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Song and Acoustic Burrow of the Prairie Mole Cricket, *Gryllotalpa major* (Orthoptera: Gryllidae)

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ABSTRACT: The calling song of *G. major,* the largest North American cricket, which survives only in relict tallgrass prairies, consists of prolonged series of brief chirps that can be heard from as far away as 400 m. Carrier frequency is ca. 2 kHz and pulse rate within the 13- to 35-pulse chirps is ca. 90 sec^{-1}. The call issues from an opening in the soil, ca. 25 × 85 mm, that is the mouth of an exponential horn that attaches to an almost spherical bulb, 3 to 4 cm in diameter. This acoustic burrow and the position of the calling male within it resemble those of congeneric European mole crickets. Flying females land at real and simulated *G. major* calls.

The prairie mole cricket is the largest North American cricket. Adults are as long as 5 cm and weigh as much as 2.6 g. Until 1986 the species was known from fewer than 75 specimens, most of which were collected more than 50 years ago. When R. D. Alexander (Museum of Zoology, University of Michigan) and T.J.W. set themselves the task of taping the songs of North American crickets they found no one who knew where the prairie mole cricket survived nor did they come across a population in field work that was otherwise successful. The fact that this greatest of U.S. crickets could not be proved extant led to its becoming a candidate for the federal endangered species list. This and the fact that many of the more recent records were from Missouri led D.E.F., in 1986, to initiate a search for populations of *Gryllotalpa major.*

These three clues guided his search: (1) Label data from museum specimens showed the former distribution of *G. major* to coincide with the former distribution of tallgrass prairies, and the habitat of one specimen was noted as "in prairie sod." (Others with habitat information had been collected at "city lights.") (2) Nearly all specimens had been collected in April or May. (3) Males had well developed stridulatory structures on the fore wings, suggesting that they, like most other male mole crickets, produce loud, distinctive calling songs. He therefore went to conserved prairies, in early spring, and listened for distinctive songs. He was soon rewarded with a song resembling the intermittent buzz of some building fire alarms. It proved to be the song of the prairie mole cricket, and the species was subsequently found in more than 60 prairie relicts in Missouri, Arkansas, Kansas, and Oklahoma (Figg and Calvert, 1987).

This paper describes the calling song of *G. major* and the burrow that the male constructs as an acoustical amplifier.

Methods

We used a portable tape recorder (Nagra IV) at 15 ips, with a dynamic microphone and 24-inch parabolic reflector, to record the songs of males calling from

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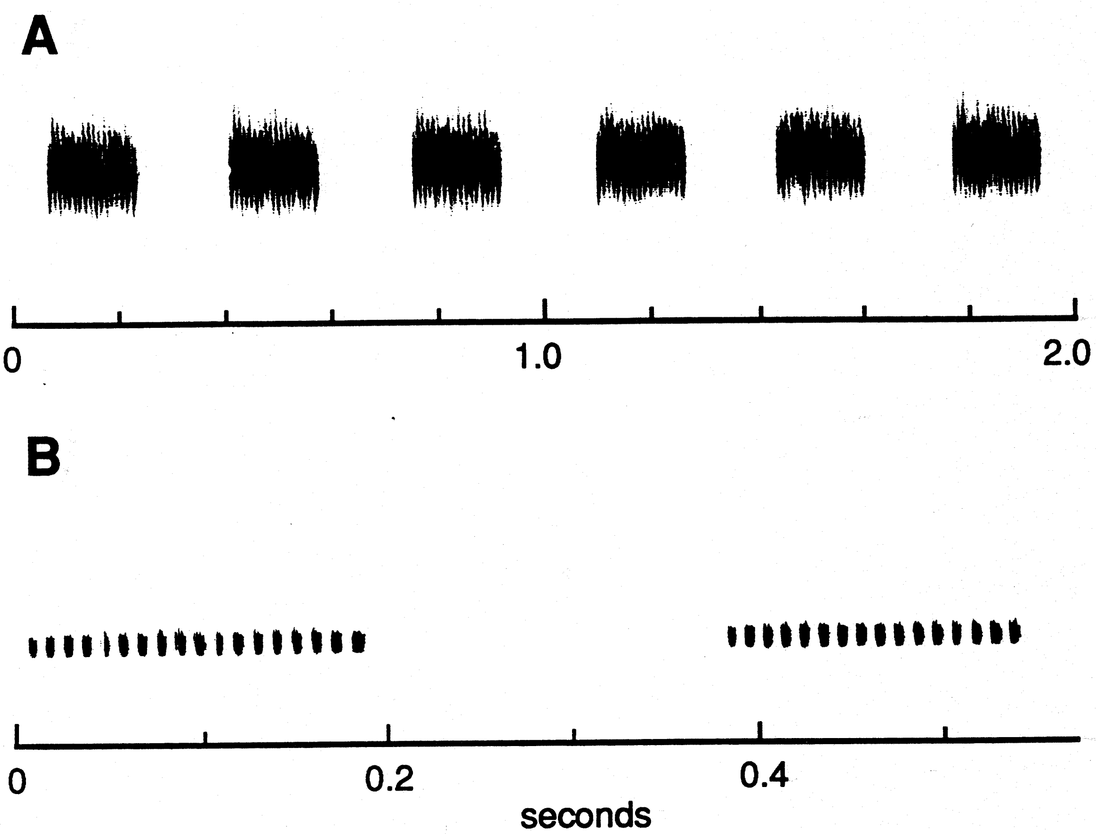

