

## Geographical Variation in Flights of the Mole Cricket, *Scapteriscus* spp. (Orthoptera: Gryllotalpidae)<sup>1</sup>

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**ABSTRACT** *Scapteriscus acletus* Rehn and Hebard and *S. vicinus* Scudder were accidentally introduced to the United States from South America, and between 1920 and 1960 they spread from northernmost to southernmost mainland Florida, a north-south distance of 600 km (= 5.7° lat.). Latitudinal variation in the life cycles of these recently established populations was studied by monitoring seasonality of flight for 1 to 3+ years at nine stations in peninsular Florida. Flights of both species generally showed a large spring peak and a small fall peak annually, with the fall peak of one year and the spring peak of the next attributable to a single generation of adults. Geographical variations in *S. vicinus* flights were minor, with the median cricket of both spring and fall flights captured at stations in north Florida several weeks later than in south Florida. Flights of *S. acletus* were likewise similar along the latitudinal gradient, except that at three stations in south Florida a summer peak of flight occurred that rivaled or exceeded the spring and fall peaks. This suggests that *S. acletus* has, in less than 40 years, made the transition from one to two generations per year, a latitudinal change that is rare in native eastern North American crickets.

*Scapteriscus acletus* Rehn and Hebard and *S. vicinus* Scudder are the most abundant mole crickets in the United States and are classed as major pests of pastures, turf, and vegetable crops in Florida and neighboring states. Both species were accidentally introduced at Brunswick, Ga., from temperate South America in ca. 1900, reached north Florida by 1920, and spread 600 km southward to the tip of the Florida peninsula by 1960 (Walker and Nickle 1981). This rapid latitudinal spread (5.7° lat.) provides an opportunity to study how two invading species have adapted to successively milder climates. At Gainesville, Fla., for example (Fig. 1), average dates of first and last killing frosts are 6 December and 14 February, making a growing season of 295 days. At Fort Lauderdale, Fla., the average growing season is 365 days, with killing frosts recorded for only 5 of 29 years (Bradley 1972).

Changes in life cycles of these mole crickets are of interest not only because of what they reveal about adaptation (see Dingle 1978, Denno and Dingle 1981), but also because they may be critical to attempts to colonize biological control agents from South America. Success should be more likely if mole cricket life cycles in the areas of introduction match those in the source areas.

The rapid range extension of *S. acletus* and *S. vicinus* can be attributed to their frequent flights, sometimes in such numbers as to disrupt lighted sporting events, or even Disney's Magic Kingdom (Jerry Hagedorn, personal communication). These flights, consisting largely of females preparing to mature a clutch of eggs, facilitate studies of geographical variations in life cycles. Sampling is easy, because each species lands in large numbers at high-intensity sources of its calling song (Forrest 1980, 1983, Walker 1982).

### Materials and Methods

Standardized sound trapping stations (Walker 1982) were established at four latitudes approximately evenly spaced from Gainesville to Fort Lauderdale, Fla. (Fig. 1). At the northernmost and southernmost latitudes, replicate stations were established to estimate the precision of trapping data at a latitude. Pilot operation at one station began on 1 September 1978. Throughout 1980 and 1981, one or more stations were operated at each latitude, except that the north-central latitude was monitored only for 1980.

The latitudinal spread (3° 37'; 400 km) of our trapping stations included most of the southward range extension of the two species. The northernmost stations were interior and had winters more severe than if coastal sites had been used. The approximate locations of all stations are mapped in Fig. 1; details are as follows.

#### North (29° 40' N. Lat.; Gainesville)

Station GVL-A (1 September 1978 to 31 December 1981) was in a 5-ha bermuda- and bahiagrass pasture surrounded by woods of slash pine and mesic hardwoods (NW corner of sec. 31, tp. R19E, T9S). Station GVL-B (15 February to 31 December 1979) was in a 2-ha bermuda- and bahiagrass pasture at the University of Florida Experiment Station Farm (SW 1/4, sec. 7, tp. R20E, T10S). Station GVL-C (1 January 1980 to 31 December 1981) was in the operations area (dominated by bahiagrass) of University of Florida, Department of Agronomy, Green Acres Farm (NE 1/4, sec. 27, tp. R18E, T9S).

#### North-Central (28° 04'; Walt Disney World)

Station DSW (1 January to 31 December 1980) was at the Grounds Maintenance Complex of Disney's Magic Kingdom (SW corner of sec. 23, tp. R27E, T24S). Bahiagrass turf surrounded buildings and waste treatment

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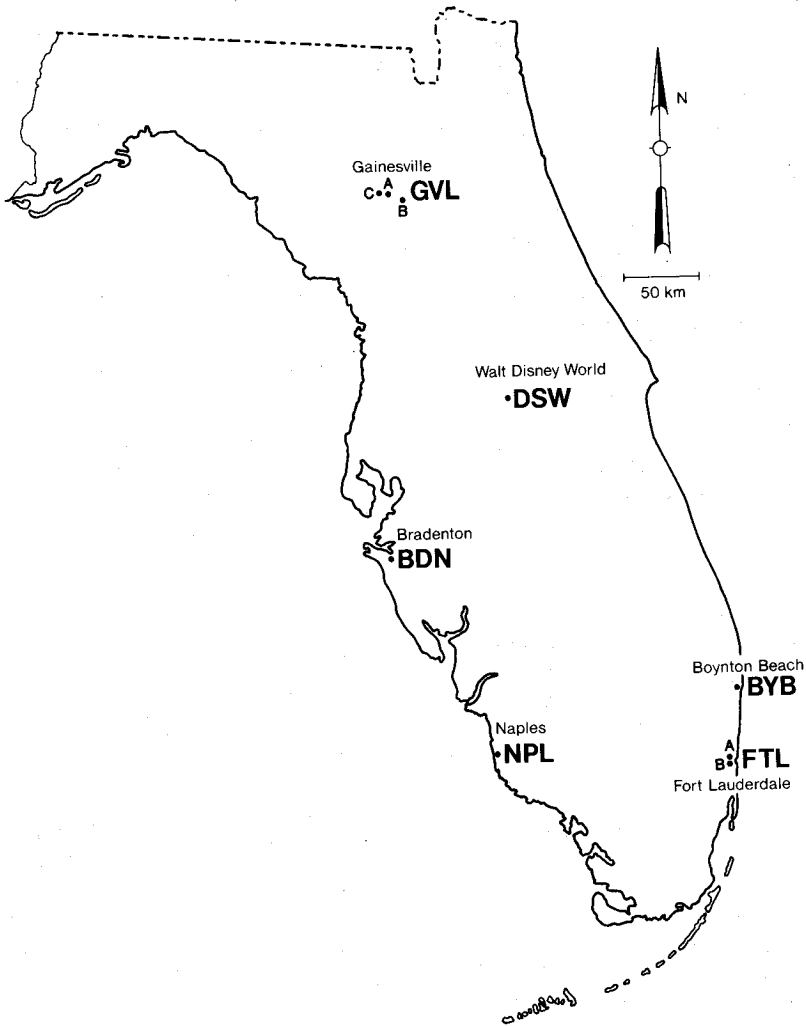


