

## **A. Grant Data**

June 30, 2008

Northeast Regional IPM Competitive Grants Program

Project Title: Integrated Management and Resistance Management of Annual Bluegrass Weevil on Golf Course Turf

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States Involved: CT, MA, NJ, NH, NY, RI

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Grant Received: May 2007

Duration of Grant: 2 years

Funding amount: \$90,000

## **B. Non-technical Summary**

To help golf course superintendents meet the challenges of maintaining annual bluegrass, *Poa annua*, turf scientists from across the northeast are collaborating to study the management of annual bluegrass weevil (ABW). As its name implies, the annual bluegrass weevil, *Listronotus maculicollis*, (formerly called *Hyperodes*), principally feeds as larvae on annual bluegrass. Adults mostly overwinter in protected areas along the edge of woods or in the rough. During the spring, adults immigrate onto golf courses, where they feed on grass blades before mating and laying eggs within the stems of *P. annua*. Eggs hatch into the first instar larvae, which feed within the grass stem, where they complete two additional larval stages. Third-instars eventually exit the stem, whereupon the fourth and fifth instars continue feeding on *P. annua* root crowns while living at the surface of the soil. After completing this feeding, the larvae transform into pupae, and then into adults. With 2-3 generations per year, this weevil can build to astonishing populations (small patches may reach 1,200 larvae per square foot) that can stress or kill annual bluegrass in greens and fairways.

In recent years, ABW has become one of the most difficult insect pests to manage on golf courses. During the previous decade, a well-timed pyrethroid spray in the spring would prevent damage for the remainder of the season. The strategy was to apply a pyrethroid spray to the fairways, or even just their perimeter, when forsythia reached the half-green half-gold late stage of bloom, or when downy serviceberry was in bloom. Adult weevils feeding at that time would encounter a lethal dose of insecticide before they started laying eggs, and the life cycle would be interrupted. The situation has changed, so that this approach no longer works on some courses. Part of the problem is due to emergence of weevil adults in two distinct waves, so that a single spray of insecticide may not be effective. The other contributing factor is the evolution of pyrethroid resistance. Tests of adult weevils have revealed that some populations are killed at dosages 30 – 100 fold greater than a susceptible population. Further tests revealed that at least two detoxification pathways are involved, which also threatens other insecticide chemistries. We have explored ways in which superintendents may effectively respond to this challenge, including tests of new and less environmentally disruptive insecticides, better tools for measuring and predicting damage from weevil populations, and exploration of biological control alternatives, especially of insect pathogenic nematodes. Changes in strategies to combat this pest are an immediate need where control practices have failed, and may prevent similar failures in the remaining locations.

## **C. Introduction**

Turfgrass is a valuable and expanding component of our urban and rural landscape. Turfgrass covers 12 million ha in the U.S. and includes more than 16,000 golf courses. Golf courses are an important component of the turfgrass industry. They are a source of green space in the urban environment and offer recreation and enjoyment for

approximately 36 million Americans. Golf courses also generate jobs, commerce, economic development, and tax revenues for communities throughout the U.S. A recent report by the World Golf Foundation stated that golf contributes \$62.2 billion worth of goods and services each year to the national economy ([www.golf2020.com](http://www.golf2020.com)).

To help golf course superintendents meet the challenges of maintaining annual bluegrass, *Poa annua*, an important grass species for low mowing heights, turf scientists from across the northeast are collaborating to study the management of annual bluegrass weevil (ABW). As its name implies, the annual bluegrass weevil, *Listronotus maculicollis*, (formerly called *Hyperodes*), principally feeds as larvae on annual bluegrass. Adults mostly overwinter in protected areas along the edge of woods or in the rough. During the spring, adults immigrate onto golf courses, where they feed on grass blades before mating and laying eggs within the stem of *P. annua*. Eggs hatch into the first instars, which feed within the grass stem, where they complete two additional larval stages. Third-instars eventually exit the stem, whereupon the fourth and fifth instars continue feeding on *P. annua* root crowns while living at the surface of the soil. With 2-3 generations per year, this weevil can build to astonishing populations (small patches may reach 1,200 larvae per square foot) that can stress or kill annual bluegrass in greens and fairways.

