PROGRESS REPORT- 1995
USGA TURFGRASS RESEARCH FOUNDATION
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CULTURAL CONTROL, RISK ASSESSMENT, AND ENVIRONMENTALLY RESPONSIBLE MANAGEMENT OF WHITE GRUBS AND CUTWORMS IN TURFGRASS

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Executive Summary:

Goals:

1) Determine factors that affect the distribution and abundance of white grubs and cutworms on golf courses.

2) Reduce the use of insecticides by identifying methods to manage white grubs and cutworm insects through modified cultural practices.

3) Provide better information on the effects of pesticides on natural enemies of turfgrass pests and other beneficial species that live in golf course turf.

Cultural practices were manipulated to determine effects on densities of Japanese beetle and masked chafer grubs. High mowing throughout the summer, or application of aluminum sulfate just before beetle flights reduced subsequent densities of grubs by as much as 48 and 77%, respectively. Beetles were attracted to irrigated turf for egg-laying, resulting in 2- to 4-fold increases in grub densities in irrigated plots. Liming, fertilization with urea, heavy rolling, and aerification had no effect on white grubs during this 4-yr study. Fertilization with composted cow manure or activated sewage sludge [Milorganite®] may result in higher populations of green June beetle grubs.

Eggs of black cutworms were laid singly on the tips of bentgrass leaf blades. Mowing at 1/8" or 3/16" was shown to remove nearly all of the eggs laid on bentgrass greens. The mower roller itself did not dislodge eggs from grass blades. This suggests that cutworm infestations may originate from larger larvae that migrate onto greens from aprons or roughs. Cutworm larvae were observed to crawl as far as 75 feet in one night. More than half of the eggs on clippings collected from mower baskets hatched into healthy larvae. These tests suggest that disposal of clippings away from greens or tees may eliminate one source of infestation. Most cutworm activity on golf greens occurred from midnight until just before dawn, suggesting that control measures would be most effective if applied in the early evening or at night. Young larvae tended to feed on the turf surface, while older larvae fed mostly from burrows. About 13% of the cutworms collected in late July were fatally infected with parasitic flies or wasps. This is the first documentation of parasitism of cutworms on golf courses. Cutworms showed no preference between aerified and non-aerified areas, but our results suggest that they may be repelled by sand top-dressing. Female black cutworm moths preferred creeping bentgrass over other grasses for egg laying.

Research continued on how long it takes for populations of predators, earthworms, and other beneficial species to return to normal levels following an insecticide treatment. Ethoprop (Mocap) applied in April resulted in 100% kill of earthworms. Populations had still not fully recovered after 30 weeks. Several important groups of predators were unaffected, while others were more sensitive to the insecticide. Comparative work on effects of two important new insecticides (imidacloprid [Merit], and RH-0345 [an insect growth regulator]) on the turfgrass ecosystem was begun in 1995.

The fraction containing the chemical sex pheromone of masked chafers was pinpointed by gas chromatography and electroantennogram/behavioral analysis. The active compound was characterized by infrared and mass spectroscopy. Identification of the pheromone is expected soon. Synthesis of this attractant will provide means for monitoring these pests on golf courses and home lawns.

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OVERALL GOALS:

The goal of this project is to better understand the factors determining the distribution and abundance of white grubs and cutworms on golf courses. We seek safer, more economical and more effective methods for managing these pests with reduced use of broad-spectrum insecticides.

OBJECTIVE 1. Examine the effects of environmental variables on the bionomics of white grubs and cutworms, and evaluate the potential for reducing populations of these pests through non-chemical, cultural manipulations.

A. Effect of Cultural Practices on White Grubs.

Three years of field experiments were completed in 1995. Data were analyzed and a manuscript was submitted, and has been accepted for publication in Journal of Economic Entomology. The Abstract of this paper is presented below:

Cultural Practices Affect Root-feeding White Grubs (Coleoptera: Scarabaeidae) in Turfgrass, by. D.A. Potter, A.J. Powell, P.G. Spicer, and D.W. Williams.

