MOLE CRICKET PHONOTAXIS: EFFECTS OF INTENSITY OF SYNTHETIC CALLING SONG (ORTHOPTERA: GRYLLOTALPIDAE: *SCAPTERISCUS ACLETUS*)

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ABSTACT

The sound pressure level of the natural call of *S. acletus* is 70 to 90 dB (measured at 15 cm). Within this range louder males attract many more conspecifics than do quieter males. Because traps that broadcast simulated calling songs at >90 dB catch enormous numbers of mole crickets, the upper limit of greater phonotaxis to higher sound levels is important to sound trap design. In three series of tests of traps broadcasting synthetic calling songs differing by 12 dB, the louder trap captured 3 to 9 times as many mole crickets as the quieter one. The effect was significantly greater in trials of 94 vs 106 dB and of 106 vs 118 dB than in trials of 116 vs 128 dB, but we failed to find the upper limit we were seeking. At all intensities a greater proportion of females than males landed within 0.76 m of the speaker.

RESUMEN

La presión del sonido del llamado natural de *S. acletus* es de 70 a 90 dB (medido a 15 cm). Dentro de esta gama, los machos que emiten sonido más alto atraen muchos más coespecificos que los machos más callados. Debido a que las trampas que emiten cantos simulados a >90 dB capturan cantidades enormes de grillotopos, el límite superior de más fonotaxis a niveles de sonidos altos es importante en el diseño de trampas de sonido. En tres series de pruebas con trampas emitiendo cantos sintéticos diferiendo por 12 dB, la trampa más alta capturó de 3 a 9 veces más grillotopos que la más baja. El efecto fué significativamente mayor en pruebas de 94 contra 106 dB y de 106 contra 118 dB que en las pruebas de 116 contra 128 dB, pero fracasamos en encontrar el límite alto que estábamos buscando. A todas las intensidades, hubo una mayor proporción de hembras que de machos que estaban dentro de 0.76 m del autoparlante.

Trapping flying mole crickets (*Scapteriscus* spp.) that land near electronic renditions of mole cricket songs is an effective means of monitoring flight activity and of securing specimens for research (Walker 1982, 1988). The numbers captured, sometimes thousands in less than 1 hr, are great enough to suggest that sound traps could be useful in control of pest mole crickets.

An important finding from previous studies of mole cricket phonotaxis is that the more intense the call, the greater the number of mole crickets attracted to it. This is true with natural variation in the loudness of calling mole crickets, 70 to 90 dB SPL (sound pressure level re 20 μPa measured at 15 cm above the sound source) (Forrest 1983). It is also true with experimentally varied electronic imitations of mole cricket calls. Ulagaraj & Walker (1975) reported that at SPL's between 70 and 106 dB the numbers of mole crickets captured, relative to a 100 dB standard, approximately dou-

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bled with each 6 dB increase. Above 106 dB, increases in captures were slight and not statistically significant. However, Forrest (1980), using improved sound generating equipment and more replication, found that a 6 dB increase within the range 101 to 111 dB gave a 5.7-fold increase in numbers caught (95% C.I. = 5.2 to 6.3). Forrest & Green (1989) showed that this degree of increase was predicted by a simple physical model based on flying mole crickets choosing the sound source that had the greatest SPL at their sound receptors.

The studies reported here extend the upper range of SPL's tested to 128 dB, 10 dB higher than any used more than once by Ulagaraj & Walker (1975) and 17 dB above the range used by Forrest (1980). Unlike the previous studies, our traps captured mole crickets landing as far as 1.83 m from the sound source and segregated the catch into those landing within the 0.76-m radius of a standard mole cricket trap (Walker 1982) and those landing up to 1.07 m farther out. We hoped to find the limits of higher intensity resulting in greater catch and to determine if very high intensities decreased the relative frequency of those landing within the standard catching area.

METHODS

Two mole cricket traps, each consisting of a 3.66 m diameter circular swimming pool with a 1.52 m diameter child's wading pool placed at center, were installed 2 m apart at University of Florida's Green Acres Farm, near Gainesville. Enough water was added to cover the bottoms of the pools. From the center of each trap, identical battery-powered sound synthesizers broadcast simulated calling song of *Scapteriscus acletus* (2.7 kHz carrier turned on and off at 50 Hz with a 50% duty cycle; see Walker 1982). SPL's of the two units were set 12 dB apart, using a Bruel & Kjaer model 2219 sound level meter 15 cm above the sound source. Sound synthesizers were switched on at sunset and off ca. 2 hr later, after *S. acletus* flights had ceased. Mole crickets that landed within the pools swam about on the water's surface until removed, sexed, and counted.

