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CONTROL OF PEST MOLE CRICKETS (ORTHOPTERA: GRYLLOTALPIDAE) IN BAHIAGRASS PASTURES WITH THE NEMATODE *STEINERNEMA SCAPTERISCI* (RHABDITIDA: STEINERNEMATIDAE)

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Mole crickets, *Scapteriscus* spp., cause nearly $100 million annual losses in revenue to cattle producers in south-central Florida, with about 50% of that loss due to reduced forage and hay production and 50% due to need for pasture renovation (Adjei et al. 2003). Mole cricket damage to pasture and turf grasses principally is caused by the tawny mole cricket *S. vicinus* Scudder feeding on roots, and by shallow tunneling (galleries) by both *S. vicinus* and the southern mole cricket, *S. borellii* Giglio-Tos (Walker & Ngo 1982; Hudson 1985). Damage first appears as yellow patches of grass that later turn brown and die. In areas of high population densities of mole crickets, the surface soil layer is honeycombed with numerous galleries and the ground feels spongy when stepped on. Heavily damaged bahiagrass (*Paspalum notatum* Fluegge) has virtually no root system and plants are easily pulled from the soil by cattle as they graze or walk. Treatment of a large cattle pasture in Florida to control mole crickets is prohibitively expensive and impractical. No insecticide is registered by EPA for mole cricket control in pastures. Consequently, we wanted to see if natural dispersal of mole crickets infected with the entomopathogenic nematode *Steinernema scapterisci* Nguyen & Smart (1990) would reduce the population of mole crickets and ameliorate the damage caused to a bahiagrass pasture. The nematode functions as a biopesticide (Leppla et al. 2004) that kills and reproduces in *Scapteriscus* mole crickets. From each mole cricket cadaver, some 50,000 infective juveniles enter the soil, usually establishing a population and functioning as a classical biological control agent (Hudson et al. 1988). Our experiment was designed to determine whether applying nematodes in strips that covered 12.5%, 25%, or 50% of a plot would result in controlling mole crickets in a larger area through natural dispersal of nematodes by mole crickets.

We collected pre-treatment data on pasture condition and on mole cricket populations by installing 6 linear pitfall traps (Lawrence 1982) in Jun 1997 on a 10-ha bahiagrass pasture in south-central Florida (A.D. Combee Ranch, Polk County, FL). The soil in the area is mostly EauGallie fine sand (USDA, 1990). The total number of mole crickets, *S. vicinus* and *S. borelli*, captured in each trap was counted once every week from Jul 1997 through Aug 2000 before any nematodes were released in the pasture. Traps were emptied, cleaned, and reset after each weekly collection. The total numbers of mole crickets trapped in the 3 years before the nematode was applied were 3456 in 1997 (Jul-Dec), 5112 in 1998, and 5347 in 1999, indicating a heavy and damaging population. Mole crickets caught in the traps were examined in Jun, Jul, and Aug, 2000, in order to determine whether any were already infected with *S. scapterisci*. None of 666 mole crickets trapped and examined was infected with the nematode, and we concluded that the nematode was not present.

The condition of the bahiagrass over the 10-ha pasture was evaluated in May 1997, 1998, 1999, and 2000 as the percentage of the pasture covered by (1) green bahiagrass and (2) yellow and dead bahiagrass, weeds, and bare ground by using a 1-m^2 quadrat subdivided into 100 small squares (Adjei et al. 2003). The quadrat was tossed randomly to 5 locations on the pasture.

On 7 Sep 2000, we established 3 blocks of plots, with each block containing 4 subplots each 41.3 m $\times$ 97.3 m, arranged near each other in a rectangular pattern (Fig. 1). Three of the plots in each block were subdivided into 16 strips, each 6.08 m wide and 41.3 m long. In 1 plot 8 alternate strips (50% of plot area) were treated with the infective juvenile stage of *S. scapterisci* in a water suspension by injecting the nematodes into the soil about 1.5 cm with a modified slit seeder. In another plot, only 4 strips (25% of plot area) received nematodes, and in the third plot only 2 strips (12.5% of plot area) received nematodes (Fig. 1). The fourth plot in each block served as a control and received no nematodes. Nematode dosages were based on overall coverage with 2.5 billion infective juveniles per hectare in the equivalent of 935 L water per ha. The injection slits were closed with press wheels mounted behind the seeder.

