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SOUND ANALYSES OF *METRIOPTERA SPHAGNORUM* (ORTHOPTERA: TETTIGONIIDAE)

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Abstract

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The song of *Metrioptera sphagnorum* (F. Walker) is a prolonged trill alternating regularly between two intensities. Oscilloscope analyses reveal two stridulation modes corresponding to the two intensity levels. These two modes are described in terms of pulse structure.

Characteristic frequency spectrograms are associated with each mode. In one mode audio frequencies are emphasized; the other mode is dominated by high intensity ultrasonic frequencies. At the approach of a conspecific male, singers were observed to prolong the audio-dominated stridulation mode.

Introduction

The stridulation of *Metrioptera sphagnorum* is audible at a few metres as a rhythmically interrupted trill. At closer range the "interruptions" are recognized as shifts to a lower intensity level, no actual break occurring in the sound (E. M. Walker 1911).[1]

The songs of Tettigoniidae can be described in terms of their temporal pulse patterns and sound frequency spectra. Such an analysis was applied to the sounds emitted by *M. sphagnorum* as a first step in determining which song parameters function in the transfer of information to conspecifics.

Materials and Methods

During early August 1968, specimens of *M. sphagnorum* were collected from black spruce bogs northwest of Fort William, Ont. Several individuals were obtained from a similar habitat 70 miles west of Hearst, Ont., beside highway 11.

Coincident with low morning temperatures, the insects were found high in the spruce trees, 3 to 6 m from the ground. In the afternoon under higher temperatures they were located on small shrubs (Ericaceae) just above the sphagnum carpet or on the sphagnum surface itself.

The insects were transported to Toronto and analysis carried out upon living specimens rather than from tape recordings. The laboratory temperature ranged between 20° and 24°C for all analyses.

Analysis equipment included a Bruel and Kjaer Co. ¼ in. condenser microphone (model 4135). The microphone was connected to a Bruel and Kjaer microphone power supply (type 2801). The signal passed from the power supply into a Tektronix storage oscilloscope (model 564) with accompanying time base (model 2B67). A Tektronix frequency analyzer plug-in unit (type 3L5) was used to obtain frequency spectrograms of the insects' stridulation.

Precautions were taken to standardize the spatial relationship between a singer and the microphone. Figure 1 shows the arrangement used. Two or three males were placed together in a 'wafer-shaped' cage $30 \times 30 \times 3$ cm constructed of ¼ in. mesh galvanized iron screening. The long axis of the microphone was aligned by eye perpendicular to the near cage surface and approximately 1 cm from it. This arrangement placed the microphone head approximately 3 cm from the dorsum of an insect resting on the far side of the

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[1] The recent passing of Dr. Walker coincided with the work reported here. This paper is offered in memory of a distinguished Canadian entomologist.

cage. The microphone was also centred directly over the insect's sound field (the modified basal region of the tegmina).

Some records were made with the singer positioned on the side of the cage near to the microphone. In such cases the distance between the ventrally directed microphone and the animal's dorsum was about 2 cm.

Results

Time–Amplitude Patterns

It is apparent to the human ear that the unbroken trill produced by this insect alternates regularly between two intensity levels. At 21°C the intensity level of the song changes approximately every quarter second.

Figure 2A is a photograph of three time–amplitude oscilloscope patterns sampled from the stridulation of a male *M. sphagnorum.* Each of the three traces was produced by a single sweep of the oscilloscope beam at a rate of 50 msec/division. Two stridulation patterns can be recognized corresponding to the two intensity levels described above. They are here arbitrarily designated stridulation mode I and stridulation mode II.

Using pulse in the sense recommended by Broughton (1963), each stridulation mode can be said to consist of two regularly alternating pulse train types: long-duration and short-duration. More detailed pulse structure can be seen by increasing the beam sweep rate as in Figs. 2B, C.

The traces of Fig. 2B show the completion of stridulation mode II and the beginning of mode I at a sweep rate of 10 msec/division. Stridulation mode I alternates a long-duration pulse train of 4 or 5 high-amplitude pulses with a short-duration train whose pulse structure is here unresolved. At 5 msec/division (Fig. 2C) the long-duration pulse train of mode II is seen to contain more than 40 pulses.

The long-duration trains of modes I and II differ in pulse amplitude and in the rate at which the pulses are delivered. Mode I pulses are approximately twice the amplitude of mode II pulses. Mode II pulses are delivered at a substantially higher rate.

Frequency Spectra

Frequency spectra records were obtained over a 0 to 100 khz range. Fig. 2D is a typical spectrum record (spectrogram) obtained by storing approximately 40 successive traces while the insect sang steadily. The most intense frequencies lie between 30 and 35 khz and almost no sound energy is produced below 10 khz. Peaks centre on 15 khz, 33 khz, and 63 khz. Ultrasonic frequencies are notably intense.

