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IMPACT OF SEASONAL AND GEOGRAPHICAL VARIATION ON THE MALE CALL SONG STRUCTURE OF THE COMMON HOUSE CRICKET *ACHETA DOMESTICUS* (L.)

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ABSTRACT

The study of the impact of geographical variation and seasonal changes on the male call song structure of house cricket, *Acheta domesticus (*L.*)* has been made in the present work. We used *A. domesticus* male call song recordings which were made in Florida, Kentucky and New York, USA and London County in UK. With the help of computer software, we extracted the temporal and frequency components of the call songs and these parameters were then used to correlate the sound structure variation with the geographical changes as well as seasonal variations. Although, we found some minor variations in the sound pattern but these certainly suggest no definite impact on the characteristics of call songs. By searching literature, we also found additional call song recordings from other geographical zones in USA, in different seasons. These recordings also appear to confirm our results and therefore these have also been included in the present comparative studies.

Key-words: male call song structure, house cricket,

INTRODUCTION

Acheta domesticus (L.) was described from Pakistan by Ghouri (1961) who also mentioned its distribution in South-Western Asia and Africa. Khalifa (1950) stated that *A. domesticus* became cosmopolitan. In modern cricket taxonomy, the external morphological characters including male and female genitalia are not considered as reliable identifying taxonomic characters (Khan, 2013). Allard (1910) noted the impact of geographical variations on the song patterns whereas Fulton (1952) was the first taxonomist who used the call songs as reliable taxonomic character to separate cricket species including their sibling species. Alexander (1957) presented the sonogram of *A. domesticus*. Weissman and Rentz (1977) re-described its sonogram with a few additional characters. In the present work with the help of new recording technologies, acoustic characters appear as the most reliable character for their identification.

A.domesticus is not found in peninsular Florida but appear to be numerous in California (Rentz and Weissman, 1978; Wiessman and Rentz, 1978). *A. domesticus* usually appear in late fall (Wiessman and Rentz, 1977). *A.domesticus* was found in different cities of Orange County, California and this species undoubtedly appear to be distributed widely and considered as cosmopolitan (Weissman and Rentz 1977). It is also found in the eastern United States (Blatchley, 1920).

MATERIALS AND METHODS

For the present studies, we took six male call song recordings of *A. domesticus* from the insect sound repository of Macaulay Library, University of Cornell, New York, USA and Natural History Museum, London archive. We have also taken one call song specimen from the internet which is cited in the references. These sounds were recorded in the months of May-June through September in different geographical locations in USA and one location in UK (See also map 1, showing distribution and Table 2 indicating months/average temperature). For analysis of the call song structure, we used freeware computer software SOUNDRULER (www.soundruler.sourceforge.net). The key song parameters such as the number of pulses per chirp, the peak amplitude, the frequency of the peak amplitude and the length of the inter-chirp intervals were extracted from these recordings. The findings of these analyses have been tabulated in Table 1. The wave forms and spectrograms of the call songs have also been plotted using the SOUNDRULER program.

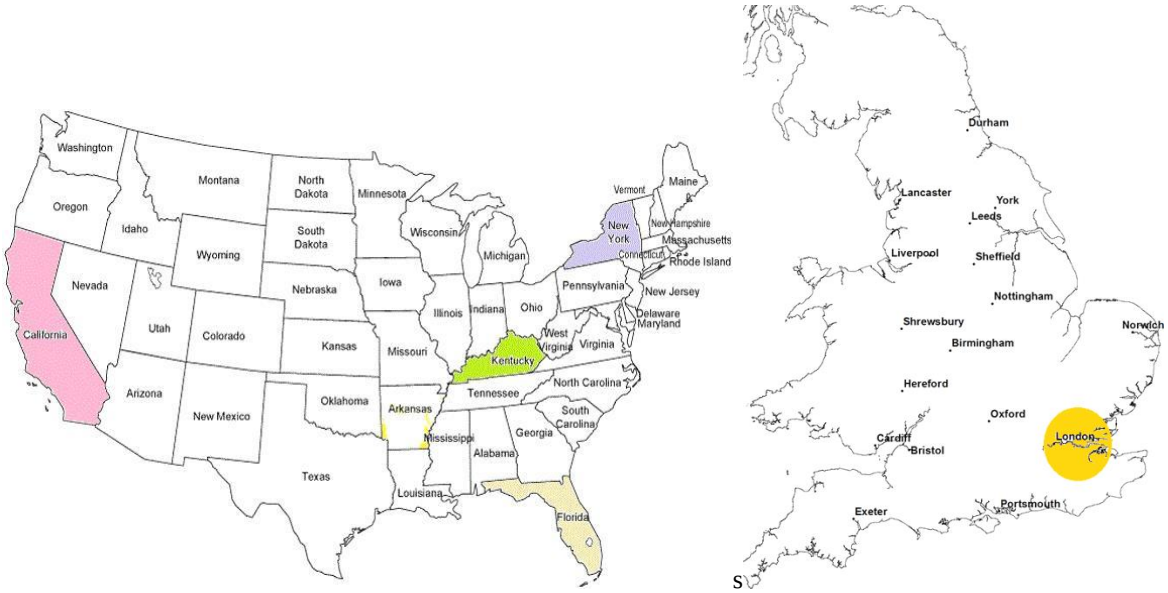
The following recordings from the Macaulay Library at the Cornell Lab of Ornithology were referenced: 161795,121187,121186,121184,121185. Sound specimen: 487SL has been taken from the web site: http://entnemdept.ufl.edu/walker/buzz/487a.htm

Table 1. Showing the parameters extracted from the sound recordings using computer software.