ABSTRACT. Cultural practices were manipulated before or during seasonal flights of Japanese beetle, *Popillia japonica* Newman, and masked chafers, *Cyclocephala* spp., to study effects on grub densities in tall fescue or Kentucky bluegrass turf. Masked chafer grubs were consistently smaller and less abundant in turf that had been treated with aluminum sulfate to reduce soil pH and in high-mown turf. High mowing or application of aluminum sulfate before beetle flights reduced total biomass of white grubs in tall fescue by as much as 55 and 77%, respectively. However, where spatial gradients in soil moisture occur, the positive response of grub populations to moisture may override effects of those treatments. Grub densities were not affected by spring applications of lime or urea or by aerification of plots before beetle flights. Plots that were irrigated before beetle flights incurred significantly higher densities of both *P. japonica* and *Cyclocephala* spp. grubs than did nonirrigated turf. The use of a 2,247 kg roller to compact the soil before beetle flights did not affect subsequent grub populations, and the roller was not effective for remedial control of 3rd instars in the fall. Application of organic fertilizers (composted cow manure or activated sewage sludge) [Milorganite®] resulted in significant increases in grubs of green June beetle, *Cotinus nitida* L., in 1 of 2 yr. Cultural practices may have general or species-specific effects on densities of white grubs. This study suggests that witholding irrigation during peak flight of beetles, raising cutting height, and light application of aluminum sulfate in spring may help to reduce the severity of subsequent grub infestations.

B. Management of Black Cutworm on Golf Courses

1. Oviposition, Egg Removal by Mowing, Hatchability Study. We hypothesized that most eggs laid on golf greens are removed by mowing, and that disposal of clippings around greens may contribute to reinfestation. We examined ovipositional behavior of black cutworms on different cutting heights of creeping bentgrass maintained on a putting green surface, determines numbers of eggs removed by mowing and clipping removal and evaluated hatchability of eggs attached to clippings in mower baskets. These studies reinforced and extended our experiments on this question from last year.

   Adult cutworms were confined in field cages over plots mowed at specific heights. Eggs were counted, their position on grass plants noted, and locations of blades bearing eggs were marked with a bit of turf paint. Plots were then removed at the appropriate heights and post-mow egg counts were taken. We also rolled the putting surface of some plots with a walk-behind mower, reels turned off, after post-mow data were collected to determine if the roller dislodges eggs onto the soil surface. If so, this could allow eggs to escape being removed by the mower. As clippings were collected into mowing baskets, they were placed in paper bags and taken to the laboratory. Grass blades bearing eggs were placed in petri dishes with moist paper. Additional clippings with were enclosed in mesh bags and returned to the peripheral area surrounding the putting green. After 4 days, the eggs were examined and the percentage that hatched was determined.

   Nearly all eggs were laid singly, near the tips of grass blades. There was no difference in numbers of eggs laid on the different cutting heights. Mowing removed almost all of the eggs laid on grass cut at 1/8 and 3/16", respectively (Fig. 1). The roller itself did not dislodge significant numbers of eggs. Hatchability of eggs in the field after passage through mower blades averaged 49% and 54% on clippings from plots mowed at 1/8" and 3/16", respectively (Fig. 2). Hatchability was higher in the lab (>75%). These tests suggest that disposal of clippings away from greens or tees may eliminate one source of infestations. The results reinforce our 1994 studies showing that most eggs laid on greens are removed by mowing. This supports the hypothesis that cutworm infestations on greens originate from surrounding, higher-mown turf.

2. Nocturnal Behavior of Black Cutworms and Incidence of Parasitism. We obtained additional data on activity patterns and behavior of cutworms on golf greens. Nightly activity was determined by systematically counting larvae with a flashlight every 2 hours, beginning 1 h before sunset until 1 h after dawn. Numbers of larvae observed "grazing" while exposed on the putting surface, or "burrow feeding" were recorded. About 300 larvae were collected live, returned to the laboratory, and reared in individual cups to allow parasitoids (natural enemies) to emerge.

Cutworms became active about 10:30 p.m. but were most active between midnight and 6:30 a.m. Peak numbers were observed between 2:30 and 4:30 a.m. Young larvae (3rd-4th instars) fed mainly by grazing, while older larvae (5th-6th instars) fed mostly from burrows. Individual cutworms were observed to move >75 feet in a few hours. These observations suggest that treatments for cutworms should be applied as late in the evening as possible to minimize loss of active ingredient to volatility and photodegradation (as well as exposure of golfers), and to coincide with the larval feeding period. A few more nights of observation are needed to confirm the differences in feeding behavior of young and older larvae.