FIG. 1. Locations and abbreviations of trapping stations.

facilities that occupied a 40-ha clearing in a pinewoods-bayhead area.

*South-Central (27° 27'; Bradenton)*

Station BDN (1 January 1980 to 31 December 1981) was in a 19-ha bahiagrass pasture at the University of Florida Agricultural Research and Education Center at Bradenton (NE corner of sec. 15, tp. R18E, T35S). The pasture was bordered on three sides by  $\geq 12$  m of slash pine and on the remaining side by a 2-ha lake.

*South (26° 03-32'; Ft. Lauderdale-Boynton Beach-Naples)*

Station FTL-A (1 January 1980 to 31 December 1981) was amidst plots of bermuda-, bahia-, and St. Augustine-grass at University of Florida, Agricultural Research and Education Center, 3205 SW 70 Ave., Fort Lauderdale (sec. 22, tp. R41E, T50S). The Center is

encompassed by urban development. FTL-B (12 March 1980 to 31 December 1981) was surrounded by bermudagrass, at the end of the driving range of the Cooper Colony Golf and Country Club (NE corner of sec. 32, tp. R41E, T50S). Station BYB (4 March 1980 to 31 December 1981) was on ChemLawn Research Farm in a 12-ha bermuda- and bahiagrass area surrounded by vegetable fields (NE 1/4 of sec. 25, tp. R42E, T45S). Station NPL (1 September 1980 to 31 December 1981) was on the driving range of the Royal Ponciana Golf Club, where bermuda is the principal turfgrass (SW 1/4 of sec. 23, tp. R25E, T49S).

Walker (1982) gave details for construction and operation of standard trapping stations. Each station consisted of two calling-song-emitting units (one *S. alectus*, the other *S. vicinus*), each centered over a 1.5-m-diameter catching device. Every evening at sunset, a timer turned on the calls for the 2 h during which mole crickets fly. Sound levels were set at 106 dB at 15 cm; by com-

parison, mole cricket males produce calls at 70 to 90 dB (Forrest 1980). Stations were usually serviced daily; catches of the two traps were identified, sexed, and tallied separately. Captured crickets were never released in the vicinity of a trapping station.

## Results and Discussion

### Relation of Flights to Life Cycle

Since the goal of this study was to discover variations in life cycles of *S. acletus* and *S. vicinus*, the relationships between the sampled behavior (flight) and other adult behaviors are crucial. The following analysis is based on data from north and central peninsular Florida. Its most important conclusion is that adult males and females of both species fly repeatedly and at varied reproductive stages.

Other than from their flights (Ulagaraj 1975, Forrest 1983, Ngo and Beck 1982, Walker and Fritz 1983), the life cycles of *S. acletus* and *S. vicinus* are known from soil sampling and outdoor rearing (Plant City, Fla. [Hayslip 1943]; Gainesville [Walker and Nation 1982, Forrest 1983, Stackhouse and Matheny, unpublished data]). In north-peninsular Florida, each species has a single generation yearly, with nearly all eggs laid during April, May, and June. Overwintering is by both adults and large nymphs. Most *S. vicinus* overwinter as adults (85% at Plant City), whereas relatively few *S. acletus* do so (25% at Plant City). Some females overwintering as adults have already mated, but most females, even those that become adult in the fall, mate for the first time in early spring. For *S. vicinus*, such matings are apparently coincidental with early spring flights, since fewer than 50% of females collected in such flights are mated (Ulagaraj 1975). However, *S. acletus* females begin their spring flights later, and most have already mated. It seems that most females of both species mate for the first time in early spring, but *S. acletus* does so without flying. Censuses of calling males bolster this interpretation (Walker 1983b)—both species call in large numbers in late February and March, indicating that males are reproductively active. In *S. vicinus*, incoming traffic may be mostly aerial; in *S. acletus*, mostly surface or subsurface.

All adults of *S. acletus* and *S. vicinus* are equipped for flight (i.e., are macropterous), and all seem to maintain their ability to fly throughout their adult lives. Other southeastern mole crickets are dimorphic in wing length (*Neocurtilla hexadactyla*) or 100% micropterous (*Scapteriscus abbreviatus*). Studies with free-living, marked *S. acletus* adults proved that some males and females fly repeatedly and over periods as long as 31 and 58 days (Ulagaraj 1975, Ngo and Beck 1982 and personal communication). Forrest (unpublished data) and Walker (unpublished data) captured males and females of both species as they landed at natural or artificial calls and confined them outdoors in 19-liter buckets of soil. All categories of individuals were observed flying after 12 or more days had elapsed (*S. acletus* male, 12 days; female, 25 days, *S. vicinus* male, 15 days, female, 14 days).

