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SURVEY OF PEST MOLE CRICKETS (ORTHOPTERA: GRYLLOTALPIDAE) ACTIVITY ON PASTURE IN SOUTH-CENTRAL FLORIDA

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Abstract

Histories of pest mole cricket activity (*Scapteriscus* spp. Scudder) (Orthoptera: Gryllotalpidae) on bahiagrass (*Paspalum notatum* Fluegge) pastures were needed to provide baseline data for evaluating on-going biological control with *Steinernema scapterisci* (Nguyen and Smart) nematodes. Seven ~4-ha pastures were selected from five county sites for the survey. These consisted of one mole cricket-infested bahiagrass pasture each from two ranches in Polk county and from one ranch each in Manatee and Pasco counties. The rest were two renovated and uninfested pastures located at the Range Cattle Research and Education Center, Ona, in Hardee county and a third in Desoto county. Six linear pitfall traps (each 12.2 m total) were installed on equal subdivisions (0.67 ha) of each of the seven pastures in July 1997 and labeled 1 to 6 at each site according to a visually-determined decreasing slope of terrain. Traps were cleaned weekly from the time of installation through December 1999, and the total weekly-captures per trap of tawny, *S. vicinus* (Scudder) and southern, *S. borellii*, (Giglio-Tos) mole crickets were recorded along with weekly rainfall for each site. The mean, weekly mole cricket capture on heavily-infested bahiagrass pastures increased exponentially over time beginning with the early summer rains. Mean weekly-count on these pastures peaked at 20-60 juveniles per trap, depending on site, in June-July and then declined sharply through September and October as mole crickets matured. The annual mean weekly-capture on heavily-infested pastures was 10 to 12 juveniles per trap. There was very little surface activity by overwintering adult mole crickets during December and January. Mean weekly-capture on uninfested new bahiagrass pasture was erratic and usually less than 2 juveniles per trap. The data suggest that peak weekly mole cricket pitfall trap captures between June and August in excess of 20 juveniles per trap and a total seasonal capture in excess of 43 m^{-1} of trap were indicative of a serious infestation problem.

Key Words: *Scapteriscus vicinus*, *Scapteriscus borellii*, *Paspalum notatum*, Linear pitfall trap, Pasture grasses

Resumen

Se necesita la historia de la actividad de plagas de los grillotopos (*Scapteriscus* spp.) (Orthoptera: Gryllotalpidae) en pastizales de grama de bahia (*Paspalum notatum* Fluegge) para proveer los datos iniciales para evaluar el control biológico en marcha con los nemátodos, *Steinernema scapterisci* (Nguyen and Smart). Siete pastizales de ~4-ha fueron seleccionadas de sitios en cinco condados para el sondeo. Estas consistian en una pastizal de grama de bahia infestada con grillotopos cada una de dos haciendas el condado de Polk y de una hacienda en cada uno de los condados de Manatee y de Pasco. Los restos fueron dos pastizales renovados y no infestados situados en el Range Cattle Research and Education Center, Ona (Centro de Investigación y Educación de Ganado de Rangos) en el condado de Hardee y una tercera en el condado de De Soto. Seis trampas de "pitfall" (trampas donde la presa cae en un hoyo en el suelo) en linea (cada 12.2 m total) fueron instaladas en subdivisiones iguales (de 0.67 ha) en cada una de los siete pastizales en julio de 1997 y marcadas 1 a 6 en cada sitio según la inclinación de terreno visualmente determinada. Se limpiaron las trampas semanalmente desde el tiempo de instalación hasta el diciembre de 1999, y se registrarón el número total del grillotopo aleonado, *S. vicinus* (Scudder) y del grillotopo sureño, *S. borellii*, (Giglio-Tos) capturados por trampa por cada semana junto con la cantidad de lluvia que cayó en cada sitio por semana. El promedio del número de los grillotopos capturados cada semana en pastizales de grama de bahia infestadas altamente aumentó exponencialmente sobre el tiempo empezando con las lluvias en el principio de verano. El promedio del número capturado semanalmente en estas pasturas llegó a lo mas alta de 20-60 juveniles por tampa, dependiendo del sitio, en junio-julio y luego bajó agudamente en septiembre y octubre cuando los grillotopos maduraron. El promedio anual del número capturado en pasturas altamente infestadas fué 10 a 12 juveniles por trampa. Habia muy poca actividad sobre la superficie por adultos de grillotopos invernando durante diciembre y enero. El promedio del número capturado semanalmente en pastizales de grama de bahia no infestadas fué érratico y usualmente menos de 2 juveniles por trampa. Estos datos sugieren que el número más alto de grillotopos capturados semanalmente en las trampas "pitfall" entre junio y agosto en exceso de 20 juveniles por trampa y una cantidad en exceso de 43 m^{-1} por trampa por toda la estación fueron indicativos de un problema de infestación seria.