About 13% of the cutworms collected in late July were killed by parasitic flies or wasps. These species will be sent to the USDA Systematics Laboratory for positive identification. This preliminary study is evidently the first to document parasitism on golf courses. The parasitism study will be expanded in 1996.

3. <u>Ovipositional and Feeding Preference Study.</u> If most eggs of black cutworm are removed from putting greens by mowing, then infestations must originate from peripheral areas. It is therefore critical to determine which turfgrasses are acceptable hosts for oviposition and feeding. Use of resistant grasses in roughs around greens could significantly reduce the reservoir population. Knowledge of which grasses are most suitable could explain why certain greens are perennially infested.

Field and greenhouse tests were conducted to study oviposition choice. The field test consisted of adjacent plots (0.5 x 0.5 m) of perennial ryegrass, creeping bentgrass, Kentucky bluegrass, and turf-type tall fescue in all possible combinations, replicated six times. Gravid moths were caged over paired plots and allowed to oviposit on either grass. All plots were maintained at the same cutting height (1 7/8"). Plots were sampled by counting all eggs deposited on vegetative tissues. Location of eggs deposited on the different grasses was also recorded. In the greenhouse test, female moths were held in screened cages and given a choice among 6" plugs of the four different grasses.

Creeping bentgrass was overwhelmingly preferred over other grasses in the field. In the absence of bentgrass in the paired choice (e.g., as with Kentucky bluegrass vs. tall fescue), many moths preferred to oviposit on the screen or cage frame rather than on the grasses. Results were less clear in the greenhouse, possibly because the behavior of the moths was confounded by variation in foliage height of the different grass species. These experiments will be modified and repeated in 1996. Flats of the four grasses, plus endophyte-infected perennial ryegrass and tall fescue, were planted for larval feeding studies, but the turf fared poorly in the hot greenhouse during summer. These have been replanted, and suitability of the different grasses for larval growth and survival will be investigated this winter.

4. <u>Response to Topdressing and Aerification:</u> Additional choice tests were conducted in 1995 to determine the behavioral response of larval cutworms to aerification and/or topdressing. Half of each plot was manipulated differently; e.g., aerified or not aerified, with or without sand topdressing. Galvanized steel enclosures were driven into the bentgrass over the boundary between two different management regimes. Cutworms were hatched from eggs and reared on creeping bentgrass clippings until used in the tests. Thirty cutworms were added to each enclosure and allowed establish burrows in the turf on either side. Enclosures were sampled by soap drench. The numbers of cutworms choosing each regime, and the proportion occupying aerification holes was determined.

   Contrary to our expectation, cutworms showed no preference between aerified and non-aerified areas in the bentgrass green. However, the larvae consistently avoided aerified or non-aerified areas that had been topdressed with sand. This suggests that topdressing may partially deter colonization by cutworms.

   Greenhouse tests were run to determine if sand topdressing has direct, adverse effects on cutworms in creeping bentgrass. Third instar larvae were added to potted cores, half of which had been topdressed with sand. We predicted that topdressing might abrade the soft cuticle of intersegmental membranes, resulting in loss of fluids and larval mortality. The results of this experiment were inconclusive. Although there was a trend for fewer surviving larvae in topdressed cores, recovery rates from all cores were relatively low, suggesting that some of the larvae escaped. We plan to repeat this experiment in early 1996.

OBJECTIVE 2. Identify the sex pheromone of northern and southern masked chafers (*Cyclocephala* spp.) and explore practical uses for the pheromone in golf courses settings.

Identification and synthesis of the masked chafer sex pheromone has several potential applications. The lure will provide a practical tool for monitoring beetle flight, allowing better timing of treatments. Timing will be especially critical with the new generation of grub control products (e.g., insect growth regulators) that work best against newly-hatched larvae. Masked chafers have localized flights, so there should be a good correlation between activity of beetles at a site and subsequent grub densities. Superintendents could employ simple traps to identify and target "high-risk" sites for more precise use of insecticides.

Grubs of the northern and southern masked chafer are morphologically indistinguishable. We therefore know little about the relative importance of these species both geographically, and within particular golf course habitats (e.g., roughs, tee banks, fairways, or particular grass species). The two chafers co-occur throughout much of the midwest and transition zone. Because they respond to the same pheromone, a synthetic lure would provide a means for studying their distributions and habitat preferences. If the species differ in susceptibility to insecticides (a likely scenario), knowing which species predominates on a particular golf course could be important in management decisions. Finally, we suspect that parasitic wasps may "home in" on the pheromone to locate their victims (grubs) in the soil. Recall that earlier in the project, we discovered that the pheromone is present in the grubs. Pheromone identification may provide a tool for studying these beneficial agents, or even a means by which they could be attracted to provide enhanced suppression of grubs.