Tests were run nightly, weather permitting, 8 May to 4 June 1980. In each series of tests, the location of the high SPL broadcast was switched between the two traps at least every second night; synthesizers were alternated between high- and low-intensity duty nightly. The first series of tests (8 to 13 May, n = 6) compared 106 and 118 dB. The substantial differences in catches, contrasting with the results of Ulagaraj and Walker (1975), led us to use 94 and 106 dB for the second series (14 to 24 May, n = 9). The synthesizers for these two series were standard "artificial crickets" (Walker 1982). In the third series (26 May to 4 June, n = 6), we used more powerful versions of the same device to compare 116 and 128 dB. These "super crickets," made by William Oldacre, the designer of the standard ones, had more batteries, a larger amplifier, and two 7.5 cm speakers 1 cm apart. Intensity was measured 15 cm above the 1 cm bridge between the two speakers. Hearing protectors were required when measuring intensities above 106 dB.

RESULTS

Traps with higher sound levels caught significantly more *S. acletus* than similar traps operated 12 dB lower (Fig. 1). The high range tests (116 vs: 128 dB) produced catch ratios (no. in high dB trap/no. in low dB trap) that were significantly lower than the ratios of the other two ranges (chi square, P<0.001). Within the low and medium range tests (94 vs 106 and 106 vs 118), but not in the high range tests, females showed a significantly stronger preference for the high dB trap than did males. The catch ratios for males and females in the low range tests were 6.7 and 9.1, respectively. Corresponding values in medium and high range tests ere 7.9 and 10.1, and 2.6 and 2.9.

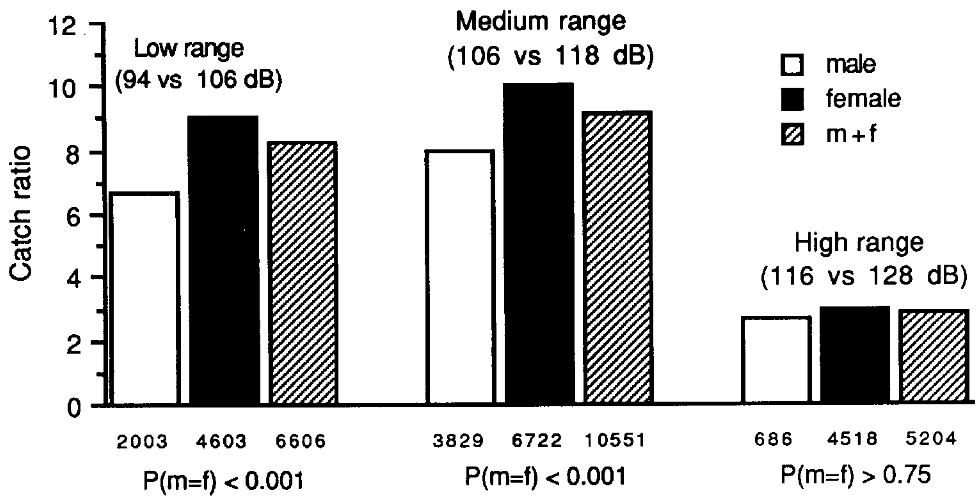

Fig. 1. Relative effectiveness of paired traps baited with synthetic *S. acletus* calls differing by 12 dB. Bars show catch ratios—i.e., (no. *S. acletus* caught in high dB trap)/(no. caught in low dB trap). Total captures and probabilities of male ratio equalling female ratio (chi square) are at bases of bars.

The majority of mole crickets captured landed within the 0.76-m radius of a standard mole cricket trap (Table 1). In the low and medium range tests, the catch ratios were significantly higher than for mole crickets captured landing farther out. In the high range tests, the higher catch ratio was for the outer ring.

In both traps in every comparison, females were significantly more concentrated in the central 1.5 m of the trap than were males (Fig. 2). Landing density ratios—i.e., the density (no./m^2) in the inner circle of the trap divided by the density in the outer ring—were 2.5 to 5.6 for males and 4.8 to 14.3 for females.

In the low and medium range tests, landings of males and females in the trap with the higher SPL were significantly more concentrated centrally than landings in the trap with the lower SPL (chi square, $P<0.05$). In the high range tests, this effect disappeared for males ($P>0.10$) and reversed for females ($P<0.001$) (Fig. 2).

TABLE 1. NUMBERS AND CATCH RATIOS (NO. CAUGHT IN HIGH dB TRAP/NO. CAUGHT IN LOW dB TRAP) FOR *SCAPTERISCUS ACLETUS* CAUGHT IN 1.83 M DIAM SOUND TRAPS BROADCASTING AT SPL'S DIFFERING BY 12 dB.

