where the use of fungicides and insecticides is rare in the Western states. Which leads us to consider an alternate approach.

Cultural Management: This approach is based on the belief that earthworms themselves are not the problem- it's only when their castings appear on the soil surface that they cause damage. Using this reasoning, it is not necessary to kill the earthworms -- only to adapt the environment to discourage casting behavior. Some cultural practices that may accomplish this are:

- Improve drainage in low lying, wet areas through topdressing and aerification programs. Better aerated soils will discourage casting behavior.
- Since earthworms prefer high organic matter media, avoid accumulation of organic matter (organic fertilizers, clippings, heavy thatch), especially in poorly draining areas.

The benefits of using a cultural approach include preservation of the beneficial aspects of earthworms and decreased pesticide use. The risk is that although this approach makes sense, we have little or no practical experience to indicate that it will be successful.

We are just beginning to explore the issue of earthworm management, and many questions remain unanswered. If you have had positive (or negative) experiences in managing earthworms, let us know about it, and we'll share results with the rest of the Info-Pak subscriber group.

Table 2. Pesticides with high toxicity to earthworms (from Edwards, 1972 and Potter, 1998). Product names followed by an asterisk (*) are not registered for use on U.S. golf courses. None of the products listed is registered for control of earthworms

Active Ingredient	Product
benomyl*	Benlate
carbaryl	Sevin
chlordane*	Chlordane
copper sulfate*	copper sulfate
fonofos	Crusade
heptachlor*	Heptachlor
methyl bromide	methyl bromide
thiophanate-methyl	Cleary's 3336, Fungo Flo

Black Cutworms: Another Type of Worm

The black cutworm, *Agrotis ipsilon,* is one of the most common and one of the most frequently treated insect pests on golf course greens and tees. The damaging stage of this pest is the immature larvae, or caterpillar, which is dark gray to black in color, and ranges from 1/8 of an inch long (when newly hatched) to almost 2 inches long and 1/4 wide when full grown. Data from the PTRI insect monitoring study indicates that in California, black cutworms are present throughout the year on golf courses, but the heaviest populations occur June - November, with particularly high numbers seen during the Fall months (September - November).

Like earthworms, black cutworms (BCWs) can be present on golf course turf, but only cause damage under specific circumstances. In the case of the BCW, the caterpillars typically wander along the surface of the turf, feeding on a blade of grass here, and a blade of grass there, with no obvious feeding damage resulting.

But at certain times in their life cycle, the larvae change their roving life style and become home-bodies instead, by digging small holes in the soil or thatch (or by occupying aerification holes), and focusing their feeding activities in the immediate area around their cozy burrow. This creates small areas of dead turf right around the BCW burrow that resemble ball marks.

Many superintendents have observed that BCW damage usually occurs after aerification. This occurs because the aerification holes -- ready made homes for the BCW -- are an invitation to take up residence on greens, and to switch their behavior from grazing throughout the green, to focusing their feeding around the aerification hole. However, it's erroneous to assume that aerification attracts the worms, although this appears to be the case. Instead, aerification just makes their presence more obvious.

The BCW is frequently blamed for bird damage on turf, but this effect is probably greatly overrated. While starlings, crows and other birds will eat BCW caterpillars, it is just as likely, if not more likely, that the birds are searching for black turfgrass ataenius grubs and adults, ground beetles, or other common turfgrass insects. For this reason, when bird activity is observed, it is important to confirm that BCW are actually present (see below) before making insecticide treatments. This will help you to avoid applying the wrong insecticide (black turfgrass ataenius does not respond to BCW products such as chlorpyrifos), or from making an unnecessary insecticide application.

Detecting Black Cutworms**:** The BCW is one of the few pests on golf courses for which a curative approach is the most effective. This allows us to wait to make insecticide applications until BCW damage is actually detected, with very little risk involved. The success of this approach relies on the availability of several very effective products (see "Controlling Black Cutworms" below) and use of the monitoring program described below:

- From April - November, monitor greens weekly for signs of BCW activity -- either small holes surrounded by rings of dead turf and/or bird pecking damage. Pay special attention immediately after aerification.