Flights may be local (within a habitat) or migratory (between habitats). Walker and Fritz (1983) compared catches at trapping stations in mole cricket breeding areas with catches at trapping stations in nearby woods to estimate the proportion of flights that were migratory. They concluded that flights of *S. vicinus* were migratory significantly more often than those of *S. acletus*.

### Seasonal Distribution of Flights

*Seasonality at Gainesville.*—Because flight trap data from Gainesville are more extensive than those from elsewhere, they are our best evidence of the extent of local and annual variations in seasonality of flights and constitute a standard against which to judge variations in seasonality among geographically distant stations. Furthermore, the Gainesville data are uniquely strengthened by concurrent life cycle studies using other techniques (see above).

All Gainesville flight trap data are concordant, in that a large spring mode and a smaller fall mode are separated by a near absence of flights in July, August, and September (Fig. 2). This flightless period corresponds to a gap between generations of adults, i.e., when nearly all *S. acletus* and *S. vicinus* are juveniles. The second flightless period (January and early February) is not a hiatus between generations but a time of cold-correlated reproductive dormancy. During spring, the adults of the previous fall are joined by those that molt from overwintering juveniles. Eggs are deposited mostly in April, May, and June. At Gainesville, the life cycles of both species are univoltine, as explained in the previous section.

Flights of GVL *S. vicinus* were similar during 1979, 1980, and 1981 for sites A, B, and C (Fig. 2). Flights during January to July (i.e., "spring") contributed 88 to 99.8% of annual totals. Dates of capture of the median cricket in the spring flights varied from 22 March to 12 April ( $\bar{x}$  = 27 March,  $n$  = 6), dates for the two stations in operation any one year were the same, or nearly so. Fall flights were small and highly variable, with catches exceeding 10 in one night only in November and December. For total fall catches of *S. vicinus* exceeding 40, the mean date of the median cricket was 26 November ( $n$  = 4).

Spring flights of *S. acletus* began later and peaked later than those of *S. vicinus* (Fig. 2). The median cricket was trapped no earlier than 5 May and as late as 29 May ( $\bar{x}$  = 19 May,  $n$  = 6). The largest fall flights were in October and November, earlier than those of *S. vicinus*. The mean date for the median fall *S. acletus* was 22 October ( $n$  = 7). Fall flights constituted 2 to 45% of the annual *S. acletus* catch; however, the extent of this variation is partly attributable to spring and fall catches of a calendar year representing different generations (of different size). For example, if the catch for the fall is compared with the generation total (fall plus following spring), the results for GVL-A are 9 to 15% ( $n$  = 3) (cf. 4 to 24% calculated the other way).

Ulagaraj (1975) studied mole cricket flights at GVL-C from 21 April 1972 to 31 July 1973. His data gen-