Adventive mole crickets *Scapteriscus* spp. (Scudder) cause serious damage to pasture, lawn and crops in Florida. It is estimated from a survey (South Florida Beef and Forage Extension Program 1999) that nearly $45 million-revenue is lost annually to cattle producers in south central Florida as a result of reduction in hay and forage production as a result of mole cricket damage and an extra $10 millon/year spent on pasture renovation.

All three pest mole crickets found in Florida: tawny, *S. vicinus* (Scudder), southern, *S. borellii* (Giglio-Tos) and short-winged, *S. abbreviatus* (Scudder); were inadvertently introduced from South America in ship's ballast into ports of Georgia, South Carolina, Alabama and Florida in the early 1900s (Walker & Nickle 1981). From these points of arrival, the tawny and southern mole crickets spread westwards and southwards, and by 1960 had covered and become serious pests throughout Florida (Walker & Nickle 1981). Due to its inability to fly, the short-winged is largely restricted to point of introduction in coastal areas.

Mole crickets spend nearly all their year-long life cycle underground (Walker 1984), which makes population sampling very difficult. Eggs are laid in clutches in underground chambers. Nymphs tunnel to the surface and feed in the upper soil and litter. Juveniles and adults make and occupy extensive gallery and tunnel systems. In south and central Florida, tawny mole cricket has one generation per year, but the southern mole cricket has two generations annually (Walker 1984). It is only during their peak mating flights in early-spring and to a lesser extent in the fall that pest mole crickets are conspicuous to the casual observer.

Mole cricket damage to pasture and turfgrass is principally due to feeding by tawny mole crickets (Walker & Dong 1982; Hudson 1984). At night, mole crickets usually leave their tunnels to bite off stems and leaves, which are dragged into their burrows to be eaten. Roots are eaten at any time from within tunnels. Mechanical damage to plants is caused by the tunneling activity of mole crickets and this is the principal detrimental effect of southern mole crickets on pasture. Damage in pasture first appears in yellow patches which die and turn brown. In areas of high mole cricket population density, the surface 20 to 25-cm soil layer is honeycombed with numerous galleries and the ground feels spongy when stepped on. Heavily-damaged pasture has virtually no root system and is easily pulled from the soil by cattle or foot traffic in a pasture.

The most direct way to evaluate classical biocontrol agents is to compare the population levels of target species before and after establishment of natural enemies. Three basic sampling techniques for monitoring mole crickets have been described (Hudson 1988) although none has overcome the basic obstacle of showing good correlation with true population density. These sampling techniques are sound traps for flying adults (Walker 1982), linear pitfall traps for monitoring the activity of immature mole crickets (Lawrence 1982) and soil flushing for both juveniles and adults (Short & Koehler 1979). More than 20 yr data have been collected around suburban Gainesville and Bradenton on adult pest mole crickets' flight with sound traps (Walker et al. 1995). However, adult mole crickets can fly over long distances, and sound trap captures may not reflect the level of mole cricket infestation on specific ranches. Hudson (1989) developed an equation for soap flushing from repeated sampling that predicted mole cricket population estimates within 25% of the true population, however, soap detergent is lethal to *S. scapterisci* nematodes (Grover Smart, Jr., pers. comm.). Lawrence (1983) used linear pitfall traps to monitor the activity of juvenile mole crickets on pasture. Data on seasonal activity of mole crickets in Florida pastures are lacking.

