have been identified from California. Results from field plots in New Jersey and California indicate that recently isolated strains were more effective in controlling Japanese beetle and masked chafer larvae than commercially available nematodes. The greater pathogenicity of the recent isolates may be due to an increase in the presence of the symbiotic, pathogenic bacteria within those nematode strains. In addition, the new nematode isolates have proven useful in molecular biology studies on the taxonomy of entomopathogenic nematodes in the U.S. and Ireland.

Efforts to identify other bacterial pathogens of white grubs have located the organism responsible for causing "amber disease" in New Zealand. These bacteria are commercially available there, but their strains have no effect on white grubs in the United States. Over 35 strains of bacteria were successfully isolated from Ohio, New Jersey, West Virginia, California, Japan and China. Fourteen isolates have been characterized in the same genus as the New Zealand bacteria. Feeding tests with those strains have been initiated against Japanese beetle larvae in the laboratory. Additional tests to identify recently isolated bacteria are underway.

Major emphasis during the next year will be to establish the identity and pathogenicity of nematode and bacterial isolates already obtained as a result of this project. In addition, efforts to obtain new isolates of both nematodes and bacteria from infected white grubs in golf course turf in Ohio, California, and New Jersey will continue. The effectiveness of all isolates against white grubs will be established in order to determine their commercial value.

University of Kentucky

Damaged Thresholds, Risk Assessment, and Environmentally Compatible Management Tactics for White Grub Pests of Turfgrass - Dr. Daniel A. Potter and Dr. Andrew J. Powell

The objectives of this project are to: 1) establish damage thresholds for root feeding white grubs on cool season turfgrasses, 2) evaluate the compatibility of turfgrass pesticides with beneficial invertebrates, 3) field test a pheromone-based system for predicting white grub densities, and 4) evaluate the potential for reducing white grub populations through non-chemical, cultural manipulations.

The impact of varying densities of Japanese beetle or masked chafer grubs on root and foliar growth and aesthetic quality of six different turfgrasses was measured in field tests using sunken enclosures and rooting boxes. Grub feeding preferences and tolerance of turf under differing management regimes were also evaluated in field and greenhouse tests. Masked chafer grubs are more damaging than Japanese beetle grubs at equal densities, however, our results show that healthy turf can tolerate at least 20 masked chafer grubs or 30 Japanese beetle grubs per ft^2 before showing visible damage.

Kentucky bluegrass is relatively susceptible, and tall fescue is relatively tolerant of grub damage. The tall fescue endophyte does not confer resistance to grubs of either species. Fall irrigation increased rooting strength and hastened recovery of turf from grub damage. Spring fertilization did not affect expression of grub damage the following fall. Japanese beetle grubs showed significant preference for perennial ryegrass, whereas masked chafer grubs showed no preference among grasses. Presence of one grub species did not affect the distribution of the other. These studies indicate that damage thresholds for white grubs are higher than previously thought, and that remedial irrigation should mask the injury from all but very severe infestations.

The impact of pesticides and growth regulators on earthworm populations was evaluated in two field tests conducted in spring and fall 1992. Of more than 40 products tested so far, only two fungicides (benomyl and thiophanate-methyl) and five insecticides (bendiocarb, carbaryl, ethoprop, diazinon, and fonofos) had significant impact on earthworms. This shows that most of the pesticides and related products used on golf courses are compatible with these beneficial elements of the soil fauna.

Studies were initiated in 1992 to compare the abundance and diversity of predatory insects and spiders in meadows, lawns, and golf course roughs. Preliminary sorting of samples suggests that golf courses support populations of predators at levels similar to those found in lawns and meadows. Feeding studies confirmed that many of the more abundant predators readily consume eggs and larvae of turfgrass pests.

Efforts to identify the sex pheromone of masked chafers were bolstered by initiation of collaboration with Dr. J. Meinwals, one of the preeminent natural products chemists in the world. While collecting virgin females for analysis, we observed and then confirmed experimentally that the adult

male beetles are attracted to both sexes of grubs. Presence of a chemical attractant in grubs was confirmed experimentally. This is the first report of attraction of adults to the larval stage for any insect species. This finding has considerable basic significance because it sheds insight on how sex pheromone communication systems may evolve. In practical terms, it extends the period during which we can collect and extract crude pheromone for chemical analysis. Identification of the attraction will increase the practicality of using traps to assess the risk of grub damage to particular sites.

Soil pH, fertilization, watering, soil compaction, and mowing height were manipulated in large field plots to determine how they would affect choice of egg-laying sites and subsequent densities of grubs. Even in this wet year, female Japanese beetle and masked chafer beetles were attracted to irrigated turf, resulting in much higher grub densities. We found about an 80 percent reduction in masked chafer grubs in plots treated with aluminum sulfate, and about a 50 percent reduction in high-mown turf. Fertilization neither increased nor decreased grubs. Soil compaction did not affect subsequent grub densities, and use of a heavy (5000 lb) roller to crush the active grubs was not effective.