RESPONSE OF FLYING MOLE CRICKETS TO THREE PARAMETERS OF SYNTHETIC SONGS BROADCAST OUTDOORS

By

S. M. ULAGARAJ and THOMAS J. WALKER

(Reprinted from Nature, Vol. 253, No. 5492, pp. 530–532, February 13, 1975)

(Reprinted from Nature, Vol. 253, No. 5492, pp. 530–532, February 13, 1975)

Response of flying mole crickets to three parameters of synthetic songs broadcast outdoors

LARGE numbers of flying crickets can be attracted to outdoor loudspeakers broadcasting male calling songs[1]. Consequently we have been able to investigate the features of calling songs that are important for attraction. Previous investigators have used laboratory-maintained crickets in acoustical environments significantly different from outdoors[2-7]. Furthermore, they have studied thoroughly no more than one or two of the important signal parameters. We have studied outdoors the responses of free-flying mole crickets, *Scapteriscus acletus*, to synthetic calling songs systematically varied in these three parameters: carrier frequency, pulse rate and intensity. Mole crickets came in greatest numbers when we broadcast, at unnaturally high intensities, carrier frequencies and pulse rates like those of the natural song.

All experiments were conducted near Gainesville, Florida, during 1972 and 1973. During the tests soil temperatures were $24 \pm 4°$ C, air temperatures, $25 \pm 5°$ C, and relative humidity, $70 \pm 20\%$ (ref. 8). We used three independent broadcasting systems, each with its own cricket-trapping funnel. A fourth funnel, without a speaker, was the control. Two test sounds and a standard sound were broadcast simultaneously. Test sounds were synthetic songs (artificial sounds synthesised and tape-recorded in the laboratory) varied in intensity, carrier frequency and pulse rate (that is, rate at which the carrier was turned on and off). Equal durations of pulses and pulse intervals were maintained. For frequency experiments (1972), the pulse rate and intensity were held constant at 60 pulses s^{-1} and 100 dB sound pressure level (SPL) (at 15 cm; reference SPL, 2×10^{-5} N m^{-2}). Similarly, in pulse rate experiments (1973), the frequency and intensity were held constant at 2.7 kHz and 100 dB. In intensity experiments (1973), frequency and pulse rate were constant at 2.7 kHz and 55 pulses s^{-1}. The standard sound was 2.7 kHz and 100 dB. It was changed from 60 pulses s^{-1} in 1972 to 55 pulses s^{-1} in 1973 to approximate more closely the natural song (that is, the actual calling song of males in the field) at 25° C[9]. The number of mole crickets trapped at each test sound was expressed as a percentage of the number caught at the standard sound. Trials with less than 10 crickets in the standard were discarded. Each test sound was used on at least two nights. We have described the trapping equipment and the broadcasting techniques before[1].

The control funnel generally caught no mole crickets and never had more than 1.5% of the number of adults in the other three funnels. In frequency and pulse rate trials the number of trapped mole crickets varied fivefold about a mode (Fig. 1). For every 6-dB increase in sound level up to 106 dB, our catch approximately doubled (Fig. 2). In addition to comparing seven pulse rates, we investigated whether any amplitude modulation at all was necessary for phonotaxis of *S. acletus*[10]. We made four trials comparing a continuous tone (no amplitude modulation) of 2.7 kHz with the 1973 standard sound (tone turned on and off 55 times per second). Because 270 *S. acletus* were captured at the standard sound, 27 at the continuous tone, and none at the control, amplitude modulation must be an important, but not essential, feature.

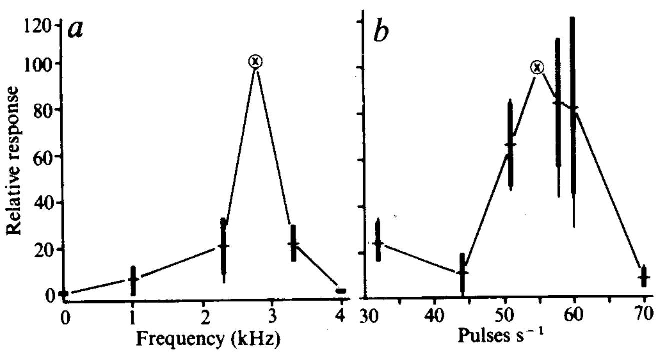

Fig. 1 The response of flying *S. acletus* to synthetic sounds that were systematically varied in frequency (*a*) and pulse rate (*b*). The relative response is a percentage of those captured at the standard sound (circle and cross) (see text). Vertical bar is 2 s.e. on either side of the mean. Narrow vertical line is range. In 16 frequency trials, 416 individuals were trapped; in 24 pulse rate trials, 843 were trapped.