Golf course greens committees are sensitive about the appearance of turf on their courses. When expanses of turf die on fairways, collars and tees, and especially on putting greens, the superintendent is held accountable for these losses and may be fired. This demand for aesthetically immaculate turf has led superintendents to be extremely conservative in pest management, and to rely heavily upon pesticides to maintain their turf.

In recent years, ABW has become one of the most difficult insect pests to manage on golf courses. During the previous decade, superintendents applying a well-timed pyrethroid spray in the spring would prevent damage for the remainder of the season. The strategy was to apply a pyrethroid spray to the fairways, or even just their perimeter, at the time that forsythia reached the half-green half-gold late stage of bloom. Adult weevils feeding at that time would encounter a lethal dose of insecticide before they started laying eggs, and the life cycle would be interrupted. The situation has changed, so that this approach no longer works on some courses. We have explored the underlying causes for control failures and ways in which superintendents may effectively respond to this challenge. Changes in strategies to combat this pest are an immediate need where control practices have failed, and may prevent similar failures in the remaining locations.

## **D. Objectives**

### Research Objectives

1. To identify and develop new chemical and biological control options for suppressing ABW on golf courses.
2. To improve monitoring methods for targeting management of ABW larval stages for control.
3. To determine the geographical extent of pyrethroid resistance in annual bluegrass weevil (includes an Extension component).

### Extension Objective

4. To extend best management practices for ABW to golf course superintendents.

## **E. Approach**

We are conducting replicated experiments to satisfy the research objectives, with parallel trials in the field and in the laboratory. Several cooperators may run the same experimental design at different sites to provide robust assessments on, for example, the usefulness of insect pathogenic nematode application in suppressing the first generation of ABW larvae, to determine whether insecticide synergists improve the efficacy of insecticides where resistance has occurred, or to evaluate new, lower environmental impact insecticides. New Jersey has provided leadership on studies of insect pathogenic nematodes, while Connecticut and Rhode Island have been working together to assess the extent and mechanisms of pyrethroid resistance, and New York and New Jersey are spearheading efforts to better understand pest phenology and monitoring.

The geographical extent of pyrethroid resistance has been investigated by making available to all the cooperating scientists, USGA professionals, and golf course superintendents pyrethroid resistance test kits. These contain a field-labeled dosage of applied to filter paper, a filter paper jointly treated with  $\lambda$ -cyhalothrin and piperonyl butoxide, a piperonyl butoxide check, and an untreated filter. These kits permit discrimination in 24-h of as few as 40 individual beetles into pyrethroid-susceptible and -resistant populations, and also determine whether the mixed function oxidase enzymes are likely to be responsible for pyrethroid insensitivity.

All participants have collaborated to develop a best management practices publication for annual bluegrass based on the findings from this multistate project. Our first publication is currently being type set for publication in *Golf Course Management*, a trade journal with extraordinarily high impact on our target audience. High quality photographs (attached) will accompany this full color article. Publications developed from this project will be distributed by participating states, and any appropriate web sites of collaborating universities (e.g., [www.umassturf.org](http://www.umassturf.org)). Members of this project will continue to make research results available through scientific journals, both refereed and non-refereed, extension bulletins, and national and international conferences and workshops. Information to the general public will be disseminated via publications in the popular press, trade magazines, oral and written presentations at workshops and at turf field days.

## **F. Progress**

A new conceptual model about how ABW adults might migrate between overwintering sites (in protected areas off the course) and developmental sites (susceptible turf on golf course playing surfaces) has arisen, and is undergoing testing. Our new ideas are that (a) adults may rely on walking to invade fairways in the spring, but rely on flight to disperse back to protected overwintering sites in the fall, and that (b) overwintering is largely done away from the fairway, primarily along defined tree lines, up to 180 feet away, to which flying adults orient in the fall.

