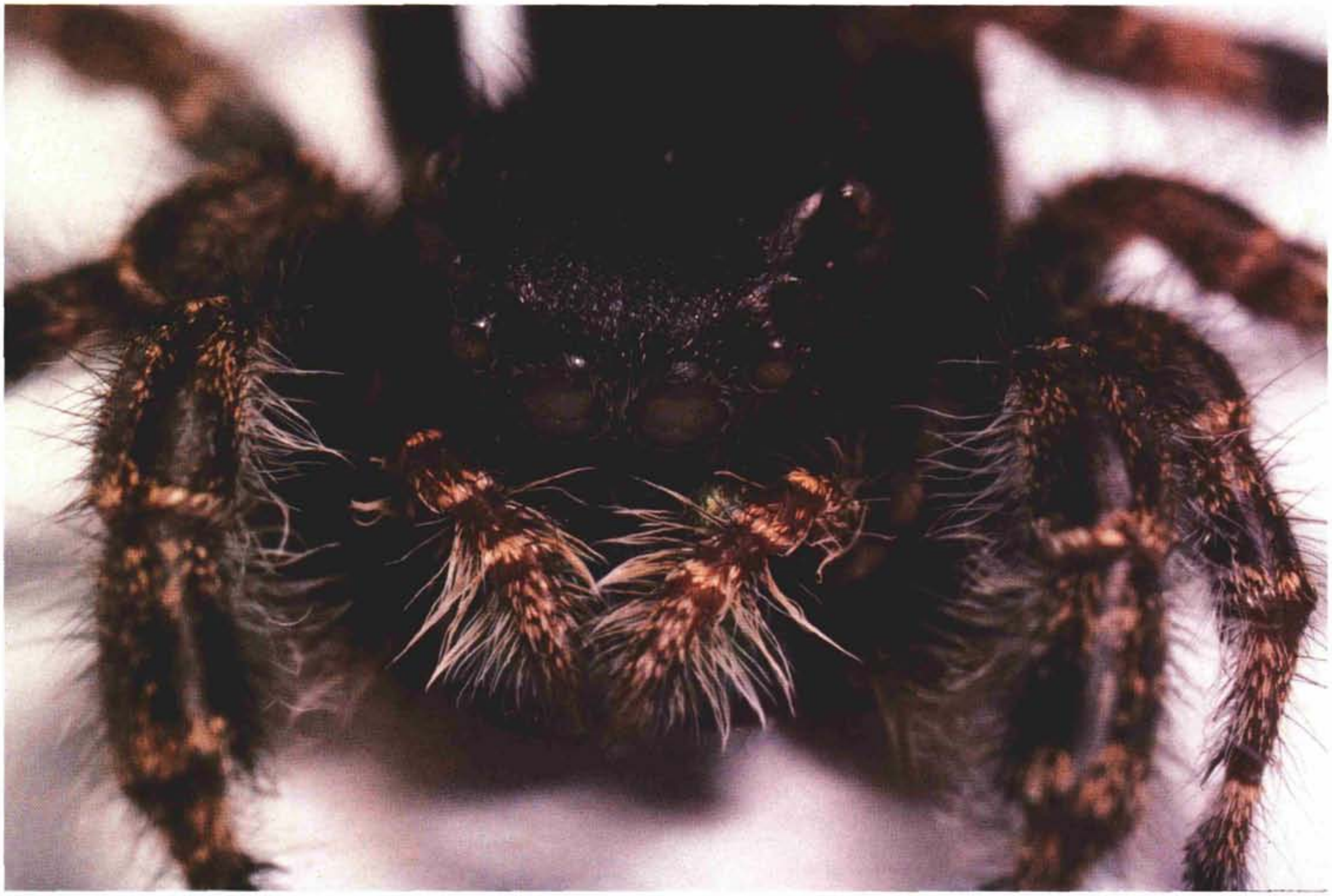

Spiders (above) and tiger beetles (facing page) are among the predators commonly found in turf.

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Natural Enemies Reduce Pest Populations in Turf

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"Big bugs have smaller bugs upon their backs to bite 'em . . . and these, in turn, have smaller still, and so on, ad infinitum."
— Ogden Nash

GOLF COURSE superintendents and other turfgrass managers generally are familiar with white grubs, cutworms, and other pests, but it is doubtful that they often give much thought to the many other kinds of insects and related small creatures that inhabit their turf. Some, such as springtails and millipedes, are relatively innocuous, feeding on plant debris or fungi. Others, especially earthworms, can be a nuisance when their burrows disrupt smoothness and uniformity, but they nonetheless play an important role in turf by aerifying and enriching the soil, enhancing water infiltration, and breaking down thatch (USGA *Green Section Record*, September/October 1991, pp. 6-8). Still others are voracious predators or parasites, roaming through the grass or burrowing in the soil and thatch in search of victims, which often include the eggs or damaging stages of pest insects such as sod webworms, armyworms, or white grubs.