This study was designed to use permanently set pitfall traps to monitor the long-term seasonal abundance of immature mole crickets on pasture in relation to rainfall and pasture damage. Abundance histories developed on specific ranches was to be used as baseline information for future evaluation of biocontrol with nematodes.

Materials and Methods

The survey was conducted on five ranches in south-central Florida and the Range Cattle Research and education Center, Univ. of Florida, following a severe mole cricket outbreak on pastures in central Florida in 1996. These sites represented two extremes of initial mole cricket infestation. In July 1997, six pitfall traps were installed on one 4-ha bahiagrass pasture at each of two ranches (A. D. Combee and George Clark) which had heavy mole cricket damage in the Green Swamp area of Polk county and one similar bahiagrass pasture each in Manatee (Harlee ranch) and Pasco (Mary Nutt ranch) counties. Six traps were also installed on two 4-ha, renovated pastures which appeared to be lightly infested with mole crickets at the Range Cattle REC, Ona, in Hardee county and another similar pasture in Desoto county.

The 4-ha bahiagrass pasture at each site was divided into six equal blocks (reps) each installed with one trap. Traps at each site were labeled 1 to 6 in decreasing slope of terrain and were cleaned weekly from July 1997 through December 1999. At cleaning, weekly-captured tawny and southern mole crickets in each trap were counted together. Body decomposition of nymphs during summer rainfall made differentiation between remaining tiny heads of tawny and southern mole crickets very difficult and unreliable. However, the heads were resistant to decomposition and used as markers for the weekly counts whenever body decomposition occurred. Development of immature mole crickets was monitored at one site in the Green Swamp area by measuring the length of the pronotum of 20 trapped mole crickets monthly from June 1998 to April 1999. Amount of weekly rainfall was recorded for the two Green Swamp sites in Polk county, the Manatee, and the Pasco sites. Bahiagrass pasture on each site was rated as to percentage green, yellow, dead or brown, bare ground, and weed cover, every spring using a subdivided m^2 quadrat. The quadrat had 100 divisions, each representing a percentage unit, and was thrown randomly to twenty-four locations (4 on each subdivision) on the 4-ha pasture.

Data on weekly trapped mole crickets were subjected to statistical analysis of variance (SAS 1999) with site as main plot and year and week as split and split-split plots in time, respectively, and traps as replicated blocks. Due to significant site by week ($P < 0.0008$) and year by week ($P < 0.0076$) interactions, weekly abundances of trapped mole crickets were fitted to week of the year, separately for each site, using SigmaPlot regression software (SPSS, Inc. 1997) that maximized regression R^2 and minimized standard error (SE). Ratings of pasture condition were analyzed as a split plot with site as main plot, year as split plot in time and pasture subdivision as replicates.

Results

The analysis of variance of weekly trapped immature mole cricket numbers on bahiagrass pastures from July 1997 to June 1999 is shown in Table 1. There was a distinct migration of pasture mole crickets from low-lying, inundated soils to drained soils at the peak of summer rains and vice versa during the dry spring period. This resulted in large trap location and trap location × week effect. As expected, trapped mole cricket numbers also varied depending on site of bahiagrass pasture, year and week of the year. The site × week, year × week interactions were significant and the site × year × week interaction approached significance ($P < 0.10$).

The 3-yr mean weekly trapped mole crickets ranged from 10.1 to 12.4/trap for the heavily mole cricket-infested pastures in the Green Swamp in Polk county, and the sites in Pasco and Manatee counties (Table 2). From 0.7 to 1.7 mole crickets/trap were found in the lightly-infested bahiagrass pastures in Desoto and Hardee counties.

Level of mole cricket infestation was highly correlated with pasture damage (r = 0.89). Sites where seasonal mean weekly mole cricket trap captures >10, such as Combee, Clark, Nutt, and Harlee ranches, had severe pasture damage (yellow + dead/weeds) ranging from 49 to 72% (Table 2). Conversely, the lightly-infested mole cricket sites including pastures at the Range Cattle REC and Desoto county stayed green in spring and showed little sward damage.