- Confirm that BCW are the cause of the damage by applying a soap drench (1 tbsp of liquid detergent/ gallon of water) spread over a square yard of turf. (Lemon scented Joy is quite effective and does not appear to damage turf). Irritated cutworms will come to the surface of the turf within one to three minutes of application.

Controlling Black Cutworms: For years, effective BCW control programs have depended on chlorpyrifos (Dursban, Pageant, etc) or trichlorfon (Dylox or Proxol). However, these organophosphate products are also among the most toxic pesticide products used on the golf course, and for this reason the Environmental Protection Agency is in the process of determining the future of their use. Agrichemical companies have responded with the introduction of several less toxic, new generation insecticides, including Conserve (produced by Dow, the same company that markets Dursban) and Mach 2 (developed jointly by Rohm and Haas and American Cyanamid). Conserve (active ingredient: spinosad, which is based on the by-products of a bacterial fermentation), is effective against many caterpillar pests, and is currently registered for use in California. Mach 2 (whose active ingredient, halofenozide, works by interfering with insect molting), is effective not only on caterpillars, but also on white grubs of the black turfgrass ataenius, chafers, and Japanese beetles. Although registered elsewhere in the U.S., California registration of Mach 2 will probably not occur until late 1998/early 1999. We encourage you to try out these and other new products as they become available, so that you can determine which products are most compatible with your specific conditions.

Last, but not Least: The Stem Nematode

Nematodes are characterized by their microscopic size ($^1/_{30}$ - $^1/_{100}$ inch long), their smooth, transparent, unsegmented bodies, and a lack of legs or other appendages. All plant parasitic nematodes have a stylet, or spear that they use to pierce plant cells. Although most nematodes are free-living, and cause no damage to plants or animal, several nematodes are serious parasites of humans, animals, and plants, and are among the most difficult of pests to control.

In the past year, we have been contacted by several superintendents at Northern California golf superintendents whose poa greens have been plagued with difficult-to-control nematode infestations. Unlike many nematodes, which damage plants by feeding on their roots, this mystery nematode feeds inside the plant stem, producing galls (a swelling of the plant) on the stem that contain 2 or more nematodes each, and up to 800 nematode eggs. Some of the galls are also filled with a bacterium, whose role in plant damage is at this point unknown. On heavily infested greens, small chlorotic patches of galled poa plants can coalesce into large areas of declining turf. The end result of the nematode infestation is a slow decline in health and vigor of the poa plants.

Because the stem nematode spends most of its life inside the plant, they do not show up in standard soil nematode counts. The short time that the nematode spends outside of a gall moving to a new plant also confounds control procedures. A better understanding of the stem nematode life cycle may improve control by timing applications to the emergence of the second

stage juvenile nematodes from the galls.

Progress on this project has been slow, but steady. With the help of nematologist Dr. Michael McClure at the University of Arizona and nematode taxonomist Dr. Tom Powers from the University of Nebraska, the nematode was tentatively identified as *Anguina pacificae.* Interestingly, this nematode was first described and named in 1984 (Vera and Magenti, 1984), when it was collected by University of California, Davis scientists from -- you guessed it -- *Poa annua* greens in Northern California. Unfortunately, the researchers were not able to follow up on their discovery, and all work seems to have been discontinued -- until now. We are currently trying to decipher the life cycle and biology of this pest, and are conducting field trials to evaluate alternate, reduced-risk control products, such as avermectin (Avid Insecticide). As far as we know, the stem nematode is restricted to golf courses on the Northern and Central California coasts. We therefore have a good opportunity now to study this pest, and to understand its biology and control, in case the infestation moves further South or East. We will keep you posted on results.

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