Fig. 1. Calling song of *G. major* (audiospectrograms of UFT 87-9, Univ. Fla. Tape Library). A. Two seconds of calling (2.9 chirps sec^{-1}, 2.1 kHz). B. Two chirps (18 and 16 pulses, 96 pulses sec^{-1}).

their burrows on two prairie preserves in southwestern Missouri. On 11 May 1987 we taped four males on Grandfather Prairie, Pettis County, and on 12 May 1987 we taped four on Niawathe Prairie, Dade County. Recorded songs were analyzed with a Kay 7029A Sona-Graph audiospectrograph and a Honeywell 1858 Visicorder oscillograph.

To determine if mole crickets flew to the calls, we broadcast simulated *G. major* song (3.4 chirps per second, each chirp of 17 pulses with a pulse rate of 96 per sec and a carrier frequency of 2.2 kHz) from the center of a 4 × 4 m plastic sheet. Our synthesizer was battery powered and used an Intel 8748 microprocessor (Walker, 1982). We operated it during the calling period at each prairie.

At Grandfather Prairie, seven burrows were located by homing on calling songs and marked with flagged stakes. The following morning, a plaster of Paris mixture was poured into each entrance and allowed to harden. The casts were retrieved by excavation and measured with dial calipers.

Results

Calling song: The calling song consists of long-continued sequences of brief chirps produced at rates varying from 1.7 to 2.9 per second (Fig. 1; Table 1). For the songs we taped, each chirp consisted of 13 to 35 pulses, which correspond to closing strokes of the forewings. Chirps of 15 to 21 pulses were most frequent. The carrier frequency of the calls was ca. 2 kHz, and the pulse rate within the

Table 1. Characteristics of songs of eight *G. major* males taped 11–12 May 1987. (Site 1 = Grandfather Prairie, 21–22°C air temperature; Site 2 = Niawathe Prairie, 17–18°C air temperature.)

		Range	
	Mean ($n = 8$)	Site 1 ($n = 4$)	Site 2 ($n = 4$)
Carrier frequency (kHz)[a]	2.0	1.9–2.1	1.9–2.1
Pulse rate (p/sec)[b]	87	82–92	80–96
Pulses per chirp (median)[c]	18	16–21	15–21
Chirps per second[c]	2.4	1.7–2.6	2.1–2.9

[a] Determined audiospectrographically.
[b] Mean of three or more oscillographed chirps.
[c] Based on 15 or more chirps.

chirps varied from 80 to 96 per second at air temperatures that ranged from 17 to 22°C.

Calling began at ca. 5 min before sunset each evening and lasted for ca. 60 min. Calls were easily heard more than 100 m from the calling burrow. D.E.F. has heard lone males from as far away as 400 m.

The plastic sheet with the broadcasting synthesizer was inspected periodically. At Niawathe Prairie a flying female *G. major* landed on the sheet at ca. 35 min after sunset and was captured. Another individual landed 5 min later but escaped.