Mean weekly capture of nymph and adult pest mole crickets on damaged bahiagrass pastures within the year was best described by an exponential curve (Gaussian 3 Parameters) (Figs. 1-4). Most mole cricket eggs normally hatch in May and June (Walker 1984), and the number of trapped nymphs on pasture reached a peak after

Table 1. Sources of variation, degrees of freedom, F-test value, and the probability of a greater F-value for weekly distribution of pest mole crickets on bahiagrass pastures in south-central Florida.

Variable	df	F	Pr > F
Trap	5	6.86	0.0001
Site	6	3.08	0.0255
Site × Trap (Error a)	30		
Year	2	7.44	0.0001
Site × Year	12	0.64	0.8979
Site × Year × Trap (Error b)	60		
Week	51	3.72	0.0001
Site × Week	306	1.84	0.0008
Year × Week	102	1.72	0.0075
Site × Year × Week	612	0.86	0.0998
MSE (Error c)	4105		

TABLE 2. THE EFFECT OF BAHIAGRASS PASTURE SITE ON 3-YR MEAN WEEKLY PEST MOLE CRICKET COUNT/TRAP AND CORRESPONDING PASTURE DAMAGE.

County	Ranch	Weekly mole cricket count/trap	Damage estimate: Green	Damage estimate: Yellow	Damage estimate: Dead/weeds
		No.	% cover		
Polk	A. D. Combee	10.1	45	4	51
Polk	George Clark	12.4	50	12	38
Manatee	Harlee Farm	11.2	28	10	62
Pasco	Mary Nutt	11.0	51	37	12
Hardee	RCREC-71A[1]	0.7	98	1.5	0.5
Hardee	RCREC-87[1]	1.7	85	5	10
Desoto	Steven Houk	1.6	97	2	1.0
	LSD $P = 0.05$	5.7	12	8	10

[1]Range Cattle Research and Education Center, pastures 71A and 87.

the first major summer rainfall in June or July. For the 2.5 yr study, week 30 (X_0) had the highest mean peak weekly mole cricket trap count ('a' value) of 23 on Combee ranch (Fig. 1), week 25 of 26 peak trap count on Clark ranch (Fig. 2), and week 25 of 40 peak trap count on Nutt ranch (Fig. 3). On all these severely-damaged fields, there was at least one weekly-spike episode that

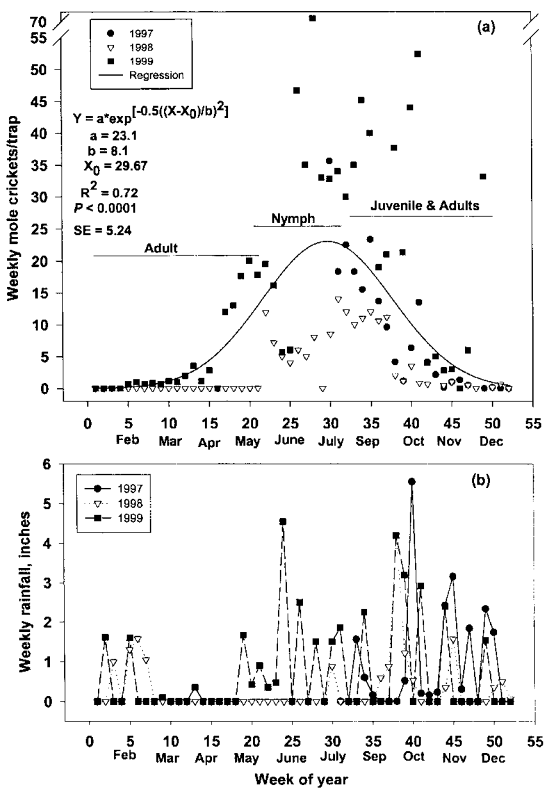

Fig. 1. Seasonal distribution (1997-1999) of mean weekly pitfall trap captures of immature *Scapteriscus* mole crickets (a) in relation to weekly rainfall pattern (b) on bahiagrass pasture at A.D. Combee Ranch in Polk county.