Recent research at the University of Kentucky has begun to document the importance of predators and parasites in reducing pest densities in turfgrass, and is providing insight on how these beneficial insects are

affected by pesticides. Here, I present evidence in support of the view that predators and parasites are important allies of the turf manager, and that preserving their populations, where possible, helps to buffer the turf against pest outbreaks.

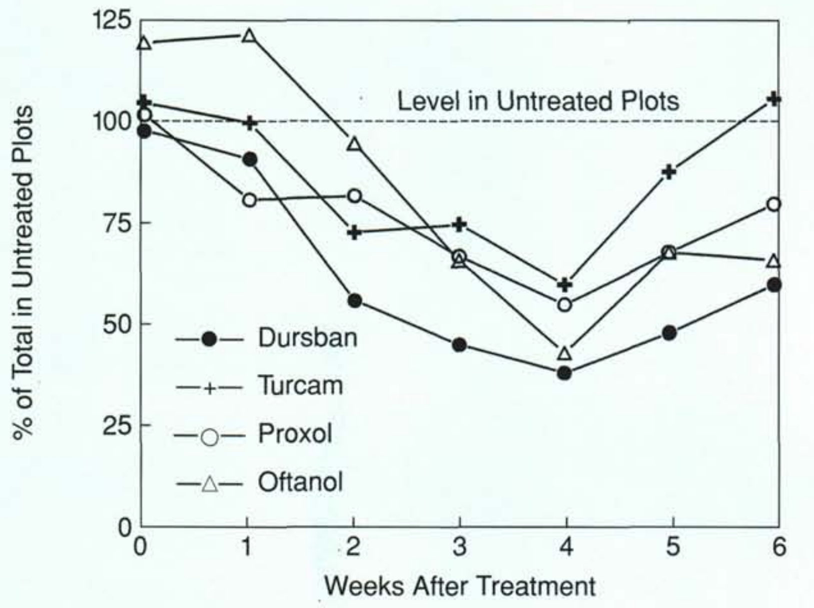
Role of Predators and Parasites in Turf

Several surveys have shown that predatory insects are often very diverse and abundant in turf. In some studies the researchers used insect nets or gasoline-powered vacuums to sample the predators. More often they used pitfall traps: plastic cups sunk to the level of the soil surface and filled partly with preservative to capture ground-dwelling insects unfortunate enough to blunder into them. Studies of this type conducted in New Jersey, Florida, and Kentucky revealed dozens of different species of ants, ground beetles, spiders, rove beetles, and other groups, many of which feed mainly on the eggs or larval (immature) stages of plant-eating insects. In my lab, we've tested dozens of species of potential predators collected from turf sites and have found that many of them readily consume large numbers of eggs and larval stages of sod webworms, armyworms, and Japanese beetles. Indeed, one common species, aptly called a tiger beetle, was observed to kill as many as 20 fall armyworm caterpillars in a single hour!

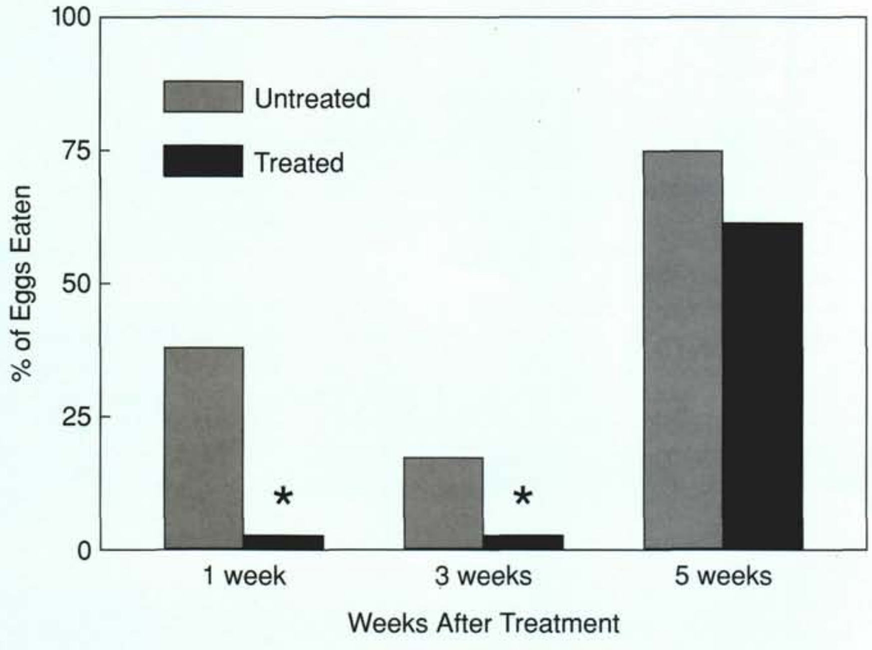
The reproductive powers of insects often are staggering. Greenbug aphids, for example, can produce 60 young per female under favorable conditions, and in the latitude of southern Indiana there may be 15 or more generations per year. Starting with a single female under these conditions, and assuming that all of the offspring survive and reproduce, a turfgrass manager would have to deal with 470,184,980,000,000,000,000,000,000 aphids, the equivalent of 77,000,000,000,000,000 (77 quadrillion) tons of aphids by the end of one year! Although most other turf insects don't develop quite as quickly as greenbugs, female sod webworms and armyworms can produce hundreds of eggs, and adult Japanese beetles, masked chafers, and other white grub species can leave 60 or more offspring in their lifetime. Why, then, are our lawns and golf courses not uniformly and regularly overwhelmed by pest insects?