Acoustic burrow: The external opening to the calling burrow of the prairie mole cricket measures ca. 25 × 85 mm and is often partially obscured by over-arching vegetation. Its walls are smooth; its lumen curves to the horizontal and narrows to about 19 × 14 mm within the first 7 cm. From this constriction the burrow expands into an almost spherical chamber (the *bulb*) 3 to 4 cm in diameter (Fig. 2; Table 2). A second opening to the bulb, 180 ± 60° from the first, leads to a tunnel system that mostly remains within a few cm of the surface. One of the seven bulbs that were cast had a tunnel exiting at 90° as well as one exiting at 210° from the opening to the horn.

Discussion

Calling song: The song of the prairie mole cricket resembles that of *Neocurtilla hexadactyla,* the common native mole cricket of eastern North America, in being a rhythmic chirp of low carrier frequency. However, the pulse rate within the chirps and the chirp rate are at least one-third greater. The introduced pest mole crickets of southeastern United States, *Scapteriscus* spp., produce long trills (*S. vicinus* and *S. acletus*) or have no calling song (*S. abbreviatus*). *Gryllotalpa vineae* and *G. gryllotalpa,* two European species, likewise produce long trills (Bennet-Clark, 1970). The only other *Gryllotalpa* known to chirp is the 23-chromosome Israeli sibling species of *G. gryllotalpa* (Nevo and Blondheim, 1972).

Acoustic burrow: Most mole crickets call, tail outward, from special burrows that increase acoustic output (Bennet-Clark, 1970, 1987; Forrest, 1983; Kavanagh, 1987). The burrows from which males of *G. major* call (tail outward) resemble those described for *G. vineae* by Bennet-Clark (1970) except that they lack a bridge across the external opening. Bennet-Clark (1970) reported that although *vineae* builds its burrow with two oval openings, the division between them is sometimes lost after several days. He showed that the cross-sectional area of the horn ex-

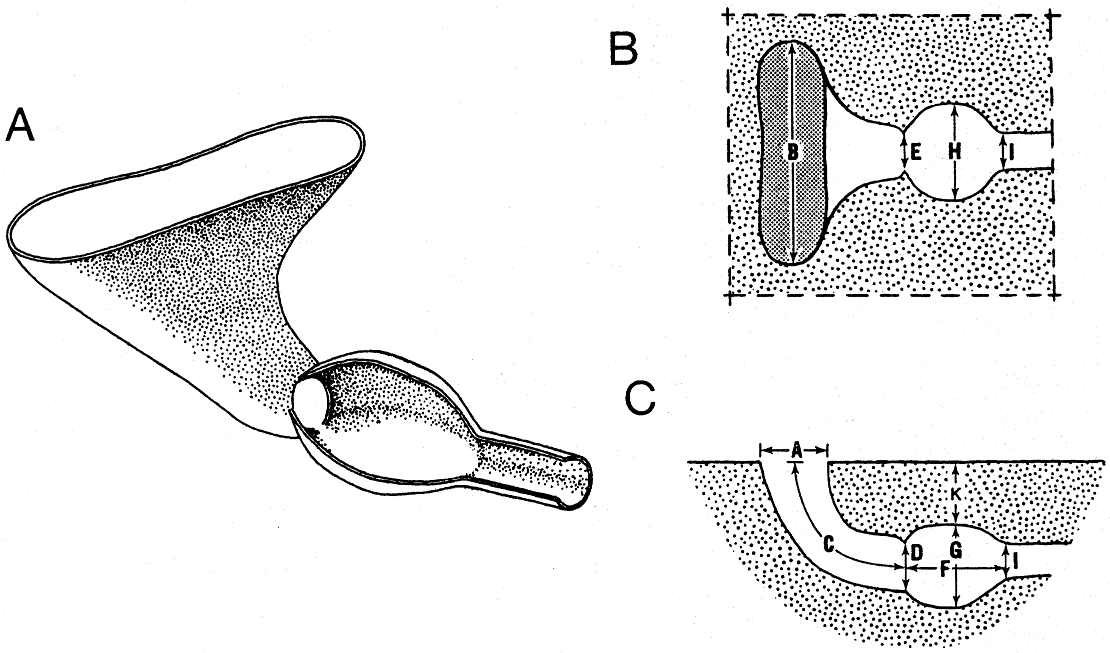

Fig. 2. Acoustical burrow of *G. major.* A. Perspective drawing of (imagined) thin latex cast of burrow, with wall of bulb and of exit tunnel cut away showing opening (to horn) that calling male fills with his body and raised forewings. B and C. Views of burrow from above and from the side showing measurements that were made from casts (see Table 2).