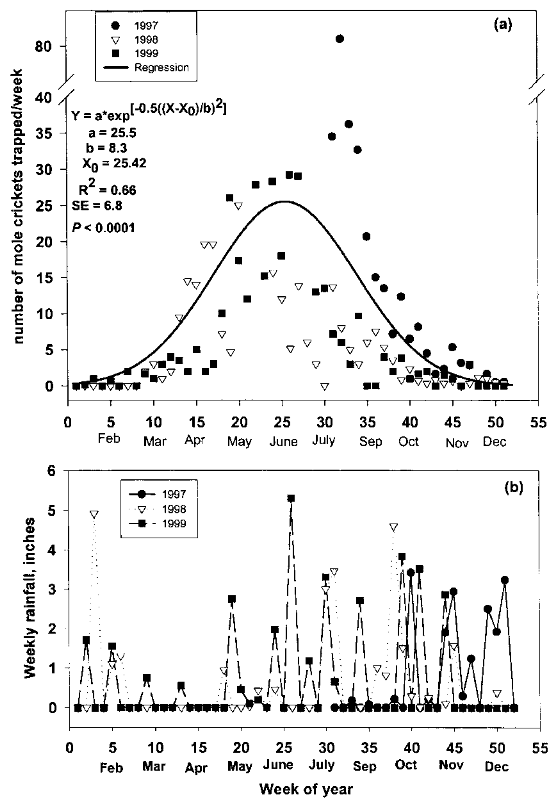

Fig. 2. Seasonal distribution (1997-1999) of mean weekly pitfall trap captures of immature *Scapteriscus* mole crickets (a) in relation to weekly rainfall pattern (b) on bahiagrass pasture at George Clark Ranch in Polk county.

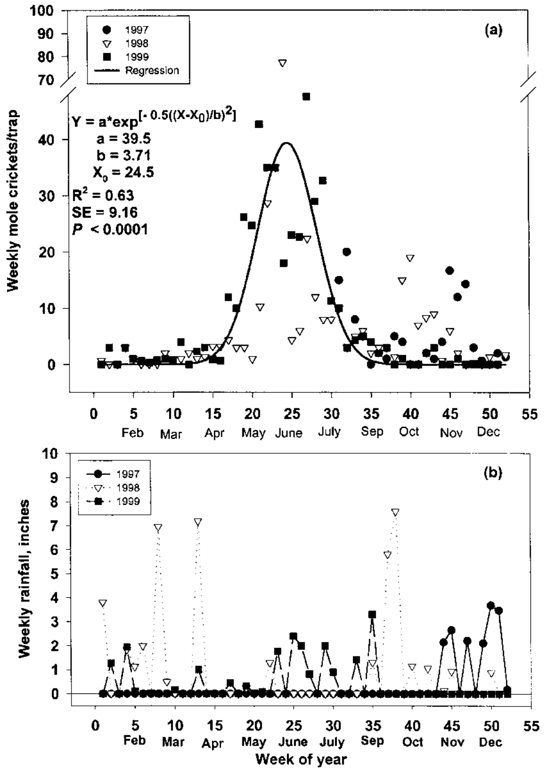

Fig. 3. Seasonal distribution (1997-1999) of mean weekly pitfall trap captures of immature *Scapteriscus* mole crickets (a) in relation to weekly rainfall pattern (b) on bahiagrass pasture at Mary Nutt Ranch in Pasco county.

