Research *You Can Use*

Understanding Annual Bluegrass Weevils

By better understanding the movements of this serious insect pest, golf course superintendents can more effectively target its control.

BY DANIEL C. PECK, MARIA DERVAL DIAZ-LYKE, AND MASANORI SETO

Due to the stem-boring activities of younger larvae and the crown-feeding activities of older larvae, unprotected fairways and greens can suffer tremendous damage.

Annual bluegrass weevil (*Listronotus maculicollis*) is an increasingly troublesome pest of high-maintenance turf on golf courses of the Northeast and Mid-Atlantic states (5). This native insect is most prevalent in annual bluegrass (*Poa annua*), which is a major component of many golf course playing surfaces in those regions (6). Due to the stem-boring activities of younger larvae and the crown-feeding activities of older larvae, unprotected fairways and greens can suffer tremendous damage (1, 4).

Regular control failures in the Northeast validate the idea that the annual bluegrass weevil is not being effectively targeted by control interventions. Applications of pyrethroid insecticides against adults has been the pillar of control programs over the last two decades. In certain areas, however, resistance to this class of insecticide has emerged in the last few years, severely compromising the continuity of reliance on this management tactic (7, 8).

While newer insecticides that target larvae (e.g., chlorantraniliprole, indoxacarb, spinosad) now offer alternatives, their best use is still being refined (1). Regardless of insecticide choice, it is the inaccurate timing and placement of controls that hamper management efforts. More effective and efficient control hinges not only on an understanding of population fluctuations on susceptible turf (3, 5, 9, 10), but on how and when adults move between the sites where they complete their life cycle during the growing season and where they overwinter during the winter season (2).

Annual bluegrass weevils overwinter as adults in protected areas separated from sites where feeding and development occur. The litter of white pine (*Pinus strobus*) has traditionally been regarded as a preferred site in which adults settle to survive cold weather (10). In spring, the reappearance of adults on susceptible turf represents a transect of habitats, from overwintering sites in tree litter and other protected areas, through high-mown turf, toward developmental sites in short-mown turf.

The current challenges of annual bluegrass weevil control highlight a need to better understand the insect's overwintering behavior; in other words, what they do during the "off-season." This research sought to identify factors that influence selection of overwintering habitats by gauging how far from fairways they overwinter, what kinds of surface substrates they prefer to settle into, and how they disperse to and from those sites. Among other possibilities, we hoped this information would reveal ways that control tactics might be targeted to either suppress adults at their overwintering sites, or during their transition between habitats.

We conducted two studies to ascertain how local microhabitat conditions influence where adults overwinter. First, microhabitat surveys were conducted on natural populations in early spring over two years. In each of six blocks separated by more than 30 meters, overwintering adults were sampled from four microhabitats: white pine litter, moss, rough-mown grass, and a combination of pine and deciduous tree leaf litter. Those substrates were further tested in field experiments to measure preferences when adults could choose from among different substrates presented to them within small field arenas.

Overall, the results from our studies on microhabitat selection do not support the idea that white pine litter is a

Adult annual bluegrass weevil.

preferred substrate for annual bluegrass weevil overwintering. The supposition that pine litter harbors and even attracts annual bluegrass weevil populations is so prevalent among golf course superintendents that some practice pine litter removal in an attempt to suppress weevil damage. In the extreme, tree removal has even been justified based on its potential to solve problems in areas of the course with consistent infestations.

While early work has shown that weevil populations can be quite high under white pine trees (10), until now there has been no explicit comparison with other potential microhabitats. We learned through other studies that adults are capable of overwintering under all microhabitat conditions, but our choice experiments showed pine litter to be the least preferred microhabitat.

We conducted another study to ascertain how habitat conditions influence where annual bluegrass weevil adults overwinter. The study was a survey of natural populations in early spring over two years with respect to distance from developmental sites on the fairway. In both years, overwintering adults were absent in areas sampled on the fairway, intermediate rough, and 1-5 meters into the rough. Weevils were recovered 10-60 meters away from the intermediate rough, and as deep as 10 meters into the woods past the tree line.

Results showed that the vast majority of weevils were recovered from the edge of the tree line and beyond. Under the conditions of our study, where a long stretch of rough separated the fairway from a defined tree line, little to no overwintering may occur on the fairway or adjacent rough areas.

