Field-Testing Pheromone Traps for Predicting Masked Chafer (Coleoptera: Scarabaeidae) Grub Density in Golf Course Turf and Home Lawns[1]

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ABSTRACT Sticky traps baited with crude female extract of the southern masked chafer, *Cyclocephala lurida* Bland, were tested at 28 sites on a golf course and on 27 individual home lawns to determine if the numbers of males captured in short-term trapping could be used to predict subsequent grub densities. Hexane rinses of female beetles were effective in luring males to traps. There was no correlation between male captures and local densities of grubs on the golf course, where movement of beetles between adjacent areas may have confounded our ability to discriminate among high- and low-density sites. In contrast, there was significant, albeit weak correlation (r^2 = 0.25) between male captures and subsequent larval populations in home lawns, even though trapping was restricted to only two nights due to limited availability of crude female extract. Identification and synthesis of the *C. lurida* sex attractant would allow season-long trapping, which could provide a more accurate assessment of beetle populations and prediction of grub densities at particular turfgrass sites. The fact that most home lawns sampled did not develop damaging infestations underscores the need for improved methods of sampling and risk assessment to avoid unnecessary preventative treatments.

KEY WORDS Insecta, *Cyclocephala lurida,* turfgrass, Scarabaeidae, masked chafer, pheromone trap.

Root-feeding white grubs (Coleoptera: Scarabaeidae) including the Japanese beetle, *Popillia japonica* Newman, southern masked chafer, *Cyclocephala lurida* Bland (formerly *C. immaculata* Olivier), and the northern masked chafer, *C. borealis* Arrow, are the most injurious insect pests of turfgrasses throughout much of the United States (Potter and Braman 1991). Because grub populations in turfgrass tend to be highly aggregated (Ng et al. 1983a,b), their damage is often localized and unpredictable. Sampling typically involves removal of sections of sod with a shovel or coring implement, followed by inspection of the soil and roots. This process is often prohibitively destructive and time-consuming, especially for the lawn service industry. The lack of simple and reliable methods for assessing the risk of grub injury to particular sites, together with low public tolerance of damage in lawns or golf courses are reasons why management of these pests often involves preventative insecticide applications or remedial treatments after damage has occurred.

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Females of *C. lurida* produce a volatile sex pheromone which attracts conspecific males (Potter 1980, Haynes et al. 1992). Release of this pheromone is behaviorally controlled by the female beetles, which emerge from the soil beneath turfgrass shortly after sunset in synchrony with emergence and flight of males. Virgin females remain on the ground or climb grass blades. Males fly close to the ground, zig-zagging upwind towards females. Mating follows, often with several males attempting to copulate with a single female. Mated females quickly burrow into the soil. Male beetles respond to solvent extracts of adult females with a flight response similar to that elicited by actual female beetles. If kept above ground in traps, *C. lurida* females or extracts are also attractive to males of *C. borealis,* a closely-related sympatric species that mates after midnight (Potter 1980). *Cyclocephala lurida* has one generation per year, with mating flights generally occurring during June and early July (Potter 1981).

Traps baited with pheromones could possibly be used to target high-risk lawns or golf fairways for selective treatments; however, there has been no work relating trap captures of adult scarabaeids to subsequent larval populations at particular turfgrass sites. Because flights of masked chafers are relatively localized and semiochemical communication seems to operate at fairly close range (authors' observations), and because damaging grub infestations often recur at the same sites, we hypothesized that the relative abundance of adult males would be significantly correlated with subsequent larval populations at a particular site. We therefore tested sticky traps baited with crude female extract to determine if the numbers of males captured in short-term trapping could be used to predict subsequent grub densities on a golf course or in individual home lawns.

