PHOTO 2

Annual bluegrass weevil larvae can cause serious damage along the edge of fairways.

Continued from page 79

or in the litter under trees (Diaz and Peck 2007). In April the adults migrate into annual bluegrass areas and, after a brief feeding period, the females start laying eggs under the annual bluegrass leaf sheaths. Development of the first generation in spring from eggs to adult takes about six weeks. The first-generation adults become active around mid to late June. Their offspring emerges as the second-generation adults in late July to August. Adults from the third generation migrate back to their overwintering sites from October into November.

Efficacy of synthetics

We have summarized data from insecticide-efficacy tests published between 1993 and 2005 conducted by university researchers in the Northeast (McGraw and Koppenhöfer 2007). The summary shows that pyrethroids were the most effective insecticides with no significant difference among the different compounds. The average control rates were 93 percent for bifenthrin (Talstar), 87 percent for cyfluthrin (Tempo), 84 percent for deltamethrin (DeltaGard) and 97 percent for lambda-cyhalothrin (Scimitar). It is presently recommended to apply pyrethroids against the overwintered adults between full bloom of forsythia and full bloom of flowering dogwood. However, our summary revealed no difference between pyrethroid applications in late April (89 percent) and early May (93 percent).

The organophosphate chlorpyrifos (Dursban) was more effective when applied in early May (83 percent) or late May (83 percent) than in late April (62 percent). While chlorpyrifos applications are now limited to 1 pound of active ingredient per acre (lb ai/acre), the data suggest that this rate was as effective as 2 to 4 lbs ai/acre. The organophosphate trichlorfon (Dylox) was ineffective when applied in late April and early May but provided 79 percent control in late May.

Insecticide resistance

Many golf courses use multiple sprays in spring to achieve adequate suppression of adult ABW to avoid damage from the larvae produced from the eggs they lay. Additional sprays may be applied against later generation adults and larvae. This excessive insecticide use strongly suggests the development of insecticide resistance, particularly to the predominantly used pyrethroids. Recent studies have shown that in several tested golf courses, pyrethroid resistance in ABW does exist. To avoid the development of insecticide resistance, it is essential to: 1) regularly rotate insecticide from different insecticide classes, 2) not exceed label rates, and 3) avoid "wall-to-wall" applications.

The regular rotation of fungicides from different classes, adherence to label rates and the avoidance or wall-to-wall applications are imperative to avoid developing insecticide resistance.

Unfortunately, most of the newer lesshazardous chemistry appears to lack the efficacy and consistency to replace pyrethroid applications, i.e., the neonicotinoids imidacloprid (52 percent control) and clothianidin (65 percent) and the insect growth regulator halofenozide (48 percent). However, the anthranilic diamide chlorantraniliprole shows great promise with 80 / 93 / 84 percent control when applied in late April / early May/ late May, respectively.

With the increasing pressure to reduce pesticide use on golf courses, there is a dire need to develop effective ABW control options with reduced environmental and health hazards and that are more IPM-compatible and, ideally, more sustainable. Biorationals and biologicals have only received very limited attention. A very limited number of trials with the fungal toxin spinosad (Conserve) suggest that it can be quite effective (80 percent control applied in late April/early May, 90 percent control applied in late May). Entomopathogenic fungi (Beauveria or Metarhizium) and bacteria (Bt = Bacillus thuringiensis) have yet to be tested.

Entomopathogenic nematodes for ABW management

Entomopathogenic nematodes (EPN) have provided good to excellent control of various other weevil pests such as citrus weevils in citrus, black vine weevil in ornamentals and billbugs in turfgrass. In Japan, the EPN species *Steinernema carpocapsae* was the major means of control (average 84 percent) of the hunting billbug before the recent registration of imidacloprid. A limited number of previous tests against ABW indicate that *S. carpocapsae* is more effective when applied as a curative against the larvae in late May than against the adult in late April or early May. Our laboratory observations confirm that adult ABW are not very susceptible to EPN.

In field trials in 2006 and 2007 and in parallel laboratory trials on field-infested turf plugs, several nematode products significantly reduced ABW larvae when applied in late May (Figure 1, p. 84). Reductions were observed as follows: *S. carpocapsae* (Millenium) (62 percent to 69 percent in field; 68 percent to 95 percent in lab); *S. feltiae* (Nemasys) (24 percent to 92 percent; 86 percent to 92 percent); *H. megidis* (Nemasys H) (45 percent to 77 percent, 62 percent to 76 percent); *H. bacteriophora* (Nemasys G) (71 percent, 37 percent); *S. kraussei* (Nemasys L) (0 to 77 percent, 67 percent to 76 percent). The

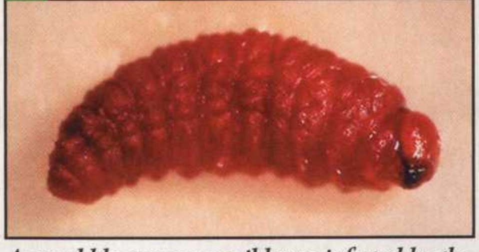
Observations suggest that natural nematode populations cannot reliably suppress ABW populations below damage thresholds.