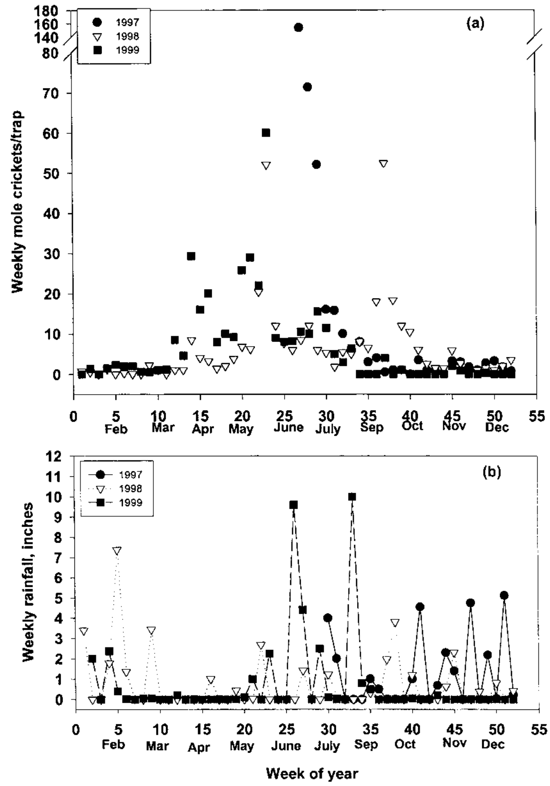

Fig. 4. Seasonal distribution (1997-1999) of mean weekly pitfall trap captures of immature *Scapteriscus* mole crickets (a) in relation to weekly rainfall pattern (b) on bahiagrass pasture at Harlee Ranch in Manatee county. Year × week interaction $P < 0.05$.

exceeded 50 nymphs/trap during the 2.5-yr monitoring. On Harlee ranch, also a heavily infested pasture, we experienced variable patterns of weekly nymph abundance over the years and a single exponential curve did not provide a good fit across years (Fig. 4). A weekly peak >100 nymphs/trap occurred in early July of 1997. A bimodal peak (June and September) averaging 45 nymphs/trap was observed in 1998, and a weekly peak of only 20 nymphs/trap in 1999 (Fig. 4). Weekly spikes of trapped nymphs on heavily infested pastures usually coincided with rainfall that saturated the soil early in the summer, forcing the nymphs to relocate within a pasture. Subsequent heavy rainfall within the season was not generally accompanied by similar hikes in nymph activity because they had already dispersed to higher grounds that were less likely to become saturated. There was also a lack of fit of trapped mole cricket data to week of sampling on the lightly-infested pastures in Hardee sites (Fig. 5) and mole cricket infestation on DeSoto site was low (‘1.6 nymphs/trap/week) but uniform throughout the year (plot not shown).

The mean pronotal length of 20 pitfall trap-captured mole crickets was 3.1 ± 0.3 mm in June; 4.8 ± 0.2 mm in July; 5.2 ± 0.3 in August; 5.8 ± 0.4 mm in September; 6.9 ± 0.5 mm in October; 7.3 ± 7 in November; and 11.6 ± 1.0 in April. When discernible, the ratio of numbers of tawny:southern mole crickets on pasture was approximately 3:1 but there was no difference in pronotal length between tawny and southern mole crickets. The increase in pronotal length and standard deviation of pronotal length over time was due to an increasing adult component in the population later in the season.

Discussion

The extent of damage observed on pastures was dependent on the level of pest mole cricket infestation. A seasonal mean-weekly mole cricket nymph trap capture >10 was associated with more than 50% pasture damage. A mean-weekly trap capture of 10 mole crickets amounts to 520 mole crickets per trap yearly. A mean-weekly trap capture of 1.7 mole crickets or 88 mole crickets per year was associated with moderate pasture damage (15%).

