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NOTES ON BIOLOGICAL STUDIES OF MOLE CRICKETS AT PLANT CITY, FLORIDA

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Investigations on the control of mole crickets were carried out in conjunction with the Mole Cricket Control baiting programs which were conducted in central Florida during the fall seasons of 1940 and 1941. With the establishment of a more permanent research program for the study of these insects in 1942 it was possible to devote more attention to the biology of the different species.

Farms, gardens, lawns and golf courses of central Florida had suffered severely from *Scapteriscus acletus* R & H (Southern Mole Cricket) and *Scapteriscus vicinus* Scud. (Changa or Puerto Rican Mole Cricket). The so-called Northern Mole Cricket, *Gryllotalpa hexadactyla* Perty, had not increased in such numbers as had the two species of *Scapteriscus*. The major emphasis of these studies, therefore, has been placed on the biology of *S. acletus* and *S. vicinus*, with some data accumulated for *G. hexadactyla* under Florida conditions.

Barret (1) in 1902 and Van Zwaluwenburg (2) in 1918 treated extensively of *S. vicinus* in Puerto Rico, while Worsham and Reed (3) in 1912 described the life history and habits of this species in eastern Georgia. *Scapteriscus acletus* from Georgia was described by Rehn and Hebard (4) in 1916. Cockerham (5) in 1922 reported damage by this species near Mobile, Alabama, and in 1931 a serious outbreak occurred at Sanford,

[1] Acknowledgment is made of the supervision of these studies by C. B. Wisecup, Assistant Entomologist, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture, in charge of Mole Cricket Investigations at Plant City, Florida, and of the assistance furnished by the other members of the staff.

Florida. Tenhet (6) studied this Florida infestation from 1934 to 1939 and has made his findings available to the present investigators.

The investigations herein reported were conducted for the purpose of comparing the biology of the various species as reported from other localities with the life histories of all three species as obtained under one set of comparable conditions, and for the further purpose of locating those periods in the biology during which the insects would be most susceptible to control.

METHODS USED IN BIOLOGICAL STUDIES

The technique for studying life histories followed closely that of Tenhet. A total of 140 rearing cages was used in the life history studies. These cages consisted of eight-inch flower pots placed upright in the soil with about two inches of the container above the ground level. The pots were filled with soil, covered with screen lids, and shaded with individual conical roofs. Grass and weeds were encouraged to grow around the pots for the shade which they would furnish. Paired adults and developing nymphs were both kept in these cages. A plentiful supply of food in the form of compost and a mixture of wheat bran and corn meal was supplied on the surface of the soil.

Incubation chambers were made by placing one of the flower pots upright in the soil, while a second pot filled with soil was inserted into the bottom container. This arrangement left space for about twenty salve tins in the bottom where they would remain at soil temperature and moisture. The eggs were removed from the cages and placed in small salve tins. An absorbent paper disc was inserted in the tin and moisture added to this disc. The tins were then stored in the incubation chambers.

The developing nymphs and adults were examined weekly during warm weather for development and egg deposition. The incubating eggs were inspected daily for hatching and moisture content. Two to four days after they had emerged, the nymphs were removed from the tins and placed in one gallon buckets with soil. These were placed in the laboratory for protection from ants, and after one week they were placed in the flower pots as described above.

Glass observation cages were constructed and placed in the laboratory. It was felt that much could be learned of the habits and peculiarities of mole crickets from this type of supple-

mentary study. The cages were constructed of panes of glass 24 inches long by 12 inches wide, placed in a grooved frame and spaced two inches apart. The cages were placed upright upon a desk where they could be observed.

Frequent observation trips were made to the field to serve as checks on the technique used in life history studies. Records were kept of egg deposition and development of the nymphs in the field. Field oviposition was studied by means of small rectangular plots which were carefully examined, using square-pointed shovels with which the soil was skimmed off in thin layers, thus exposing all egg cells without destroying them.

