MOLE CRICKETS AND THEIR CONTROL IN FLORIDA PASTURES

J. Howard Frank

Entomology & Nematology Department
University of Florida, Gainesville

INTRODUCTION

Mole crickets of the genus *Scapteriscus* are immigrants to Florida and are important pests of turf and pasture grasses. The only native mole cricket in Florida, *Neocurtilla hexadactyla* (Perty), is not a pest. The destruction wrought by *Scapteriscus* generally is attributed in the popular press to "the mole cricket" so that all members of the mole cricket family (Gryllotalpidae) now have a bad reputation, deserved or not.

ORIGIN OF MOLE CRICKETS

The northern mole cricket (*Neocurtilla hexadactyla*) is distinguished readily from the others by the row of 4 "fixed claws" (tibial dactyls) on its front "feet." These 4 "fixed claws" look like a little rake, and are used for digging. It is distributed widely in the eastern USA, but is largely restricted to wet habitats along the margins of ponds and streams. Its specialist natural enemies probably keep its populations in check.

Mole crickets of the genus *Scapteriscus* have only 2 "fixed claws." They arrived from southern South America at the end of the 19th century in ships' ballast. Disembarking at port cities in the southeastern USA, their populations grew rapidly, probably due to absence of specialist natural enemies. Three of them are now recognized: the short-winged mole cricket (*S. abbreviatus*Scuddelyr), thely southern mole cricket (*S. acletus* Rehn & Hebard), and the tawny mole cricket (*S. vicinus* Scudder) (Walker 1985).

The name *Scapteriscus acletus* may prove to be a synonym of *S. borellii* Giglio-Tos. Two additional species [*Scapteriscus didactylus* (Latreille) and *S. imitatus* Nickle & Castner] occur in the West Indies, where both are immigrants from northern South America (Nickle & Castner 1984). Early reports of the "changa or West Indian mole cricket" (*S. didactylus*) in Georgia and Florida are due to misidentification. Similarly, reports of S. *vicinus* in the West Indies are due to misidentification.

NATURAL HISTORY

Adults of the short-winged mole cricket cannot fly and this species still is restricted largely to coastal areas in southwestern Florida and eastern Florida and Georgia. Adults of the southern and tawny mole crickets can fly, and their range has expanded northward to North Carolina and westward to Louisiana. The southern mole cricket has also colonized eastern Texas and, more recently, extreme western Arizona and neighboring California. Flights of the southern and tawny mole crickets peak during their spring breeding season.

All mole crickets spend most of their lives underground. Each clutch of eggs is laid in an underground egg chamber and sealed after oviposition. Hatchlings take 4-5 months to develop to the adult stage. The spring breeding season of tawny and southern mole crickets produces nymphs which develop during the summer months. The short-winged mole cricket, in contrast, breeds throughout the year.

Males of tawny and southern mole crickets have a species-specific song which attracts females and some natural enemies (see below). Female mole crickets, and males of the short-winged mole cricket, do not sing.

The habitat of all three *Scapteriscus* species in Florida is light, sandy soils, and slightly heavier soils which are made friable by cultivation. Such soils are typical almost everywhere in Florida as well as in the plains of other southern states. The community of insects (and other animals) in these soils probably is similar generically throughout the region, though with differences at the species level. Human activities, in the form of conversion to pasture, turfgrass, horticulture and cultivated crops, and in pesticide load added, must surely have an important influence on population densities and species composition of the fauna which, in turn, will influence mole cricket populations. These same human activities also may provide a much more plentiful food supply for mole crickets than would the natural vegetation.

DAMAGE

Tawny and short-winged mole crickets feed almost entirely on plants, and much of their damage is directly to the roots. Southern mole crickets include many other insects in their diet, and are less damaging directly to plants. But all three species tunnel actively in the ground and loosen and weaken plant roots, which is especially damaging during drought. Nymphs and adults of all three species emerge from the ground at night in warm, wet weather to feed above ground, resulting in damage to stems and leaves of grasses and other plants.

