World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 3.347

ACOUSTICS OF FIELD CRICKET (ORTHOPTERA: GRYLLIDAE) SONG FROM A LOCALITY IN GORAKHPUR

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Article Received on 10/06/2016 Article Revised on 01/07/2016 Article Accepted on 22/07/2016

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ABSTRACT

Acoustical signaling by males is the predominant form of communication in crickets (Orthoptera: Gryllidae). They produce three qualitatively distinct types of song dependent on the social context. The aggressive song of *Gryllus bimaculatus* De Geer is very distinct and was analysed for its temporal and frequency characteristics. Despite a large literature on cricket bioacoustics, we currently know remarkably little about the functional significance of cricket song beyond the importance of calling song in attracting females. This study also implores the effect of energy and muscle physiology constraints on the song characteristics.

KEYWORDS: Gryllidae, Cricket, bioacoustics.

INTRODUCTION

Communication in crickets (Orthoptera: Gryllidae) predominantly involves acoustical signaling by males. They produce calling song to attract females, who locate males by phonotaxis. The songs produced by male crickets are generally grouped into at least three qualitatively distinct types, depending on social context: calling song, courtship song, and aggressive song (Alexander, 1961). Tegminal stridulation is thought to have evolved from wing movements during non-acoustic sexual displays (Alexander, 1962; Alexander & Brown, 1963). The displays became acoustic when the tegmina evolved a file-and-scraper mechanism capable of producing a pulsed calling song. Sexually receptive females were attracted to the male song and approached first by flight, in macropterous taxa, and then on foot (Boake, 1983; Otte, 1992).

Although much work has been done on cricket bioacoustics, we currently know remarkably little about the functional significance of cricket song beyond the importance of calling song in attracting females. They produce specific structurally different songs in different social contexts and this has strong fitness consequences for the animals. In this study we have analyzed the acoustic parameters of songs of Field Cricket *Gryllus bimaculatus* De Geer from a Gorakhpur locality (26.7588°N 83.3697°E) in the state of Uttar Pradesh, India.

General Features of Cricket Calling Songs

Song in crickets is produced in a two-step process (Bennet-Clark, 1999; Michelsen, 1998). The first step is stridulation in which muscles which are too slow (7–30 Hz) to cause a 2 - 8kHz vibration, achieves this feat by frequency multiplication. Fairly slow muscular contractions are used for rubbing the forewings against each other causing the plectrum of the left wing hits a series of cuticular teeth or file under the right wing during wing closure. The result is a wing vibration with a spectrum in which the tooth-impact rate (the number of teeth hit per unit time) corresponds to the lowest component in a harmonic series (Michelsen, 1998, Robillard et al, 2013).

The second step is to obtain an efficient sound emission by signal amplification and involves the action of a wing resonator. This requires a reasonably large surface, which vibrates with a large amplitude. In the male cricket, this is obtained in a triangular part of the wing known as the harp. The lowest harmonic in the series produced during the stridulation dominates the emitted sound therefore cricket emits an almost pure tone (Michelsen, 1998).

The acoustic energy thus produced is radiated by special area(s) of the tegmina, acting as the resonator, which modifies the frequency of the sound so that it fits both its own resonance frequency and the striking speed of the file over the plectrum. This is the carrier frequency of the call (Nocke 1971; Michelsen & Nocke 1974; Sismondo 1979; Bennet-Clark1999). One wing closure gives rise to one elementary part of the song, called a pulse (or syllable). Pulses are arranged in various regular or irregular temporal patterns: a long series of pulses emitted at regular and short time intervals constitutes a ‘trill’, while a shorter series is called a ‘chirp’. Duration of Chirps is very diverse. They often show an irregular pulse distribution or modification in pulse rate. Moreover the emitted intensity of the song may also vary in the course of emission (amplitude modulation; Beeman 1998). Cricket songs are thus characterized by their temporal characteristics, intensity and carrier frequency; these are the only characteristics with noticeable interspecific differences (Bennet-Clark 1989; Fletcher 1992).

The Information Content of Gryllid Songs

Information content of acoustic signals requires signal consistency to be meaningful. Individual consistency in cricket song has been shown in several species. On the other hand, there must be variation between individuals of the same species in song characteristics conveying fitness-related phenotypes (other than species identifiers), as these phenotypes themselves vary between signaling individuals. Phenotypic information content has been shown to be conveyed in song characteristics that span four general categories: frequency, amplitude, amount of calling (e.g., duty cycle, bout duration, and onset of calling), and temporal characteristics (e.g., number of pulses per chirp,pulse duration, and length of interpulse interval).

MATERIALS AND METHODS

The crickets were placed in seperate confined space and were allowed to rest for sometime. The songs were recorded using smartphone equipped with high quality condenser (electrets) microphone. High quality software was used to record the songs in small clips. The audio was recorded in wav. format using high quality recording application set at 44,000 Hz sampling rate with a bit depth of 16 bit.

The terminology proposed by Ragge &Reynolds (1998) was followed : (1) a syllable is generated during a complete opening (silent) and closure (noisy) of the forewings, (2) an echeme is a group of syllables emitted with a definite pattern; it is the unit of the song which is repeated at length during calling, and (3) an echeme sequence or song bout corresponds to one, uninterrupted series of echemes. We will use the term “trills” to describe\ “continuous trains of rapidly repeated, ungrouped syllables, lasting indefinitely\ (often more than one minute)” (Ragge & Reynolds, 1998). Trills, thus, differ from continuous, dense echeme-sequences, where short echemes are repeated rapidly and continuously. The syllable rate is the number of syllables emitted per second within an echeme, and the echeme rate is the number of echemes emitted per minute during a song bout. Acoustic analyses were performed with Avisoft SASLab and Raven Lite softwares.