INFORMATION ON *SCAPTERISCUS ACLETUS* AND *S. VICINUS*

(a) Egg

Both species deposit their eggs in sealed, ovate shaped cells or chambers, the long axis of which measures about one and one-half inches. These cells are located from one inch to about one foot beneath the soil surface, depending upon the moisture, the temperature and the type of soil. Low temperatures and dry soil resulted in cells being placed deeper, while cells were made nearer the surface in warm, moist soils. Most of the chambers were found in the upper five inches of the soil where truck crops were grown. An average of about 35 eggs were found in field collected cells. Mole cricket eggs of these species are oval and unsculptured and are dirty gray or brownish in color when first laid, although a few are nearly white. Most of the eggs have a dusty appearing surface, while others are shiny. As the eggs mature they change color and become larger. When first deposited the eggs average about one-eighth by one-sixteenth inch, and just before hatching they are about 25 percent larger. As development proceeds the color changes to a milky white or light brown and just before the nymphs emerge the reddish-brown appendages become visible through the chorion. The eggs are not cemented together in any way, but lie free in these ovate shaped cells. The adult female never attends her eggs or young as does *G. hexadactyla.*

Table 1 records the data obtained from three field samples showing egg deposition, each of which comprised 18 square feet. Samples "a" and "b" were made on the same low moist field at different dates, sample "a" being made on April 21, and sample "b" on May 5, 1942. Sample "c" was obtained from a different field of high, sandy soil on May 6. The difference in depth of

egg cells in the two fields was outstanding, averaging 3.8 inches for the low moist soil and 7.25 inches for the high, sandy soil. The average number of eggs per cell was 35, and the average number of nymphs was 25. The difference, about 30 percent, between the number of eggs and nymphs was probably due to cannibalism and imperfect incubation. Five cells per 18 square feet found on April 21 compared with 12 cells found on May 5 on the same property demonstrates the increase of eggs and young nymphs. This heavily infested property probably contained over one million eggs and tiny nymphs per acre on May 5.

TABLE 1.—FIELD SAMPLES OF MOLE CRICKET EGG CELLS.*

	Cell Number	Depth in Soil (Inches)	Number Eggs in Cell	Number Nymphs in Cell
a.	1	4	31	—
	2	3.5	30	—
	3	4	31	—
	4	4	37	—
	5	4	34	—
Average		3.9	32	—
b.	1	1	—	7
	2	3	20	—
	3	3.5	40	—
	4	4	—	35
	5	3.5	38	—
	6	4	56	—
	7	4	—	26
	8	4	—	34
	9	4	48	—
	10	4.5	50	—
	11	5	Cell destroyed—no count	
	12	4	41	—
Average		3.7	42	25
c.	1	4.5	25	—
	2	5.5	26	—
	3	5.5	10	—
	4	7	41	—
	5	7.5	29	—
	6	10	40	—
	7	6.5	33	—
	8	6.5	39	—
	9	9	27	—
	10	10.5	40	—
Average		7.25	31	—

* Sampling areas (a, b and c) were 3 ft. by 6 ft. in area and at least 18 inches deep.

Egg deposition for both species began the latter part of March in 1942 in the field and in the laboratory life history cages. In the rearing cages the peak of egg deposition was

reached in May. As shown in Figure 1, the last eggs were deposited by *S. vicinus* during the latter part of July while *S. acletus* deposited eggs until the early part of September. About 77 percent of the *S. vicinus* eggs and 70 percent of the *S. acletus* eggs were deposited from May 1 to June 15. Nearly 99 percent of the eggs of *S. vicinus* were laid by the first of July compared with 89 percent of the *S. acletus* eggs.