Damage by *Scapteriscus* was first noticed in the USA to truck crops, then to turfgrass, and finally to pastures. This is in part because of their spread from coastal areas where truck crops predominated, in part because of the different economic thresholds in the three habitats: small numbers of *Scapteriscus* mole crickets can cause extensive damage to truck crops (especially seedlings) and turfgrass (especially golf course greens), whereas damage to pastures is negligible until much higher population densities are reached. *Scapteriscus* mole crickets are capable of total destruction of bahia grass pastures.

Florida currently experiences higher damage by *Scapteriscus* mole crickets than does any other southern state. There are at least four reasons for this. First, almost all of Florida's soils are sandy and ideal for mole crickets. Second, several ports in Florida and one in southeastern Georgia were the first areas to be colonized, and mole crickets are still spreading north and west. Third, Florida's winters are milder, permitting mole cricket activity in more weeks of the year. Fourth, the cause of damage is not at first realized when mole crickets invade, and damage has been attributed to other pests before recognition of the culprits.

There is no current estimate for damage to pastures, though undoubtedly it is many millions of dollars annually. Damage to turfgrass currently is estimated as about $44 million annually in Florida, and about $33 million in the other southern states jointly. These levels of damage resulted in Florida taking the lead in research into control methods.

CHEMICAL CONTROL

The first chemical control methods used in the USA were baits containing arsenic. These and baits using cyanide were used very widely in truck crops and golf courses almost until the end of World War II. Chlorinated hydrocarbons were developed during the war as control measures for other pests, especially mosquitoes. One of them, chlordane, was found to be an excellent material for killing mole crickets. It was so cheap, effective and persistent that it could be used economically in pastures against mole crickets. Unfortunately, these attributes caused the cancellation of the short-lived Florida Agricultural Experiment Station research project of the 1940s into biocontrol of mole crickets, a decision which can only be regretted. Not until the 1960s were the environmental consequences of use of chlordane discovered, and not until the 1970s was its use banned.

Cancellation of the research program into biocontrol of mole crickets in the 1940s was due simply to the ascendancy of chlordane. In retrospect this is highly regrettable, and it is a symptom of the economic system in our society. The society rewards the ability to "make a buck", in this instance by the production and sale of chlordane. The alternative of classical biological control (see below for definition), which was being attempted, would, if successful, have cost a few thousand dollars of public funds (or funds provided directly by farmers), but the savings to farmers could have been enormous if it had been successful. It seems that research into classical biological control is funded only if all profit-making schemes have failed, and only as a last resort. Current research on horn fly is another case in point. While horn fly is becoming resistant to chemical after chemical, funds for research on classical biocontrol are extremely hard to obtain (in the experience of the writer), even though the potential savings to farmers are infinitely greater than by use of chemicals.

Newer chemicals (carbamates and organophosphorous compounds) had been researched and some were available by the time that use of chlordane was banned. However, they generally were more costly, and whereas their adoption in the form of sprays or granules could be justified economically in truck crops and turfgrass, their use in pastures could not be justified. Thus, ranchers were left without a cheap, persistent and effective chemical for use in pastures. This prompted a request to the state legislature for renewed funding for research on mole crickets, and the IFAS mole cricket research program was born in 1978 (Koehler et al. 1979). The program had to research many aspects of mole cricket biology (taxonomy, physiology, biochemistry, toxicology, behavior, ecology and sampling methods) because these were largely unknown and were necessary backgrounds, before emphasis could be placed on biological control.

The IFAS mole cricket program developed a user-formulated bait containing malathion (a relatively safe organophosphorous compound) as a stop-gap measure until biological control could be achieved. This is less expensive than commercially-available baits with carbaryl, malathion, or trichlorfon. The summer months, when nymphs are present and feeding actively, are the appropriate time to apply such baits, and timing of application is critical (Hudson & Frank 1987).

NATIVE NATURAL ENEMIES

Many other animals kill mole crickets. Amphibians (such as frogs and toads), birds (such as egrets and sandhill cranes), mammals (such as armadillos and foxes), insects (such as tiger beetles and assassin bugs), and spiders have been seen to kill them. Perhaps as many as a third of all mole cricket nymphs in pastures are killed by such predators, but the number of mole crickets killed simply is not enough to prevent damage. Among the reasons why unlabelled chemicals should not be used in pastures is the risk to these beneficial natural enemies which are among the non-target organisms.

