2012

Intraindividual Variation in the Calling Songs of the Cricket Gryllus Pennsylvanicus

Lauren Van Putten
Andrews University, vanputtl@andrews.edu

J. N. Andrews Honors Program
Andrews University

Honors Thesis

Intraindividual variation in the calling songs of the cricket *Gryllus pennsylvanicus*

Lauren Van Putten

April 2, 2012

Advisor: Dr. Gordon Atkins

Primary Advisor Signature:__________________

Department: Biology

Abstract

The goal of this project was to examine intraindividual variability in the calling song of the male cricket, *Gryllus pennsylvanicus*. We evaluated syllable period and chirp period lengths under both constant and changing temperature conditions. Significant variability in chirp and syllable period length was found under constant conditions, suggesting males are subject to internal variability without any effects from the environment. Significant variability was also seen in chirp and syllable period length for crickets under changing temperature conditions. There was a two to five minute delay in response to the temperature change.

Introduction

Early work in phonotaxis described both the calling song of the male and the female's response to it as stereotyped, with either an absence or low levels of variability in both the signal and the response (Walker 1957; Thorson et al. 1982). Recent studies show significant variability in phonotaxis and calling song, raising questions about the stereotype for these systems (Stout et al 2002; Stout et al 2006; Atkins, et al 2008). Phonotactic response from females ranges from very unselective to very selective. Different chemical injections change female selectivity (Atkins et al. 2008).

Male calling songs also show a significant amount of variability (Burden 2009). Recent research has mathematically modeled the plasticity of the male's calling song. Specific characteristics including amplitude, syllable duration, syllable period, chirp period, and carrier frequency, vary within a chirp. These characteristics vary based on a variety of environmental conditions including humidity, ambient temperature, vegetation height, time of day, the day of the breeding season, and solar elevation.

Previous modeling of the males' calling song only evaluated *inter*individual variability or variability within a population of crickets (Burden 2009). Temperature was a significant factor in the variability found in her population study. Temperature was a significant factor affecting the male's calling song. The study accounted for a large percentage of the variability seen in male cricket calling songs. While the study focused on variability within a population, it did not describe the variability within each individual. This could be the basis of some of the unexplained variability seen in Burden's work. In the present study, we evaluated *intra*individual variation or the variability within individual crickets under constant and changing temperature conditions.

Methodology

Six half hour to hour-long recordings of males' songs were made using a parabolic microphone and digital recorder at Sarret Nature Center in Benton Harbor, MI. Three of the six recordings were collected under constant temperature conditions where the temperature varied less than 2 °C. A digital thermometer was used to measure temperature. Three of the six recordings were collected under changing temperature ranging up to ten degrees Celsius on a particularly cloudy day. Recordings were analyzed with Sound Studio 4 on a Macintosh computer.

For the constant temperature recordings, I analyzed the first minute of every ten minutes over the duration of the recording. For changing temperature recordings, I analyzed the minute before and after a temperature change and in two-minute increments after that.

I measured syllable period in milliseconds within each chirp, which is the time interval between the beginning of one syllable to the beginning of the next. Syllables one to four were evaluated separately since they vary within the chirp (Burden 2009). I also measured chirp period in milliseconds, which is the time from the onset of one chirp to the onset of the next chirp. Data was logged into Microsoft Excel. Microsoft Excel was also used to calculate standard deviation and average. Standard deviation was compared to Burden's calculation of standard deviation for a population.

Results

While some crickets exhibited rather constant calling songs throughout the hour-long recordings, some crickets showed a significant amount of variability even though there was no substantial temperature change. Figures 1a-3 show examples of one cricket that was analyzed under constant conditions. We found that with constant ambient and ground temperature, syllable period one, two, and three were fairly constant. Mean syllable period one=29.96 ms, mean syllable period two=46.15 ms, and mean syllable period three=53.34 ms. Chirp period was also constant over the hour-long recording, the mean=554.97 ms. Figures 4a-6 show graphs for a cricket under constant conditions, we found that with constant ambient and ground temperature, syllable period one, two, and three varied considerably. From the first ten-minute period to the second ten-minute period, there was a substantial change in syllable period length when the temperature had only varied 0.3 degrees Celsius. The second ten-minute period dropped 5 ms in syllable one and two and 10 ms in syllable 3. This is a large change in syllable period length with little temperature change. For this recording, mean SP 1=22.97 ms, mean SP2=36.99 ms, and mean SP3=43.93 ms. Chirp period was also variable over the hour-long recording, the mean=324.99 ms. The chirp periods gradually shortened in length and then they gradually grew longer about half-way through the recording.