S. No.	Specimen ID	Inter Chirp Duration (s)	Chirp Duration(s)	No. of Pulses	Peak Amplitude of Chirp	Inter Pulse Duration (s)	Pulse Duration	Dominant Frequency Of Chirp (KHz)	Locality	month	Fig.
a.	ML161795	0.39	0.18	4	0.82	0.02	0.03	4.4	NY	AUG	1 a-d
b.	ML121187	0.71	0.06	2	0.43	0.02	0.02	4.9	FL	SEP	2 a-d
c.	487SL	0.57	0.07	2	0.29	0.02	0.03	4.9	FL	MAY	3 a-d
d.	ML121186	0.27	0.09	3	0.06	0.01	0.02	4.6	KY	JUN	4 a-d
e.	ML121184	0.01	0.14	4	0.03	0.02	0.02	5.3	KY	JUN	5 a-d
f.	ML121185	0.31	0.09	3	0.10	0.02	0.02	4.7	KY	JUN	6 a-d
g.	393:8	0.82	0.16	1-2	0.98	0.02	0.03	4.6	UK	JUN	7 a-d
h.	Weissman and Rentz 1977	0.06	0.18	2-4	_____	0.09	0.08	_____	CA		8
i.	Gray (1997)	0.2-0.3	0.16	03		0.02	0.06		CA		9

Table 2. Call songs recorded in different months with average temperature.

State	Month	Average Temp.
New York Figs. 1 a-d	August	
Florida Figs 2 a-d	September	
Florida Figs 3 a-d	May	26.5 ºC
Kentucky Figs. 4 a-d	June	
Kentucky Figs. 5 a-d	June	
Kentucky Figs. 6 a-d	June	
London Figs. 7 a-d	June	28 ºC
California Fig. 8	-	20 ºC
California Fig. 9	-	-



Map showing state-wise distribution of *A. domesticus* in USA and UK.

RESULTS

Acoustic features:

Specimen 1. (Figs. 1 a - d)

Calling songs of *A. domesticus* from New York in August appear to have pitched sound. Oscillogram of stridulating song of the present specimen reveals series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.03 seconds with inter-pulse interval (IPI) duration 0.02 seconds. These pulses form chirps containing 4 pulses per chirp. Chirp frequency is about 02 chirps per second and single chirp duration is almost 0.18 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.3-0.4 seconds.

FFT analysis of song confirms that the carrier frequency of specimen is about 4.4 kHz.

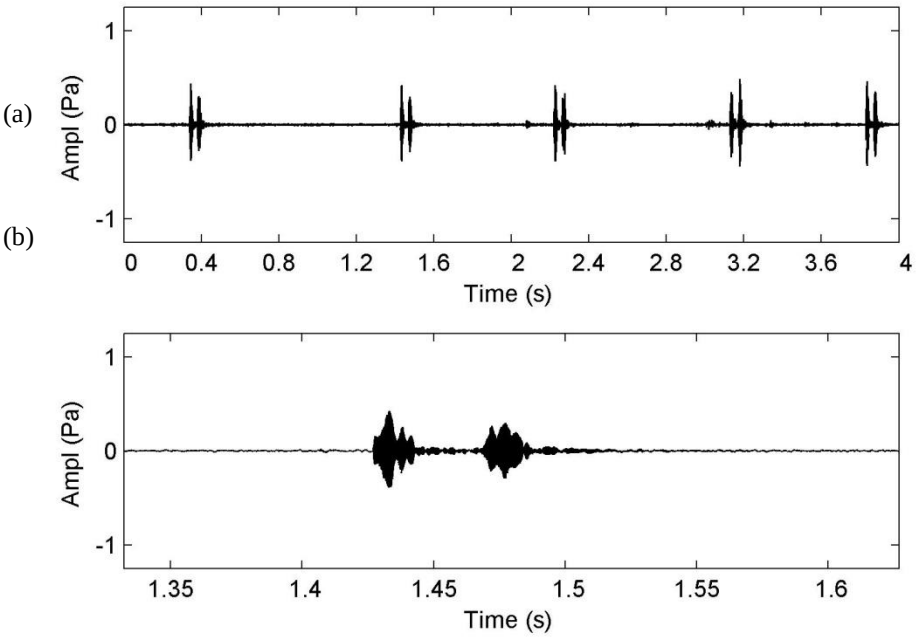
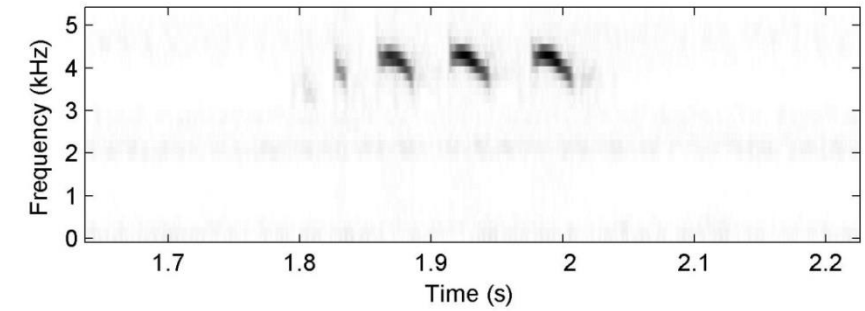


Fig. 1 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig.1 (b). An exploded view of the oscillogram showing the chirp structure.