The various natural enemies mentioned above are not specific to *Scapteriscus* mole crickets - they have a varied diet. Specific natural enemies - those which will feed only on *Scapteriscus* mole crickets and nothing else - are likely to be found in the homelands of *Scapteriscus,* following a long history of co-evolution. To emphasize this point, it is known that the native, northern mole cricket does have specific natural enemies in Florida, but these specific natural enemies do not attack *Scapteriscus* mole crickets.

BIOLOGICAL CONTROL

Biological control is the deliberate attempt to control pests by the use of natural enemies. Two of its major forms are classical (= inoculative) biocontrol and use of biopesticides.

Classical biocontrol is used mainly against immigrant pest species (such as *Scapteriscus* mole crickets) and requires search for and importation of specific natural enemies from the area of origin of the pest. The natural enemies generally are predators, parasites, parasitoids, or competitors. It is then expected that the imported natural enemy can be established and will reduce the population of the pest to a non-damaging level permanently. This method of biocontrol generally does not result in a product that can be marketed by a commercial company, so research costs have to be met by the beneficiaries and/or by government.

Biopesticides also are biocontrol agents, but generally are pathogens. They may be of native or foreign origin, but produce no permanent effect on the pest population. Thus, a marketable product is produced, and research therefore is supported often by commercial companies which can benefit from sales. Biopesticides are applied in much the same way as chemical pesticides but are safe to the environment. They need repeated application just like chemical pesticides. The economics of use of biopesticides, therefore, are very different from those of classical biocontrol.

Larra A short-lived attempt was made in the 1940s to import biocontrol agents into Florida. This was stimulated by successful establishment by 1940 of *Larra bicolor* F. (a parasitic wasp of the family Sphecidae) in Puerto Rico from Pará, Brazil. However, failure to obtain living *Larra* from Puerto Rico or northern South America delayed the project, which then was canceled on discovery of the efficacy of chlordane for killing mole crickets (Frank 1990).

A renewed attempt was made to import *Larra bicolor* from Puerto Rico in the late 1970s. Planning for the importation included preparation of 5 release sites with plantings of a weed [*Spermacoce verticillata* (L.) (a preferred nectar source for the parasitoid)] and a laboratory comparison of attack by *L. bicolor* on adults of several *Scapteriscus* species (Castner 1984). Culminating in 1981, several dozen adult *L. bicolor* from Puerto Rico were released at each of the sites, but establishment occurred only at a site in Broward County (Frank 1990). Study of the established population in 1986-1987 failed to show that it was attacking southern and tawny mole crickets, and revealed only a small proportion of field-collected short-winged mole crickets attacked by it (Castner 1988a). This raises questions of which species (*Scapteriscus abbreviatus, S. didactylus*, *S. imitatus*) is attacked by *L. bicolor* in Puerto Rico, and whether this parasitoid regulates populations of any of them; no answer is evident in Puerto Rican literature.

The life cycle and behavior of *L. bicolor* are described by Castner (1988b). All species of *Larra* (of which *L. analis* and *L. bicolor* are the best-known) are believed to be parasitoids of Gryllotalpidae. Some effort has been put into study of other South American *Larra* species relative to their importation into Florida as biocontrol agents for *Scapteriscus* (F.D. Bennett, unpubl.).

Steinernema The *Scapteriscus* mole crickets which are pests in Florida originated in southern South America, so in the mid-1980s, the IFAS mole cricket program supported a search for natural enemies in southern Brazil, Uruguay, Paraguay and northern Argentina. A species of insect-parasitic nematode was among the natural enemies discovered in Uruguay. It was at first misidentified as a species that occurs commonly in the USA, but later was found to be an undescribed species and was named *Steinernema scapterisci* Nguyen & Smart (Nguyen & Smart 1990).

