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Phonotaxis of Crickets in Flight: Attraction of Male and Female Crickets to Male Calling Songs

Abstract. *Large numbers of two species of mole crickets flew to loudspeakers playing the appropriate calling song outdoors. Mated females were more frequently captured than unmated ones, and males were 12 percent of the catch. Crickets of three other subfamilies were trapped as they flew to mole cricket songs resembling their own.*

Most male crickets and katydids (*1*) make species-specific calling sounds that enable appropriate mute females to find their way to them (*2*). Generally the unmated female walks or runs to the conspecific male. In the only reported case of flight bringing the pairs together, orientation to the conspecific sound occurred before flight (*3*). In studying the acoustic behavior of two species of mole crickets, we discovered that males and mated females as well as unmated females terminated long-range flights (*4*) by orienting to and landing near sources of conspecific calling songs.

Scapteriscus acletus (southern mole cricket) and *S. vicinus* (changa) are important agricultural pests in the southeastern United States. The males burrow in soil and produce calling songs in specially constructed chambers. When we discovered that flying mole crickets were landing near the entrance to the burrow where the male was singing, we broadcast a recorded calling song and dozens of flying mole crickets rained on the speaker. We studied this phenomenon in 1972 and 1973 near Gainesville, Florida, at a lighted golf course and an unlighted pasture. Our experimental setup consisted of two independent broadcast systems and three large metal funnels (1.2 m in diameter) placed 3 to 15 m apart (Fig. 1). Each broadcast system included a battery-operated tape recorder, a battery-operated audioamplifier, and a speaker (*5*). Each speaker was mounted in the center of a funnel and was aimed directly upward. A jar ring was soldered to the bottom of each funnel (5 cm in diameter), and the adults that flew into the funnels were collected in numbered 500-ml jars. The natural calling songs of *S. acletus* and *S. vicinus* were tape-recorded in the field, with the microphone 15 cm above ground level. The soil temperature was 25°C. Synthetic calling songs were made and tape-recorded in the laboratory (*6*). The intensity of the broadcast songs was measured 15 cm above the speaker (*7*) and was maintained at 100 ± 3 db during all experiments (*8*).

Broadcasting trials began about 0.5 hour after sunset and continued until most flight ended, about an hour later. Tests were made only when the soil temperature was 25 ± 3°C. During each trial both calls were broadcast simultaneously, and the trial was ended when at least one of the 500-ml jars contained 20 or more mole crickets. A predetermined duration was not used for each trial because the numbers of mole crickets flying varied greatly at different seasons, dates, and times. Trials in which no jar yielded as many as 20 mole crickets were disregarded. The jars with trapped mole crickets were detached from the funnels after

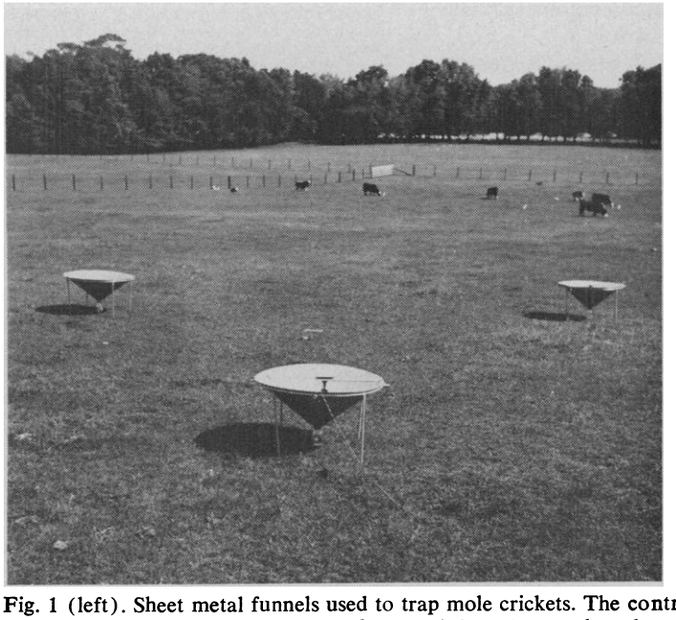

Fig. 1 (left). Sheet metal funnels used to trap mole crickets. The control trap (left back) has no speaker.