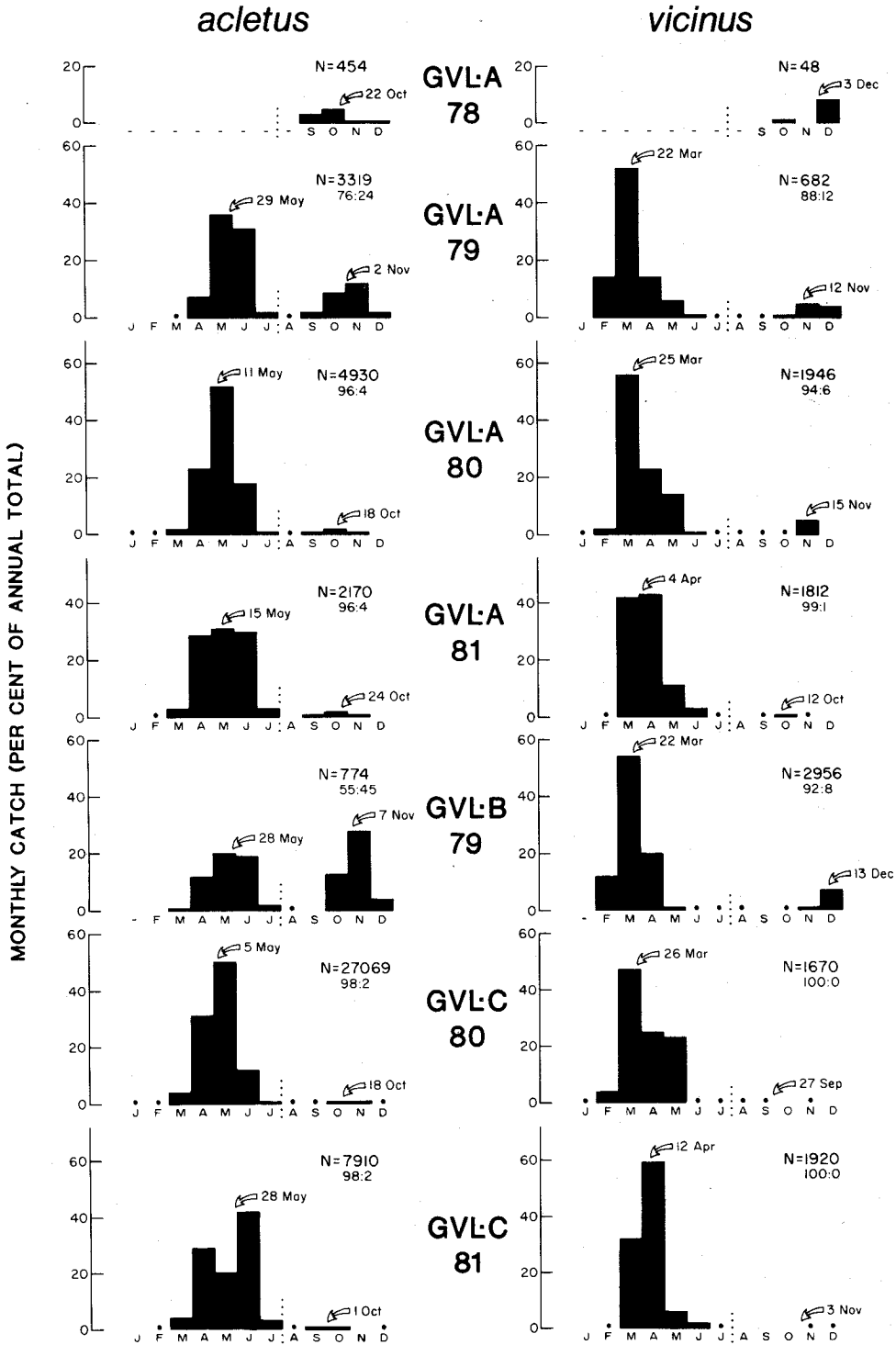


FIG. 2. Seasonal distribution of mole cricket flights at Gainesville, the northernmost trapping area. Monthly catches of *S. acletus* and *S. vicinus* are graphed on the left and right respectively. The trapping station and year are at center. Vertical dotted lines through abscissas divide months between modes (spring and fall in this case). Percent of total catch that each mode contributed is given beneath N. Arrow and date above each mode show when the median cricket for that period was collected. A dash (in place of a letter) denotes that the station was not in operation that month. A dot indicates that crickets were captured that month but that they numbered fewer than 0.5% of the year's total. In calculating the monthly values for GVL-A 1978, we assumed that 90% of the year's totals had flown before September (when trapping was initiated).

erally agree with ours, except that the 1973 spring flights of *S. acletus* peaked in mid-June. Ngo and Beck (1982) monitored the flights of *S. acletus* 2 km south of GVL-B during the spring of 1980. Their 9,347 captures, in three standard sound traps, tracked the 1980 seasonal distributions we recorded at GVL-A and GVL-C.

**Geographical Variation in Seasonality.**—Before our studies, we might have predicted that *S. acletus* and *S. vicinus* would fly and reproduce year-round in south Florida. The growing season at Fort Lauderdale for frost-sensitive plants is usually 365 days, and the mean minimal temperature for the coldest month is 16°C (Bradley 1972). Furthermore, *Scapteriscus abbreviatus* Scudder, established there since 1914, occurs in all stages at all times of year (J. A. Reinert, unpublished data). Alternatively, we might have predicted that *S. acletus* and *S. vicinus* would show essentially the same univoltine life cycles as at Gainesville, since many native crickets with even wider latitudinal ranges in eastern United States are unvaryingly univoltine (Table 1). Our results showed an apparent change in voltinism for *S. acletus* but not for *S. vicinus* (Fig. 3 and 4).

Data from stations in north (GVL), north-central (DSW), and south-central (BDN) Florida, and from one station in south Florida (FTL-A), revealed no changes in voltinism for either species (Fig. 3). However, three other stations in south Florida showed an additional peak of *S. acletus* flight that we interpret as an additional generation (Fig. 4, left). Specifically, at stations FTL-B (7 km southwest of FTL-A), BYB (55 km north), and NPL (at about the same latitude as FTL but on the opposite coast), *S. acletus* exhibited a strong peak of flight during midsummer, a season characterized by near absence of flight at all other stations (Fig. 2 and 3). These differing annual patterns of *S. acletus* flight were consistent from year to year at south Florida stations: in both 1980 and 1981, FTL-B and BYB showed midsummer peaks constituting 37 to 72% of annual flights, and FTL-A showed none (Fig. 3 and 4). A possible cause of the different patterns is that FTL-A was the only station not near vegetable growing areas. The numbers flying in midsummer at south Florida stations correlated with the extent of nearby vegetable fields (thousands at

BYB and NPL, hundreds at FTL-B, none at FTL-A). No *S. acletus* were found in the immediately surrounding turfgrasses at FTL-A and FTL-B (J. A. Reinert, unpublished data). Our reason for equating a midsummer *S. acletus* flight peak with an additional generation is that in areas where life cycles are known from other data (north and central Florida; see above), practically no adults occur in midsummer. This suggests that the large numbers of adults flying in July and August at most south Florida stations were the progeny of those that flew in the spring and that their progeny would fly in the late fall of the same year and in the early spring of the next. The absence of a midsummer peak at FTL-A could be caused by summer generation *S. acletus* making no long-distance flights. A portion of spring and fall *S. acletus* adults do fly long distance at GVL, but temporal variations in the proportions migrating support the notion that such flights could be rare or lacking among midsummer adults in south Florida (Walker and Fritz 1983).

Flight peaks that were comparable from north to south showed minor latitudinal changes, and the relationships among stations were consistent during the years of the study. For example, the median cricket in the spring flight of *S. acletus* flew on ca. 1 April at FTL-A and DSW but 4 to 6 weeks later at BDN and GVL. The average dates of last spring frost at the four sites are 3 January (FTL; most springs have no frosts), 25 January (DSW), 15 January (BDN), and 14 February (GVL) (Bradley 1972; Kissimmee data used for DSW). Obviously, no simple relationship exists between spring temperatures and timing of spring *S. acletus* flights in peninsular Florida. Timing of spring rains apparently affects spring *S. acletus* flights at Gainesville, but station-to-station variation in spring rains, confounding effects of large scale irrigation, and the few years of our records discourage detailed analysis.

Spring flights of *S. vicinus* peak before spring droughts become severe, and they show correspondingly less variance in timing than spring flights of *S. acletus*. The median spring *S. vicinus* flew ca. 10 March in south Florida (FTL-A, FTL-B, BYB) and ca. 2 to 3 weeks later at all stations farther north.