2007 field trial also suggested that species combinations and split application (applied one week apart) can further improve EPN efficacy against ABW larvae. Further trials in 2008 should help solidify our observations and identify the best nematode species and application strategies.

We are also studying seasonal dynamics of ABW and EPN on golf course fairways that are not treated with insecticides other than imidacloprid for white grub control. Naturally occurring *S. carpocapsae* and *H. bacteriophora* infect mostly fourth and fifth instar larvae, but some third instars and pupae also can have significant impact in all three ABW generations (up to 54 percent generation mortality). But our observations also suggest that natural nematode population cannot reliably suppress ABW populations below damage thresholds.

Continued on page 84

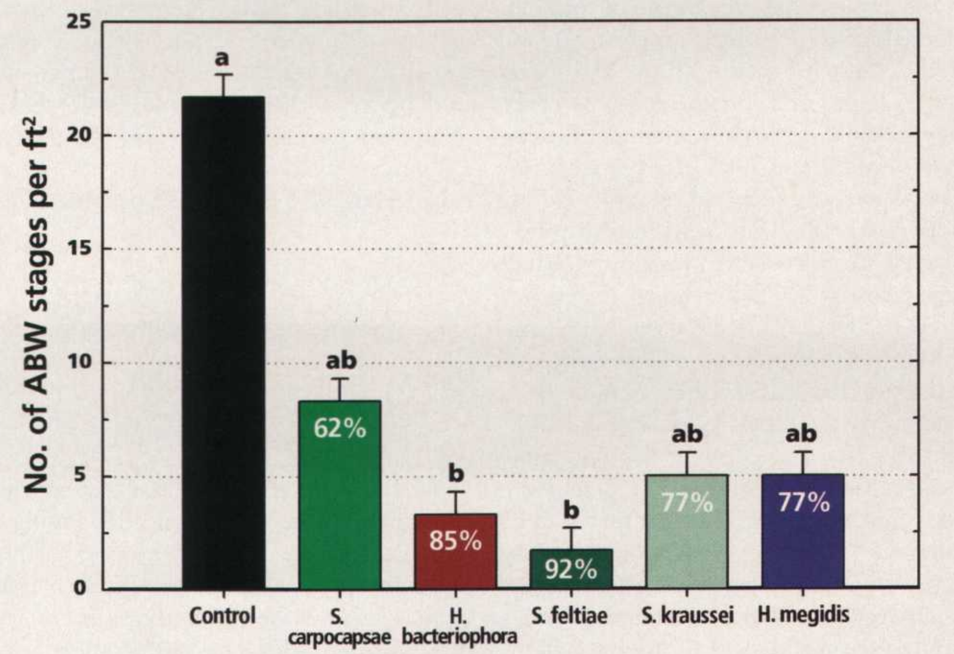
PHOTO 3



Annual bluegrass weevil larva infected by the nematode Heterorhabditis bacteriophora.

The chart to the right represents results from annual bluegrass weevil field trials in 2006 and 2007. The percentages represent the amount of control for a particular species. Letters above the bars indicate statistical correlations.

FIGURE 1



Continued from page 83

Outlook

Turfgrass entomologists throughout the Northeast are now collaborating to develop a better understanding of ABW biology, better ways of predicting and monitoring ABW populations and finding safer ABW management tools. Ultimately, this will allow superintendents to replace preventive blanket pyrethroid sprays with spot treatments on an as-needed basis using less toxic alternatives. This in turn would allow existing natural enemies of ABW and other turfgrass pests to contribute more effectively to the suppression of pest populations.

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Albrecht Koppenhöfer is associate professor/ extension specialist in turfgrass entomology at Rutgers University in New Jersey. His research and teaching emphasize the development of integrated pest management strategies for important turfgrass insect pests in the Northeast, in particular for the white grub complex and the annual bluegrass weevil.

Benjamin McGraw is a doctoral student at Rutgers University. He is working on annual bluegrass weevil management, especially in the aspects of biological control.

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Modern Insecticides, Including Combo Products, Fit Nicely With IPM

By Rick Brandenburg

This installment on the discussion of integrated pest management (IPM) begins with the premise that challenges have emerged as we have new products that have a more favorable environmental profile but might need to be applied in a more preventive manner. We pick up with that concept in part two and look further at newer chemistries and how they fit into what we do each day.