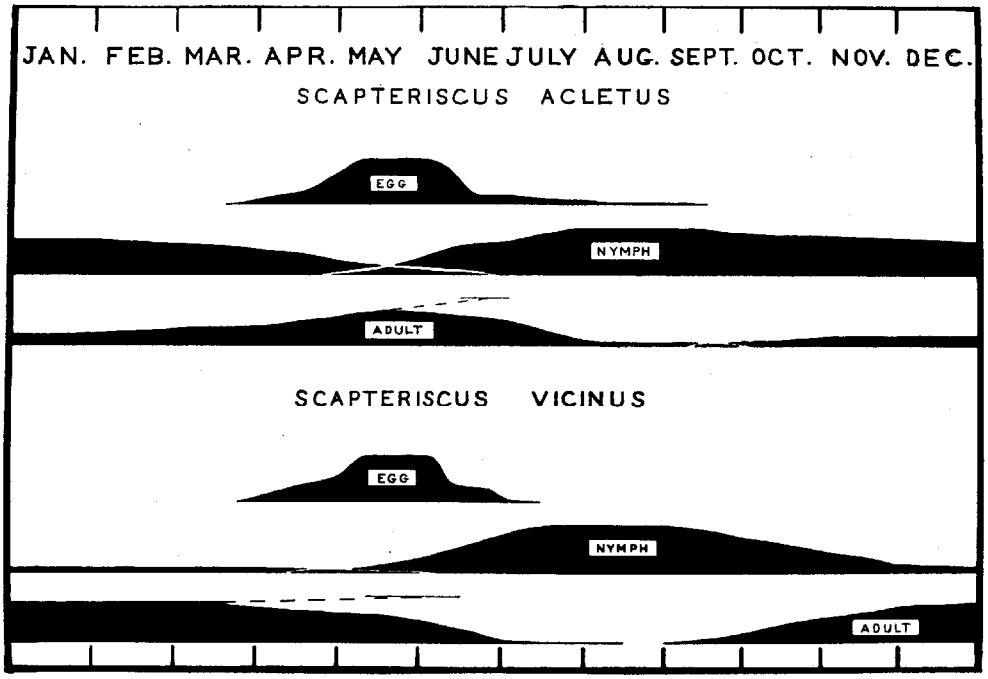

Fig. 1.—Seasonal development of *Scapteriscus acletus* and *S. vicinus*.

A total of 146 egg-cells was obtained from *S. acletus* females in the life history cages. These cells contained from 1 to 50 eggs, the average being 22 eggs per cell. The average number of cells for each female was 4.8. A total of 96 cells was obtained from *S. vicinus* females. These cells contained from 1 to 38 eggs, averaging 20 eggs per cell. The average number of cells per female was 3.4. The number of eggs found in 112 field collected cells of both species ranged from 10 to 59 with an average of 35.6 eggs per cell. This is a much larger number than was obtained from the life history cages, but such is to be expected since the confinement and constant disturbance of the crickets in the pots probably decreased the amount of egg deposition.

The period of incubation appears to be definitely influenced

by the temperature. Table 2 shows the decrease in the incubation period which occurred with an increase in the mean monthly temperatures. Eggs which were deposited in late March required 37 days to hatch for *S. acletus* and 32 days for *S. vicinus* during the mean temperature of 69.3 degrees F. Eggs deposited in July required 16 days for *S. acletus* and 11 days for *S. vicinus* during July and August when the mean temperature was about 84 degrees F. The average incubation period for the entire period was 21 days for *S. acletus* and 18.5 days for *S. vicinus*. The average percent incubation for the entire lot of eggs was 47 percent for *S. acletus* and 42 percent for *S. vicinus*. Observations have indicated that a larger percent hatch in the field under normal conditions.

TABLE 2.—EGG DEPOSITION AND PERIOD OF INCUBATION FOR *S. acletus* AND *S. vicinus* DURING 1942.