panded approximately exponentially and that the cricket called, tail outward, with its pronotum in the bulb and with its raised stridulating forewings filling the throat of the horn. He pointed out than an exponential horn increases the efficiency with which a small sound source (the forewings) can function. He also did calculations showing that the bulb was of appropriate volume to further improve acoustical efficiency, and that a linear horn mouth would produce a sound field with direc-

Table 2. Measurement (in mm) of casts of seven calling burrows of *G. major,* Grandfather Prairie, 12 May 1987. Letters refer to dimensions shown in Fig. 2.

	Mean ± SE	Range
Exponential horn		
A Opening, width	26 ± 1.2	22–31
B Opening, length	86 ± 4.4	75–103
C Length (estimate)	64 ± 2.0	55–70
D Throat, height	19 ± 0.7	17–22
E Throat, width	14 ± 0.6	11–15
Bulb		
F Length	39 ± 0.8	36–41
G Height[a]	33 ± 1.2	29–37
H Width	37 ± 1.4	32–42
I Exit, height[b]	14 ± 0.4	13–15
J Exit, width[a]	14 ± 0.5	13–16
K Roof-to-surface (estimate)	19 ± 5	3–35

[a] $n = 6$ (one cast incomplete).
[b] $n = 5$ (two casts incomplete).

tional properties similar to those he had measured for *vineae*. *G. major* has a linear horn mouth; and, like the summed values for *vineae*'s two mouths, its long axis approximates half the wavelength of the song's carrier frequency: *G. vineae,* 3.4 kHz = 9.9 cm wavelength; 50 mm sum of mouths. *G. major,* 2.0 kHz = 17.2 cm wavelength; 86 mm mouth.

Subsequently, Bennet-Clark (1987) experimentally analyzed the calling burrows of *Scapteriscus acletus,* which like those of *vineae* and *major* have an outer exponential horn and an internal bulb. He found that an artificial sound source that was similar to a mole cricket's wings produced sound pressures as much as 24 dB higher in the burrow than in free air. Destroying the bulb decreased the acoustical gain by 6 to 10 dB.

We carefully examined ten of the external openings to *G. major* calling burrows and discovered that two had slight inward projections at the midpoint of the outer lip. One had a thin bridge of moss across the center of the orifice. These observations suggested that *major* begins the construction of its burrows in the same manner as *vineae.* Because D.E.F. has seen only one double-opening horn among more than 200 that he has checked, we doubt that *major* uses a double horn until the bridge collapses (as Bennet-Clark concluded for *vineae*). Of three *G. major* males that T. G. Forrest (pers. comm.) placed in buckets of soil in hope of measuring their acoustic output, only one built a calling burrow. It had a single opening.

Another noteworthy feature of the calling burrow of *major* is that the shallow horizontal tunnel system leading from it occasionally terminates 0.3 to 1.0 m away in a bulb and horn that are indistinguishable from the ones found by homing on the male's call (Figg and Calvert, 1987). The function (if any) of this second acoustic structure is not known; the few examples we have seen have been early in the calling season.

The calling burrows of *S. acletus* and *vicinus* are plugged with soil when not in use. Those of *Gryllotalpa* spp., including *major,* are not.

The calling burrow of *G. major* should function like that of *vineae* and beam the sound upward (see Figs. 14 and 17 of Bennet-Clark, 1970). This suggests that flying females are a principal target. The attraction of a flying female to the synthesizer at Niawathe Prairie and the collection of females at lights well-removed from habitat suitable for *major* support this conclusion. More recently, D.E.F. has observed several flying females drop to the ground in the vicinity of calling males. The low carrier frequency of the call (2.0 kHz compared to 3.4 for *vineae*) suggests that the call may also reach nearby females in the soil (Forrest, 1983).

Acknowledgments

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