Fall flights of *S. vicinus* peaked in September or October in both south and central Florida, but usually 1 or 2 months later at GVL (Fig. 2 to 4). Large ( $n > 100$ ) fall flights of *S. acletus* peaked in October at all stations lacking a midsummer flight peak. For BYB, the station with the largest midsummer flight, fall *S. acletus* flights peaked in mid- to late November, a delay in keeping with our hypothesis of an extra generation.

The latitudinal transition between one and two generations a year was apparently made by *S. acletus* in less than 40 years as it spread southward less than 6° lat. This transition is noteworthy because it has no parallel in native crickets (Table 1). Of the 36 species in eastern United States that occur over more than 5° lat. and for which life cycles are known, none having a range less extensive than 15° lat. makes this transition. Of the 10 species that seem to make the change, at least two are probably false examples, each consisting of a

**Table 1.** Latitudinal variation in voltinism in 36 native cricket species that occupy more than 5° latitude in eastern United States (Love and Walker 1979, Walker 1962, 1963, 1969a, 1969b, 1973, 1974, 1977a, 1980, and unpublished data)

Life cycle	Latitudinal range (degrees)			
	5-9	10-14	15-19	20-22
Univoltine throughout range	2	15	5	
Bivoltine throughout range	1	3		
Univoltine in north; bivoltine in south			6 <sup>a</sup>	4 <sup>b</sup>

<sup>a</sup>*Gryllus firmus* Scudder, *Miogryllus saussurei* (Scudder), *Hapithus agitator* Uhler, *Neonemobius cubensis* (Saussure), *Eunemobius melodius* (Thomas and Alexander), *Oecanthus niveus* (De Geer).

<sup>b</sup>*Allonemobius fasciatus* (De Geer), *Eunemobius carolinus* (Scudder), *Oecanthus argentinus* Saussure, *Oecanthus quadripunctatus* Beutenmuller.

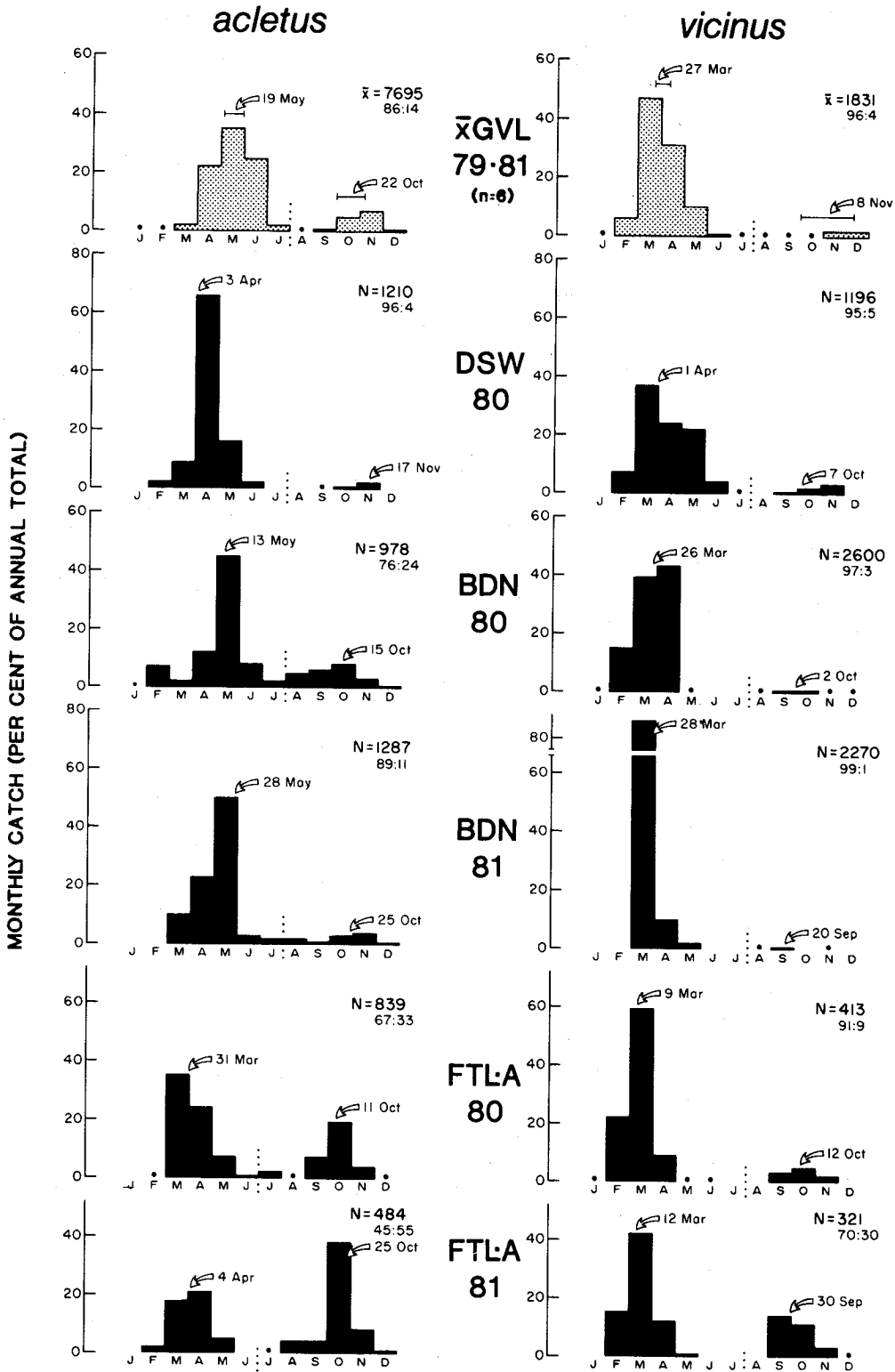


FIG. 3. Seasonal distribution of mole cricket flights at four stations spaced along a north-south distance of 400 km ( $3^{\circ} 35'$  lat.) (see Fig. 1). Lines, arrows, dates, hyphens, and dots are explained in legend of Fig. 2. The monthly data for GVL are mean values for the 6 full station-years depicted in Fig. 2. The range of dates for all GVL stations-years is shown by a horizontal line beneath each arrow that points to mean date of capture of median cricket.