We conducted another study that used paired pitfall traps to determine the timing and directionality of adult movement over the season. Dispersal across the surface was greatest in spring, with a clear directionality from the rough toward the fairway. In the fall, however, there was no peak of activity to indicate adult dispersal from the fairway toward the rough.

Based on our results, we propose a conceptual model to explain the seasonal flux of annual bluegrass weevil adults in the golf course landscape.

In the late summer and fall, adults emigrate from developmental habitats and immigrate to overwintering habitats largely by flight. To accomplish this, they orient to defined tree lines as a broad visual cue in the horizon. Once they reach the edge of the tree line, they drop to the ground and settle into preferred microhabitats according to secondary cues related to composition of the surface substrate. In the spring, adults emigrate from overwintering habitats and immigrate to developmental habitats largely by walking or a combination of walking and flitting (very short flights).

Our improved understanding of how annual bluegrass weevils overwinter in the golf course landscape will help us to overcome the challenge of targeting the insect in space and time. The results of our ecological studies will refine how superintendents interpret annual bluegrass weevils on their own courses. This may be as small as shifting the focus to defined tree lines, not white pine needle litter, per se (unless those pines comprise the tree line). On the other hand, it might open the path to entirely new approaches, such as how adults might be intercepted as they transition between habitats.

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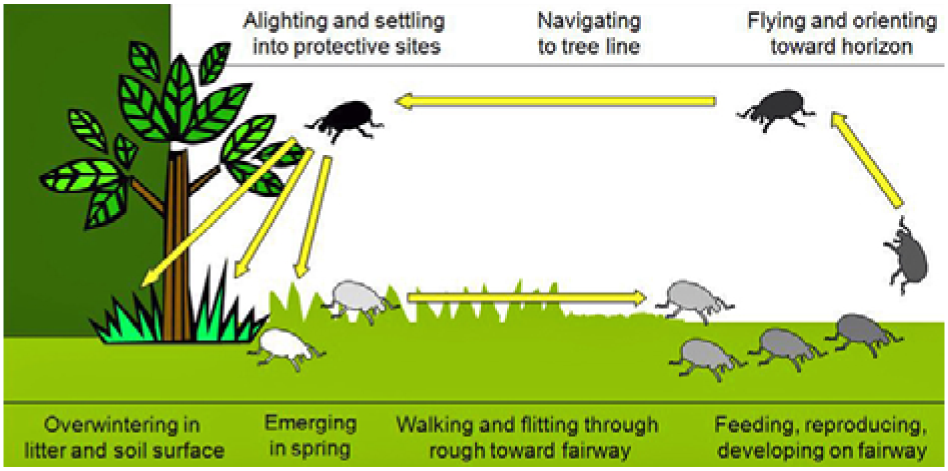
Eggs hatch into the first-instar larvae, which feed within the grass stem, where they complete two additional larval stages. The plant can yellow and may appear drought stressed. When crown feeding occurs, the turf can be easily pulled from the soil.



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CONNECTING THE DOTS

An interview with DR. DANIEL PECK *on researching the movement of annual bluegrass weevils.*

Q. *How serious are annual bluegrass weevils (ABW)? How would you rank ABW against other insect pests regarding turf damage they cause and the time and money spent for control?*

A. ABW is currently the most serious turf-infesting insect pest on golf courses of the Northeast. Other insects, such as white grubs and black cutworms, are widespread and can pose threats year after year, but we know how to manage them and are able to reliably prevent damaging outbreaks. In contrast, we have no broadly reliable strategy for combating ABW, meaning that many superintendents lack confidence in their management approaches. Moreover, the damage caused by ABW is highly visual. As fairways and greens collars are the most susceptible areas for injury, damage on those playing surfaces is right under the feet of players, where the visual impact is stark. Risk adversity and targeting uncertainly combine to make this pest a tremendous concern for superintendents. Whereas white grub control might be a single application over widespread areas of the course, and black cutworm multiple applications over a small area of the course, ABW control currently depends on multiple applications over widespread areas of the course.

Q. *Your research showed that white pine litter was not a preferred overwintering habitat for ABW. To your knowledge, how did this belief that white pine litter is a preferred overwintering substrate and should be removed get started? What have been the responses from superintendents when you present your data?*

A. The over-indictment of white pine litter in the maintenance of ABW populations may be symbolic of how we iterate our way to best management practices. An early descriptive study showed tremendous ABW populations in white pine litter, but did not test for a preference, per se. The concept of a preference may have taken on a life of its own as new ways to control the insect were sought out in desperation. The continuing modern challenge of ABW definitely compels us to further refine what we know. Sometimes those areas are not revealed until new challenges emerge as new opportunities for research.