(c)



(d)

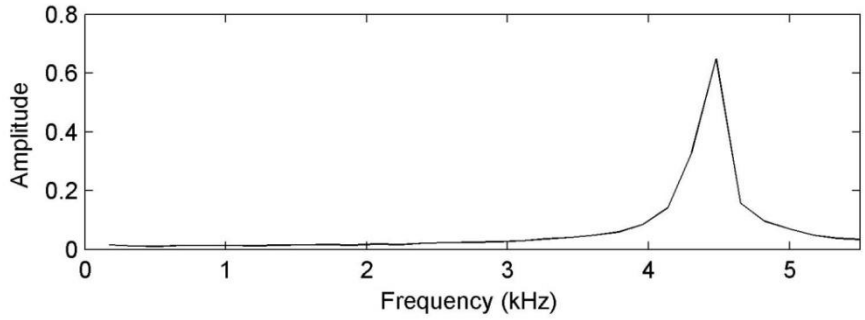


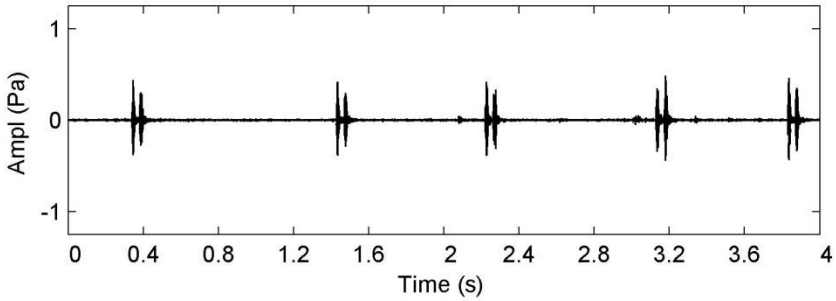
Fig. 1 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 1 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 2 (Figs. 2 a – d)

Calling songs of *A. domesticus* from Florida in September also appear to have high pitched sound. Oscillogram of stridulating song of the present specimen reveals series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.02 seconds with inter-pulse interval (IPI) duration 0.02 seconds. These pulses form chirps of varying lengths with 2 pulses per chirps. Chirp frequency just about 01-02 chirps per second and single chirp duration is about 0.06 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.71 seconds.

FFT analysis of song confirms that the carrier frequency of specimen is about 4.9 kHz.

(a)



(b)

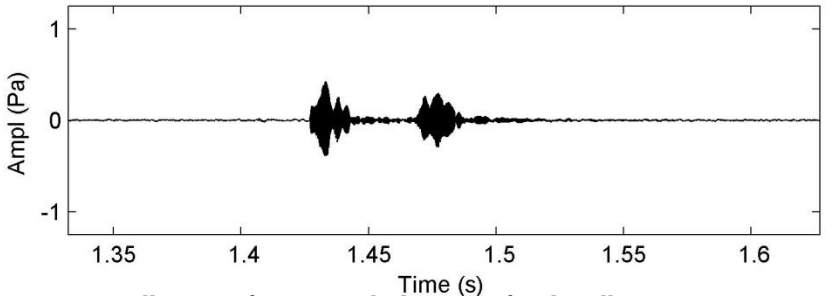
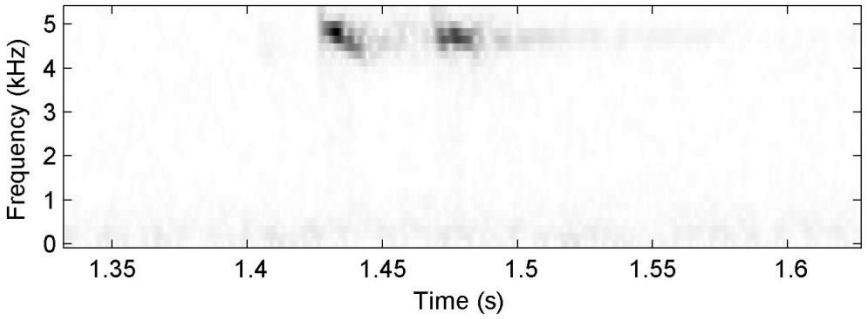


Fig. 2 (a). Oscillogram of 2-4 seconds duration of male call song
Fig. 2 (b). An exploded view of the oscillogram showing the chirp structure.

(c)



(d)

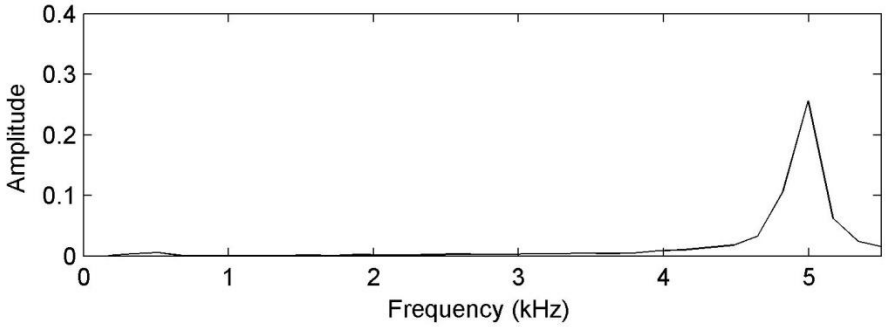
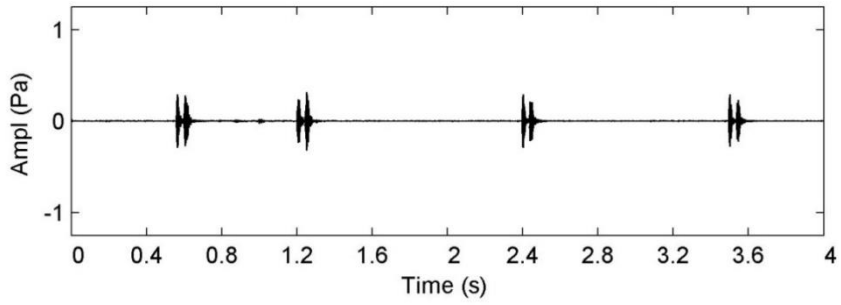