I think it is important that we not overlook the significant differences in the toxicities of today's modern insecticides. If we go back just 10 to 12 years ago, we were using products that had oral LD50 (lethal dose to 50 percent of the test population) to rats and birds that were measured in single digits. The lower the number, the more toxic the compound. A product with an LD50 in the single digits (kilograms/milligrams) is toxic. This included such household insecticides as diazinon. Over the past 10 years, we have seen the emergence of products that are no longer in the single digits. In fact, they aren't even measured in double digits, but rather in hundreds units and a few of them in the thousands. This is a dramatic change in the toxicity of the insecticides we were applying to the turfgrass. Insecticides under development at this time continue that trend and are pushing towards LD50s measured above 10,000. Additionally, the newer products tend to be applied at much lower rates of active ingredient per acre.

A new addition to the insecticide market has further challenged our approach to IPM and the idea of treating only when necessary. Recently, Bayer Environmental Sciences and FMC Corp. released a product called Allectus. This product contained the active ingredients of two popular insecticides Talstar and Merit. There are several perceived benefits to this product that include its broad spectrum of control that has the potential to control both surface and soil insect as did some of the older, more toxic chemistries, such as diazinon.

While the concept of a more broad-spectrum insecticide, such as diazinon, being back on the market might sound very attractive to us, there are a couple of things we should keep in mind. First, broad-spectrum control historically meant a higher level of toxicity to unintended organisms in addition to insects. This could include aquatic organisms, birds, people and pets. This was a characteristic that companies have worked hard to get away from. We should remember that diazinon uses were severely curtailed and eventually eliminated a number of years ago because there were numerous documented cases of bird kills, particularly on golf courses. While we don't want to regress environmentally to attain broad-spectrum control in our products, some characteristics of the older products are still viewed by turfgrass managers as being very favorable.

Fortunately, when we combine two products that have modern chemistries to obtain a broader spectrum of control, such as addressing surface-feeding and below-ground insects, we don't necessarily increase the hazard or risk. If the two insecticides used in the combination product have favorable environmental profiles, then it is quite likely that the overall concern won't be any greater than that of the product's individual characteristics. This is important to understand as Allectus is one of several combination-type products we are beginning to see in the marketplace.

A second consideration that concerns some people about using combination products is that in some instances, you might be applying two active ingredients and only getting a benefit from one of them. In other words, it might be viewed as a wasted application or simply overkill by others. How often do you have two insects causing a problem in one location? Well, it can and does happen as I have seen fire ants, mole crickets, white grubs, and other insects all pose problems at the same time in one area.

A combination product is going to cost more than a product that contains only one insecticide. Therefore, the vast majority of turfgrass managers are going to take a long, hard look at such products and ask the question as to whether or not they are getting additional benefit from the use of such a product. The answer in some instances will probably be "no", and another, less-expensive product likely will be selected.

In other situations where multiple pests are likely to occur and there is an economic incentive to manage more than one pest with a single application, I think turfgrass managers will look at such products as being valuable tools in their operation. For example, in a home-lawn setting that has a strong likelihood of white grubs, mole crickets, fire ants and chinch bugs, a combination product applied at the proper timing would be an excellent choice. This scenario is seen time and time again in home lawns in the southeastern United States.

A combination product might be a great choice for

Continued on page 88

Continued from page 86

scarab grub, black turfgrass ataenius and cutworm protection on golf putting greens or white grubs, mole crickets, fire ants, and even armyworm or webworm populations in other areas on a golf course. The same could be said for athletic fields susceptible to fire ants, armyworms, grubs and mole crickets. There are numerous situations where a single active ingredient might not be able to get the job done. In these situations, the use of a combination product such as Allectus could certainly be the most cost-effective and efficient way to do business. Again, we don't want to introduce new products that might regress environmental stewardship, but the value of a broad-spectrum insecticide for a number of turfgrass settings cannot be overstated.

Some might be critical of the fact that two active ingredients are being applied when in fact only one might be needed. I disagree with the perspective that you are wasting or misapplying one of the active ingredients. If one didn't know that there were two active ingredients, but simply that it was a broad-spectrum insecticide, would it matter?

For example, what if you apply Merit for white grubs (which is also effective against mole crickets) but you don't have mole crickets? Did you waste the broad-spectrum aspects of Merit? Should you have used a product that only controlled white grubs? I think the obvious answer to that is "no." If you use the mentality that Allectus is too broad, then I think you should use that approach for all product selections and use only products that have the most limited spectrum you can find but include the pest you are struggling with. That's not how we do business, nor should we be expected to. I would be concerned if the new products had serious environmental or toxicity issues, but those are not the characteristics of these new products.