Crickets under changing temperature showed a two to five minute delay in response to temperature change. For the first cricket (Fig. 8a-10) of the three that were analyzed under changing temperature, we found that with changing ambient and ground temperature; syllable period one, two, and three increased in length as temperature dropped. Each of the syllables did not change right away with the temperature change, but took at least a couple of minutes to gradually increase in length. Chirp period also showed this delay in response to temperature change where the chirp periods increased in length as the temperature dropped. For the second changing temperature recording (Fig. 11a-13), we found that with changing ambient and ground temperature, syllable period one, two, and three showed two minute a delay in response to temperature change. Chirp period also showed this delay. When the temperature rose drastically and we analyzed those couple minutes, there was not much of a change seen in syllable and chirp period length. Then as the temperature dropped, we saw the syllable and chirp periods grow longer gradually. This indicated that a sudden temperature drop that does not last more than two minutes might not affect syllable period and chirp period length for crickets. After the second temperature shift, we saw the same lengthening of syllable and chirp period as from the first recording. For the third changing temperature recording (Fig. 14a-16), we found that with changing ambient and ground temperature there was a substantial amount of variability. This recording had two temperature changes analyzed in it as well. The first four minutes that we analyzed showed that syllable and chirp period exhibited little change as the temperature increased. The last four minutes that we analyzed began to show an increase in syllable and chirp period length as temperature decreased. Within all of these changing temperature recordings, we found that crickets responded two to five minutes after temperature change. As temperature decreases, syllable and chirp period lengths increase.

Discussion

The goal of this study was to see how individuals vary in syllable and chirp period in relation to temperature. A previous study on the population of male crickets found a large amount of variability in the calling song due to different environmental factors (Burden 2009). What my study did was focus on the individual variability rather than the variability within a population. It was expected that the constant temperature recordings would have crickets singing at fairly constant syllable and chirp lengths as compared to crickets singing under changing temperature. However, the data shows that crickets singing under constant temperature—varying less than a few degrees—have a large amount of variability in their songs. While the first cricket analyzed under constant temperature had little variability over an hour, the second cricket showed a large change in syllable period length from the first minute to the tenth minute with only a 0.3 °C temperature change (Fig. 5c). This suggests that intraindividual variability occurs beyond what temperature predicts. This variability could be due to a number of factors including the presence of neighboring crickets or other environmental conditions.

When comparing standard deviation calculated by Burden (2009) to standard deviation calculated for this study, the deviation was lower for individuals than for the population (Fig. 7). Some of the variability that Burden accounted for in her study as a result of changing environmental conditions could actually be this intraindividual variability.

With changing temperature recordings, crickets songs change two to five minutes after the temperature changes. In the crickets studied under changing temperature, syllable and chirp period length gradually become longer as temperature drops (Fig. 9c).

The data collected in Figures 15a-16, show a temperature increase and a temperature decrease. Four minutes were analyzed for both of these temperature shifts, the first shift shows little change in the syllable and chirp period lengths because there was not enough time for the cricket to register the temperature change before the temperature shifted again. Thus, this suggests that there is a delay in response to temperature change in the male cricket calling song. This might have influenced Burden's data collected for a population of crickets under a certain temperature is incorrect. For example, a cricket could be observed to be chirping in cooler temperature conditions but internally it is still adjusting from the previous weather conditions that could have been a few degrees warmer.

Previous research suggests that females phonotactically respond to a variety of syllable and chirp period lengths (Stout et al. 2010). The fact that females are relatively unselective for the males' calling song could be an adaptive feature that accounts for the intraindividual variation and the time lag in response to temperature change, leading to a greater success in phonotaxis and mating.

