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This publication includes lecture notes of papers presented at the 2005 New Jersey Turfgrass Expo. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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Dr. Ann Brooks Gould, Editor
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DEVELOPMENT OF NEW MANAGEMENT TOOLS FOR THE ANNUAL BLUEGRASS WEEVIL ON GOLF COURSES

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BIOLOGY/ECOLOGY

The annual bluegrass weevil (ABW), *Listronotus maculicollis*, formerly 'Hyperodes weevil,' is a serious and difficult to control pest of close-cut annual bluegrass (*Poa annua*) on golf courses (greens, tees, fairways) and tennis courts of the Northeast. Turf damage by the ABW has been reported from NJ, NY, PA, DE, CT, and all other New England states. The worst problems have historically occurred in northern NJ, southeastern NY, Long Island, and southwestern CT. More recently, severe infestations have been reported from all other states of the Northeast (DE, MA, ME, MD, NH, NJ, NY, PA, RI, VT), west into Ontario, and north into Quebec.

Adult ABW only cause limited damage to the grass by chewing small holes or notches along the edge of the leaf blade when feeding and by chewing small holes into the leaf sheath to deposit eggs. Some yellowing of the plant will occur from adult feeding. However, ABW larvae can cause serious damage to annual bluegrass. There have been occasional reports of ABW feeding on bentgrass, particularly the varieties 3way and L93. But ABW clearly prefers annual bluegrass over bentgrass, and annual bluegrass also appears to be less tolerant of ABW feeding activity. Young larvae tunnel into the stems, causing the central leaf blades to yellow and die, whereas the older larvae feed externally on the crowns, sometimes completely severing the stems from the roots. The most severe ABW damage normally is caused by the 1st generation older larvae, usually around late May/early June in the NY metropolitan area. Damage during this time usually starts from the fairway edges or the collars where it also tends to be the most severe. 2nd generation larvae appear in early to mid-July and are distributed over a larger spatial scale, and therefore the damage is usually more localized and less severe than the coalesced patches caused by 1st generation larval feeding. There often is a 3rd generation in the metropolitan area, but other stresses (e.g., diseases, soil compaction, and heat) mask the weevil damage on annual bluegrass.

Overwintering takes place in the adult stage in protected areas around turfstands, in the rough, or in the litter under trees. Past research has shown a clear preference for white pine litter for overwintering, but recent observations in NJ and NY showed no preference for white pine litter. 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 1st generation in spring from eggs to adult takes about 6 weeks. The 1st generation adults become active on the surface around mid- to late June, and their off-spring emerge as the 2nd generation adults in late July to August. Adults from the 3rd generation migrate back to their overwintering sites from October into November.

EFFICACY OF PRESENTLY AVAILABLE SYNTHETIC INSECTICIDAL COMPOUNDS

Since the early 1990s, numerous test have been conducted by university researchers in the Northeast to find alternatives to organophosphate and carbamate insecticides for ABW management. As a base for our further studies, we have summarized data from such tests published between 1993 and 2003 (Arthropod Management Tests Vols. 18–28). The summary shows that pyrethroids were the most effective insecticides, with no significant difference among the different compounds with an overall average of 90% control. The average control rates for the different pyrethroids were 93% for bifenthrin

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(Talstar), 87% for cyfluthrin (Tempo), 84% for Deltamethrin (DeltaGard), and 97% for lambda-cyhalothrin (Scimitar).

To achieve the best ABW control rates, 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 (4/15 to 5/3; 89% control) and early May (5/4 to 5/15; 93%). In addition, recent research has shown no difference in bifenthrin efficacy between applications in late April (87%), early May (91%), or late May (88%), indicating that at least this pyrethroid has also very good efficacy as a curative application against the larvae.

Our summary indicated that the organophosphate chlorpyrifos (Dursban), the old standard for ABW control, was more effective when applied in early May (83% control) or late May (83%) than in late April (62%), suggesting a combined effect on adults and larvae. However, most of the experiments included rates of chlorpyrifos at 2 or 4 lb a.i. (active ingredient)/acre, whereas applications are now limited to 1 lb a.i./acre. In the late April application period, the 1, 2, and 4 lb a.i./acre rates have provided 60, 64, 61% control, respectively (with only 2 observations for 1 lb rate); in the early May application period, the same rates have provided 100, 80, 77% control, respectively (with one observation for 1 lb rate); for the late May application period only data for the 2 lb rate were obtained (83%). Thus, more studies may be necessary to clarify if the 1 lb ai/acre rate can provide adequate control.