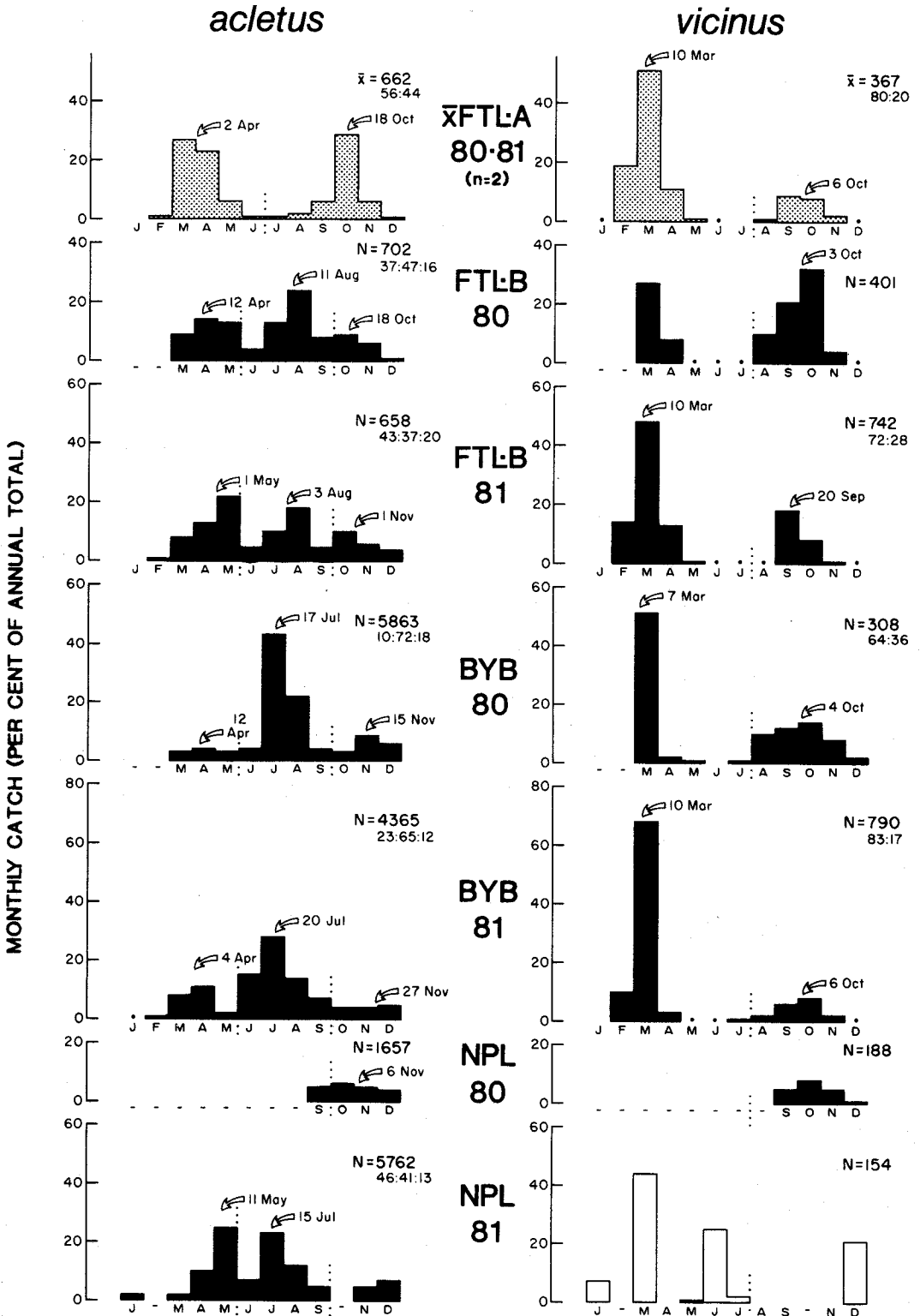


FIG. 4. Seasonal distribution of mole cricket flights in south Florida. Lines, arrows, dates, hyphens, and dots are explained in legend of Fig. 2. The data for FTL-A are mean values for the 2 station-years in Fig. 3. Data for NPL 81 *S. vicinus* are deemphasized because they are scant and incomplete.

pair of sibling species with contrasting voltinism. Examples of documented pseudotransitions are the siblings pairs *Orocharis saltator* Uhler (univoltine) and *O. luteolira* Walker (bivoltine) (Walker 1969a), and *Oecanthus nigricornis* Walker (univoltine) and *O. celerinictus* Walker (bivoltine) (Walker 1963). Further illustrating the rarity of univoltine-bivoltine transitions is *Velarifictorius micado* (Saussure), an oriental burrow-dwelling cricket that has recently become established in the United States from Washington, D.C., to north Florida (Walker 1977b). It maintains a univoltine life cycle throughout this 9° lat. range.

#### Other Aspects of Flights

**Peak Catches and Night-to-Night Variation.**—Figures 2 to 4 illustrate month-to-month variations in catches. As many as 52% of the *S. acletus* and 86% of the *S. vicinus* caught at a station during a year were trapped in a single month. Not only were flights much greater at certain seasons, but during these seasons a substantial portion of the year's total was captured on a single night—an average of 8% for *S. acletus* and 22% for *S. vicinus* (Table 2). Often, few or no mole crickets were captured on nights preceding and following nights of peak flight. For example, the average nightly number caught during 3 days before and after the peak flight (i.e., 6 days) averaged 4% of the peak night in *S. vicinus*, and 16% in *S. acletus* (Table 2).