Observations have confirmed that seasonal population fluctuations are contributing to poor control of the overwintered adults. In some years, arrival of adults to highly-maintained turf is rapid and synchronous, which provides ideal circumstances for effective targeting with a well-timed insecticide application. In other years, including 2008, adults immigrate in two waves, or stretched out over a longer period of time. As a result, these populations are difficult to target effectively with a single insecticide application.

Several field trials have been conducted in all the participating states to determine the efficacy of pyrethroids, new and old alternatives to pyrethroids, and biological control agents. Populations have been tested in CT, NJ, NY, and PA for resistance to pyrethroids.

As mentioned above, we are reaching out to golf course superintendents with an article in *Golf Course Management* to provide an update on this research project and best management practices for annual bluegrass weevil.

## **G. Results**

Rather than relying on pyrethroids to intercept and target adults immigrating onto the fairway from overwintering sites, more emphasis may have to be placed on targeting the larvae slightly later in the season. An advantage of this approach is the opportunity to spot treat areas in a curative fashion, i.e., once scouting has indicated where populations are localized and determined whether thresholds have been surpassed. That degree of fine tuning is not possible with the standard preventive approach. Along with savings from unnecessary insecticide applications, spot treatments could reduce the total area treated and the proportion of the weevil population being selected with insecticides, thereby reducing selection for resistance.

Products that can be used for targeting larvae, and which we have confirmed as being effective against ABW larvae are trichlorfon (Dylox), spinosad (Conserve), chlorantraniliprole (Acelepryn), and indoxacarb (Provaunt). Although we know the optimal timing for using Dylox, more studies are needed to make reliable suggestions for the use of the other chemistries. Unfortunately, chlorantraniliprole effectiveness against ABW larvae appears in our preliminary results to be compromised by pyrethroid resistance.

Provaunt and Conserve have each demonstrated some activity against both ABW adults and larvae. Intriguingly, indoxacarb is known to be made more toxic to the insect through the action of the same family of enzymes (cytochrome P450s) implicated in resistance to pyrethroids. Therefore, Provaunt may have special value for targeting

pyrethroid-resistant ABW populations. Both Conserve and Provaunt are known from agricultural systems to be less toxic to beneficial predators, and are overall much less toxic to the applicator, golfers, and the environment than Dylox or pyrethroids.

Two species of EPNs (*Steinernema carpocapsae* and *Heterorhabditis bacteriophora*) regularly infect ABW stages from the third larval instar through newly eclosed adults. The impact of EPNs on ABW was variable, ranging from 0 to 50% mortality within ABW generations. EPN were found during all months that ABW stages were detected on fairways (early April to mid October), yet their densities were shown to fluctuate dramatically with ABW densities and environmental conditions. EPNs are sensitive to extreme moisture and temperature conditions. Not surprisingly, EPN populations crashed during excessively hot summer conditions. The variable ABW mortality and sensitivity to environmental extremes suggest that resident populations of EPNs are unlikely to reduce ABW populations consistently to the low thresholds for damage imposed by most golf course operations. However, the ability of natural populations to infect a wide range of ABW stages and cause moderate generational mortality suggest that there is potential in using EPNs as inundative, curative controls against the damaging soil dwelling stages of ABW.

This grant, in combination with support from the USDA Regional Hatch Project NE-1025, has attracted additional funding from the Golf Course Superintendents Association of America, U. S. Golf Association, GCSANJ, LIGCSA, Keystone AGCS, and the Pennsylvania Turfgrass Council.

Approximately 100 superintendents have participated in surveys related to their management of annual bluegrass weevils. In addition, approximately 75 superintendents have received pyrethroid resistance test kits.

## **H. Impacts**

### *1. Safeguarding human health and the environment*

- Superintendents have identified populations of annual bluegrass weevil that are resistant to pyrethroids in Connecticut, New York, and Pennsylvania.
- Superintendents have adopted the use of less toxic insecticides, such as Conserve and Provaunt, which have low environmental and human health risks, for managing ABW in the larval stages.
- Superintendents have adopted spot treatment of affected areas, rather than prophylactic treatment of entire fairways.