Progress on pheromone identification got back on track in 1995. We collected and shipped about 4,000 masked chafer grubs, and living male beetles to pheromone chemists at Cornell University with whom we are collaborating. The chemical peak representing the active compound was pinpointed by simultaneous gas chromatography and electroantennogram analysis. The active compound has Kovat's indices of 1790 and 2356 on nonpolar and polar columns, respectively. The compound was purified and subjected to infrared and mass spectroscopy. The molecular weight is 246. The compound appears to be a secondary or tertiary alcohol. The active fraction is present in very minute amounts, making it difficult to get enough material for analysis. It is, however, extremely potent. Our collaborators are very close to identifying the compound. Purification of the grub extracts is time consuming, and the Cornell group has no funding to work on this project. We are trying to obtain $5000 to $10,000 in additional funding to help them retain a post-doctoral scientist who can devote additional time to the project.

A preliminary experiment was run in August 1995 to determine if *Tiphia*, a parasite of masked chafer grubs, is attracted to the pheromone. Sticky traps baited with crude extracts of grubs or virgin females were set out in areas where parasitized grubs were found. No wasps were captured. This may have been the result of an inefficient trap design, improper timing, or the short life of the crude extract in the field. We know that *Tiphia* is able to locate and discriminate between chafer grubs and Japanese beetle grubs underground. Identification of the sex pheromone will allow a better test of the hypothesis that this is guided by chemical cues. As soon as the pheromone is identified, we can begin a new study of the relative abundance and distribution of the two masked chafers on golf courses.

OBJECTIVE 3. Investigate the recovery of populations of beneficial invertebrates following an insecticide application to large turf areas such as golf courses.

A field study was conducted during 1994-1995 to determine how long it takes for populations of beneficial invertebrates to recover following treatment of turf with a broad-spectrum, organophosphate insecticide. Ethoprop (Mocap 5G) was applied to large (12.5 x 12.5 meter) or small (4 x 4 m) plots of Kentucky bluegrass on 16 May 1994. Corresponding control plots were left untreated. We sampled earthworms and soil microarthropods on five dates: 3, 15, 20, 30 and 45 weeks after treatment. Samples were taken close to the plot edge and in the interior of the plots. Pitfall traps were run continuously throughout the growing season to monitor relative numbers of spiders, ground beetles, rove beetles, ants, and other predators known to feed upon pest insects in turf.

Ethoprop eliminated 100% of the earthworms at 1 week after treatment (Fig. 3).

Populations were still significantly reduced in inner portions of large treated plots 30 weeks after treatment (29 December). Earthworms appear to have slow recuperative potential, even near plot edges (Figs. 3). Impact on most groups of predatory arthropods was surprisingly slight. There was no significant reduction in abundance of two of the most important groups, Carabidae (ground beetles) or ants (Formicidae) (Figs. 3,4). In contrast, Staphylinidae (rove beetles) were very sensitive to ethoprop and did not return to normal levels in large treated plots for at least 14 weeks. Spiders were also less abundant in small or large treated plots for as long as 10 weeks after treatment. Samples have been further subdivided to examine recovery of particular species within the more abundant groups. This work will be submitted for publication in 1996.

NEW, RELATED STUDY: I have recruited a new graduate student who is interested in turfgrass entomology. This student has begun a 2-year study of the relative impact of imidacloprid (Merit®), RH-0345 (tentative trade name = Mimic®), and bendiocarb (Turcam®) on the turfgrass environment. RH-0345 is a new insect growth regulator that has shown exceptional activity against white grubs. It is root systemic, providing simultaneous control of surface feeders. Like Merit, RH-0345 has several month residual activity against grubs. Unlike Merit, it works well against all instars of grubs. RH-0345 has very low mammalian toxicity, and we expect that it has low impact on beneficials. Registration of RH-0345 is expected in time for the 1997 growing season. Merit and RH-0345 are likely to be the most widely-used turf insecticides in the next decade. This will be the first thorough comparison of their relative impact on beneficials, including specific routes of exposure (direct contact, residual toxicity, feeding on poisoned prey, etc.). This project will be supported in part by residual USGA funds.