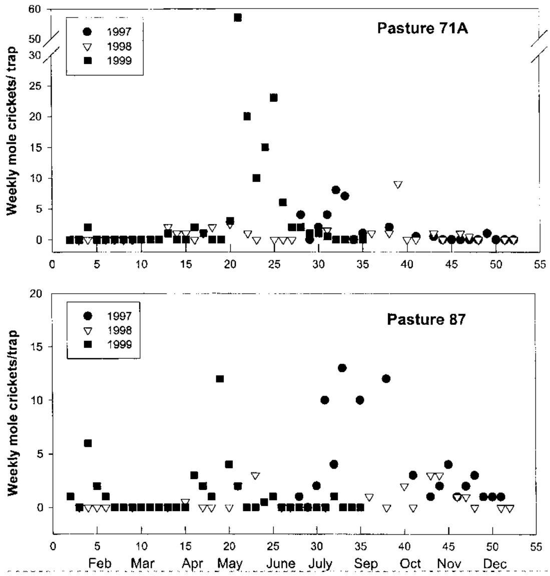

Fig. 5. Seasonal distribution (1997-1999) of mean weekly pitfall trap captures of immature *Scapteriscus* mole crickets on bahiagrass for Pastures 71A and 87 at the Range Cattle REC, Ona, in Hardee county.

Each trap had a total length of 12.2 m which suggests that the seasonal damage threshold falls somewhere between 7 and 43 mole crickets m^{-1} on bahiagrass pasture. In a 1-year study (1 May 1982 to 30 April 1983), Lawrence (1983) installed three linear pitfall traps (5.5 m total length) on bahiagrass turf in Palm Beach within 4.6 m of a sound trap station (Walker 1982) and captured 609 immature mole crickets of which 89 were *S. borellii*, 139 were *S. vicinus* and 381 were *S. abbreviatus.* Within the same 12 month period, 13,496 adult *S. borellii* and 197 *S. vicinus* were captured in the sound station. It is known that many crickets attracted to sound callers miss the sound trap, therefore, Lawrence's (1983) total capture of 111 *Scapteriscus* nymphs m^{-1} of pitfall trap could have been inflated by egg deposition in the vicinity from adult females which missed the sound traps. We did not encounter any *S. abbreviatus* in our study on ranches in central Florida probably because that species was restricted to coastal areas where it was first introduced because it cannot fly. Similar to our data, 85% of Lawrence's (1983) mole cricket nymphs were captured between June and August, and the nymphs increased in pronotal length from 2 to 9 mm between June and April.

Mole cricket buildup on Hardee and DeSoto sites following pasture renovation was slow. Results seem to agree with the general producers' perception that it takes >3 yr after a successful pasture renovation before mole cricket populations in bahiagrass fields build up to damaging thresholds.

Decline of mole cricket pitfall captures in late summer and fall has been attributed to marked differences between nymph and adult mole cricket behavior (Hudson 1989) and also to the action by generalist native natural enemies (Hudson et al. 1988). Available evidence (Hudson 1985; Hudson & Shaw 1987) suggests that nymphs are largely nomadic, with no "home" burrow, and so are more likely to seek escape on the surface whereas adults often have an established and deep burrow system into which they retreat rather than coming to the surface. Adult females in the fall tend to dig a permanent burrow system and stay there, with little apparent foraging. Males are more active on the surface but not as active as nymphs and they also dig extensive burrow systems (Nickerson et al. 1979).

Both the natural decline in surface activity and the action by generalist natural enemies have been inadequate to prevent heavy damage in pastures and turf during fall, for which reason a program was begun to import South American specialist natural enemies (Sailer 1984). Four specialist natural enemies have been imported to Florida, three of them released and established, and their future in integrated pest management of pest mole crickets has been outlined (Frank & Parkman 1999). The nematode, *S. scapterisci* Nguyen & Smart (1990), received research emphasis in the late 1980s, attracted attention from industry as a biopesticide, and perhaps appeals to most ranchers because it can be purchased and applied as a pesticide (a method familiar to them). Our preliminary analysis did not show nematode infection of mole crickets trapped in any of the test sites. Other biocontrol agents such as *Ormia depleta* Wiedemann and *Larra bicolor* F. may yet prove to be more effective and less costly, but data on their efficacy are incomplete, and methods for management of their field populations are inadequately researched because of lack of funds.

Development of mole cricket seasonal activity history on bahiagrass pasture is critical for evaluation of a successful outcome of any biocontrol agent. Spikes of nymphs exceeding 100 per pitfall trap may be captured following the early summer rains, but a mean seasonal capture >10 nymphs m^{-1} of trap may indicate the start of a mole cricket infestation problem and may represent a working threshold for future studies.

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