Month Eggs Deposited	Mean Temperature (F.)	Percent of Eggs Deposited		Average Period of Incubation (Days)	
		S. acletus	*S. vicinus*	*S. acletus*	*S. vicinus*
March	63.4	0.7	1.1	37.0	32.0
April	69.3	13.5	18.5	30.5	24.5
May	75.2	49.8	53.9	22.0	17.9
June	80.5	25.5	25.4	18.4	15.5
July	84.6	8.6	1.1	16.1	11.0
August	83.6	1.2	—	16.5	—
September	81.1	0.7	—	—	—

(b) Nymph

Hatching first occurred during the latter part of April for *S. vicinus* and the early part of May for *S. acletus* in the life history chambers. The peak of hatching was reached during the first half of June for both species. The last hatching for *S. vicinus* occurred the latter part of July and for *S. acletus* the early part of September.

The nymphs escape from the egg by means of a longitudinal slit in the chorion. The young nymph is almost pure white, but quickly becomes bluish on the prothorax and on the appendages. From bluish the nymphs turn blue-black, and then almost black, with white or gray markings. Some of the nymphs when first hatched have yellow abdomens. Immediately after hatching, the young nymphs search and fight for food in the egg cell and have been observed eating eggs, the chorion, and other weaker

living nymphs. Many of the mole crickets are destroyed in this manner. The nymphs of *S. vicinus* are known to remain in the cell for a week or more after hatching, under laboratory conditions.

Two egg cells of *S. vicinus* which were laid against the glass in the observation cages were watched for several weeks. Both of these groups of nymphs required about nine days before they were able to escape from the burrow, which they accomplished by digging a small tunnel straight up from the egg cell to the surface.

No record was kept on the number of molts, but the young nymphs grow rather rapidly during the summer months and adults begin to appear in September. Very little development occurs after cold weather arrives, and those nymphs which have not reached the adult stage by this time overwinter as nymphs, transforming into adults in the spring. About 75 percent of the *S. acletus* and 15 percent of the *S. vicinus* have overwintered as nymphs during the past two seasons in this area.

(c) Adult

These subterranean orthopterous insects average about one and one-fourth inches in length, exclusive of antennae or cerci, and are about three-eighths inch in width. Their bodies are well adapted for burrowing, the strong shovel-like forelegs serving to dig the tunnel and the greatly enlarged heavily chitenized prothorax serving to shape and firm the soil. The fore wings which overlap and are rounded on the ends, are shorter than the abdomen. The hind wings which are thin and transparent fold fan-like beneath the fore wings and extend over the tip of the abdomen. A dark spot on the fore wings of the male, resulting from a coalescence of wing veins which forms the file of the stridulating organ, distinguishes this sex from the female. This character may be observed in the large wing pads of the developing nymphs, making possible the separation of sexes before they become mature.

The morphological characters used in separating the species of *Scapteriscus* are found in the fore legs and the terminal ventral plates. Figure 2 shows these morphological differences. In the fore-legs of *S. acletus* the two tibial dactyls are separated by a space almost as great as the width of one of them, while in *S. vicinus* these tibial dactyls are separated by a space de-

cidedly less than the width of one of them; i.e., U-shaped in *S. acletus,* but V-shaped in *S. vicinus.* Another definite characteristic concerns the dark pigmented spot which may be noted toward the basal end of the trochanter in both *S. acletus* and *S. vicinus* and a dark sclerotized ridge which runs basally on the apical end of the trochanter. In *S. acletus* this ridge ends well above the pigmented spot, while in *S. vicinus* it is found to end nearly even with the darkened spot. The terminal ventral plate of the male *S. vicinus* is narrowly and conspicuously prolonged posteriorly, but the corresponding plate of the male *S. acletus* is not prolonged. When viewed dorsally the prothorax of *S. vicinus* is broader than that of *S. acletus.*