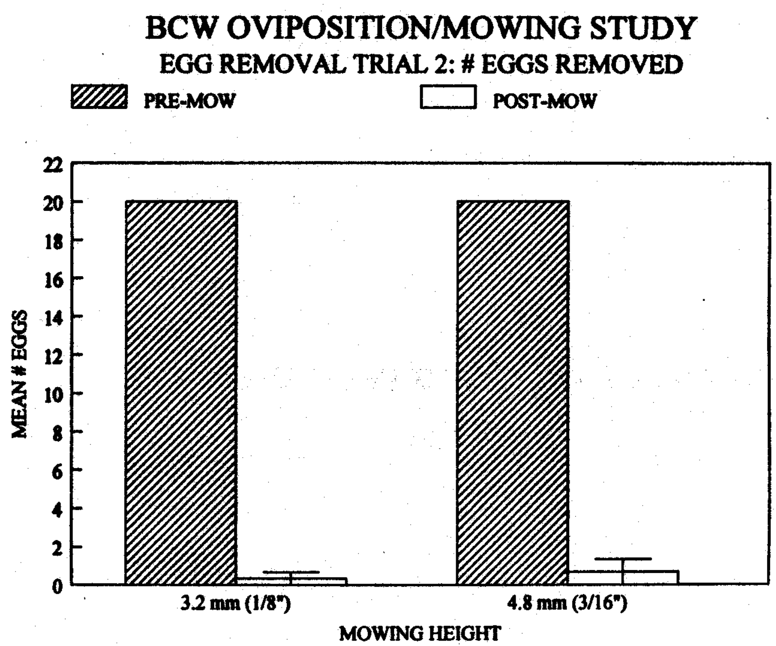

Fig. 1. Removal of marked eggs of black cutworm on a bentgrass putting green by mowing.

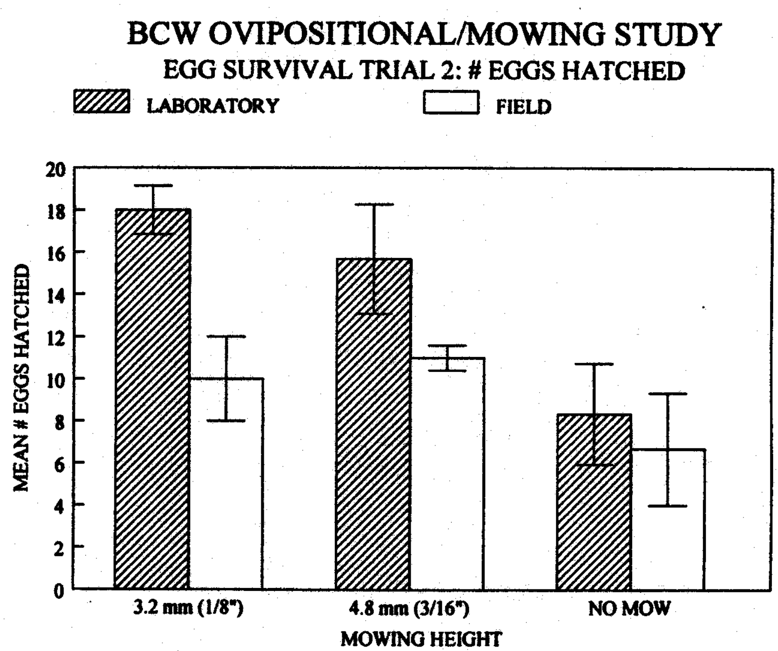

Fig. 2. Number of eggs hatched (out of groups of 20) on clippings collected from the mowing basket and held in the laboratory or the field.