## *2. Economic benefits*

- Use of effective products has reduced the risks of catastrophic pesticide failures with the attendant loss of high value turf and firing of superintendents.

## *3. Implementation of IPM*

- Multiple trials on golf course in each of the participating states confirmed the value of alternative new insecticides and biological control agents
- Educational materials are available through [www.nysipm.cornell.edu/factsheets/turfgrass/abw.pdf](http://www.nysipm.cornell.edu/factsheets/turfgrass/abw.pdf) and best management practices will soon be available in print and on Golf Course Management's web site.
- Numerous educational programs have been presented by the contributors in each of our states

### **I. Appendices**

- Please note the educational material mentioned under "Implementation of IPM"
- New photographs for shared use in educational programs are attached below.



Damage at the edge of a fairway caused by the spring generation of ABW larvae.



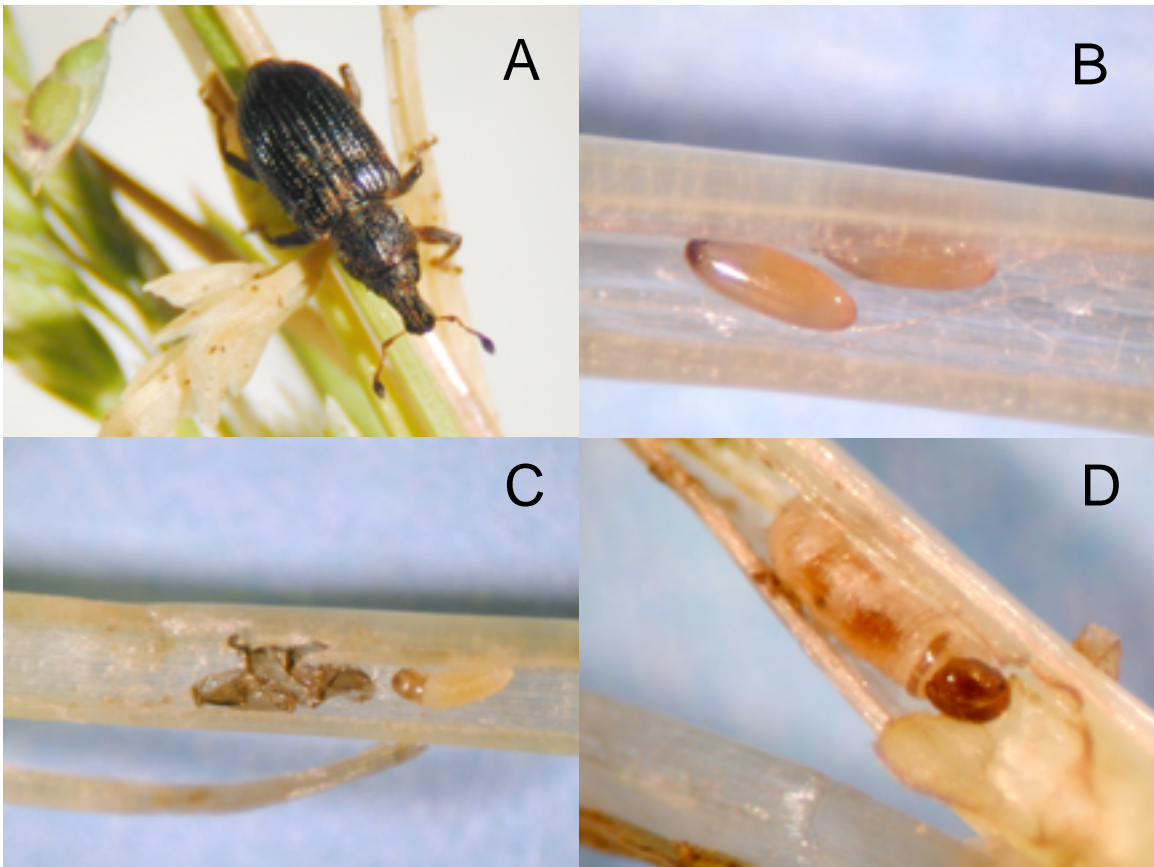
Detail of damage to *Poa annua* caused by the internal feeding of early instar ABW.