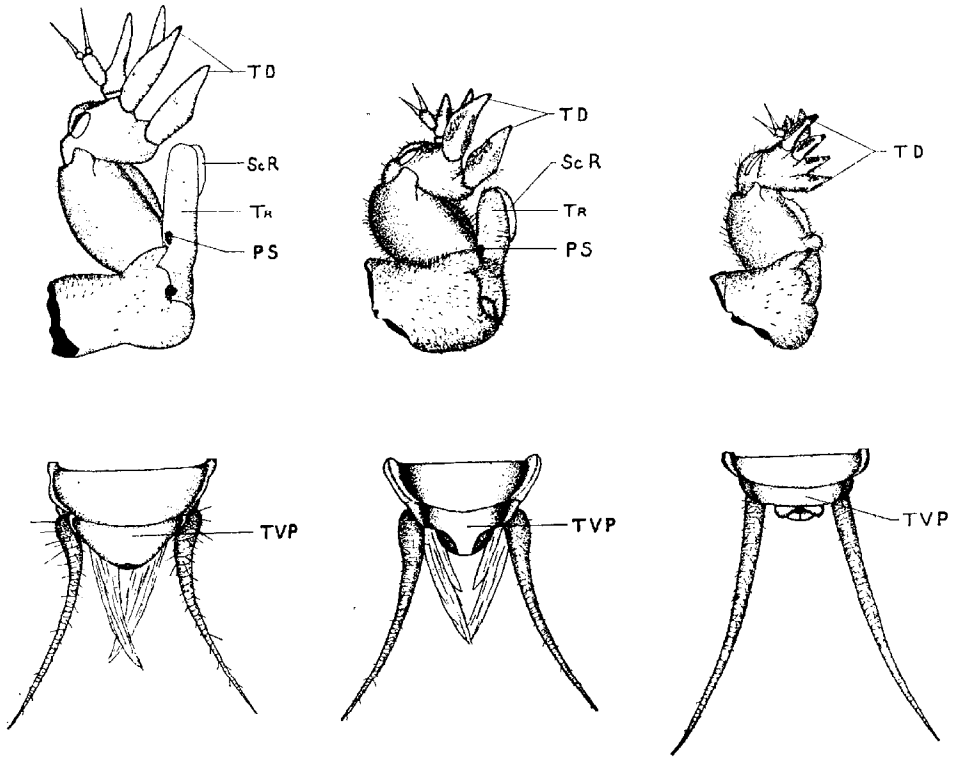

Fig. 2.—Fore leg and terminal ventral plate of: a *(S. acletus),* b *(S. vicinus),* and c *(Gryllotalpa hexadactyla).* TD = tibial dactyls; Tr = trochanter; PS = pigmented spot; ScR = sclerotized ridge; TVP = terminal ventral plate.

The color pattern of the two species is usually distinct, but cannot be depended upon for separation in all cases as there are extreme gradations within the same species. In general, *S. acletus* is brownish-gray with white or greenish markings on the lateral surfaces of the abdomen, while *S. vicinus* is red-

dish to creamy brown with darkened areas. *S. vicinus* has the habit of "playing possum" when exposed or disturbed, while *S. acletus* always burrows into the soil the moment it is exposed, except when the weather is cold.

There are heavy flights of adults in the spring and fall. Such flights usually occur following a shower during warm weather. The mole crickets are attracted to lights and some of them can be caught in light traps during these flights. Flights seem to be for the purpose of dissemination alone, since it appears that mating occurs in the burrows. Flights usually begin shortly after dark and last for about one hour. The mole crickets do not fly during bright days, but they have been observed to take wing on dark cloudy days. *S. acletus* has been the dominant species collected during fall flights, while both species took part in the spring flights.

There are two distinct "types" of development; namely, those nymphs which reach the adult stage in the fall before the weather becomes cold, and those which pass through the winter as nymphs, transforming into adults in the spring. In order to present reliable data, these "types" of development have been considered separately, as an average would give figures which would fit neither "type." Table 3 presents a summary of the life cycles of *S. acletus* and *S. vicinus,* separated according to the stage of overwintering. Egg deposition began about one month earlier for the overwintering adults, probably giving the subsequent nymphs a better chance to reach the adult stage prior to lower temperature than the progeny of the spring adults. The life cycle of both species appears to be about one year.