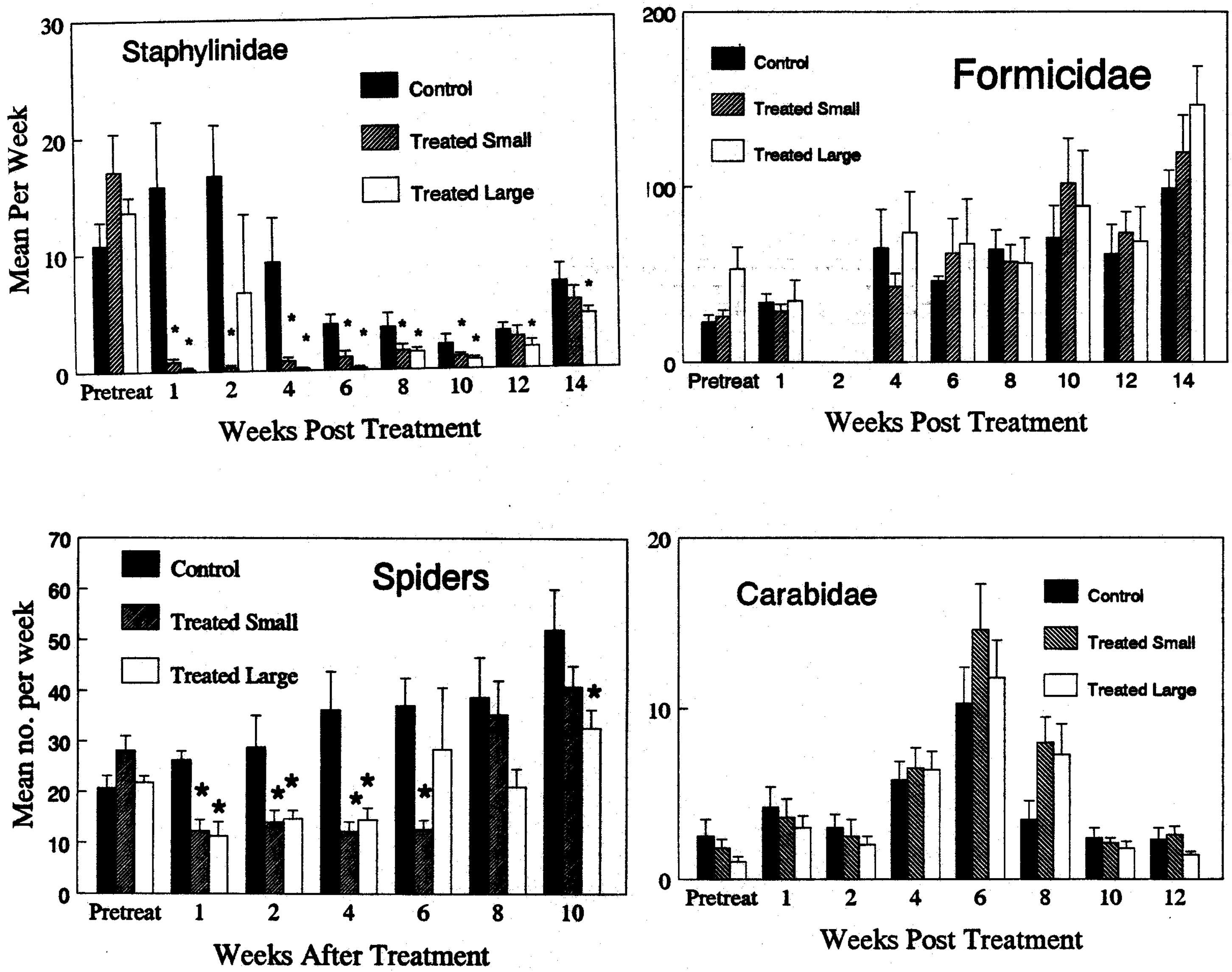

Fig. 4. Pattern of recovery of selected families of predators following treatment of small or large turf areas with ethoprop (Mocap).