Before treatment, 6 pitfall traps were installed in each plot, 3 in nematode-treated strips and 3 in untreated strips in the treated plots. For the untreated controls, 6 traps in each plot were arranged similarly to those in the treated plots (Fig. 1). The total number of mole crickets captured in each trap was counted weekly from Sep 2000 through Dec 2002. Traps were emptied, cleaned, and reset after each weekly collection. Periodic assessment of nematode infection of trapped mole crickets was done twice each month from Oct 2000 through Jun 2002, and from Oct

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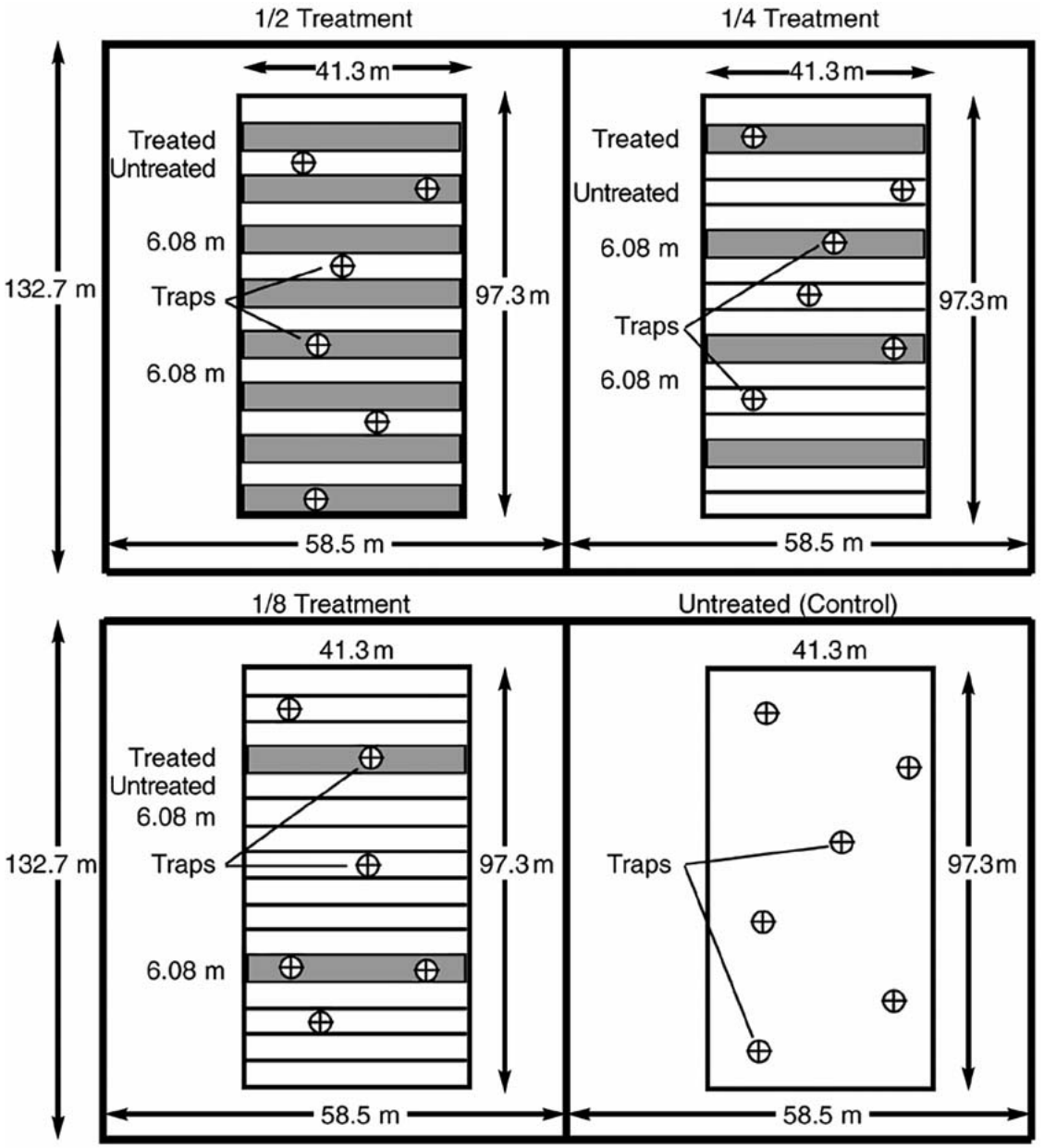


Fig. 1. One of 3 blocks (replicates) with 3 treated plots and a control plot. Treatment plots were subdivided into 16 strips, each 6.08 m wide, as indicated by the shaded and unshaded areas in the diagram. *Steinernema scapterisci* were applied to 8, 4, or 2 strips per plot to provide coverage of 50%, 25%, or 12.5% of the plot area, respectively. The control plot received no nematodes. Each of the 4 plots in a block had 6 pitfall traps to capture mole crickets. Captured crickets were held to determine if nematodes emerged from the dead crickets. The 3 blocks covered a 10-ha pasture.