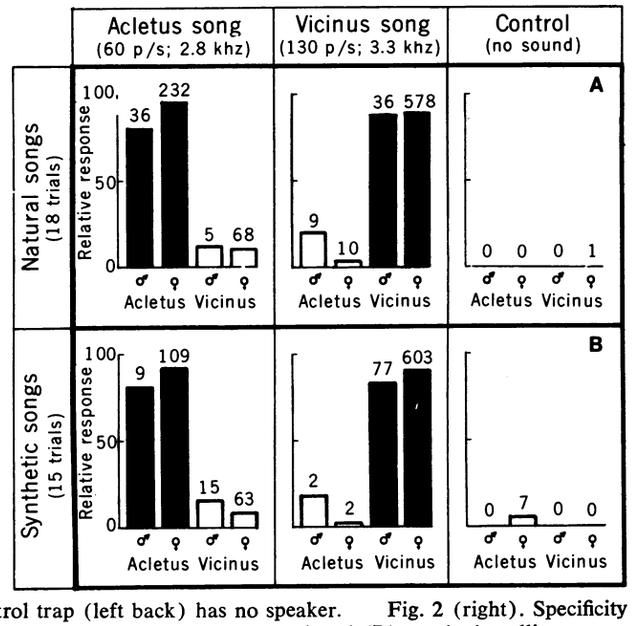

Fig. 2 (right). Specificity of response of flying *Scapteriscus acletus* and *S. vicinus* to broadcast tape recordings of (A) natural and (B) synthetic calling songs. Crickets captured in traps broadcasting conspecific songs are indicated by black bars. Others are indicated by open bars. Each bar shows the percentage of the total number of a sex and species that was captured by traps during the trials with natural songs or during the trials with synthetic songs. The number of individuals is indicated above each bar; *p/s*, pulses per second.

Table 1. Attraction of other flying crickets to broadcast songs of *Scapteriscus acletus* (60 pulses per second; 2.8 khz).

Subfamily and species	Number attracted		Calling song of attracted species (25°C)		Source of *S. acletus* song
	Male	Female	Pulses per second	Carrier frequency (khz)	
Gryllinae,					
Gryllus rubens	7	12	55	4.8	Natural and synthetic
Oecantinae,					
Oecanthus celerinictus	3	11	65	3.8	Synthetic
Nemobiinae,					
Neonemobius cubensis	0	8	55	7.3	Synthetic

each trial and replaced with empty ones.

The speaker first used to broadcast a particular song was selected randomly; in subsequent trials of the same pair of songs the speakers used were alternated in order to negate position effects. During each trial one of the three funnels served as a control (*9*). At the end of each evening's trials the mole crickets in each numbered jar were identified (*10*), sexed, and counted. For each species, on three or more occasions separated by 1 week or more, 10 to 25 of the trapped females were examined for sperm in the spermathecae.

At the golf course mole crickets could be seen flying at lights 100 m from the funnels. When broadcasting began, the crickets would alter direction and fly toward the funnels. Many dropped or flew into the funnels. Others landed on the sod nearby. At the unlighted pasture the crickets could be seen only as they neared the funnels. Trials involving playbacks of taped natural songs (Fig. 2A) showed that *S. acletus* and *S. vicinus* are principally attracted to their own songs.

Trials with synthetic songs (Fig. 2B) produced results similar to those with natural sounds, thus showing that no differences other than those in the carrier frequency and pulse rate were required to elicit the species-specific responses (*11*). For each species, with both natural and synthetic songs, a larger proportion of females than males showed conspecific responses. A significantly higher proportion (10 percent) of *vicinus* females were trapped at *acletus* songs than vice versa (3.4 percent) ($P < .01$). Of 66 *acletus* females examined, 91 percent had sperm in the spermathecae. Of 56 *vicinus* females, 61 percent had sperm.

Crickets other than mole crickets sometimes flew into the traps broadcasting *acletus* songs (Table 1). In none of the trials were such crickets captured in the silent (control) trap or in the trap broadcasting *vicinus* songs. Although the three species captured represented three subfamilies, their calling songs were similar to that of *acletus*. Specifically, the calling songs of all three were trills with pulse rates at 25°C within five pulses per second of the *acletus* trill. Males of only two of the species were captured. At least some of the *Gryllus rubens* females had mated before capture, for they subsequently laid fertile eggs.

