An Inside Look at Mole Cricket Management

Understanding these pests' behavior is vital to controlling their numbers.

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TWO species of mole crickets, the tawny mole cricket (*Scapteriscus vicinus*) and the southern mole cricket (*S. borellii*) are among the most devastating insect pests in the southeastern United States. The tawny mole cricket is primarily a root feeder, while the southern mole cricket is a predator of other soil arthropods (insects).

The cost of control and the impact of damage often is measured in tens of thousands of dollars per golf course in many areas. Neither of these pests is native to the U.S.; they were introduced to several locations along the Southeast coast in the early 1900s. Since that time, they have migrated northward well into North Carolina and westward to eastern Texas. Soil type and temperature should limit much additional spread, but a few isolated infestations are also showing up in the southwestern United States.

The costs associated with controlling mole crickets, the lack of effective control following insecticide application, and the lack of an adequate understanding of mole cricket ecology and behavior prompted the development of a proposal to the USGA Green Section Research Committee in 1992. A collaborative effort was established to take advantage of the applied research program on mole crickets at North Carolina State University under the direction of Dr. Rick L. Brandenburg and the soil insect ecology program directed by the late Dr. Mike Villani at Cornell University.

This team received funding from USGA and for the next seven years embarked on an ambitious program to better understand the biology, ecology, and behavior of this most troublesome turfgrass insect pest. The research program focused on several field and laboratory research projects. Each of these projects was targeted toward developing information that will complement economically and environmentally sound mole cricket management programs.

Field Research

Field research was conducted on several golf courses in New Hanover and Brunswick counties along the southeastern coast of North Carolina. Additional studies were conducted in laboratories and greenhouses at North Carolina State University in Raleigh, N.C.

A study to monitor mole cricket development and to develop an equation to forecast or predict mole cricket egg hatch was initiated early in the research program. Acoustic sound traps that synthetically produced the mating call of the male mole cricket were used to monitor mating flights. These were placed at two golf courses in Brunswick County. In addition, a network of automated soil and air temperature recording units was installed throughout the two-county area to monitor degree-day accumulation.

Course fairways were monitored weekly from late spring to late summer. Intensive sampling consisted of using a 2% soapy water solution applied to square meter areas to bring mole crickets to the surface. Crickets were collected, returned to the laboratory, and recorded for species, size, and stage of growth. These data provided indications of egg hatch and cricket development as related to soil and air temperature. Monitoring over a three-year period of time provided situations with significant variations in degree-day accumulations, but did not establish a strong relationship with cricket egg hatch, development, or mating flight patterns.

Subsequent greenhouse evaluations at North Carolina State University determined that soil moisture does play a significant role in the egg laying process. Soil moisture affects the timing and intensity of mole cricket egg laying. Mole crickets prefer adequate soil moisture if they are to lay their eggs. Thus it appears there is an important interaction between soil moisture and soil temperature that influences mole cricket development each year.

Additional studies sought to define turf areas that could be considered at high risk for mole crickets. This project focused on the mole cricket abundance as influenced by soil moisture, various soil parameters, and topography. In addition, the relationship between the presence of adults in the spring and the subsequent outbreaks of the next generation of crickets in late summer was investigated.

The intensity of adult abundance was measured in the spring through a standardized grid rating system. A wide range of turf areas were monitored, including those with little or no damage. Soapy water flushes were then used in the same areas late in the summer to determine the abundance of recently hatched mole cricket nymphs. Soil samples were taken weekly and soil moisture, texture, silt and clay content, as well as pH and organic matter were determined. General observations on topography were also noted.

Results show a strong relationship between the presence of adults in the spring in a specific area and subsequent outbreaks of nymphs and turf damage later in the summer. This correlation is important since the majority of conventional insecticide applications are most effective when applied against small mole cricket nymphs long before obvious surface damage is visible. Such a relationship allows a superintendent to map areas of adult damage in the spring and strategically apply insecticides in those locations during the summer as egg hatch occurs.