Fig. 2 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 2 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 3; (Figs. 3 c - d)

Calling songs of *A. domesticus* from Florida in May also have high pitched sound. Oscillogram of stridulating song of the present specimen reveals series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.03 seconds with inter-pulse interval (IPI) duration of 0.02 seconds. These pulses form chirps of varying lengths with 2 pulses per chirp. Chirp frequency just about 01-02 chirp per second and single chirp duration is about 0.07 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause 0.57 seconds. FFT analysis of song confirms that the carrier frequency of specimen is about 4.9 kHz.

(a)



(b)

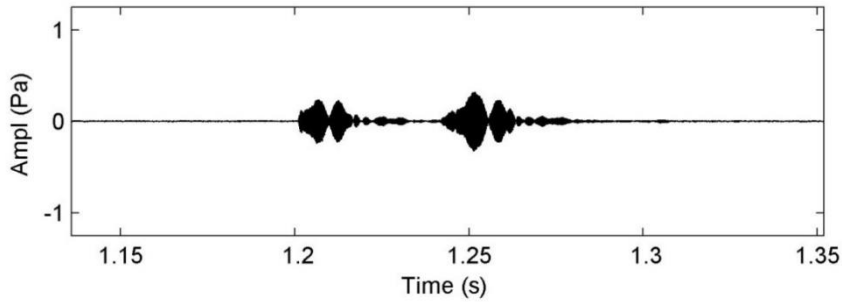
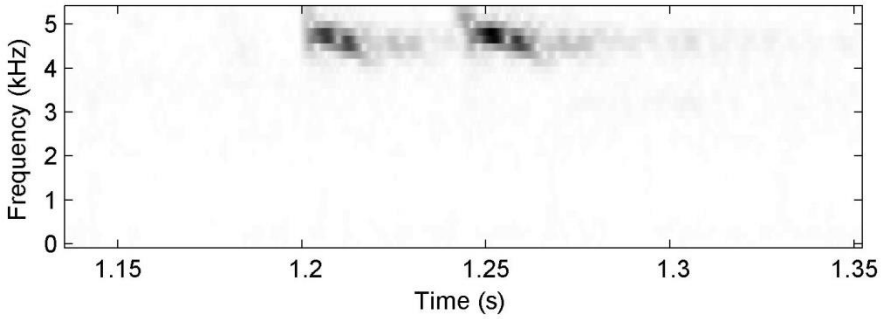


Fig. 3 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig. 3 (b). An exploded view of the oscillogram showing the chirp structure.

(c)



(d)

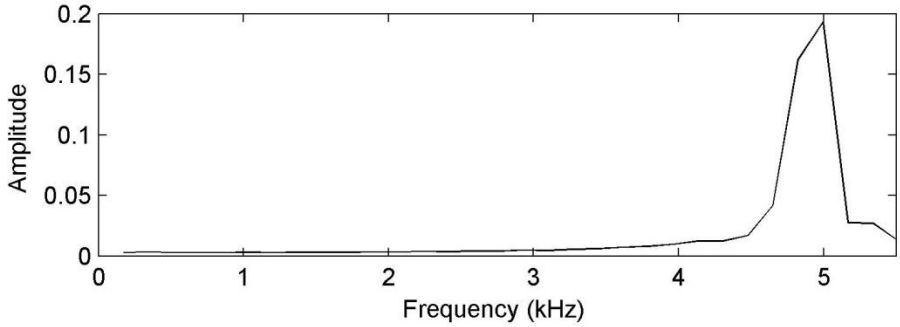


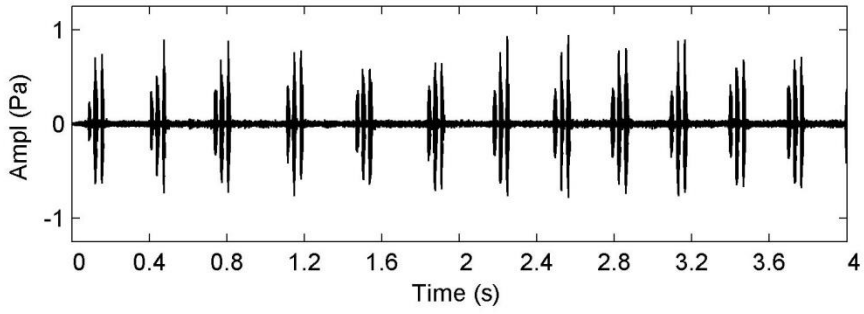
Fig. 3 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 3 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 4 (Figs. 4 a - d)

Calling songs of *A. domesticus* from Kentucky (a) in June also have high pitched sound pattern. Oscillogram of stridulating song of the present specimen reveals a series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.02 seconds with inter-pulse interval (IPI) duration 0.01 seconds. These pulses form chirps of varying lengths containing 3 pulses per chirp. Chirp frequency is about 03 chirps per second and single chirp duration is almost 0.09 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.27 seconds.