Fourth instar with roots



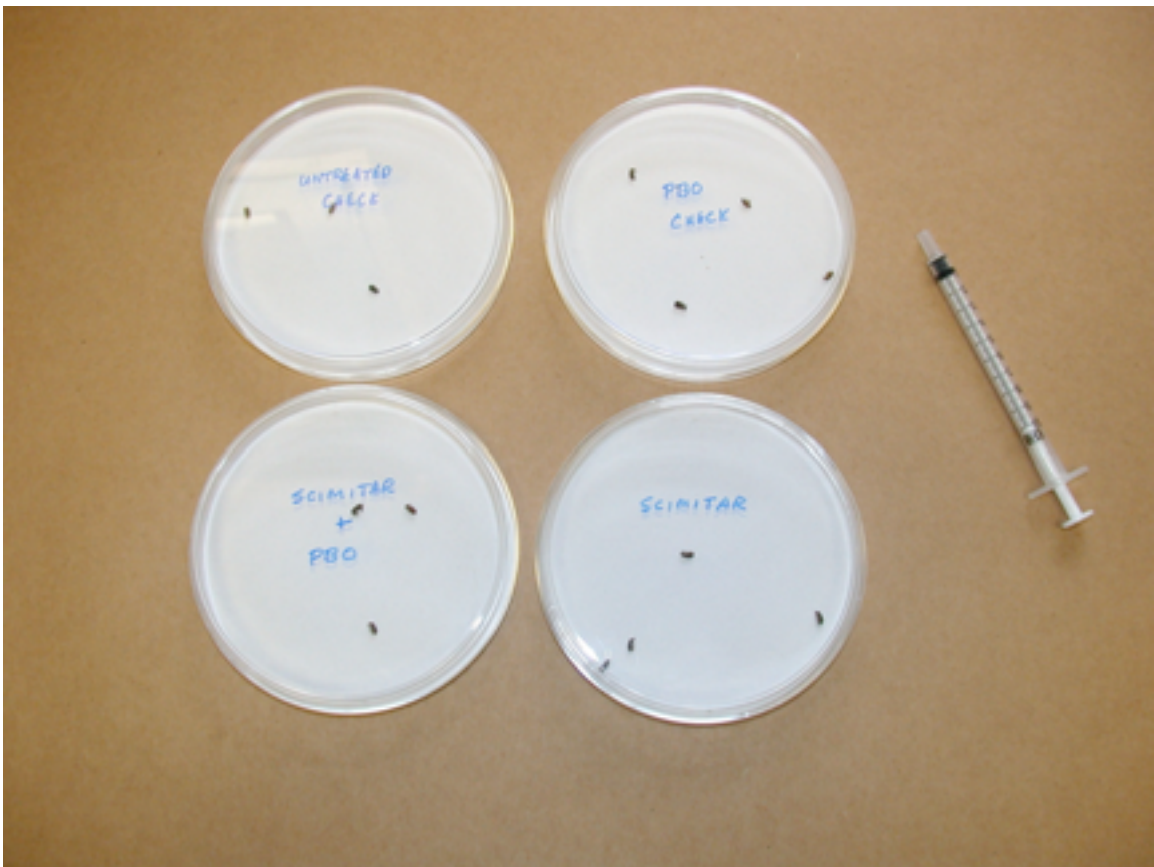
Annual bluegrass weevil pupa



Stages of annual bluegrass weevil: A, adult; B, eggs; C, newly hatched first instar; D, second instar



ABW larva infected with *Heterorhabditis bacteriophora* nematodes.



Test kits provide an effective tool for superintendents to determine whether their populations of ABW are susceptible or resistant to pyrethroid insecticides.