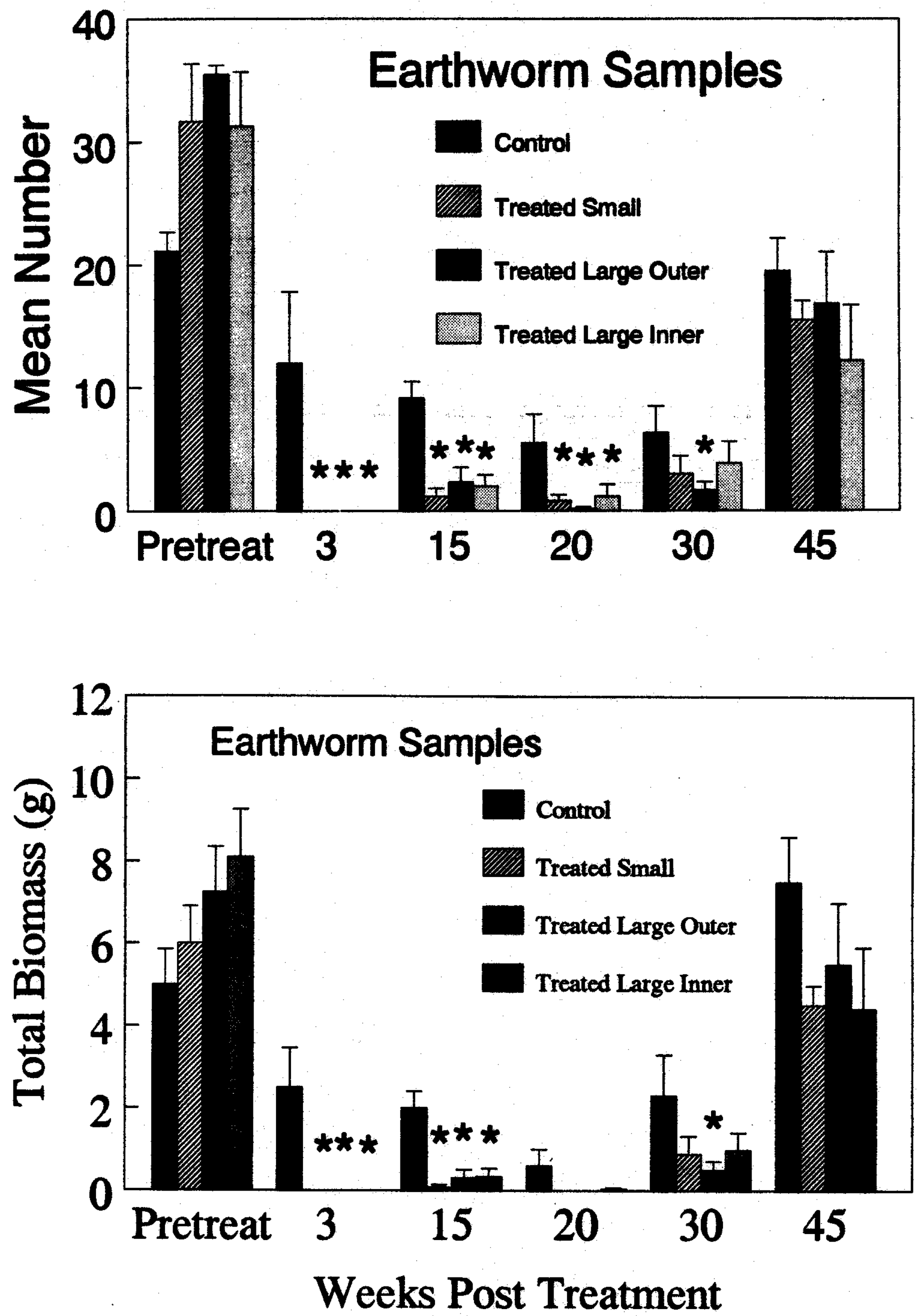

Fig. 3. Pattern of recovery of earthworm abundance and biomass following treatment of small or large turf areas with ethoprop (Mocap).

PUBLICATIONS

The following publications have resulted from research supported by this project, or from our previous USGA project which expired in 1994. All papers include acknowledgment of USGA funding. Additional papers are in preparation.

A. Refereed Scientific Papers and Book Chapters:

1. Potter, D.A. 1992. Pesticide and fertilizer effects on beneficial invertebrates and consequences for thatch degradation and pest outbreaks in turfgrass. pp. 331-343, In: Fate and Significance of Pesticides in Urban Environments. K.D. Racke & A. Leslie (eds). ACS Books, Washington, D.C.

2. Haynes, K.F., D.A. Potter, & J.T. Collins. 1992. Attraction of males beetles to grubs: evidence for evolution of a sex pheromone from larval odor. Journal of Chemical Ecology 18: 1117-1124.

3. Terry, L., D.A. Potter, C.G. Patterson, & P.G. Spicer. 1993. Insecticide impact on predatory arthropods and predation on Japanese beetles eggs and fall armyworm pupae in turfgrass. Journal of Economic Entomology 86: 871-878.

4. Potter, D.A. 1993. Integrated insect management for turfgrasses: Problems and prospects. Internat. Turfgrass Soc. Research Journal 7: 69-79.

5. Potter, D.A. & K.F. Haynes. 1993. Field-testing a pheromone-based risk assessment system for predicting masked chafer grub densities in golf course turf and home lawns. Journal of Entomological Science 28: 205-212.