FFT analysis of song confirms that the carrier frequency of specimen is about 4.5 kHz.

(a)



(b)

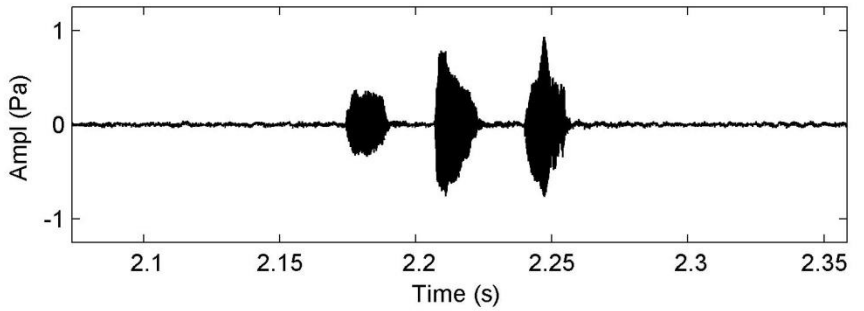


Fig. 4 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig. 4 (b). An exploded view of the oscillogram showing the chirp structure.

(c)

(d)

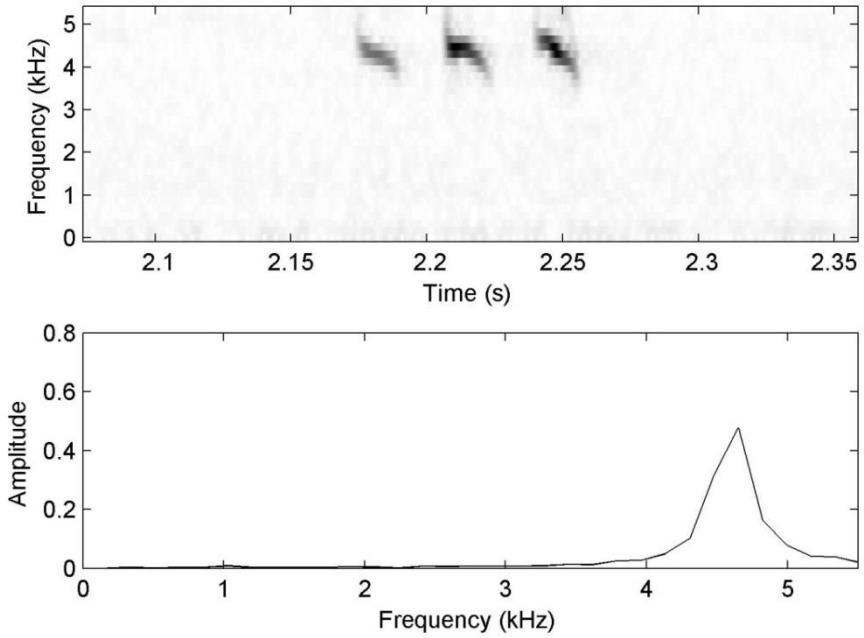


Fig. 4 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 4 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 5 (Figs. 5 a - d)

Calling songs of *A. domesticus* from Kentucky (b) in June also have high pitched sound pattern. Oscillogram of stridulating song of the present specimen reveals a series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.024 seconds with inter-pulse interval (IPI) duration 0.02 seconds. These pulses form chirps of almost same lengths containing 4 pulses per chirp. Chirp frequency is about 04 chirps per second and single chirp duration is about 0.14 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.01 seconds.

FFT analysis of song confirms that the carrier frequency of specimen is about 5.3 kHz.

(a)

(b)

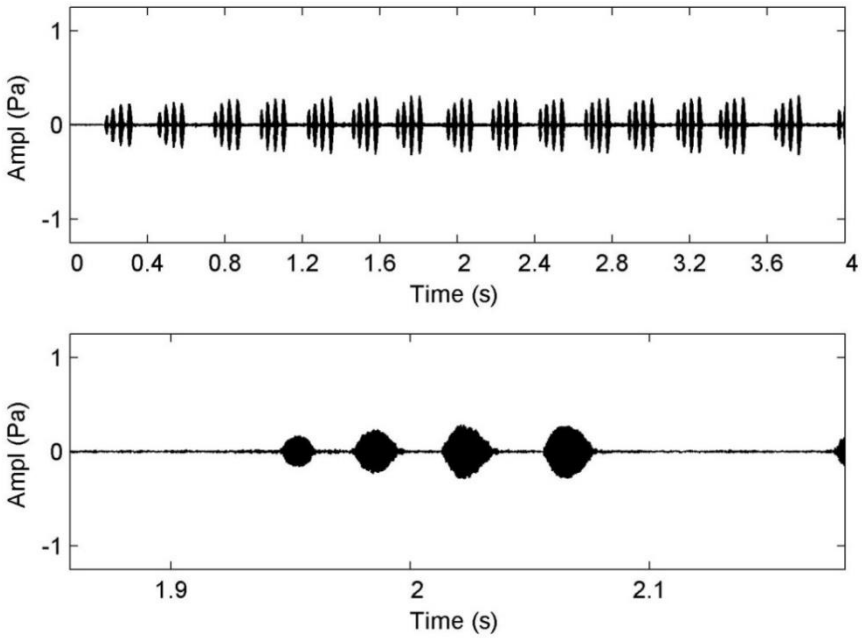
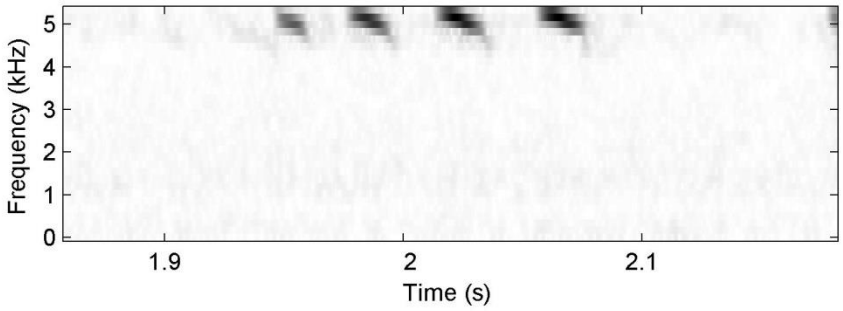