Materials and Methods

Golf course test. During mid-June to early July 1990, adult female *C. lurida* were collected on golf course fairways at the Lexington Country Club, Lexington, KY. Females are relatively conspicuous during their nocturnal activity period (9:00 to 11:00 p.m.) and with the aid of a flashlight were collected by hand. The beetles' sex was confirmed by examining the shape of the tarsal claws (Tashiro 1987). Female *C. lurida* were placed together in paper cans (473 ml). At 11:00 p. m. the female beetles were taken to the laboratory, where they were placed in groups of about 60 in glass Ehrlenmeyer flasks (500 ml). The exact number of females per flask was recorded. Twelve hours later, the flask and the females were rinsed with 20 ml of hexane. Most of the hexane was recovered and placed into a graduated cylinder. A small volume of hexane was added to compensate for solvent absorbed by the beetles until the resulting solution had 3 female equivalents (FE) per ml. These solutions were stored in 4 dram vials in a freezer at -10°C. This procedure was repeated until more than 200 FE were stored. All of the stored solutions were mixed together to ensure that all aliquots used in traps were equivalent.

In late June, we selected 30 widely-spaced sites (at least 50 m apart) in roughs surrounding four fairways at the Lexington Country Club golf course. An attempt was made to select sites with both low and high levels of beetle activity based upon observations during the first 2 wk of *C. lurida* flight activity. The

precise location of each trap site was marked with a wooden stake (2 × 2 × 5 cm) driven nearly flush to the ground and with several spikes driven beside each stake to facilitate relocation with a metal detector. Traps consisted of 36 by 46 cm styrofoam trays (TK-0136; Mobil Chemical, Canadaigua, NY), of which the upper surface was thoroughly coated with about 90 g of Tangletrap adhesive (Tanglefoot Co., Grand Rapids, MI). Each trap was anchored by two wooden plant stakes that were placed through the trap and into the ground. Traps were baited with 1 ml of female extract solution, containing 3 FE. The extract was pipetted into a 5 cm diam aluminum weighing dish (Fisher Scientific, Cincinnati, OH) which was placed at the center of each tray. Traps were operated at all sites on 3 July and 9 July 1990. The traps were baited at the beginning of the male flight period (8:30 - 8:45 p.m.) and retrieved after nightly flight was complete (11:00 p.m.). For each night the number of male *C. lurida* caught was counted and recorded. Two of the 30 sites were eliminated from the study because a sprinkler system flooded them on the second night.

The turf at each site was sampled for grubs on 9 August, 1 month after the last trapping date. By that date the observed grubs of *Cyclocephala* were predominantly first instars with smaller numbers of second instars also present. Twelve soil and turf cores (15.2 cm diam, 12 cm deep) were removed from each site using a golf-type core cutter, four each at 0.5, 1.0 and 2.0 m from the wooden stake; i. e., the former location of the trap. The angular coordinates of the samples were 0, 90, 180 and 270° at both the 0.5 and 2.0 m distances, and 45, 135, 225 and 315° at the 1.0 m distance. Each core was carefully broken apart and examined over a tray. All grubs that were found were placed in moist soil in plastic cups (150 ml), labeled with the trap location number and taken to the laboratory, where they were identified by their characteristic rastral patterns (Tashiro 1987).

Home lawn test. The basic experiment described above was repeated in 1991 using 30 widely-scattered residential home lawns in Lexington as trapping sites. The experimental procedures were nearly identical to those used in the golf course test with the following exceptions. Adult female *C. lurida* were collected and extracted in mid-June. Cooperators were solicited through a memorandum sent to more than 60 faculty and staff in the College of Agriculture, University of Kentucky, and by door-to-door solicitation in the senior author's neighborhood. Only two of the trapping sites were contiguous properties.