The fact that severe insect outbreaks are relatively uncommon in low-maintenance turf suggests that many pests normally are held in check by natural buffers. Environmental stresses such as drought can take a heavy toll on some pest insects. Eggs of most white grub species, for example, cannot survive in very dry soil. Naturally occurring microbial pathogens, including bacteria, fungi, parasitic nematodes, and other disease-causing agents also help to reduce pest populations.

Predators and parasites also contribute to regulate pest populations. Much of the evidence for this comes from accounts of pest outbreaks at sites where the natural enemies had been inadvertently eliminated by broad-spectrum insecticides. For example, turf entomologists at Rutgers University reported outbreaks of winter grain mite on lawns in New Jersey that had been treated with carbaryl. Evidently, the insecticide killed the predatory mites that normally



Decline and recovery of spider populations in Kentucky bluegrass following treatment of small (33 × 33 ft.) plots with insecticides. This short-term response seems to be typical for many groups of predators.



Reduced predation on sod webworm eggs placed in Kentucky bluegrass at 1 or 3 weeks after the turf was treated with Dursban, and recovery after 5 weeks. Asterisks denote that the difference between treated and untreated plots was statistically significant.

held the pest mites in check. Similar outbreaks of southern chinch bugs were documented on heavily treated home lawns in Florida. Such phenomena are called "pest resurgences" if the outbreak pest was the target of the original treatment, or "secondary pest outbreaks" if another pest was the original target. These occurrences are common in orchards, vegetable and cereal crops, and other systems that receive heavy insecticide use.

Practically every turfgrass pest has one or more predators or parasites associated with it. Some of the parasites are relatively specific, but most of the predators seem to be general feeders. We know very little about which natural enemies are most important in regulating particular pests, but it may be that their cumulative effects are more important than those of any one species. While manipulation of specific predators or parasites for the purpose of mass rearing and release generally has not proven to be practical or effective, conservation of beneficial species where possible should be a concern of professional turf managers.

Effects of Insecticides on Predators

Broad-spectrum insecticides are toxic to beneficial insects as well as pests. In one study in Kentucky, a surface application of chlorpyrifos (Dursban) or isofenphos (Oftanol) in June reduced populations of predators such as spiders and rove beetles by as much as 60%, the effects lasting for at least six weeks. In Ohio, use of isofenphos on home lawns reduced populations of some groups for as long as 43 weeks. Different predator groups are affected to varying degrees by different insecticides, but unfortunately there have been few comparative studies from which to draw generalizations. Most studies suggest that predators will repopulate relatively small areas within one to three months after treatment. We do not know how long it takes for predators to recover in larger treated areas such as golf courses, but it would probably be much longer. Surveys in Kentucky showed that predator populations generally are less abundant and diverse in high-maintenance lawns than in low-maintenance turf.

Evidence for Importance of Predators

Only a few studies have attempted to measure the impact of natural enemies on the abundance of pest insects on turf. Several years ago, we compared rates of natural predation on sod webworm eggs in untreated turf and in turf that was treated once with chlorpyrifos at the labeled rate. Sod webworms were a good choice for this test because the female moths lay hundreds of tiny eggs as they fly over the turf at night. The eggs fall to the base of the grass plants, where they would seemingly be vulnerable to predators. We hypothesized that insecticides applied during the egg-laying period would kill predators and might allow more egg survival.