Another trend that isn't really new but is becoming more popular on a wider basis is the application of insecticides on a fertilizer carrier. The ability to do two things at once is attractive in almost anything that we do. This saves time and money if we can apply our fertilizer and obtain insect control at the same time. I really like a lot of the newer fertilizer/insecticide combinations. They are easy to apply, and the fertilizer acts as a very good carrier that readily releases the insecticide and allows it to get to work. While the application of two things (fertilizer and insecticide) at one time can be a big time saver, savings are only realized if you actually get something out of both products. In other words if it makes sense agronomically to apply fertilizer, then does it also make sense biologically to apply an insecticide? I'm not referring only to whether or not insects are present but whether or not they are present at the life stage that is susceptible to the insecticide. In some cases, the timing might not allow the insecticide to be very effective. Look at the use of fertilizer carries from more than just the cost perspective. Look at it from a biological concept.

We are also seeing more interest in the use of baits. Many fire ant products use the bait approach, and some are very successful. These often are considered to be a key component in IPM as they tend to affect only the pest species and are put out only when the pest species are present and active. There are several efforts underway to go back and take a renewed look at baits for insects such as mole crickets.

I think it is easy to see that our industry continues to make good progress in developing the products that are less toxic to organisms other than insects and more environmentally friendly, yet still do a good job of controlling the insect pest. Our challenge is to develop ways to incorporate these new products into our programs, using them in a timely manner so they are very effective, applying them only when necessary, and using our knowledge of pest biology to make sure timing of application is accurate.

Who said our jobs get any easier? Despite the challenges, we are in better shape than ever to meet the demands for the highest quality turfgrass maintained in the most environmentally friendly manner and addressing any societal concerns over pesticide use. Our industry has made great strides in the past decade, and I look for continued progress in the next one.

Dr. Rick Brandenburg has been conducting research and education on insect pest management for more than 25 years. He currently serves as co-director of the Center for Turfgrass Environmental Research and Education at North Carolina State University. He can be reached at rick_brandenburg@ncsu.edu.

Landscape Types Influence Severity of Nitrate Leaching

By Richard J. Hull and José A. Amador

The leaching of nitrate-nitrogen (NO_3-N) from turf has received considerable attention by those concerned with preserving groundwater quality in suburban communities. While turf has generally been found to leach less than 10 percent of applied fertilizer nitrogen below its root zone (Petrovic 1990), very little information is available concerning nitrogen retention by other components of residential, institutional, municipal or recreational landscapes. Before the true environmental impact of landscape designs and maintenance can be assessed fully, all planted elements of the landscape must be evaluated for their contribution to nitrate leaching losses. What follows is a report on a 21-month study of nitrate leaching from eight planting elements of an established landscape in southern New England that we published recently (Amador et al. 2007).

To give this research maximum practical value, we conducted the study in the University of Rhode Island Botanical Garden, an area that had been a landscaped garden complex for at least 50 years and had undergone its most recent renovation more than 10 years before this study began. Data were collected from a nearby native woodland, and some areas in the garden that were not planted but covered with pine-bark mulch. To collect soil-water samples to be analyzed for NO_3-N, 2-foot-long suction lysimeters were installed vertically so the porous ceramic sampling cup was at a soil depth of 20 inches. Soil water samples were collected on 23 occasions between June 2002 and November 2003, one day following each rain event of approximately 1 inch or more. Sampling involved creating suction within a lysimeter for one hour during which time soil-water was drawn into the ceramic cup from which it was later pumped into a collection flask. Soil samples were collected monthly from the upper 4 inches of each site and analyzed for extractable NO_3 and ammonium (NH_4) as well as soil pH and organic matter content.

Soil water nitrate

The concentration range of NO_3-N in soil-water spanned more than two orders of magnitude (100- to 1,000-fold differences) but did not show any consistent seasonal patterns. The various vegetation types exhibited soil water NO_3-N levels that fell into four significantly different concentration ranges. The highest median concentrations (mid-point values between 1.4 milligrams of nitrogen per liter (mg N/liter) to 7.8 mg N/liter [parts per million or ppm] NO_3-N) were found under ground covers, unplanted mulched sites, turf, and deciduous and evergreen trees with no true differences among these five vegetation types. The middle concentration range (0.2 ppm to 0.3 ppm NO_3-N) was observed under perennial and annual flowers and deciduous and evergreen shrubs. Again, no real differences existed among these four plant types. Not surprisingly the unfertilized native woodland yielded the lowest median soil water NO_3-N concentration at 0.01 ppm.

Of these vegetation types, only forests and turf have had soil-water NO_3-N concentrations reported by others. We are encouraged that our values fell within published ranges. For example, Gold et al. (1990) reported an earlier study on similar soils in Rhode

Continued on page 92

PHOTO 1

The University of Rhode Island Botanical Garden shows some vegetation types studied for their nitrate leaching. In foreground: perennial flowers; mid-ground: unplanted site; background: evergreen shrubs; background left: deciduous trees.

Their research team.