Each cooperator was given two traps, a wooden stake, two aluminum dishes, two vials each containing 3 FE of extract, and detailed written instructions concerning experimental procedures several days before the experiment was to be conducted. Traps were positioned near the center of the lawn by the individual homeowners and were baited between 8:30 and 9:00 PM on two nights, 19 and 24 June 1991, during heavy beetle flight. The trapping was conducted earlier in 1991 than 1990 because an exceptionally warm spring accelerated the flight period. Cooperators recovered the sticky trap on the morning following a trapping night and returned it to our laboratory. The numbers of male *C. lurida* and *C. borealis* caught were determined for each night and site. Sites were sampled from 1-6 August. Sampling procedures were identical to those described for the golf course test, except that grubs were preserved in 75% ethanol and identified after all of the lawns had been sampled. The turf cores were replaced

after examination and thoroughly watered to encourage regrowth. One site was eliminated from the test because of an objection to possible damage to the lawn by our core sampling. Data were incomplete at two other sites, either because the cooperator conducted the trapping on the wrong night, or because the trap was lost.

Data analyses. Within each test, the relationship between the total number of beetles captured at each site on the two nights of trapping (independent variable) and the total number of grubs recovered from that site (dependent variable) was tested by linear regression analysis. Significance of correlation between the first and second nights' trap catches within sites was also tested.

Results

Golf course Test. The open, tray-type sticky traps were very effective in capturing male *C. lurida.* Males displayed upwind flight and orientation to the female extract, hovered above the traps, and then dropped into the Tangletrap adhesive, behaviors similar to those involved in normal response to females on the turf surface (Potter 1980). Captures of male *C. lurida* per trap ranged from 1 to 49 beetles on 3 July 1990 (mean [± SE] = 15.4 ± 2.2) and from 8 to 139 beetles on 9 July 1990 (mean = 31.2 ± 4.8). Within sites, there was weak but significant correlation between the number of males captured on first and second nights (F = 4.71; df = 1,26; $P < 0.04$; r^2 = 0.15). Of the 1335 total male *Cyclocephala* captured, only four were *C. borealis* and the rest were *C. lurida.*

Densities of *Cyclocephala* grubs at the 28 golf course sites ranged from 0 to 55.9 larvae/0.1 m^2 (mean = 9.42 ± 2.07). Smaller numbers of two other scarabaeid grub species, *P. japonica* (mean = 1.83 ± 0.96; range = 0 to 26.8), and *Ataenius spretulus* (Haldeman) (mean = 3.0 ± 0.71; range = 0 to 14.1) were also present in the samples. However, regression of *Cyclocephala* grub densities at particular sites on the total number of male *C. lurida* captured on the two nights of trapping was not significant (F = 0.01; df = 1,26; P = 0.93; r^2 = 0.0003; Fig. 1).

Home lawn test. Captures of male *C. lurida* at the 28 home lawn sites ranged from 14 to 87 beetles /trap on 19 June 1991 (mean = 46.0 ± 3.3) and from 8 to 37 beetles/trap on 24 June 1991 (mean = 22.2 ± 1.5). Within sites there was no correlation between the numbers of male beetles captured on the two nights of trapping (F = 0.67; df = 1,26; P = 0.42; r^2 = 0.025). Of the 1935 total male *Cyclocephala* captured, only four were *C. borealis* and the rest were *C. lurida.*

Densities of *Cyclocephala* grubs were generally much lower in the home lawns than they had been in the preceding year on the golf course, averaging 1.45 ± 0.29 larvae/0.1 m^2 across all of the sites (range = 0 to 5.91 grubs/0.1 m^2). No *Cylocephala* grubs were found in samples from eight of the 28 lawns. Smaller numbers of *P. japonica* (means = 0.78 ± 0.37, range = 0 to 10.5 grubs/0.1 m^2). and *Phyllophaga* spp. (mean = 0.12 ± 0.06, range = 0 to 1.8 grubs/0.1 m^2) were also present in turf samples. Linear regression of the number of *Cyclocephala* grubs recovered from particular sites on the total number of male *C. lurida* captured in the two nights of trapping was significant ($y = 0.038x - 1.108$, where y = grubs per 0.1 m^2, x = total males trapped; F = 8.40; df = 1,26; P = 0.008, r^2 = 0.25; Fig. 2).