Several features of male calling songs are known or suspected to cause species-specific responses in crickets[2-7]. For mole crickets, Bennet-Clark[11] suggested that carrier frequency might be important to flying females. Our data (Figs 1 and 2) demonstrate that both carrier frequency and pulse are important to species-specific phonotaxis in *S. acletus*. This insect (Orthoptera, Gryllotalpidae) should be able to separate its own song from songs of most other crickets by pulse rate (Fig. 1); however, there are crickets occurring in the same habitat with pulse rates overlapping those of *S. acletus*. *S. acletus* could distinguish the songs of its own males from the songs of these other crickets by carrier frequency, since carrier frequency of these songs is higher than in *S. acletus*[1].

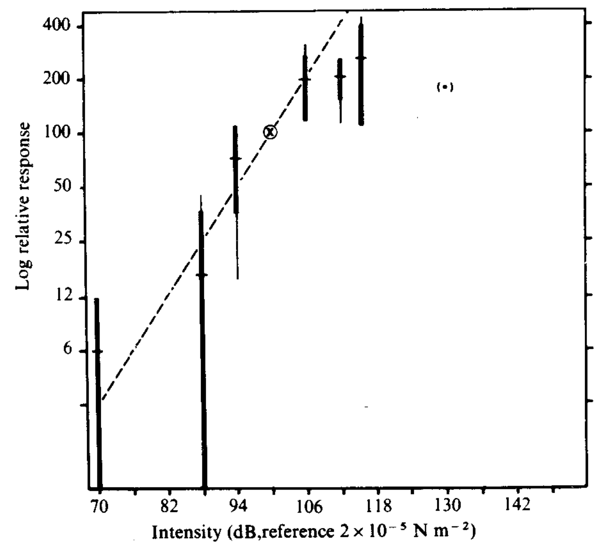

Fig. 2 The response of flying *S. acletus* to various intensities. Relative response is a percentage of those captured at the standard level (circle and cross, 100 dB). (●) Represents result of a single trial with a different speaker. The dotted line represents a doubling of the number for each 6 dB increase in sound pressure level. Vertical bar is 2 s.e. on either side of mean. Narrow vertical line is range. In 33 intensity trials, 1,606 individuals were captured.

Doubling of catch for each 6-dB increase in sound level agrees with the following model. Sound waves radiate in all directions from loudspeakers, and sound pressure is generally halved (that is, drops 6 dB) for each doubling of distance from a sound source. Whatever the shape of the sound field, its diameter would double for each 6-dB increase in sound level. To orientate to a calling song, the flying adults must first encounter an appropriate sound above a threshold pressure. If mole crickets fly in a single plane and maintain straight courses, the catch should double for each doubling of diameter (not the area) of the sound field. The failure of doubling to continue with each increase of 6 dB beyond 106 dB could result from the crickets being repelled by such high intensities or from an inability to orientate owing to saturation of their auditory organs.

The synthetic songs that trapped maximal numbers of mole crickets had pulse rates and frequencies like those of the natural song but the catch was increased 30-fold at intensities 38 dB or more above natural intensities, which average 68 dB[9]. Such attraction may prove useful in control of these agricultural and turf pests.

We thank Dr J. E. Lloyd and Mr D. L. Mays for criticising our manuscript.

S. M. ULAGARAJ
THOMAS J. WALKER

Department of Entomology and Nematology,
University of Florida,
Gainesville, Florida 32611

Received November 4; revised December 19, 1974.

1 Ulagaraj, S. M., and Walker, T. J., *Science*, **182**, 1278 (1973).
2 Walker, T. J., *Ann. ent. Soc. Am.*, **50**, 626 (1957).
3 Loftus-Hills, J. J., Littlejohn, M. J., and Hill, K. G., *Nature new Biol.*, **223**, 184 (1971).
4 Schuvalov, V. F., and Popov, A. V., *J. evol. Biochem. Physiol.*, **9**, 152 (1973).
5 Katsaki, Y., and Suga, N., *J. exp. Biol.*, **37**, 279 (1960).
6 Nocke, H., *J. comp. Physiol.*, **80**, 141 (1972).
7 Dragsten, P. R., Webb, W. W., Paton, J. A., and Capranica, R. R., *Science*, **185**, 55 (1974).
8 Ulagaraj, S. M., *Environ. Entomol.* (in the press).
9 Ulagaraj, S. M., *Ann. ent. Soc Am.*, (in the press).
10 Busnel, R. G. (ed.), *Acoustic q.havior of animals* (Elsevier, New York, 1963).
11 Bennet-Clark, H. C., *J. exp. Bieol.*, **52**, 619 (1970).

Printed in Great Britain by Henry Ling Ltd., at the Dorset Press, Dorchester, Dorset