This study also provided preliminary indications concerning the relationship of certain soil conditions and mole cricket abundance. Of greatest importance appears to be clay and silt content. Slight increases in clay or silt content of the soil were generally associated with reduced mole cricket abundance. While this relationship needs to be studied more closely, it does indicate two possible management options. One is that certain areas may be defined as "high risk" based on soil characteristics. Such information could be useful in managing these pests.

Research investigating the impact of irrigation, both before and after the application of insecticides, proved inconclusive. Large plots (50 ft. × 50 ft.) were established and subjected to various treatments and irrigation regimens. Treatments included no irrigation, pre-treatment irrigation, post-treatment irrigation, and both pre- and post-treatment irrigation on replicated plots. When the effects of these irrigation schedules were studied in conjunction with the use of several synthetic pyrethroid insecticides, the results were very inconsistent.

Two factors possibly added to this inconsistency. One is that as more water was applied (as either pre- or post-treatment irrigation), surface activity increased in spite of the insecticide. However, the extent to which surface activity increased with increasing soil moisture was difficult to assess in this experiment as it was designed.

Another important factor adding to inconsistent control is an avoidance behavior of the mole crickets when an insecticide is applied to the soil. The exact nature of this avoidance is not well understood, nor has the degree to which it occurs in the field been fully explored. However, reversed-rate responses in pesticide field testing trials are not uncommon. In other words, due to the insects' ability to detect and avoid the insecticide, higher insecticide application rates sometimes result in less control of the pests.

The field behavior of mole crickets was examined by creating castings of cricket tunnels with the use of a fiberglass resin. The resin, commonly used for auto body repairs, provided an easy-to-pour material that flowed smoothly into the tunnels in the soil and hardened quickly with the addition of a catalyst. The casting material formed a lightweight, durable casting that could be easily excavated from the soil. The fiberglass resin also often encased the cricket occupying the tunnel, making species identification easy.

Tunnels for the root-feeding tawny mole cricket almost always produced the "Y"-shaped castings consistent with those observed in the laboratory soil radiographs. The structure recovered from the predatory southern mole cricket consisted of a meandering type of tunnel that might be associated with general searching in the soil. Castings from this species of mole cricket were also consistent with radiographs taken in the laboratory. The castings document a consistent tunneling pattern for an individual species and marked differences between the two species. These are obviously related to the general diet of the two species and to the behavior required to meet those dietary needs.

The southern (left) and tawny mole crickets are the most serious soil insect pests in the southeastern United States.

Greenhouse studies of field-collected crickets also indicate differences in response and possible susceptibility to specific insecticides by the two species. The actual effect of behavioral differences and individual cricket susceptibility to contact with a particular insecticide needs further investigation. These species differences, in addition to soil type and climate, may account for the variability in product performance often observed by superintendents in a specific region.

An additional area of research focused on the use of a fungal pathogen to help add insight into the findings of specific laboratory experiments. Several strains of the pathogen *Beauveria bassiana* were applied for mole cricket control on golf course fairways and the effect on the population was monitored. Treatments included several strains of this pathogen applied with both surface and subsurface application equipment.

The results of their trials are not impressive in terms of level of control typically desired by golf course superintendents. However, the study does provide insight into the use of such control agents. The use of subsurface application equipment appears to improve the efficacy of these products, possibly by reducing the likelihood of exposure to sunlight or desiccation of the fungal spores. The results are consistent with laboratory findings examining fungal pathogens and mole cricket behavior.

Laboratory Research

To further our understanding of the impact of environmental factors and disease on mole crickets, a clear picture of "typical" tawny mole cricket and southern mole cricket behavior was necessary. Studies were initiated using radiographic technology (x-rays) to visualize the movement and feeding patterns of both tawny mole crickets and southern mole crickets in the soil matrix. Mole crickets were placed in plexiglass soil arenas (1.5 × 12 × 15 inches). Through the placement of a small lead tag on each cricket, tunnel construction and cricket movement in the tunnel could be monitored over extended periods of time.

A series of radiographs indicate a consistent behavior of a single late-instar tawny mole cricket nymph. This nymph produces a characteristic "Y"-shaped tunnel that allows two escape routes to the surface and down into the soil to escape predators, including larger southern mole crickets, and a long tunnel into the soil profile that most likely aids in thermal and water regulation.

