The large amounts of pesticides used to control white grubs in lawns could be reduced by environmentally safe and effective pathogens. Grub above is infected by *Bacillus popilliae*, a selective, self-replicating, highly persistent bacterial natural enemy of white grubs.

Biological control of white grubs in California turfgrass

Michael P. Parrella

Insects are a major problem in turfgrass maintenance. Approximately 40 insect species are considered to be destructive turf pests within the United States. The University of California publication *Turfgrass Pests* lists 19 types of insects causing damage in California turf (Division of Agriculture and Natural Resources Publication 4053).

Surveys show that relatively large amounts of pesticides are used in urban environments. Much of this high rate of use is in response to aesthetic rather than real injury, and to the development of a commercial lawn care industry that often relies on scheduled insecticide treatments. Because of the potential hazards of toxic materials in heavily populated areas, however, pesticide use in urban environments should be reduced. This might be done through more effective monitoring of pest populations and the integration of alternative control methods.

A serious pest

White grubs (the larvae of scarabid beetles) are a major problem in turf throughout the United States and one of the most serious pests in California. White grub species damaging turfgrass in California include *Cyclocephala hirta* and *C. pasadenae*. Unfortunately, most work dealing with white grub control concerns the Japanese beetle (*Popillia japonica*), *C. immaculata* and *C. borealis*, or *Phyllophaga* species.

White grubs feed on grass roots; heavy infestations of grubs can destroy much of the root area, so that turf can be pulled back like a carpet. This type of destruction can cause the death of large areas of turf.

Currently, the only effective method of white grub control in California is the application of suitable pesticides, yet even this does not give consistent results. To be effective, insecticides must come in contact with target insects in the root and soil layer, but grass and its accumulated thatch form barriers to penetration. Most currently used turfgrass insecticides also degrade too quickly to allow much downward movement into the soil layers. Another potential problem in any insecticide-based control program is the possible development of resistance in target insects.

The problems associated with chemical control justify study of alternative control strategies, including the use of resistant turfgrass varieties, cultural control, and biological control. Breeding programs to develop turfgrass varieties resistant to pests have just begun. Very little has been done to develop cultural methods for control of turfgrass pests, and the effects of different management practices remain to be investigated. A more immediately promising approach is biological control, or the use of natural enemies for white grub control. In general, biologicals are far safer than chemicals and have little or no effect on nontarget organisms or the environment.

The most promising biological control agents for use against white grubs are pathogens. These are often formulated for use much like insecticides, and so can be made available as commercial products. Pathogens with control potential for *Cyclocephala* grubs are *Bacillus popilliae* (*Cyclocephala* strain) and insect-feeding nematodes in the genera *Steinernema* and *Heterorhabditis*.

Possible parasites

Bacillus popilliae is a parasite causing milky disease in a variety of scarabid grubs, with no effect on other organisms. White grubs become infected by eating spores of the bacterium; after a period of vegetative growth, the bacteria sporulate in the host grub, turning it a milky color. The grub eventually dies and rots, and more spores are liberated into the soil, where they may survive for years. *Bacillus popilliae* has the advantages of being safe, selective, self-replicating, and highly persistent.

The nematodes known to infect white grubs include *Steinernema feltiae*, which attacks a wide range of insects, and a recently discovered *Heterorhabditis* sp., designated Victorville strain. Nematodes in both genera are very similar in their habits. The infective form is the third larval stage. The juvenile nematodes respond to chemical stimuli, such as insect excretory products, and eventually penetrate the host, where they inject an associated bacterium that multiplies and kills the host, generally within 48 hours.

Bacillus popilliae is now being produced commercially for control of the Japanese beetle, but this strain has little effect on *Cyclocephala* grubs. It is necessary, therefore, to demonstrate the efficacy of *B. popilliae*, *Cyclocephala* strain, in order to encourage its commercial production. Commercial preparations of *Steinernema feltiae* are already available in California, and there are plans for the production of *Heterorhabditis* species.

The objective of this research project was to evaluate the infectivity of *S. feltiae*, *Heterorhabditis* sp. (Victorville strain) and *B. popilliae* (*Cyclocephala* strain) in greenhouse tests for control of white grubs.

Cyclocephala were collected from a commercial nursery and a golf course. The larvae were brought to the UC Riverside greenhouse, acclimated, and assessed for the possible presence of naturally occurring diseases. Ten larvae were placed in each of a series of 5-inch pots containing Kentucky bluegrass. Applications of 75 milliliters of each test solution were made to five pots per treatment. The test solutions contained the two species of parasitic nematodes and the bacterium *B. popilliae* in two dilutions, plus the insecticide diazinon, a standard insecticide for control of white grubs. Posttreatment mortality readings were made two to four weeks after application by removing the grass mat and noting the condition of all grubs.

Effectiveness of controls

The applications of *B. popilliae* and *Heterorhabditis* sp. caused mortality in grubs that approximated that obtained from diazinon. While the insecticide provided a more rapid and complete kill, after four weeks the mortality from the bacteria and nematode treatments was still increasing. Many grubs appeared sickly and probably would have died eventually had the experiment been carried on for a longer period. (A potential advantage of biological control agents is their persistence in the soil. These organisms would be capable of killing a new infestation of grubs long after diazinon residues were dissipated.)

This study demonstrated that these biological control agents have potential for white grub control in California turfgrass. Research is needed in the actual urban environment to further demonstrate the feasibility of this approach outside the laboratory.

Michael P. Parrella is Associate Professor, Department of Entomology, University of California, Riverside.