The egg laying period of the two species was quite different in the life history cages. The oviposition period of each female *S. acletus* averaged 61 days, compared with 33 days for *S. vicinus.* Many adults died immediately following the deposition of the last cell of eggs. The peak of mortality for the *S. vicinus* adults occurred in June, with the last laboratory specimens dying on July 17. The peak of mortality for *S. acletus* adults occurred in July, and the last specimen died on September 11.

(d) Food Habits

Only a limited amount of information is available on the food habits of these species. The greatest injury is noted in

TABLE 3.—SUMMARY OF LIFE CYCLE OF *S. acletus* AND *S. vicinus*, SEPARTED AS SPRING ADULTS AND FALL ADULTS.*

	Average *S. acletus* Adult Transforming in Fall	Average *S. acletus* Adult Transforming in Spring	Average *S. vicinus* Adult Transforming in Fall	Average *S. vicinus* Adult Transforming in Spring
Date became adult	Oct. 20	April 8	Oct. 15	April 9
Preoviposition period	6 months	37 days	6½ months	43 days
Date eggs deposited	Apr. 17 - June 19	May 15 - July 13	Apr. 26 - June 3	May 22 - June 20
Oviposition period	63 days	59 days	38 days	29 days
Date female died	July 7	July 24	June 13	June 29
Length of adult stage	8½ months	107 days	8 months	81 days
Incubation period	30 - 18 days	22 - 16 days	24 - 16 days	18 - 16 days
Date nymphs hatched	May 17 - July 7	June 6 - July 30	May 20 - June 19	June 9 - July 6
Nymphal period — fall adult	133 days	133 days	135 days	135 days
Nymphal period — spring adult	9 months	9 months	10 months	9½ months
Date became adult** — in fall	Sept. 27 - Nov. 17	Oct. 17 - Dec. 10	Oct. 2 - Nov. 1	Oct. 22 - Nov. 18
Date became adult** — in spring	April 8	April 8	April 9	April 9

* This summary is based upon 10 months laboratory biological studies and one and one-half years field collection records and observations.

** Only a few specimens transformed into adults after October. Most of those not reaching the adult stage by November overwintered as nymphs.

seed beds where the mole crickets uproot plants severely. The moist loose soil in such locations is a favorite habitat for these insects. Some damage is done in the truck farms, especially immediately following the transplanting of young seedlings. This injury is in the form of uprooting or drying out of the plants, and in some cases the actual chewing and severing of both roots and stems of plants. Mole crickets have been observed cutting off plants and pulling them down into their burrows in order to feed on the stems. Another possible indirect injury which is difficult to evaluate is the reduced vigor of the plants due to the constant burrowing around the roots throughout the crop season.

Mole crickets are believed to feed largely on decomposing organic matter in the soil. They are usually plentiful in old compost piles and are often numerous in poultry yards and stock pens. They come to the surface and eat ripening strawberries and sometimes chew on the crowns of the plants. When peanuts were planted where *S. vicinus* was plentiful severe damage to the developing nuts was experienced. This damage to peanuts usually consists of holes through the shell with the kernels eaten. Mole crickets will eat each other, and other animal matter has been found in their crops. They are attracted to wheat bran, corn meal and cottonseed meal. Corn syrup, cane syrup and honey appear to add to the attractiveness of some slightly attractive materials but does not add to the attractiveness of wheat bran.

Most of the surface feeding appears to occur during the time when the soil is moist and the weather warm; however, some feeding is done during dry weather. Marked injury has been noted where transplanted seedlings in dry fields had been watered, the mole crickets appearing to prefer these moist places and to burrow and feed around the freshly watered plants. Most of the feeding occurs at night or in the late afternoon, the crickets then being more active near the surface where they make the haphazard characteristic burrows. During periods of inactivity the mole crickets retire to a more permanent burrow which extends to a depth of about 14 inches. Each individual has its own burrow, and remains here for long periods of time during cold weather.