Trichlorfon (Dylox), another organophosphate, was ineffective when applied in late April (0% control) and early May (25%), but provided 79% control as a curative in late May.

INSECTICIDE RESISTANCE AND THE NEED FOR ALTERNATIVES

Many golf courses with ABW infestations use multiple sprays in spring to achieve adequate suppression of the adult stage and to avoid damage from feeding from the larvae produced from the eggs they lay. In some areas, more applications are needed against later generation adults and larvae. While many sprays are probably unnecessary, multiple sprays against each weevil generation suggest the development of insecticide resistance, particularly to the predominantly used pyrethroids.

To avoid the development of insecticide resistance in ABW on a golf course it is essential to follow these guidelines: (1) regularly rotate insecticides from different insecticide classes; (2) do not exceed label rates; and (3) avoid ‘wall-to-wall’ applications.

Unfortunately, at least under high ABW pressure, most of the newer, less hazardous chemistry appears to lack the efficacy and consistency to replace pyrethroid applications, i.e., the neonicotinoids imidacloprid (Merit) (52% control) and clothianidin (Arena) (69%, but variable and limited data thus far) and the insect growth regulator halofenozide (Mach 2) (48%). However, a new compound from a new insecticide class, the anthranilic diamides, has shown great promise in recent trials with 80/95/84% control when applied in late April/early May/late May.

With the increasing pressure from government agencies and the general public to reduce pesticide use on golf courses and the absence of any alternatives at this time, 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. The fungal toxin spinosad (Conserve) may hold promise providing 80% control with applications against the adults in late April (but only three observations so far). 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%) of the hunting billbug, *Sphenophorus venatus vestitus*, before the recent registration of Merit. EPNs also have the potential to provide control of more than one pest generation. A limited number of tests against ABW indicate that *S. carpocapsae* is more effective when applied as a curative against the larvae in late May (51%) than against the adult in late April or early May (30% and 44%, respectively).

Since *S. carpocapsae* has achieved up to 98% in late May applications, we are planning to further investigate this species as we believe that we may be able to optimize its use. In addition, we are planning to test various other nematode species that are already commercially available, i.e., *Heterorhabditis bacteriophora*, *H. megidis*, *S. feltiae*, and *S. kraussei*. The latter three species are active at lower temperatures than *S. carpocapsae* and may therefore also be tested against adult ABW in late April/early May. We have initiated laboratory studies to determine the virulence of these EPN species against the various ABW life stages and to test the effect of temperature on their virulence. Ultimately, we are planning to field-test the most promising EPN under field conditions.

We conducted a statewide survey of New Jersey golf courses in June of 2005 to find EPNs that naturally infect ABW. Nematode field-isolates may prove to be better adapted to ABW as a host and/or the golf course environment and will therefore be included in our above described virulence studies. Soil samples were collected from historically ABW infested sites on 11 golf courses in 5 counties in central and northern New Jersey. Seven of the sites had ABW present in the samples and two of the sites contained larvae infected by EPNs. EPN-infected stages were late-instar larvae or pupae. 98% were infected by *Heterorhabditis* sp. (probably *H. bacteriophora*) and 2% by *Steinernema* sp. (probably *S. carpocapsae*). EPNs were detected in the soil of 29% of all samples with 34% of isolates being *Heterorhabditis* sp. (probably *H. bacteriophora*) and 66% *Steinernema* sp. (probably *S. carpocapsae*).

During 2005 we also studied ABW and native EPN seasonal dynamics through weekly monitoring on a golf course where the survey uncovered high ABW densities. The course did not apply pesticides in the fairways to control ABW, and large numbers of larvae and infected individuals were found in several areas across the course. Transects were established on three fairways to describe the relative abundance and distribution of ABW and nematodes and their interactions. ABW densities (all stages included) peaked on June 9 and decline rapidly thereafter. Only very low ABW numbers were detected for the second and potential third ABW generation. ABW large larvae and pupae of the first ABW generation were regularly found to be infected with *H. bacteriophora*, but no infections were found in the following generations. Both ABW and nematode populations were probably negatively affected by unusually warm and dry conditions during July.

For more information on biology, monitoring, and management of ABW, refer to Rutgers Cooperative Research & Extension (RCRE) publication FS1016 "An Integrated Approach to Insect Management in Turfgrass: Annual Bluegrass Weevil" at: http://www.rcre.rutgers.edu/pubs/publication.asp?pid=FS1016.