This parasitic nematode proved to be a specific natural enemy with the unique capability of being able to reproduce in *Scapteriscus* mole crickets as well as kill them. In small-plot field tests in pastures in Alachua County it reduced populations of southern and tawny mole crickets, and its descendants persisted in the plots (Hudson et al. 1988). The tests were set out in summer 1985 with a single application of nematodes. The tests were monitored to the autumn of 1990, at which time *Scapteriscus* populations were still very low. There was no observed effect on populations of the non-pest, native, northern mole cricket, and the nematode had spread to neighboring parts of Alachua County, presumably carried there by newly-infected flying mole crickets before they sickened and died of the infection.

Possibilities of use of this nematode looked very promising even by summer of 1986, but it could not be produced in sufficient quantities for large-scale field trials because of the apparent need to apply it at the dosage of 800 million per acre. A commercial company became interested in its development as a biopesticide, especially for the turfgrass market, and performed research on industrial-scale production. By the summer of 1989, success had been achieved, and the IFAS mole cricket program was supplied by the company with billions of the nematode, for large-scale trials. These trials were established in pastures in Clay, Flagler, Highlands, Hillsborough, Osceola and Pasco counties in August-September 1989, and are scheduled to be evaluated in August-September 1991. Preliminary results in the pastures with the highest initial mole cricket populations appear very promising.

Use of this nematode would still be very expensive if it has to be applied over large areas at 800 million per acre. Current research therefore has two aspects. First, if the nematode is applied over a small area, how long will it take to spread outward over specified distances? Satisfactory answers will enable it to be applied on worst-infected area, to spread to lesser areas. Second, what are the possibilities of attracting mole crickets to concentrations of the nematode? Electronic emitters synthesizing the song of tawny and southern mole cricket males are the basis of this research. The nematode still is not being produced commercially - for any company to undertake production will demand satisfactory return on the investment.

Ormia IFAS mole cricket program investigation in the mid-1980s in South America revealed that gravid (pregnant) adult females of a parasitic fly called *Ormia depleta* (Wiedemann) (family Tachinidae) are attracted at night to the song of male *Scapteriscus* mole crickets. It took about three years before rearing of the fly had been accomplished successfully in an IFAS laboratory in Gainesville. As a result, flies were released in Alachua County in April 1988 for the first time, in October 1988 in Manatee County, in April 1989 in Osceola County, and in March 1990 in Dade County. These four release sites are experimental, to test the effect of flies on local mole cricket populations. The fly, known to the press as the "red-eyed Brazilian fly" apparently is established at three of the four release sites, and results from the releases are anticipated eagerly. The fly is specific to *Scapteriscus* mole crickets and harmless to non-target organisms.

If the fly proves successful in reducing mole cricket populations, then it could be mass-produced by the Florida Department of Agriculture and Consumer Services for release at sites throughout Florida. It is a true classical biological control agent of no commercial interest.

Pathogens The IFAS mole cricket program also discovered pathogens of mole crickets in South America. These include fungi, bacteria, protozoa, and a virus. To date, two of the fungal pathogens seem promising in the laboratory, but field-release methods have not been developed. It is hoped that a commercial company will fund development of at least one of them as a biopesticide which would have more use on turfgrass than in pastures. Current IFAS mole cricket program funds are all being expended on the nematode and the fly, leaving none for the development of these pathogens.

Pheropsophus Larvae of the South American bombardier beetle *Pheropsophus aequinoctialis* appear to be specialist predators of *Scapteriscus* eggs. They may become useful classical biocontrol agents for these mole crickets, but research on host-specificity is at an impasse due largely to problems in rearing these insects. Funds are lacking to divert to solving the rearing problems, because all available funds are being spent on research on the nematode and fly.

INTEGRATED PEST MANAGEMENT

It may be that the parasitic nematode and/or the parasitic fly will provide sufficient control of *Scapteriscus* mole crickets in Florida that no further control is needed in pastures. This situation would be ideal, resulting in permanent control with no need to apply purchased materials, and with long-term benefit to ranchers. If a further biocontrol agent is needed to supplement what the nematode and fly can achieve, this may perhaps be provided by the bombardier beetle. The economics of the lower damage threshold in truck crops and turfgrass probably will dictate supplemental methods in terms of integrated pest management.