A large number of single-sweep spectrograms was obtained at a sweep rate of 20 msec/division. At this rate a record is completed in 200 msec. Since 250 msec is the duration of a stridulation mode many of the resulting spectrograms were completed entirely during one or the other of the two modes. Resulting records could be separated into three groups typified by (1) moderately high ultrasonics, (2) audio frequencies and very low ultrasonics, and (3) apparent composites of groups 1 and 2. The spectrograms of group 1 may be conveniently described as ultrasonic-dominated, those of group 2 as audio-dominated. Fig. 3A is a typical group 2 spectrum record; Fig. 3B is a typical group 1 spectrogram.

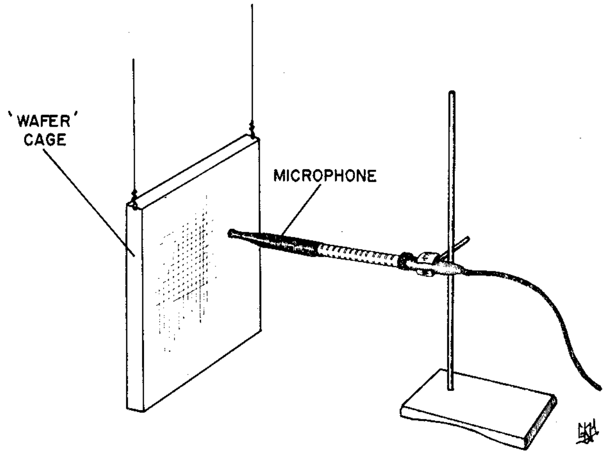

Fig. 1. Arrangement of cage and microphone during sound analysis.

Another distinction can be drawn between the spectrograms of groups 1 and 2. The ultrasonic-dominated spectrograms appear as a horizontal series of widely spaced vertical beam deflections. The vertical deflections of the beam in audio-dominated spectrograms are more closely grouped. This effect is related to the stridulation mode during which the record was obtained.

The Tektronix analyzer, with appropriate range settings, surveys successive frequencies between 0 and 100 khz. The insect's song is essentially a series of

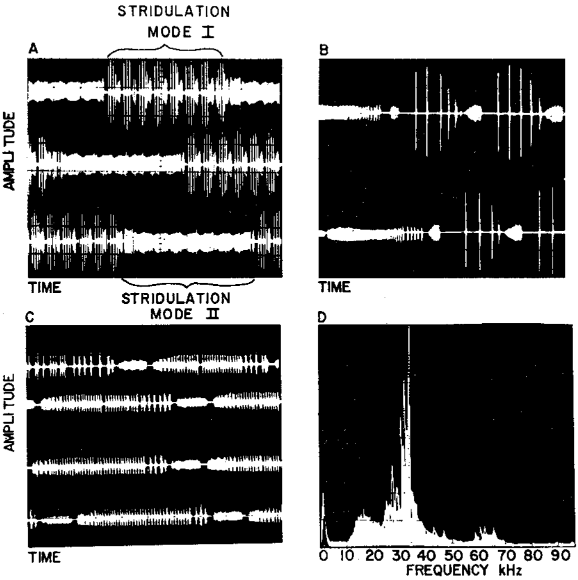

Fig. 2. Oscilloscope traces of *M. sphagnorum* stridulation. A, time–amplitude patterns obtained at a sweep rate of 50 msec/division. B, time–amplitude patterns of the end of stridulation mode II and the beginning of mode I at a sweep rate of 10 msec/division. C, time–amplitude patterns of stridulation mode II at a sweep rate of 5 msec/division. D, a frequency spectrogram accumulated over 4 sec at a sweep rate of 10 msec/division with the microphone 3 cm dorsal to the insect's sound field.