6. Potter, D.A., P.G. Spicer, C.T. Redmond, & A.J. Powell. 1994. Toxicity of pesticides to earthworms in Kentucky bluegrass turf. Bulletin of Environmental Contamination and Toxicology. 52: 176-181.

7. Potter, D.A. 1993. Impact of turfgrass management practices on beneficial invertebrates and processes. In: Integrated Pest Management for Turfgrass and Ornamentals. A. Leslie (ed). Lewis Publ./CRC Press, Boca Raton, Fl. pp. 59-69.

8. Crutchfield, B.A. & D.A. Potter. 1994. Preferences of Japanese beetle and southern masked chafer grubs among cool-season turfgrasses. Journal of Entomological Science 29: 398-405.

9. Potter, D.A. 1994. Side-effects of pesticides on beneficial insects and earthworms in turf. In: Turfgrass Insect Pests. Entomological Society of America Pest Handbook Series. pp. 101-104.

10. Davidson, A.W. & D.A. Potter. 1995. Response of plant-feeding, predatory, and soil-inhabiting invertebrates to *Acremonium* endophyte and nitrogen fertilization in tall fescue turf. Journal of Economic Entomology 88: 367-379.

11. Haynes, K.F. and D.A. Potter. 1993. Sexual response of male beetles to larvae suggests a novel evolutionary origin for a pheromone. American Entomologist 41: 169-175.

13. Crutchfield, B.A. & D.A. Potter. 1995. Tolerance of cool-season turfgrasses to feeding by grubs of Japanese beetle and southern masked chafer (Coleoptera: Scarabaeidae). Journal of Economic Entomology 88: 1380-1387.

14. Crutchfield, B.A. & D.A. Potter. 1995. Irrigation and fertilization affect injury by root-feeding white grubs in Kentucky bluegrass and tall fescue turf. Crop Science 35: 1122-1126.

15. Crutchfield, B.A. & D.A. Potter. 1995. Damage relationships of Japanese beetle and southern masked chafer (Coleoptera: Scarabaeidae) grubs in coll-season turfgrasses. Journal of Economic Entomology 88: 1049-1056.

16. Crutchfield, B.A. & D.A. Potter. 1995. Survival, growth, and feeding impact of Japanese beetle and southern masked chafer grubs on common lawn weeds. Crop Science. In Press.

17. Haynes, K.F. & D.A. Potter. 1996. Chemically-mediated sexual attraction of male *Cyclocephala lurida* (Coleoptera: Scarabaeidae) and other scarabaeid beetles to immature stages. Environmental Entomology. In Press.

18. Potter, D.A., A.J. Powell, P.G. Spicer & D.W. Williams. 1996. Cultural Practices Affect Root-feeding White Grubs (Coleoptera: Scarabaeidae) in Turfgrass. Journal of Economic Entomology. In Press.

B. Industry-oriented papers:

1. Potter, D.A. 1991. Earthworms, thatch, and pesticides. U.S. Golf Assoc. Green Section Record, Sept/Oct issue.

2. Potter, D.A. 1992. Natural enemies reduce pest populations in turf. U.S. Golf Assoc. Green Section Record, Nov/Dec issue.

3. Williamson, R. C. & D. J. Shetlar. Black cutworms: Where are they coming from? U.S. Golf Assoc. Green Section Record, Sept/Oct 1994. (written after RCW came to Kentucky)

4. Numerous other reports in state and local industry bulletins and newsletters.

C. Papers presented:

This grant has helped to support a number of papers and lectures on turf insects presented at various professional and industry meetings. These include a Keynote Address at the International Turfgrass Research Conference, 12 papers at national meetings of the Entomological Society of America, and meetings of turf care professionals in several states.

D. Graduate Students Supported:

B.A. Crutchfield (Ph.D., Oct. 1994) is now employed as Plant Pest Biologist, West Virginia Department of Agriculture, Charleston, WV.

R. Chris Williamson (Ph.D candidate) is presently being supported. Mr. Williamson will present an invited symposium paper on his USGA-supported studies at the Entomological Society of America National Conference in Dec. 1995. He is the only graduate student invited to participate in this symposium.

Dacelle Peckler (non-thesis M.S. degree, Dec. 1995) plans to pursue a career in Veterinary Medicine.

Brian Kunkel (M.S. candidate). Began studies in turf entomology, summer 1995.