Integration of use of the above classical biocontrol agents with use of pesticides could employ either biopesticides or chemical pesticides. Chemical pesticides, as noted above, are available now. Biopesticides will take further research and development. In spring 1990, the personnel of the IFAS mole cricket program were highly optimistic about the impending success of the program in the near future. If it is as successful as they hope, they would like to turn their attention to biocontrol of horn fly and its relatives (house fly and stable fly), which also are major problems for the beef and dairy industries in Florida.

SUMMARY

Tawny mole crickets and southern mole crickets are important pests of pastures in Florida and other southeastern states. They are immigrant species from southern South America. Northern mole crickets are native to Florida and are not pests. Short-winged mole crickets are immigrants and are pests but are restricted to coastal areas.

Tawny mole crickets and southern mole crickets breed in the spring. Their eggs are laid in clutches of 24 to 60 in underground chambers. The hatchlings (nymphs) feed actively and grow during the summer months, and their parents die. Nymphs molt several times during the summer, and eventually molt to become adults in the autumn. These pests spend most of their lives underground in tunnels which they dig. Their tunnelling disturbs and weakens grass roots, especially under dry conditions. Their feeding on grass roots kills grass. Adults fly mainly during the spring breeding season.

Mole crickets are not difficult to kill with chemical pesticides, but few pesticides are labelled for use in pastures. Chemical control is only temporary because pastures will be invaded by more mole crickets, and it is not cheap. Baits containing chemicals are at present the most efficient way of using chemicals.

Various native amphibians, birds, mammals, insects and spiders act as non-specific natural enemies and kill mole crickets, but their action generally is not enough to reduce populations below damaging levels.

In contrast, some South American natural enemies are specific to mole crickets. Among, these a wasp (*Larra bicolor*), a nematode (*Steinernema scapterisci*), a fly (*Ormia depleta*), and a beetle (*Pheropsophus aequinoctialis*), have been imported to Florida for study. The wasp has been largely unsuccessful. The nematode shows great promise in being able to reduce mole cricket populations permanently, and is now the subject of intensive field trials. The fly also is undergoing field trials. The beetle is undergoing laboratory study. Various pathogens are available for development as biopesticides when funds are available, for use in integrated pest management.

REFERENCES

Castner, J.L. 1984. Suitability of *Scapteriscus* spp. mole crickets (Orthoptera: Gryllotalpidae) as hosts of *Larra bicolor* (Hymenoptera: Sphecidae). Entomophaga 29: 323-329.

Castner, J.L. 1988a. Evaluation of *Larra bicolor* as a biological control agent of mole crickets. Ph.D. dissertation, Univ. Florida, ix + 139 p.

Castner, J.L. 1988b. Biology of the mole cricket parasitoid *Larra bicolor* (Hymenoptera: Sphecidae) [p. 423-432, IN:] Gupta, V.K. (ed.) Advances in Parasitic Hymenoptera Research. Brill; Leiden, 546 p.

Frank, J.H. 1990. Mole crickets and other arthropod pests of turf and pastures. Southern Cooperative Ser. Bull. 355: 131-139.

Hudson, W.G., Frank, J.H. 1987. Mole crickets: controlling them in Florida pastures is a tough job. Florida Cattleman (April 1987): 28, 30, 36.

Hudson, W.G., Frank, J.H., Castner, J.L. 1988. Biological control of *Scapteriscus* spp. mole crickets (Orthoptera: Gryllotalpidae) in Florida. Bull. Ent. Soc. Am. 34: 192-198.

Koehler, P.G., Short, D.E., Barfield, C.B. 1979. Mole crickets: IFAS research project. Florida Cattleman (June 1979): 91, 99.

Nguyen, K.B., Smart, G.C. 1989. *Steinernema scapterisci* n. sp. (Rhabditida: Steinernematidae). J. Nematol. 22: 187-199.

Nickle, D.A., Castner, J.L. 1984. Introduced species of mole crickets in the United States, Puerto Rico, and the Virgin Islands. Ann. Ent. Soc. Am. 77: 450-465.

Walker, T.J. (ed.) 1985. Mole crickets in Florida. Univ. Florida Agr. Exp. Stns Bull. 846 (1984): i-iv, 1-54.