Tawny mole crickets typically feed at the root/soil interface between the "Y" arms and are therefore always near an escape route. As tawny mole crickets grow, their tunnels widen and extend further into the soil profile, suggesting a possible cause for the difficulty in bringing older crickets to the surface through soap flushes and baits. Crickets also seem to maintain their tunnel system, rebuilding collapsed tunnels over time.

The "Y" tunnel patterns of the tawny mole cricket do not seem to change in the presence of predatory southern mole crickets. Tawny mole crickets appear to "wall-off" their tunnels when southern mole crickets are present, but further studies are needed to confirm this behavior.

By comparison, southern mole crickets will move as far from each other as possible when placed together in a chamber. This behavior suggests the presence and activity of a chemically mediated avoidance behavior in this species. There is also an indication that mole crickets can detect and avoid conventional synthetic insecticides in the soil.

Additional studies on cricket behavior utilized arenas (12 × 20 × 8 inches) filled with moist sandy loam soil and topped with a commercial sod. A single tawny mole cricket was placed in the arena and allowed to tunnel into the surface. At the end of seven days, each arena was sampled to determine the tunneling pattern of the cricket. To form a paraffin cast, the entrance to the mole cricket tunnel was located by looking for a disturbed area of turf. Solid paraffin wax was heated until liquid and poured slowly, to allow escape of air bubbles, into the tunnel entrance. After a short time (about 10 minutes), soil was carefully excavated from around the hardened wax and the full casting was retrieved.

To reveal the tunnel of a single tawny mole cricket over a one-week period, soil was removed at 1.5-inch intervals from the surface to reveal the tunnel as it descended into the soil profile. The red-tinted casting represents that portion of the tunnel revealed by removing soil in that 2.5-inch layer (previously exposed tunnels are white). The castings showed the typical "Y"-shaped construction and extensive tunneling at the root-soil interface where the cricket foraged for food.

Preliminary studies with spray applications of the fungal pathogen *B. bassiana* indicate that reverse-rate responses often occur with higher rates. This may be the result of avoidance behavior associated with higher rates. Mole crickets detect and avoid formulations containing pathogenic fungi by remaining deep in the soil profile. This behavior allows mole crickets to avoid the fungal pathogen until it becomes inactive.

Laboratory studies were initiated to evaluate mole cricket behavior toward soil-borne, entomopathogenic fungi (fungi that cause disease in insects) and to evaluate the efficacy of subsurface and surface fungal applications. In these experiments, tawny mole crickets had no choice but to tunnel through a layer of fungal-treated sand in order to reach a sod food source. One late-instar tawny mole cricket was placed in each arena and allowed to tunnel for one hour before strips of sod were placed on top of the sand. After four days, the sod was removed and two inches of fungal-treated sand was added to the surface of the sand. An equivalent layer of clean sand was added in control treatments.

Two hours after treatment, 40% of the tawny mole crickets in both treated and untreated arenas had tunneled through the treatment layer and returned to the surface. After three and six days, 60% of treated and 80% of untreated tawny mole crickets had tunneled through to the surface sod. The amount of tunneling in the treatment layer area was significantly lower in arenas treated with the entomopathogenic fungi compared to the arenas containing the clean sand layers. Tunneling in the untreated layer below the interface was not significantly different in any treatment.

These findings of avoidance behavior in mole crickets suggest that placement of fungal pathogens in the soil profile may influence the effectiveness of a product to control mole cricket damage to turf. The avoidance response seen in these experiments may be evidence of an evolutionary adaptation to avoid infected insects and areas of soil with high concentrations of fungal spores. Avoidance behavior may explain the inconsistent results found in the field with high doses and surface applications of fungal pathogens. Subsurface applications of fungal pathogens, however, may lengthen the time a pathogen remains viable compared to pathogen survival after surface application.

This field and laboratory research demonstrates the value of a good understanding of pest biology and ecology. These studies help us better understand the reasoning behind some of our strategies for mole cricket management. At the same time, they also reveal why mole crickets continue to be such a difficult pest to manage. Further studies will help ensure our ability to cost effectively manage this serious pest.

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