The causes of peak flights are multiple and imperfectly understood. Peak flights occur on evenings that are optimal for flight (warm, wet, still), especially after extended sequences of unfavorable evenings. Such unfavorable sequences are most likely in "early spring" (actually late winter) or late fall, the seasons at which *S. vicinus* is most likely to fly, and must account for some of the greater unevenness of *S. vicinus* flights as compared with *S. acletus* flights. However, when there were long sequences of favorable evenings during the principal flight season of either species, flights still showed pronounced highs and lows. Ngo and Beck (1982) illustrated this phenomenon in *S. acletus* and attributed it to the ovipositional cycle of ca. 10 days that Forrest (1981) had described. They did not discuss what factors might synchronize the cycles of individual females, a synchrony that must occur if the cycles are to account for the fluctuations in numbers trapped. The likely synchronizers are periods of cold or drought during which females that reach a certain stage in their oviposition cycle must postpone further progress until conditions ameliorate.

**Sex Ratio.**—Fewer males than females are caught in sound traps. In this study, 23% of captured *S. acletus* (16,024 of 70,431) and 11% of captured *S. vicinus* (2,275 of 20,417) were male. Sex ratios for each species varied little geographically (Table 3). Summed fall flights of *S. acletus* at a station generally had higher sex ratios than the summed spring flights (11 of 16 station-years); however, the trend failed a chi-square analysis ( $P > 0.10$ ). Conversely, summed fall flights of *S. vicinus* had a lower sex ratio than summed spring flights (12 of 16

station-years), and the trend was statistically significant ( $P < 0.05$ ).

Sex ratios of flying mole crickets are not fairly sampled by sound traps. Matheny et al. (1983) showed that *S. acletus* landing within 0.75 m of a sound source (i.e., those caught in a standard trap) were 18% male, whereas those landing at 1.5 to 3.5 m were 36% male; *S. vicinus* landing within 0.75 m were 7% male, whereas those landing at 3.8 to 5.3 m were 19% male. Matheny et al. (1983) also reported that 64% of *S. acletus* and 92% of *S. vicinus* landing in response to loud synthetic calls land outside the 1.5-m-diameter catching devices used in our studies. Also indicating that sound trap sex ratios are a female-biased estimator of flight sex ratios is that mole crickets that land at lights include a higher proportion of males than do simultaneously soundtrapped specimens (Ulagaraj 1975). For example, of 3,018 *S. vicinus* Ulagaraj collected at light, 27% were male.

A further complexity in sound-trap sampled sex ratios is that there are significant night-to-night variations and within-season trends that vary from year to year (unpublished data). Ngo and Beck (1982) documented these effects in their studies of *S. acletus* trapped in three adjacent pastures. They reported an overall sex ratio of a 0.20 ( $n = 9,347$ ), but between 15 April and 15 May the 7-day mean sex ratio increased from  $<0.05$  to  $>0.30$  and then fell steeply to  $<0.05$ , only to rise to  $>0.10$  during the next 30 days.

A final determinant of flight sex ratios, more fundamental than those discussed before, is the adaptive significance of the flights for the two sexes. How do the reproductive consequences of flight compare in males and females? Forrest (1980, 1981, 1983) has watched mole crickets after they land near naturally calling males. About 30% of the females (and not just unmated ones) enter the burrow of the calling male and evidently mate with him. The remainder of the females and apparently all of the males dig into the soil and disappear. Females that enter the caller's burrow get a high-quality mate (but apparently do not take over the male's burrow). All females benefit from terminating their flight at a site suitable for egg laying and removed from their previous egg batches. The males find a habitat favorable for calling (to flying females on subsequent evenings) and perhaps gain from the chances of finding and mating with females that did not go to, or have finished with, the male whose call cued their landing.

**Specificity.**—For every 100 *S. acletus* caught in a trap beneath the conspecific song, we caught 21 at the heterospecific song. The corresponding figure for *S. vicinus* was 26. Catching mole crickets at the heterospecific trap has two components: (1) proximity of the traps, and (2) response to the heterospecific song. Matheny et al. (1983) derived formulae that predict that a silent 1.5-m-diameter catching device centered 3.5 m from a standard *S. acletus* trap should catch 7 *S. acletus* for every 100 caught by the *S. acletus* trap. The same silent catching device should catch 40 *S. vicinus* if 3.5 m from a standard *S. vicinus* trap that catches 100. This component thus explains 33% of the errant *S. acletus* and 150% of the errant *S. vicinus*. Response to heterospecific song



Table 2. Peak one-night flights of Florida mole crickets

Species, station, and year	Date of largest catch	No. caught	% Of annual total	Mean no. caught $\pm 3$ days <sup>a</sup>	$\pm 3$ -Day mean/peak
<i>S. acletus</i>					
GVL-A 1979	2 June	228	7	56	0.25
GVL-A 1980	11 May	396	8	104	0.26
GVL-A 1981	5 June	139	6	37	0.27
GVL-B 1979	31 May	17	2	8	0.47
GVL-C 1980	2 May	3,297	12	286	0.09
GVL-C 1981	5 June	569	7	136	0.24
DSW 1980	3 Apr.	412	34	13	0.03
BDN 1980	16 May	47	5	28	0.60
BDN 1981	26-28 May	>184 <sup>b</sup>	>14	—	—
FTL-A 1980	4 Apr.	63	8	12	0.19
FTL-A 1981	30 May	19	4	8	0.42
FTL-B 1980	18 Aug.	20	3	8	0.40
FTL-B 1981	2 Aug.	27	4	1	0.04
BYB 1980	8 July	408	7	125	0.31
BYB 1981	30 June	183	4	85	0.46
NPL 1981	12 July	540	9	76	0.14
$\bar{x}$		>409	ca. 8	66	0.16
<i>S. vicinus</i> <sup>c</sup>					
GVL-A 1979	22 Mar.	241	35	4	0.02
GVL-A 1980	11 Mar.	309	16	9	0.03
GVL-A 1981	31 Mar.	605	33	23	0.04
GVL-B 1979	22 Mar.	864	29	44	0.05
GVL-C 1980	11 Mar.	453	27	4	0.01
GVL-C 1981	31 Mar.	454	24	9	0.02
DSW 1980	9 Mar.	>200 <sup>d</sup>	>17	—	—
BDN 1980	2 Mar.	366	14	47	0.13
BDN 1981	26-31 Mar.	>309 <sup>e</sup>	>14	—	—
FTL-A 1980	24 Feb.	69	17	3	0.04
FTL-A 1981	19 Feb.	35	11	2	0.06
FTL-B 1981	19 Feb.	76	10	4	0.05
BYB 1980	6 Mar.	40	13	8	0.20
BYB 1981	10 Mar.	398	50	5	0.01
$\bar{x}$		>316	ca. 22	14	0.04