Fig. 5 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig. 5 (b). An exploded view of the oscillogram showing the chirp structure.

(c)



(d)

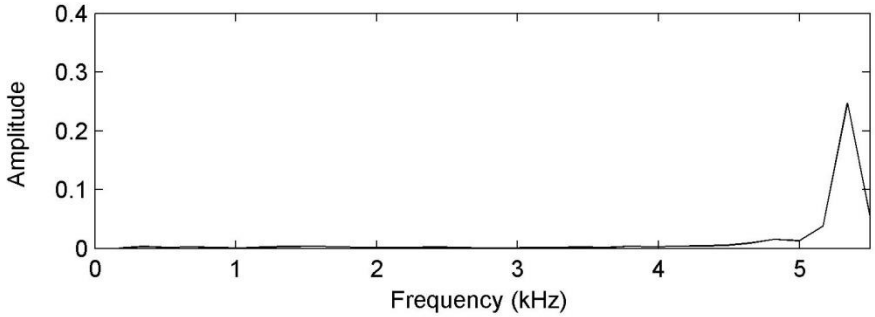


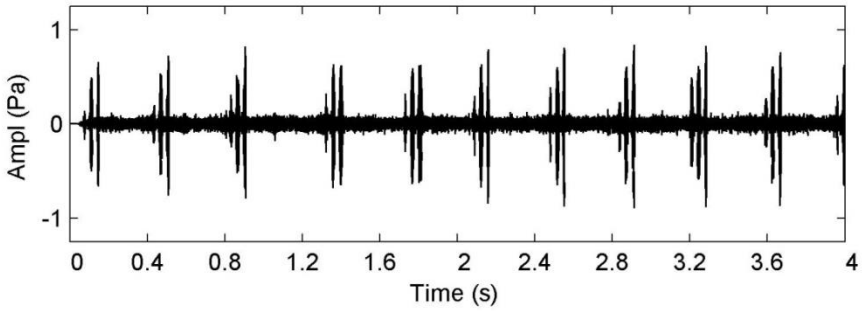
Fig. 5 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 5 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 6 (Figs. 6 a - d)

Calling songs of *A. domesticus* from Kentucky (c) in June also have high pitched sound pattern. Oscillogram of stridulating song of the present specimen reveals a series of pulses having time interval of 04 seconds. Width of its pulses measured approximately 0.02 seconds with inter-pulse interval (IPI) duration of 0.02 seconds. These pulses form chirps of varying lengths containing 3 pulses per chirps. Chirp frequency is about 2-3 chirps per second and single chirp duration is about 0.09 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.31 seconds.

FFT analysis of song confirms that the carrier frequency of specimen is about 4.7 kHz.

(a)



(b)

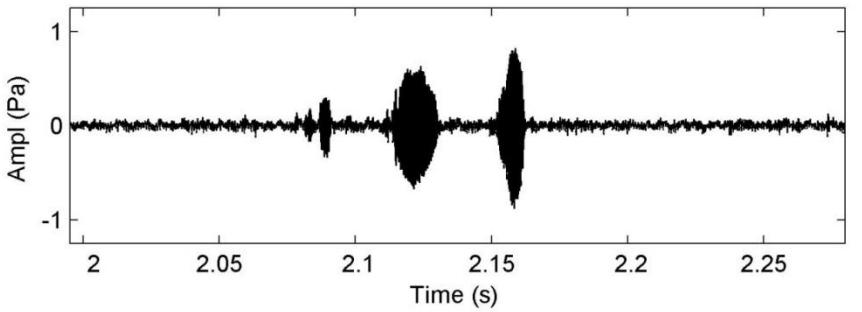


Fig. 6 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig. 6 (b). An exploded view of the oscillogram showing the chirp structure.