Q. *Were there other aspects of your study that surprised you? In retrospect, are there aspects of your study you would have done differently?*

A. Our studies on overwintering sites were conducted on late winter/early spring populations. The patterns we described are thereby a function of both preference and success. Although unlikely, we cannot rule out that ABW adults exhibit no preference for where they overwinter, and that the pattern we observed in spring is related to differential mortality across sites. If we were to conduct this study again, we would clarify the contribution of preference versus success by gathering data from both before and after winter.

Q. *How does your research integrate with the overall goals of the multi-state project, Northeast Regional Hatch Project NE-1025?*

A. Funding from the USGA gave us something of a head start in addressing ABW ecology and thereby strengthen the rationale and prospects for NE-1025. We were therefore able to take on a considerable role in the regional project. My program's emphasis was on filling knowledge gaps in ABW natural history that could guide advances in management approaches. We addressed four major questions: what goes on at the overwintering sites, what goes on at the developmental sites, what is the relationship between those habitats, and how the understanding could be exploited to improve IPM. Our goal was to conduct the biological and ecological studies that would not only expose new control opportunities, but would principally help regional collaborators to refine management tactics. Together in NE-1025, we are bringing all elements of research together to formulate best management practices.

Q. *To what extent have annual bluegrass weevils become resistant to pyrethroid insecticides? What other chemical control options are available?*

A. Resistance to pyrethroid insecticides is proven in many courses, but it is unknown how widespread this situation is. Courses in close proximity may have very different resistance profiles. A vast majority of courses in the Northeast probably do not exhibit resistance. As we still do not know how the history of pyrethroid use is linked to the development of resistance, superintendents should ascertain whether their populations are still susceptible. If so, counter the development of resistance by targeting ABW only once with a pyrethroid insecticide and choose an alternative insecticide for any follow-up application. When NE-1025 was launched, pyrethroid resistance was still unknown, and alternative chemistries were only just emerging. Going pyrethroid-free is highly feasible, as there are a number of alternative insecticides that can target adults and/or larvae. While individual products continue to be rigorously field tested, we have not validated the success of management programs that are defined by multiple applications and area-specific recommendations.

Q. *You state that your work might "open the path to entirely new approaches," including intercepting adult ABW as they transition between habitats. Are you suggesting that superintendents could apply insecticide only along the borders of tree-lined fairways and get effective control?*

A. As we build confidence in our understanding of where the insects overwinter, how they transition back to susceptible turf, and what habitat and host plant conditions they prefer, then we can expose and exploit new prevention or intervention tactics. An example is trap cropping. Imagine a perimeter "dew path" maintained through spring at fairway height some distance between the overwintering and developmental habitats. Like a crocodile-filled moat, adults mobilizing from overwintering sites might stop to cool off (i.e., settle into the favorable fairway-like habitat) and then be suppressed with a localized insecticide application before reaching the valuable playing surface. Such an approach may be utterly infeasible, but the example illustrates the value of strengthening our understanding of ABW's association with the golf course landscape.

Q. *What is the next part of your research to better understand the movement and control of annual bluegrass weevils?*

A. For me, the key issues remain in the area of how to better target the insect in both space and time. The better we are able to predict the "where" and the "when" of ABW, the better we are able to target scouting and monitoring activities and insecticidal interventions. Our work to develop a degree-day model to predict the timing of ABW life stages holds promise as a management tool, but more work has to be done before it is robust enough to serve over the broad geographic area where ABW occurs as a pest. Other specific areas of research should address spring mobilization, adult feeding behavior, host-plant selection, and habitat selection. And in the back of my mind is always the core question: If ABW is native to most U.S. states, why is the geographic area affected by it expanding? The increasing area of impact reads like the spread of an invasive insect, with the first reports of damaging infestations from Connecticut in 1931, and most recently Virginia (2006) and Ohio (2007).

Q. *What is the most important message from your research for superintendents?*

A. Overall, I would challenge superintendents to review their management programs in light of our new concepts on how ABW associates with the golf course landscape. This will build confidence in understanding ABW as an insect, interpreting it as a pest, and suppressing it as a target.

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