Figures and Tables

Constant Temperature

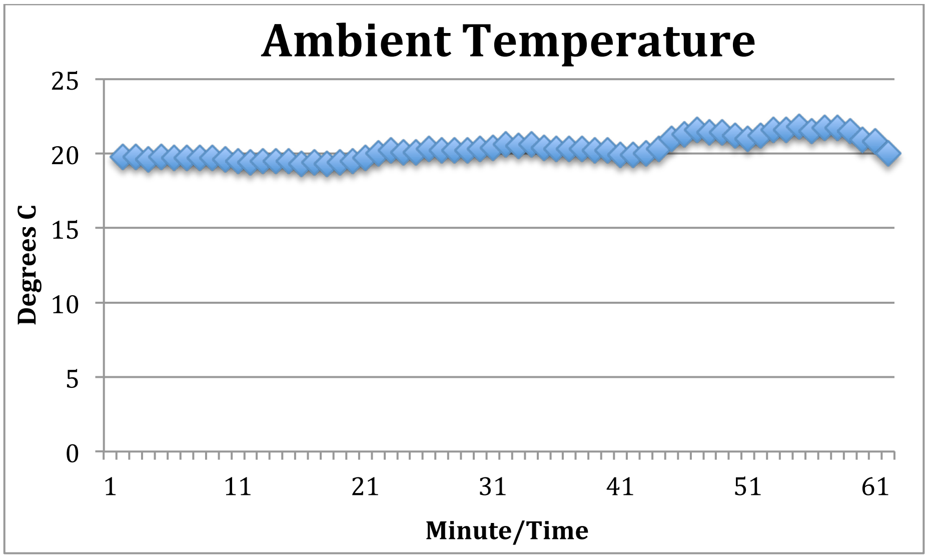

Fig. 1a

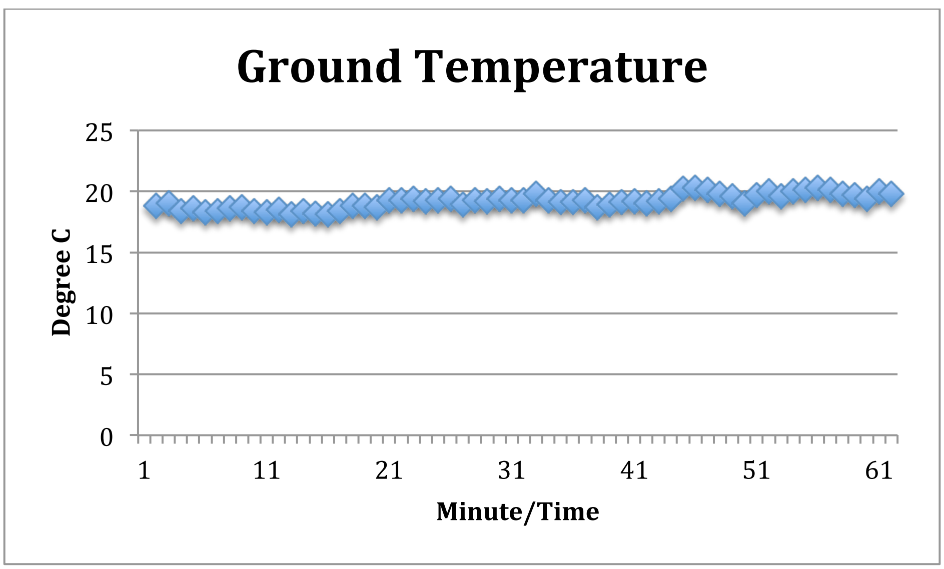

Fig. 1b

Fig. 1a: Cricket 1. This graph shows constant ambient temperature for an hour-long recording. Each point represents a minute in the hour-long recording as connected to ambient temperature at that time. Minutes 1, 11, 21, 31, 41, and 51 were analyzed. **Fig. 1b:** This graph shows constant ground temperature for an hour-long recording. Each point represents a minute in the hour-long recording as connected the ground temperature at that time.

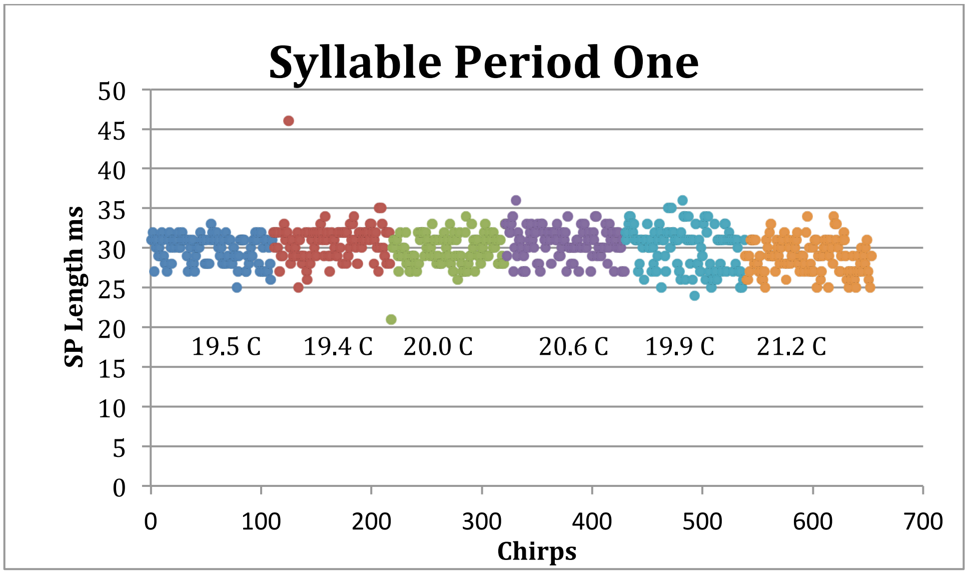
Syllable Period One
SP Length ms
50
45
40
35
30
25
20
15
10
5
0
19.5 C
19.4 C
20.0 C
20.6 C
19.9 C
21.2 C
0
100
200
300
400
500
600
700
Chirps