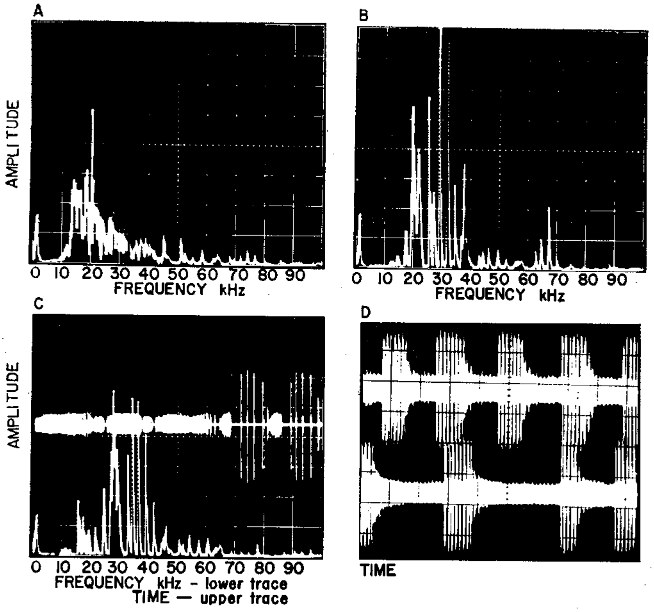

FIG. 3. Oscilloscope traces of *M. sphagnorum* stridulation. A, a single-sweep frequency spectrogram obtained at a sweep rate of 20 msec/division with the microphone 3 cm dorsal to the insect's sound field. B, a single-sweep spectrogram of the same specimen obtained at an identical sweep rate and without alteration in microphone–insect alignment. C, a single-sweep frequency spectrogram with superimposed time–amplitude pattern, both traces made at a sweep rate of 20 msec/division. D, time-amplitude patterns, at a sweep rate of .2 sec/division, of an isolated singer (upper trace) and of the same individual on the approach of a conspecific male (lower trace).

discrete pulses separated by intervals during which little or no sound energy is being produced. If no pulse of sound energy is forthcoming at the instant the analyzer 'examines' a particular frequency then there will be, of course, no vertical deflection of the oscilloscope beam. The effect of this is to reveal the time–amplitude pattern in the spectrogram trace. An examination of Fig. 3C will make this clear. A time–amplitude pattern has been superimposed on an ultrasonic-dominated spectrogram. Both traces were made at 20 msec/division. The long-duration pulse train of stridulation mode I can be compared with the series of vertical deflections of the spectrogram between 32 and 42 khz. The rates are identical.

The foregoing permits one to associate ultrasonic-dominated spectrograms with stridulation mode I and audio-dominated spectrograms with stridulation mode II. Another more obvious basis for matching arises out of a comparison of the intensities achieved in time–amplitude patterns and in spectrograms. Standardization of microphone and insect alignment makes such intensity comparisons meaningful. Stridulation mode I is far more intense than stridulation mode II; ultrasonic-dominated spectra show far greater levels of sound energy than do audio-dominated spectra.

Field singers, disturbed by an approaching human, bring the normal intensity cycle of the trill to an end by prolonging for 1 or 2 sec the audio-dominated stridulation mode II. Similar prolongation has been noted as stridulation was resumed following a period of silence. On several occasions in the laboratory when a singer was approached within a few inches by a silent conspecific male, stridulation mode II was prolonged apparently in response to the approaching individual. The silent male then withdrew and the singer reverted to the usual cycle without ever having ceased to stridulate. The upper trace of Fig. 3D is a normal sequence of stridulation modes. The lower trace shows the prolongation of the audio-dominated mode coinciding with the approach of a second male.

Discussion

The sound spectra of several tettigoniid species have been shown to remain largely unaffected by the alteration of tegminal structures (Dumortier 1963; Broughton 1964; Suga 1966). Experiments in which the author loaded the basal forewing area of *Metrioptera roeseli* (Hagenbach) with a blob of sealing wax resulted in no discernible deviation from normal in the frequency spectrograms subsequently obtained. The severing of certain wing veins of *M. roeseli* likewise had little effect, contrary to ideas expressed in an earlier paper (Morris and Pipher 1967).

With the same tegminal apparatus *M. sphagnorum* produces two distinctive spectra. Together with the mutilation experiments just mentioned this suggests that wing structure is not of itself very critical in governing which frequency a species will emphasize. The way in which the file and scraper are employed (the file region used, the force with which the wings are brought together etc.) would appear to be far more effective in determining spectra content.

The long-duration pulse trains of modes I and II comprise the bulk of *M. sphagnorum* song. In one mode relatively few teeth are struck and at a low rate; the resulting sound pulses are of relatively high amplitude and ultrasonic frequencies predominate. In the other mode, teeth are struck at a high rate; the resulting sound pulses are of relatively low amplitude, and low ultrasonic and audio frequencies predominate. Perhaps similar correlations can be made in the case of other Tettigoniidae.

Many of the specimens of *M. sphagnorum* taken at Fort William were host to larval trombidiid mites of the genus *Eutrombidium*. These large bright red parasites were grouped in clusters of as many as six on the underside of the wing areas modified for sound production. It is unlikely in view of the sealing wax experiment that the presence of these animals alters the sound frequencies produced.

The change in stridulation pattern observed at the approach of a conspecific male is doubtless a signal—perhaps associated with threat. The latter interpretation seems likely in view of overt aggressive interactions observed by the author between conspecific males of *M. roeseli*, *Orchelimum*, and *Conocephalus* (Tettigoniidae).

Acknowledgments

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