It has been noted that *S. acletus* has been responsible for a great proportion of the surface burrowing, the damage from this species consisting essentially of the mechanical injury re-

sulting from such excessive burrowing. While *S. vicinus* appears to do much less surface burrowing, this latter species has demonstrated that it is responsible for much of the direct feeding injury which has been found. Much of the *S. vicinus* damage to transplanted seedlings has occurred with little or no evidence of surface burrowing, the insect merely burrowing up under the plant and feeding on it.

(e) Observations on Natural Control

Cannibalism occurred in the laboratory where it was very pronounced among the young nymphs, and this probably holds true in the field. In the adults it is probably of little value in reducing the population, but it is believed that the tiny nymphs, in devouring each other, greatly reduce the population even before they emerge from the egg cell.

No study of natural control has been made, but observations show that birds, chickens, skunks, and toads take a toll of mole crickets in this area. The predaceous bug *Sirthenea carinata* is found in large numbers in certain areas. Two fungi have been observed to attack these insects, especially in the adult stage. The mummified mole crickets are first filled and then covered with white hyphae which later bear light green spores in the case of *Metarrhizium anisopliae* but have a distinct brick red appearance in the case of *Sorosporella uvella*. There are indications that the fungi are more prevalent on *S. vicinus* and appear to be materially reducing the population of this species.

INFORMATION ON *GRYLLOTALPA HEXADACTYLA*

The native mole cricket is found in the heavier moist soils, and is not a problem on most truck farms.

The eggs are deposited in a pocket-like cell opening into the permanent burrow of the female. Field samples indicate that from 30 to 70 light gray eggs may be found in each cell. The female guards over her eggs and young nymphs. Most of the eggs were deposited in May, and the incubation period averaged 19½ days in the life history cages. The nymphs develop rapidly through the summer with most of them reaching the adult stage by the time cold weather sets in. Nymphs in the life history cages transformed into adults in October and November. The adults of this species have never been observed in flight in this area and it seems very doubtful that the short wings are large enough for this purpose.

DISCUSSION

The information on life history which has been secured at Plant City, Florida, as summarized in Table 3 and presented in Figure 1, agrees quite closely with the data of Tenhet regarding *S. acletus*. It appears that there has been no change in the habits of this species during the ten years it has been under observation in peninsular Florida.

In general, the life history of *S. vicinus* in Puerto Rico as described by Van Zwaluwenburg corresponds to that found for this species at Plant City. He states that individuals were brought to the adult stage every month of the year, but that there seemed to be a fairly well defined preponderance of final molts during the fall months. He further states that females (in captivity) deposited eggs every month of the year except December, the greatest activity being shown during April, May and June.

The observations on *S. vicinus* in central Florida indicate that this somewhat tropical species is more restrained by the climatic conditions which prevail at Plant City and is kept within more definite limits of development. This species practically disappears from the upper soil areas during the normal winter weather, burrowing only during periods of warm weather. From November until March it is usually possible to find specimens of this species only by digging deeply into the soil where they are found at the end of their burrows in a sluggish, almost inactive, condition.

The fact that the egg laying and hatching periods for all of the species of mole crickets in this area coincide so closely during April through June indicates that the cultural practice of deep plowing as suggested by Tenhet for the control of *S. acletus* should merit further attention in the study of control measures for all species in central Florida.

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THE MUTILLIDAE OF GEORGIA

Mr. P. W. Fattig, Curator of the Museum at Emory University, has just (July 1st) published a bulletin (Number 1 of the Museum) which will be of considerable interest to our readers who are interested in the velvet ants. Undoubtedly a good percentage of the species listed in this bulletin are also found in Florida and his publication should be very useful to one interested in the Mutillidae of Florida. He has paragraphs on the hosts of Mutillidae to which he has added 13 new hosts; also one on the mating of the Mutillidae. He lists 58 species as found in Georgia giving the localities in which they were collected. In all he records 3,793 collections. A bibliography of the group is also included.

Professor Fattig is well known to the older residents of Florida, as he was connected with the University for several years.—Ed.