<sup>a</sup>Average number caught for 3 days before and 3 days after the date of largest catch (i.e.,  $n = 6$ ).

<sup>b</sup>During 26 to 28 May 1981, 551 *S. acletus* were trapped.

<sup>c</sup>The largest one-night *S. vicinus* flight yet recorded was 1,060 at a station at Jacksonville, 16 November 1980; only 1 other individual was caught  $\pm 3$  days (J. A. Reinert, unpublished data).

<sup>d</sup>The *S. vicinus* calling unit was down, but the *S. acletus* trap caught 103 *S. vicinus*.

<sup>e</sup>During 26 to 31 March 1981, 1,851 *S. vicinus* were trapped.

has not been studied in detail. Walker (unpublished data) collected 236 *S. vicinus* in three isolated traps emitting synthetic *S. acletus* calls at 106 dB or higher, 7 April to 7 May 1980. However, Forrest (1981) baited traps with live males and found no heterospecific attraction to natural calls.

**Potential for Estimating Population Levels.**—In spite of *S. acletus* and *S. vicinus* being major pests, their populations have not been monitored. In view of the imminent introduction of biological control agents from South America, it is important to collect prior data on population densities. The annual catches reported here are the closest available approximations of base-line population data, but their relationship to absolute density (number per unit area) is uncertain and probably highly variable.

Local placement of trapping stations influences the numbers of mole crickets caught. For example, GVL-A

and GVL-C were only 3.7 km apart, but the catches for *S. acletus* in 1980 were 5,000 and 27,000 respectively; for 1981 they were 2,000 and 8,000. The station-to-station differences are concordant with the extent of adjacent fields; the fact that catches of *S. vicinus* did not show similar differences can be attributed to their higher proportion of long-range flights (Walker and Fritz 1983). The decline in numbers of *S. acletus* captured at each station in 1981 may be due to an exceptionally dry spring—less than 20 mm of rain between 30 March and 4 June, compared with a 70-year mean for this period of ca. 185 mm (University of Florida 1982) and a 1980 rainfall of 235 mm for this period. (*S. vicinus* spring flights were essentially complete before the 1981 drought became severe.)

Considering the variability in annual catches of *S. acletus* among the stations at Gainesville, we are reluctant to attribute much significance to variations in *S.*

Table 3. Sex ratios of Florida mole cricket flights as sampled by standard sound trapping stations (proportion male,  $\bar{x} \pm SD$ )

Flights	North (6 station-years) <sup>a</sup>	Central (3 station-years) <sup>b</sup>	South (7 station-years) <sup>c</sup>
<i>Scapteriscus acletus</i>			
All flights	0.22 $\pm$ 0.06	0.21 $\pm$ 0.05	0.23 $\pm$ 0.06
Spring flights	0.20 $\pm$ 0.05	0.19 $\pm$ 0.06	0.18 $\pm$ 0.03
Fall flights	0.23 $\pm$ 0.08	0.26 $\pm$ 0.02	0.30 $\pm$ 0.09
Summer flights	—	—	0.22 $\pm$ 0.12 <sup>d</sup>
<i>Scapteriscus vicinus</i>			
All flights	0.09 $\pm$ 0.03	0.16 $\pm$ 0.02	0.08 $\pm$ 0.06 <sup>e</sup>
Spring flights	0.09 $\pm$ 0.02	0.16 $\pm$ 0.02	0.08 $\pm$ 0.06 <sup>e</sup>
Fall flights	0.03 $\pm$ 0.06	0.12 $\pm$ 0.07	0.08 $\pm$ 0.05

<sup>a</sup>GVL-A 79, 80, 81; GVL-B 79; GVL-C 80, 81. For fall flights  $n = 7$ , because GVL-A 78 data were included.

<sup>b</sup>DSW 80; BDN 80, 81.

<sup>c</sup>FTL-A 80, 81; FTL-B 80, 81; BYB 80, 81; NPL 81. For fall flights  $n = 8$ , because NPL 80 data were included.

<sup>d</sup>FTL-B 80, 81; BYB 80, 81; NPL 81 ( $n = 5$ ).

<sup>e</sup>During spring 1981 NPL *S. vicinus* sex ratios were doubtfully determined; we therefore excluded them (making  $n = 6$ ).

*acletus* catches among stations to the south. However, annual catches of *S. vicinus* were relatively uniform in north and central Florida (700 to 3,000,  $n = 9$ ), as were those in south Atlantic coastal Florida (300 to 800,  $n = 6$ ). The apparently lower populations of *S. vicinus* at the FTL and BYB stations may reflect the replacement or reduction of *S. vicinus* in some habitats by *S. abbreviatus*, a flightless species of *Scapteriscus* (Reinert, unpublished data).

Our permanently removing all captured mole crickets (as many as 27,000 *S. acletus* from one station in 1 year), could have suppressed populations from one year to the next. Nonetheless, the only major reductions in catches (GVL 1981) coincided with severe drought. Furthermore, studies of mole cricket dispersal (Walker and Fritz 1983, Ngo and Beck 1982) suggest that mole crickets are so mobile that significant suppression is unlikely.

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