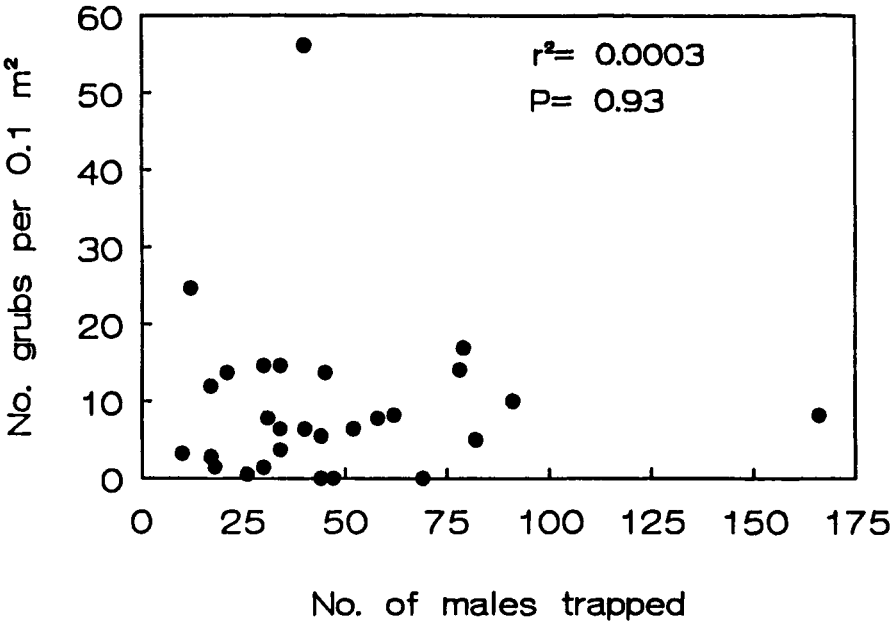

Fig. 1. Lack of correlation between total captures of *C. lurida* adult males in pheromone-baited traps during two nights of sampling (3 and 9 July 1990) at 28 sites on the Lexington Country Club golf course and subsequent larval populations in the surrounding turf.

Discussion

As has been reported previously (Potter 1980, Haynes et al. 1992) solvent rinses of virgin or recently-mated female *C. lurida* were highly attractive to male beetles and were effective in luring males to traps. We had hypothesized that local abundance of male beetles during mating flights would be correlated with the abundance of females, and that short-term trapping could be used to predict subsequent densities of grubs at particular sites. One reason for the absence of such correlation in the golf course test may have been that searching males dispersed beyond the immediate site from which they emerged. Most of our trapping sites were in non-irrigated golf roughs bordering irrigated fairways. Movement of males between adjacent areas may preclude prediction of local grub densities on as fine a spatial scale as was attempted here. Dispersal of mated females away from their emergence site before laying eggs could also contribute to lack of correlation between the intensity of local mating flights and subsequent grub density.

We did find significant, albeit relatively weak correlation ($r^2 = 0.25$) between trap captures of male *C. lurida* and densities of grubs on home lawns. This suggest that local populations of grubs in home lawns may be more discrete than among sites on golf courses, perhaps because of greater heterogeneity of grass