The turf was treated in mid-June and then groups of several hundred eggs were set out in small dishes level with the soil surface at one, three, and five weeks after treatment. Different sets of eggs were used each time. Pitfall traps were used to assess the impact of the insecticide on predators. We watched the dishes at night and kept a record of the predators that fed upon or carried away the eggs. The number of eggs that were eaten within 48 hours was compared between treated and untreated plots on each date.

We were amazed to find that predators, especially ants, consumed or carried off as many as 75% of the eggs in the untreated plots within 48 hours. Numbers of predators were much lower in the treated plots, and consumption of the eggs was significantly reduced for at least three weeks after treatment. Predator populations had begun to recover after five weeks, and predation on the eggs was similar in treated and untreated plots. Predators were live-trapped in the turf and taken to the lab, where 16 of the 21 species we tested were found to readily eat sod webworm eggs. These findings suggest that high rates of natural predation on their eggs may be one reason that outbreaks of sod webworms are uncommon on most golf courses and home lawns.

In 1991 we conducted a similar but larger field experiment with three different insecticides — carbaryl (Sevinmol), isazophos (Triumph), and cyfluthrin (Tempo 2) — to study their relative impact on predators and to evaluate their compatibility with predation on pupae of the fall armyworm and eggs of the Japanese beetle. We also wanted to see if premature grub treatments applied during the Japanese beetle flight period could possibly encourage outbreaks of grubs by interfering with predation on the eggs.

Large plots (1,000 square meters) of Kentucky bluegrass were treated in mid-June at recommended rates, and the impact of the insecticides on predators was assessed with pitfall traps for ten weeks. Eggs of the Japanese beetle and pupae (the non-mobile stage between caterpillar and adult moth) of the fall armyworm were implanted under the turf where they naturally occur. Two sets of eggs and pupae were implanted at one or two weeks after treatment. Each group of eggs or pupae was examined after 48 hours to compare rates of predation between the insecticide-treated and untreated turf. Additional predators were live-trapped at the study site and tested in the lab to see if they would feed upon the pest insects. Finally, in late summer (September 3) we sampled the naturally occurring grubs in the treated and untreated plots to see if the treatments applied in June had indirectly affected grub populations by reducing predation upon the eggs and very young larvae.

Predators killed up to 60% of the implanted fall armyworm pupae in just 48 hours. Many of the pupae had been torn to pieces, and some were still being eaten by predatory beetles when we attempted to recover them. Cyfluthrin had relatively little impact on predators in this particular test, but numbers of ants, spiders, rove beetles, and some other predators were significantly reduced by isazophos, and to a lesser extent by carbaryl. Nevertheless, predation on the pupae was not reduced by the insecticides. Perhaps this is because most of the predation on fall armyworm pupae is by large, relatively mobile ground beetles, which