The attraction of virgin female crickets to male calling songs is easily understood. The attraction of females with sperm in their spermathecae (*12*) and especially the attraction of males are less easily interpreted. We interpret the flights of these individuals (and perhaps of virgin females, too) as dispersive, and we suggest that they are using the sexual signaling of males of their species as an indication of a habitat suitable for colonization. We originally thought that those flying toward the sound as a habitat-indicating signal and those flying toward it as a male-indicating signal should end their flights differently. We therefore predicted that those landing within the sound trap would include a significantly higher proportion of females than those landing outside the trap. However, we compared the sex ratio of 769 *acletus* that had landed outside the trap with that of 694 that had landed inside and found no significant difference ($P = .21$). We now believe that both sexes, and mated as well as unmated females, home in on the sound with equal accuracy, but we conjecture that on landing the virgin females run to the singing male's burrow while others run and burrow elsewhere. Morris (*13*) demonstrated phonotaxis by males to male calling songs in conocephaline katydids; however, the context was male-male aggression over occupation of territory (or broadcasting space). Male-male aggression occurs in crickets and has been studied and described, but approach of males to male calling songs has not been reported (*14*). We have never observed it in earthbound mole crickets.

Attraction of large numbers of flying crickets may prove useful in control—either as a means of destroying crickets or as a means of timing control procedures. We have already put it to use in studying the flight ranges of mole crickets and in studying the features of the songs responsible for species-specific responses (*4, 11*).

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References and Notes

1. Crickets and katydids are in the order Orthoptera, families Gryllidae and Tettigoniidae, respectively.
2. R. D. Alexander, *Annu. Rev. Entomol.* **12**, 495 (1967).
3. J. D. Spooner, *J. Ga. Entomol. Soc.* **3**, 45 (1968).
4. Mark-release-recapture studies of *S. acletus* showed that some individuals fly at least 715 m (S. M. Ulagaraj, in preparation).
5. We used Nagra III and Nagra IV tape recorders during 1972 and cassette tape recorders (Bell & Howell model 294, 7235, and Sony model TC-66) during 1973. The latter were checked daily for excessive flutter and aberrant tape speed. The amplifiers were an Alton Electronic audio amplifier (1972) and a Realistic model MPA-20 (1973). The speakers were Realistic model 40-1228 covered with aluminum wire screen.
6. The electronic synthesis was similar to that described by T. J. Walker, *Ann. Entomol. Soc. Am.* **50**, 629 (1957). The pulse interval ratio was maintained at 1 : 1.
7. A General Radio model 1551-B sound level meter was used to monitor the intensity.
8. The intensity of calling males measured in the field was 42 to 92 db at 15 cm above the burrow entrance. We discovered that the catch of mole crickets in sound traps was dramatically increased by using higher than natural sound levels.
9. An empty funnel with no sound (control) generally caught no mole crickets. It never had more than 1.5 percent of the number of mole crickets in the other two traps.
10. *Scapteriscus* species can be easily identified by morphological characters [W. S. Blatchley, *Orthoptera of Northeastern America* (Nature Publishing, Indianapolis, Ind., 1920)].
11. Further experiments with synthetic sounds showed that the species-specific response of *S. acletus* includes discrimination of both pulse rate and carrier frequency (S. M. Ulagaraj and T. J. Walker, in preparation).
12. One of us (S.M.U.) has twice observed a female land and enter the burrow of a calling male. One of the two females was dug out a few minutes later and found to have sperm in the spermathecae. It is doubtful that mating was completed during the interval. We do not know whether female mole crickets mate more than once or with more than one male. Because they lay substantially fewer (but larger) eggs than most other female crickets, we doubt that multiple matings are usual.
13. G. K. Morris, *J. N.Y. Entomol. Soc.* **80**, 5 (1972).
14. R. D. Alexander, *Behaviour* **17**, 130 (1961).
15. We thank J. E. Lloyd for criticism and advice and S. Blomeley for photographic help. Florida Agricultural Experiment Station Journal Series No. 5000.

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