OBSERVATION & RESULT

The acoustical analysis of the song pattern from field cricket was executed using Raven Lite version 1.0 for windows from the Cornell Lab of Ornithology-Bioacoustical Research Program and Avisoft SASLab. Various temporal and frequency characteristics were measured from the waveform (Fig.1) and spectrogram (fig.2).

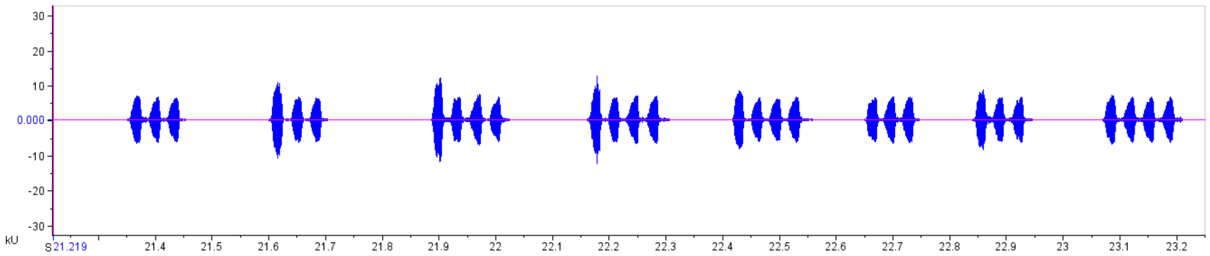

Fig 1: Waveform of Field Cricket song.

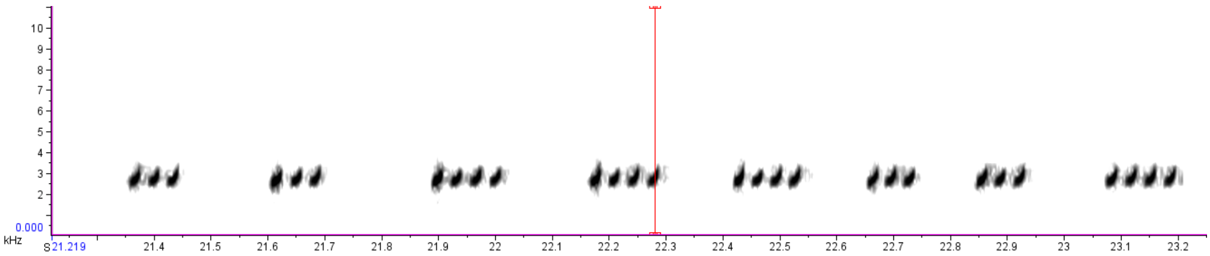

Fig 2: Spectrogram of Field Cricket song.

Temporal characteristics

The mean duration of echeme with 3 syllables was found to be 87.8±1.9 millisecond. Whereas the mean duration of echeme with 4 syllables was 125.2±2.8 ms. The mean time interval between two successive 3 syllabeled echemes was 203.2 ±3.8ms. Whereas the same between two successive 4 syllabeled echemes was 243.4 ±4.4ms. The mean time interval taken to produce a 4 syllabeled echeme after a 3 syllabeled echeme was 289.4 ± 12.9ms. Whereas mean the time interval taken to produce a 3 syllabeled echeme after a 4 syllabeled echeme was 235.2 ±3.6ms.

Frequency characteristics

The fundamental frequency range of syllables in and across the echeme were determined to range from 2163.4 ±9.9 to 3472.2 ± 12.8 Hz.

DISCUSSION

In any echeme the syllables were evenly separated but the mean time interval between two successive 4 syllabeled echemes was consistenty more than the same between two successive

4 syllabeled echemes. This shows a refractory period necessary. The mean time interval taken to produce a 4 syllabeled echeme after a 3 syllabeled echeme was 289.4 ± 12.9ms. It was significantly more than the mean time interval taken to produce a 3 syllabeled echeme after a 4 syllabeled echeme, which was 235.2 ±3.6ms. These temporal and frequency characteristics of a cricket song emphasize a definite pattern governed by energy tradeoffs and muscle physiology. A longer refractory period is necessary before a longer bout of echeme. Similarly, the time interval is longer between two 4-syllabeled echeme which again emphasizes this constraint of muscle physiology.

The rate at which an animal can do apply force through a distance is normally limited by how fast muscles can contract. But deformed cuticle can return the work that went into its deformation much faster than a working muscle. Many insects are known to utilize this elastic energy to achieve faster and powerful movement in this way (Bennet-Clark and Lucey, 1967; Burrows, 2003; Krasnov et al., 2004, Montealegre, 2006),. It needs to be investigated as to what extent the crickets invoke the power capability of elastic energy stored in cuticle to generate high-frequency output by low-velocity wing movement.

The cricket thus stands out as an animal that has evolved a sophistsicated mechanism of auditory communication. Each song type conveys some different aspect of mate quality (i.e. multiple messages), although there may be some overlap between what is communicated to males and females (as suggested by Nelson & Nolen, 1997) and males may repeat certain critical information in more than one social situation. This study on *Gryllus bimaculatus* De Geer song is first in Gorakhpur and the spectral and temporal data will enable thorough intraspecific, interspecific and phylogenetic comparison.

ACKNOWLEDGEMENT

The authors thank Dr. J.K. Lal, Secretary and Principal, St. Andrew’s College, Gorakhpur, for his constant encouragement and providing laboratory and library facilities.

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