(c)

(d)

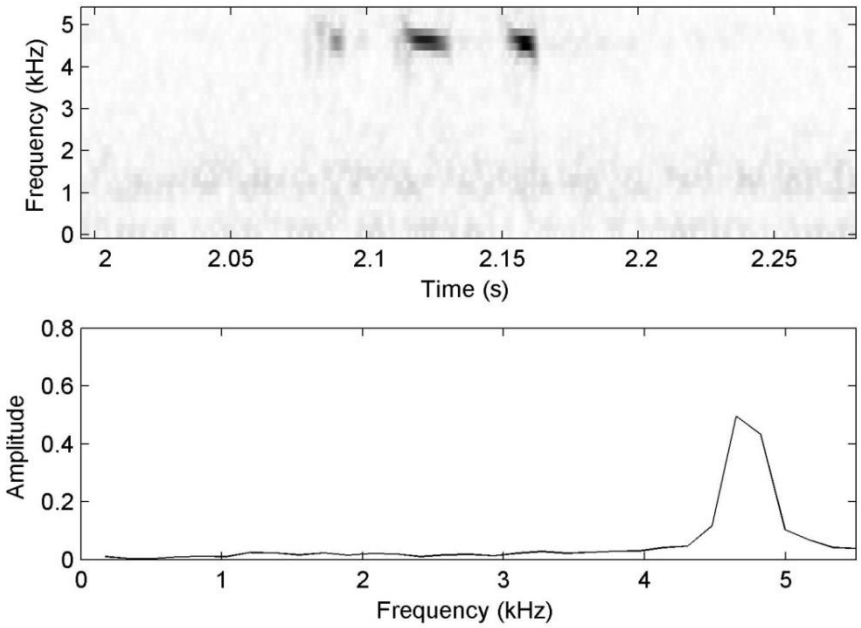


Fig. 6 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 6 (d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 7 (Figs. 7 a-d)

The calling song of *A. domesticus* recorded at Natural History Museum acoustic lab, London, in the month of June at temperature 28ºC also appears to have high pitched sound. Oscillogram of stridulating song of the present specimen reveals a series of pulses in time interval of 04 seconds. Width of its pulses measured around 0.03 seconds with inter-pulse interval (IPI) duration 0.02 seconds. These pulses form chirps of varying lengths with 01-03 pulses per chirp. Chirp frequency is about 01-02 chirps per second and single chirp duration is about 0.16 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.82 seconds.
FFT analysis of song confirms that the carrier frequency of specimen is about 4.6 kHz.

(a)

(b)

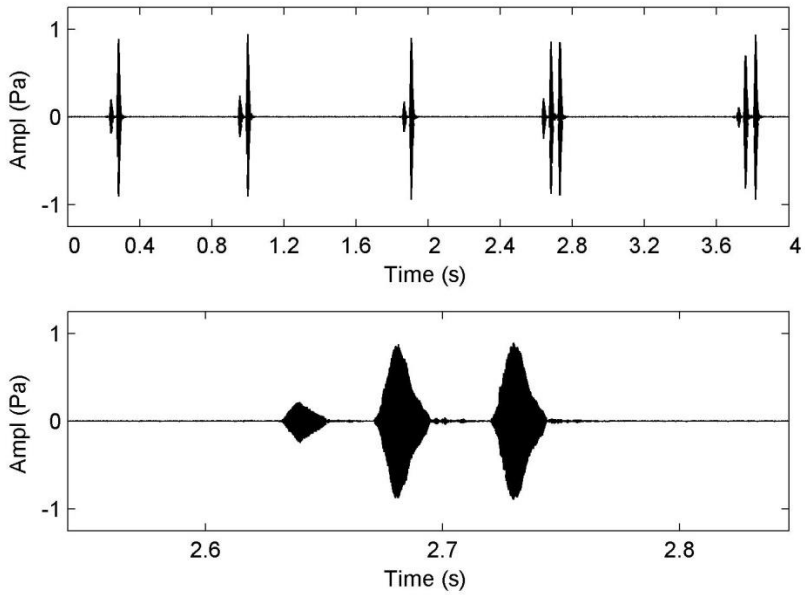
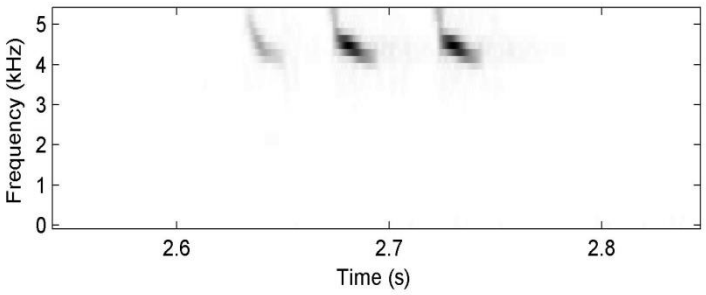


Fig. 7 (a). Oscillogram of 2-4 seconds duration of male call song.
Fig. 7 (b). An exploded view of the oscillogram showing the chirp structure.

(c)



(d)

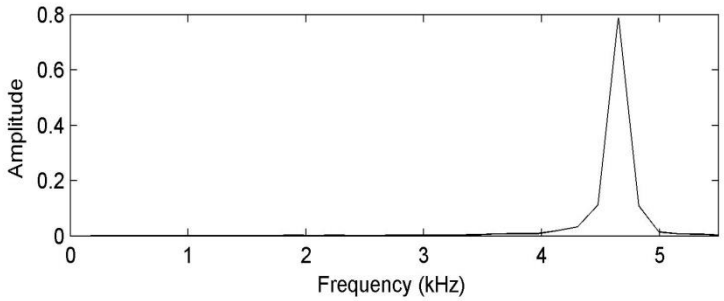


Fig. 7 (c). The spectrogram of the male call song showing the variation of frequencies with respect to time.
Fiq. 7(d). The power spectrum of the call song indicating the dominant frequency of the chirp.