2002 through Mar 2003. Trapped adult mole crickets were placed individually in vials and kept for 14 d to await possible emergence of infective juveniles from the cadavers. Emerging nematodes were identified as *S. scapterisci* by methods described by Woodring & Kaya (1988). Only adults were examined because the adults are more susceptible to infection than nymphs (Hudson & Nguyen 1989). The condition of the bahiagrass was evaluated in May 2001, 2002, and 2003 as for the pretreatment evaluation with the quadrat tossed randomly to 5 locations on each plot.

The weekly captures of mole crickets and monthly numbers of adults infected with nema-

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todes were analyzed statistically by the GLM procedure (SAS 1999), with treatment as main plot, treated vs. non-treated strips as subplot, and year and week/month as sub-subplot and sub-sub-subplot in time, respectively. Following a significant *F*-test in the analysis of variance, treatment means were separated by Tukey's Studentized Range Test. Average plot ratings were analyzed statistically as a split plot experiment, with treatment as main plot, and year as split plot in time. Sources of variation examined in the statistical analysis of variance included replications, treatment, treatment × replication (error a) year, year × treatment and residual (or error b) effects.

After *S. scapterisci* was applied in Sep 2000, the total numbers of mole crickets trapped in 2000, 2001, and 2002 were 3,251, 3,326, and 676, respectively. The number trapped in 2002 was 79.2% less than the number trapped in 2000. In 2002, in plots with 12.5%, 25%, and 50% of the area treated, the average percentage of infected mole crickets was 89%, 84%, and 86%, respectively. This indicated that treating 12.5% of the area was as effective as treating 50% of the area, thus, potentially saving 75% of the purchase of the nematodes and application cost. Within treated plots, no differences ($P > 0.60$) between treated strips vs. non-treated strips were observed on any sampling date, and strips had no interaction with the other variables**.** The percentage of infected mole crickets in the control plots was significantly less than in all treatment plots in Apr 2001, but thereafter, with the exception of May and Jun 2002, there were no significant differences between treated and control plots because an average of 41% of the crickets trapped in control plots were infected with *S. scapterisci*. It is highly probable that movement of infected mole crickets from the treated plots into the control plots occurred because the control plots were very close to the treated plots (approximately 18 m from a treated plot). March and April are the months of maximum activity by adult mole crickets in central Florida, and most likely it was during these months in 2001 that infected mole crickets dispersed to both untreated strips in the treated plots, and to the control plots.

At the beginning of the study in 1997, the pasture showed classic symptoms of damage by mole crickets (Walker & Ngo 1982; Hudson 1985). Patches of yellow and dead grass, bare ground, and weed growth covered 58% of the area in 1997, 61% in 1998, 65% in 1999, and 67% in 2000. After *S. scapterisci* was applied, the damaged area declined to 51% in 2001, 18% in 2002, and 4% in 2003, and concomitantly, the bahiagrass coverage increased to 49% in 2001, 82% in 2002, and 96% in 2003 (Fig. 2). We conclude that strip application of the nematodes is a satisfactory method of dispersing the nematode and is significantly less expensive than broadcast application of nematodes.

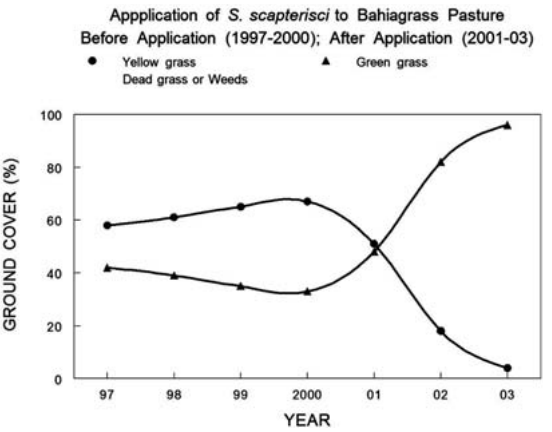


Fig. 2. Condition of a 10-ha bahiagrass pasture monitored annually from 1997-2000 (before application of *Steinernema scapterisci)* and from 7 Sep 2000-2003 (after application of *S. scapterisci*.

Because the control plots became infested by the nematode from the treated plots within 7 months after application, it is obvious that control plots must be much farther from treated plots to prevent infestation. How far control plots should be from treated plots requires further research.

Applications of *S. scapterisci* reduce populations of *Scapteriscus* mole crickets (Parkman et al. 1994), and once *S. scapterisci* is established, the nematodes persist for years in Florida pastures (Frank et al. 1999; Parkman et al. 1993a). Over time, *S. scapterisci* applied to Florida pastures should spread widely as a classical biological control agent.

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SUMMARY

The entomopathogenic nematode, *Steinernema scapterisci*, applied in strips to a 10-hectare bahiagrass pasture reduced populations of mole crickets, *Scapteriscus* spp., by 79.2% over a 3-year period. Bahiagrass cover increased from 33% to

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96% in the same time period. Strip applications were much less expensive than treating the entire pasture, but equally effective in providing biological control of mole crickets.

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