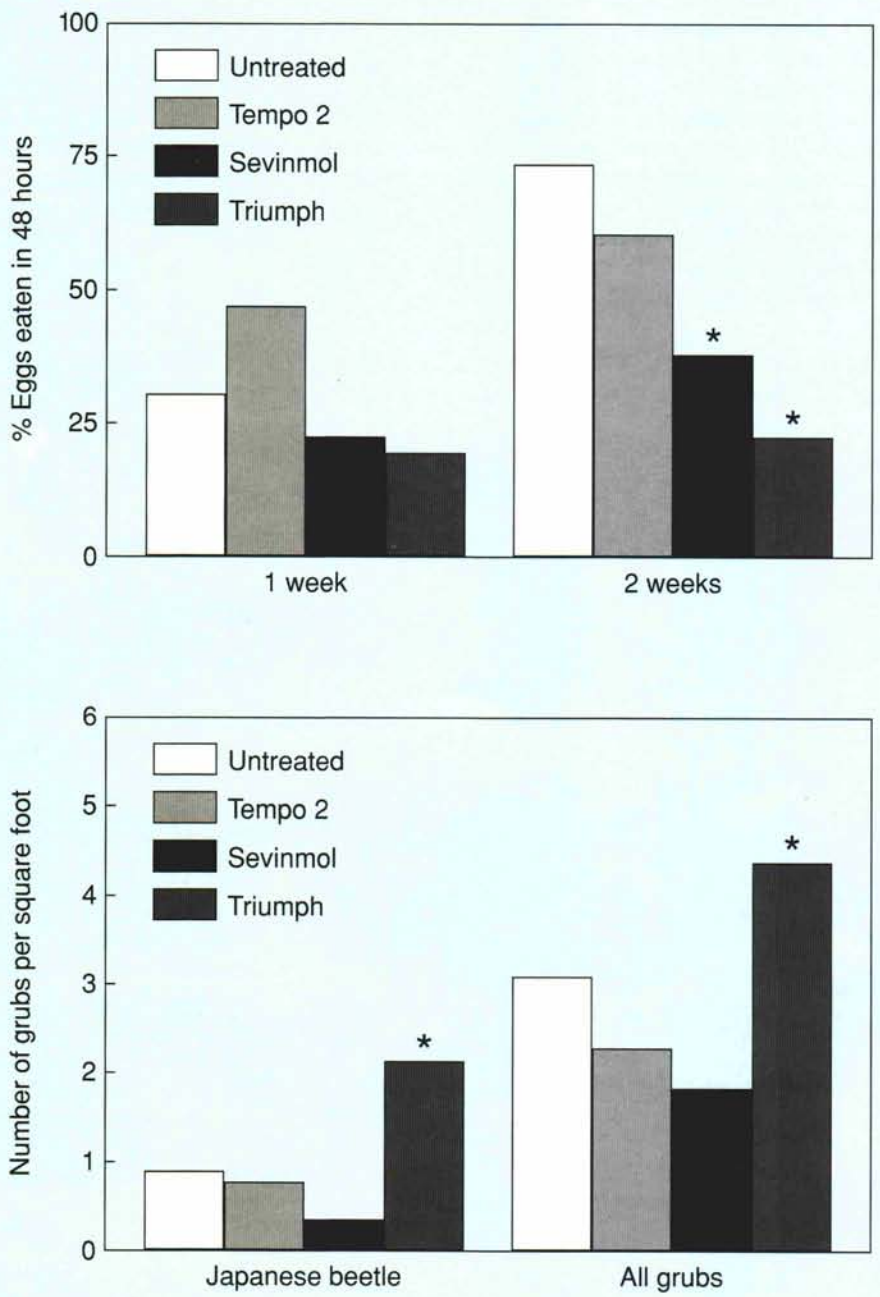
Remains of fall armyworm pupae that were killed and fed upon by predators. Many had been torn to pieces, and some were still being eaten by predatory beetles when sampled.

seem to repopulate treated areas more quickly than some of the other predator groups.

Rates of natural predation on the implanted Japanese beetle eggs ranged from 60% to 74% in the untreated plots. Numbers of eggs eaten were much lower in the isazophos- and carbaryl-treated plots, evidently because the insecticides had reduced the number of predators. Most notably, we found that naturally occurring grub populations in late summer were *higher* in plots that had been treated with isazophos the preceding June. This suggests that short-residual grub treatments applied prematurely, before the grubs have hatched, have the potential to induce higher grub populations by interfering with natural predation on the eggs.

Note, however, that there was also a trend for grubs to be slightly less abundant in carbaryl-treated plots. The reason for this is not known, but was probably not due to residual toxicity of the insecticide. Perhaps the treatment killed some adult female beetles as they entered the soil to lay eggs. This experiment underscores the complexity of possible interactions in the turf system. Clearly, some predators are affected more than others by particular insecticides, and the outcome with regard to predation and subsequent pest densities also may vary.

Upper graph: Reduced predation on Japanese beetle eggs implanted beneath Kentucky bluegrass turf at 1 or 2 weeks after treatment of the turf with isazophos or carbaryl. Lower graph: Higher grub densities in late summer in plots that had been treated with isazophos in mid-June. Asterisks denote treatments that are statistically different from the untreated check.



Conclusion

The work described here has only begun to clarify the role of natural enemies in helping to buffer turfgrass against outbreaks of pests. A better understanding of these interactions is needed to identify insecticides that kill the pests while preserving the beneficial insects and earthworms. My intent certainly is not to condemn all use of insecticides on turf. Insecticides and other pesticides are powerful and versatile tools, and at present they are often the only means by which professional turf managers can prevent severe damage from unexpected or heavy pest infestations. However, like human medicines, pesticides can have adverse side effects that should be weighed against the overall benefit that a treatment will provide. Unnecessary or excessive applications can encourage development of pest resistance to insecticides or enhanced microbial degradation, i.e., the breakdown of pesticide residues by soil microorganisms before the treatment has had time to work. Use of certain compounds can aggravate thatch problems by eliminating earthworms (see USGA *Green Section Record*, September/October 1991). Broad-spectrum insecticides kill beneficial insects as well as pests, but fortunately, populations of predators and parasites seem to recuperate relatively quickly following individual applications. However, repeated treatment may have cumulative, adverse effects on these natural controls. Awareness of these interactions provides additional justification for professional turf managers to apply pesticides at the proper time and rate, and only as needed to control specific problems.

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