Specimen 8. (Fig. 8) Weissman and Rentz (1977)

Calling songs of *A. domesticus* from California at 20' C- also have high pitched sound pattern. Oscillogram of stridulating song of the present specimen reveals a series of pulses having time interval of 01 seconds. Width of its pulses measured approximately 0.08 seconds with inter-pulse interval (IPI) duration 0.09 seconds. These pulses form chirps of varying lengths containing about 2-4 pulses per chirp. Chirp frequency is about 11 chirps per second and single chirp duration is almost 0.18 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.06 seconds.

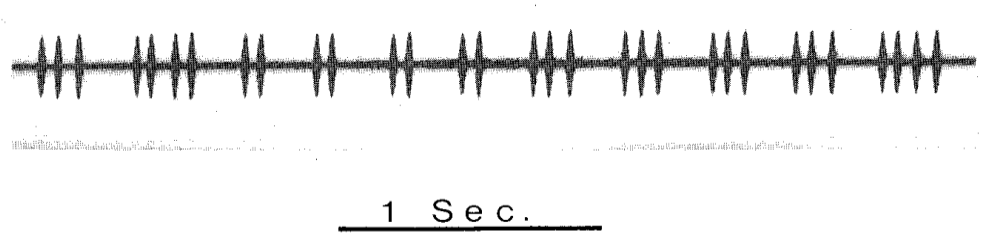


Fig. 8. Calling song modified from Weissman and Rentz (1977)

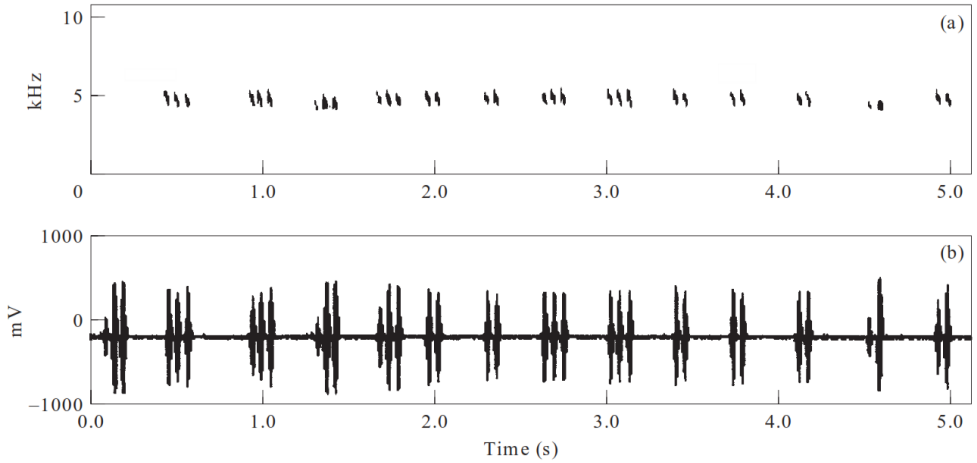


Fig. 9. Calling song modified from Gray (1997).

Specimen 9 (Fig. 9) Gray (1997)

Calling songs of *A. domesticus* from California also have high pitched sound pattern. Oscillogram of stridulating songs of the present specimen reveals a series of pulses. Width of its pulses measured approximately 0.06 seconds with inter-pulse interval (IPI) duration 0.02 seconds. These pulses form chirps of varying lengths with 04-05 pulses per chirp. Chirp frequency is about 03 chirps per second and single chirp duration is almost 0.16 seconds. Inter chirp interval (ICI) or duration between two chirps or chirp pause is about 0.2-0.3 seconds.

DISCUSSION

In the past, very little or hardly any studies were reported which established although minor or limited but some impact of geographical and seasonal variations in the most reliable taxonomic characteristics i.e. song structure of any cricket species in the sizable population. In the present studies, we have analyzed the call song structure of the sounds taken from the repository of recordings through the modern computer software analyzing the impact of variations of season as well as geographical locations on the call song patterns of *A. domesticus*.

These recordings were made at different geographical locations in USA and one location in UK during the months from May-June through September. Numerous studies have shown that among other taxonomic parameters, the male call songs appear to be the most reliable taxonomic character (Khan, 2013). It appears that *A. domesticus* had moved into Europe and North America from Arid and semi-Arid areas of North Africa or South-Western Asia, the present comparative studies appear to support its complicated distribution pattern as shown in earlier literature (Ghouri, 1961).

The present work suggested that the variation in acoustic characteristics due to seasonal and geographical changes is limited or minor, specially in most of the specimens the variation in the pulse duration is in the range of 0.02-0.75 seconds. The No. of chirps varies 2-4 per second and the No. of pulses produced by different specimens are in the range of 2-5 pulses per chirp. Some studies have shown that acoustic song structure of some species of insects is affected by the ambient temperature of the environment (Brooks, 1882; Dolbear, 1897; Bessey and Bessey, 1898). To compensate the thermally induced effects on the structure of call songs, different groups of insects either allow their body temperature to fluctuate with the change in temperature or they regulate their body temperature independent of external temperature change (Villet *et al*., 2003; Allen, 2006). In this way, insects try to maintain consistent song structure over a range of temperature to establish reliable acoustic communication to attract their mates.

However, we have also noted some call song features which appeared to be consistent despite the seasonal or geographical changes. We observed a consistent behavior in the dominant frequency of calling songs as in most of the specimens it was found to be around 5 KHz. Moreover, we also noted consistency in the chirp duration which was found to be approximately 0.1 seconds in most of the specimens.

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