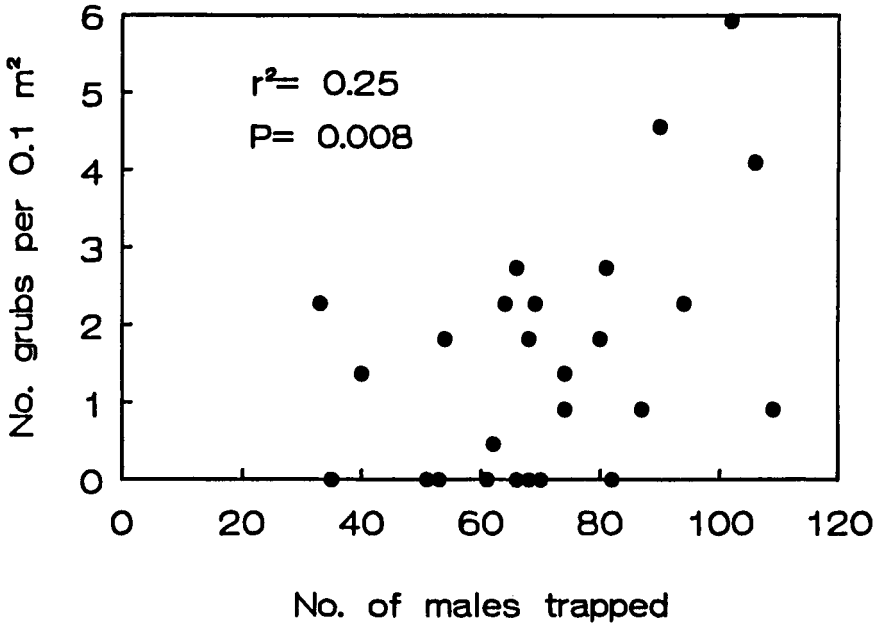

Fig. 2. Relationship between total captures of *C. lurida* adult males in pheromone-baited traps during two nights of sampling (19 and 24 June 1991) on 27 home lawns in Lexington, KY and subsequent larval populations in the surrounding turf.

species and management practices. The concept of risk assessment from pheromone trapping may be more applicable to the home lawn setting.

There are no known morphological characteristics that can be used to reliably distinguish between grubs of *C. lurida* and *C. borealis* (Tashiro 1987). Presence of large numbers of grubs of *C. borealis* would therefore have confounded detection of a relationship between numbers of males of *C. lurida* captured and subsequent densities of grubs. We believe that this was unlikely in the golf course test because a sample of about 200 total grubs collected from the same fairways and roughs about 8 wk earlier and reared in the laboratory yielded adults of *C. lurida* only. Scarcity of grubs of *C. borealis* could not have been assumed from the low numbers of males captured because the adults are active mainly after midnight (Potter 1980) and trapping was terminated at 11:00 p.m.

In contrast, traps in the home lawn test were left out until the following morning, so the scarcity *C. borealis* males probably indicates that the grubs we sampled were predominantly *C. lurida*. Previous work has shown that extracts of female *C. lurida* placed in traps at dusk will remain attractive to males of *C. borealis* later in the night (Potter 1980).

Flights of *C. lurida* males can be highly variable from night to night (Potter 1980), being affected by wind, rainfall or irrigation, soil moisture and temperature (Potter 1981). These factors may have contributed to the weak correlation

between nightly captures of males in the golf course test and the lack of correlation between nights in the home lawn tests. Identification and synthesis of the *C. lurida* sex attractant would allow season-long trapping, which we expect would provide a better assessment of population density in particular residential lawns. The recent discovery that the *Cycloephala* sex attractant is produced by both sexes of larvae (Haynes et al. 1992) may facilitate pheromone identification by extending the period during which insects are available for extraction and chemical analysis.

It is noteworthy that the highest grub density encountered among the 27 home lawns sampled was only about 6 grubs/0.1 m^2, well below the estimated aesthetic damage threshold of 10 to 12 grubs/0.1 m^2 for Kentucky bluegrass turf (Potter 1982). This illustrates that the preventative treatments which are routinely applied by many homeowners and by some commercial lawn care companies in Kentucky and elsewhere are often unnecessary. Improved methods of sampling and risk assessment for white grubs, including use of inexpensive traps throughout the *Cyclocephala* flight period to target high-risk lawns or to eliminate ones with low beetle populations, could help to reduce needless insecticide use on turf.

The difficulty of relating trap catches of adult insects to pest density or damage levels is considered the major limitation of pheromone-monitoring systems, and there are few examples where this relationship has been defined (Wall 1989). This study suggests that short-term trapping of masked chafer males will probably not be adequate to predict subsequent larval populations at particular sites. Nevertheless, the demonstration of some correlation between captures of adult males and grub densities in home lawns on the basis of short-term sampling is encouraging and should provide incentive for additional research directed at pheromone identification and further testing of this concept.

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