injury is always more widespread in dry years when turf is water stressed. However, weather conditions alone do not seem to adequately explain an increase in ataenius problems. One factor may be the lack of natural enemies of ataenius on golf courses. Natural enemies seem to be effective on home lawns where ataenius is rarely a problem. Perhaps some management practice is suppressing an important pathogen or predator of ataenius grubs.

Ants continue to be a problem on many golf courses, particularly ones with sandy soil. Soil insecticides such as Dursban and Triumph suppress ant mounding for 2 to 4 weeks after each application. Superintendents do not like the burden of monthly insecticide applications to tees and greens because of the cost of labor and pesticide, and the hazards associated with insecticide handling. In some places, the ant mounding on fairways is also a problem. This presents an even greater problem because frequent insecticide applications are almost cost prohibitive on fairways.

Some golf courses in southern Michigan that never had grub problems before developed a problem this year. Most of the damage was to roughs and not fairways, probably because of daily irrigation and insecticide use on fairways. In many cases, the skunk damage in September was worse than the grub damage. Superintendents found various ways to remove skunks, including a trap and release method.

Black cutworms were occasionally a problem on tees and greens. Insecticides were sometimes used to prevent them from making pencil-sized tunnels in the green, and clipping grass blades around their tunnels, leaving golf ball-sized yellow marks.

Billbug, chinch bug, June beetle grubs, and greenbugs were rarely found to be a problem on golf courses this year. Some nuisance insects became abundant toward the end of the year. Yellow jacket wasps and the even larger cicada killer wasps were abundant in some places. Generally, a soil insecticide sprayed over the ground where they are nesting, followed by irrigation, is effective in eliminating them from areas where they may be a nuisance.

1991 ENTOMOLOGY RESEARCH

Most home lawns and golf course fairways do not need insecticide treatment, and may actually be hurt by unnecessary applications. Insecticides eliminate natural enemies, suppress decomposers, and cause a build-up of thatch. The best approach is integrated pest management (IPM). In IPM, low populations of pest insects are tolerated, and other management strategies such as daily irrigation and the planting of resistant cultivars are used as much as possible. A key component of IPM is the use of a threshold value for insect pests. When the pest species is below threshold level, no insecticides are used. When it exceeds the threshold, an insecticide may be applied to prevent turf damage. Better information is needed to determine accurate thresholds for grubs in turf.

In 1990, we initiated a project designed to define thresholds for grub injury to turf and how these thresholds are affected by irrigation practices. Part of the confusion for turf managers is that when the soil is moist, root-pruning injury may not be expressed as a visible symptom. The blades may remain green and apparently healthy even when the root system has been seriously injured by grubs. Then, under dry weather conditions and water stress, the grass suddenly wilts and dies.

In initial tests, rooting boxes worked well as a method of evaluating root damage caused by grubs. In 1990, a negative correlation was found between the number of grubs per square foot and root strength. However, no correlation was found between percent brown or dead turf and the number of grubs per square foot. This was expected for irrigated turf and supports the initial hypothesis that some kind of root strength parameter is needed to evaluate grub injury.

In 1991, we refined the rooting box method to obtain better information on grub feeding damage to turf. Zero, 10, 20 or 30 grubs were placed inside each rooting box after the turf was well established and the roots had grown through the wire mesh into the soil below the boxes. The boxes were pulled up six weeks later and the force required to lift them was measured.

A strong relationship was found between the number of grubs per square foot and the force necessary to lift the rooting boxes (Figure 2). The data from this test indicates that 15 - 18 grubs per square foot will remove about 50% of the turf root system within six weeks. This agrees with some recent thresholds for grubs estimated to be 15 - 20 grubs per square foot. This seems to be a good

working threshold because the turf will remain green and appear to be healthy, even with 20 grubs per square foot, as long as it is not severely water stressed. More research is necessary to determine thresholds for water stressed turf.

EUROPEAN CHAFER TEST

(Table 1) A grid of 3 ft x 3 ft plots separated by 1 ft wide buffer strips was established at Blythefield Country Club in Belmont, Michigan. The plots were established on irrigated rough with sandy soil. Each insecticide treatment was replicated six times. Granular insecticides were applied with modified "salt" shakers. Insecticides were mixed with 1500 ml of water and applied at a rate of 137 ml/9ft^2 (175 gal/acre) with single nozzle, hand-held wand CO_2 sprayer from R&D Sprayers. The application was made at 50 psi through an 8003 flat fan nozzle.

Several of the NTN 33893 treatments were applied in June and July prior to egg laying, and the rest of the treatments were applied to second and third instar grubs in August. All treatments were applied between 10:00 AM and 12:30 PM. The entomophagus nematodes from Biosys and the Triumph treatment were applied while the grass was wet with dew, then hand irrigated with ¼" of water applied through a watering can immediately after application. European chafer larvae were counted on September 16 by removing a 14 in x 14 in area from the center of each plot.

All of the insecticide treatments and none of the nematode treatments reduced the number of European chafer larvae compared with the control (Table 1). NTN 33893 applied in June or July as a granular or flowable formulation provided the best control (0.0 to 1.2 grubs per sample). Mocap and Dylox were also very effective (1.0 and 2.2 grubs per sample, respectively) compared with the control treatment (15.8 grubs per sample) but not as effective as when it was applied in June or July. Lesco 19299 and 19312, Sevin 7G, Triumph, and Sevimol also reduced the number of grubs per sample (5.3, 5.5, 7.8, 8.0 and 10.2, respectively) when compared with the control treatment (15.8, Table 1).

ANT TEST

(Table 2) 12 ft x 12 ft plots (144 ft^2) separated by 3 ft buffer strips in a fairway infested with ants at the Ionia Golf Club in Ionia, Michigan were used for this test. Treatments were applied July 25. Each treatment was replicated six times. Plots were sprayed with an R&D hand-held boom sprayer with four 8006 nozzles at 50 psi for 24 s (to give 4 gal/1000 ft^2). Granular products, which had been pre-weighed, were applied evenly throughout the plots with custom-made hand shakers. The fairway was irrigated 3-5 times per week depending on rainfall. Active ant mounds were counted just prior to insecticide treatment and once per week for 5 weeks afterward. Ant mounds were counted from a standing position.

Before insecticides were applied, all treatments had a similar level of ant activity (56-74 mounds per 144 ft^2, Table 2). Dursban 1G, Dursban 4E and Pageant ME20 reduced the number of ant mounds by 88-95% at one wk after treatment. After five weeks, the same treatments still provided ant control, but at a lower level (53-65% reduction). Orthene 5G at 3.0 lb AI, Orthene 5G at 1.0 lb AI and Orthene 76.1 S at 1.0 lb AI reduced ant mounding for 3, 2 and 1 weeks, respectively, after treatment. The greatest level of control for any Orthene treatments was a 64% reduction one week after treatment with Orthene 5G at 3.0 lb AI (Table 2).

CHINCH BUG TEST

(Table 3) A grid of 3 ft x 3 ft plots separated by 2 ft wide buffer strips was set-up in a home lawn with an infestation of chinch bugs in Okemos. Chinch bugs were counted in each plot on July 10 before insecticides were applied. Counts were made by observing each plot for a timed one minute period. The treatments were blocked out based on these counts. Afterward, six replications of each treatment was applied on July 10 between 10:00am and 3:30pm. The temperature when treatments were made was 85° - 90°F with a 0-5 mph wind. Granular products were evenly applied over the plot with hand-held shakers. Liquid products were applied with a single nozzle, hand-held CO_2 sprayer

Figure 2. The amount of root damage to turf grown in rooting boxes with different numbers of Japanese beetle grubs.