	Inner circle (0.76m radius)			Outer ring (0.76-1.83 m)		
Test range	Low	High	Catch ratio	Low	High	Catch ratio
94 vs 106 dB	371	4002	10.8[a]	345	1888	5.5
106 vs 118 dB	514	5593	10.9[a]	522	3922	7.5
116 vs 128 dB	761	1902	2.5	581	1960	3.4[b]

[a]Catch ratio higher than in outer ring (chi square; $P<0.001$).
[b]Catch ratio higher than in inner circle (chi square; $P<0.001$).

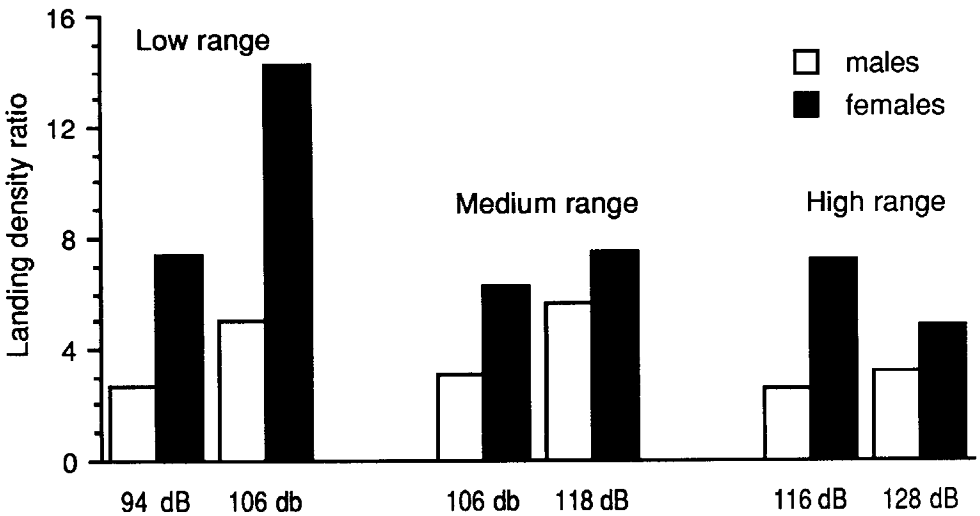

Fig. 2. Relative densities of *S. acletus* landing in central and outer portions of traps baited with synthetic *S. acletus* calls. For each SPL in each range, bars show landing density ratios—(landing density in central circle)/(landing density in outer ring)—for males and females. In every trap females were significantly more concentrated centrally than were males (chi square, $P<0.001$).

Discussion

We failed in our quest of a limit to higher intensities catching more *S. acletus* (Fig. 1). The reduction in the degree of effect in tests of 116 vs 128 dB can be attributed to intensity effects diminishing at such high SPL's, to crickets attracted to the louder trap landing in the adjacent softer trap, or to our use of two-speaker artificial crickets. Whether SPL's above 128 dB would be even more effective is probably of little practical importance, because equipment to produce such SPL's is not readily available and because of potential problems with hearing damage, noise-nuisance complaints, and law suits.

Our data on landing patterns confirmed a phenomenon reported in earlier studies—viz., males are more dispersed in their landing sites relative to the sound source than are females (Forrest 1981, Matheny et al. 1983). Males landing at the sound of another male are probably less likely to benefit from entering the calling male's burrow than are females; however, the only study of behavior of mole crickets landing near a burrow found no significant sexual difference in the frequency of entering (Forrest 1983).

Effects of SPL on landing patterns seem complex (Fig. 2), and our switching to two-speaker synthesizers for the 116 vs 128 dB tests makes it unprofitable to compare those results with results from tests in the other two ranges. In the 94 vs 106 and in the 106 vs 118 tests, the landing density ratios of both males and females were significantly greater at the higher SPL. That this was a relative rather than an absolute effect is shown by comparing landing density ratios at 106 dB paired with 94 dB and with 118 dB (Fig. 2). For both males and females the ratios at 106 dB differed under these two conditions (chi square, $P<0.001$. A possible reason for higher landing density ratios at the higher intensity is that a portion of the crickets landing in the low dB trap were attracted to the high dB trap but landed a few meters away. Matheny et al. (1983), who studied landing patterns about a single sound source, reported that landing densities 3 m from the sound source were still 10 to 20% of those within 0.75 m. The edge of the low SPL sound trap in our experiments was only 3.83 m from the synthesizer in the high intensity trap. Any "cross-catching" that occurred would diminish the landing density ratio in the low SPL trap more than in the high SPL trap (because many more cross-caught crickets would land in the low intensity trap). Cross catch would also reduce the catch ratios shown in Fig. 1.

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