Fig. 2a

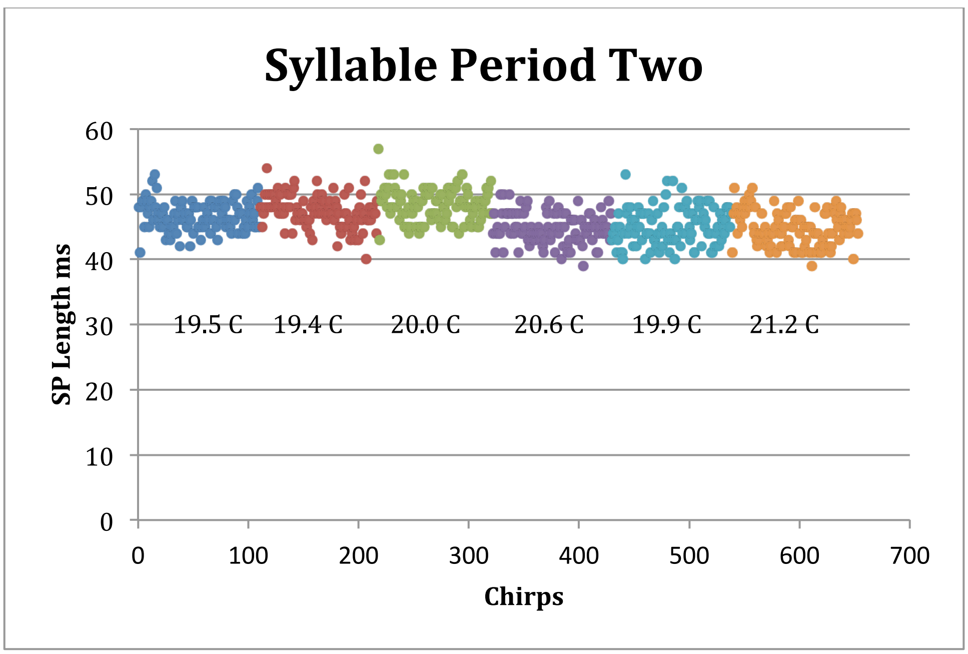
Syllable Period Two
SP Length ms
60
50
40
30
20
10
0
19.5 C
19.4 C
20.0 C
20.6 C
19.9 C
21.2 C
0
100
200
300
400
500
600
700
Chirps

Fig. 2b

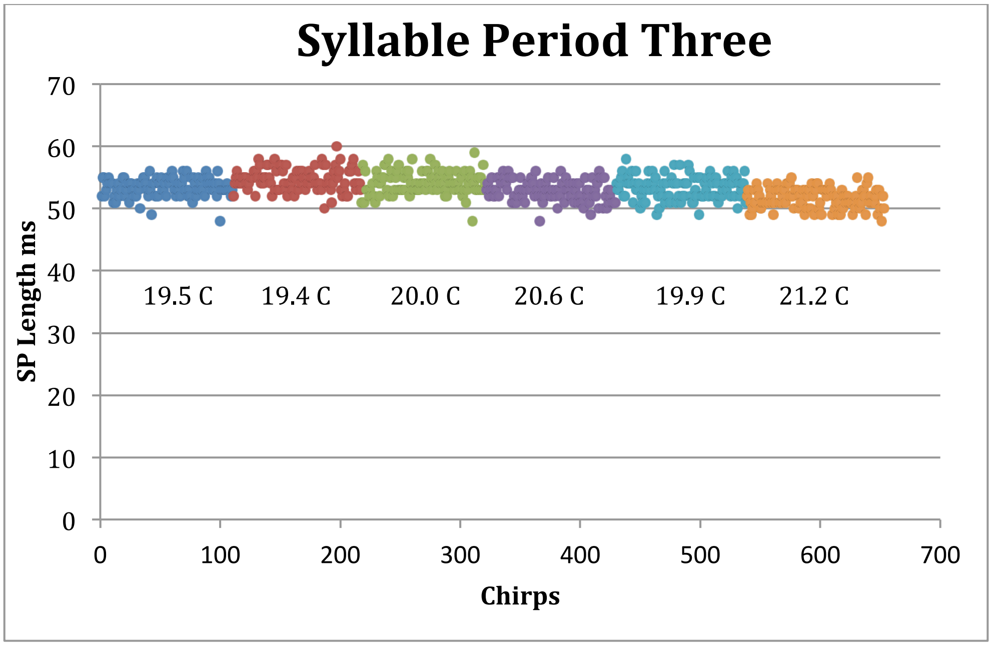

Fig. 2c

Fig. 2: Cricket 1. These graphs show syllable period lengths over an hour. Each color represents a different minute over the hour. Each point is a syllable period length within a chirp. Syllable period lengths stay fairly constant over the hour without temperature change.

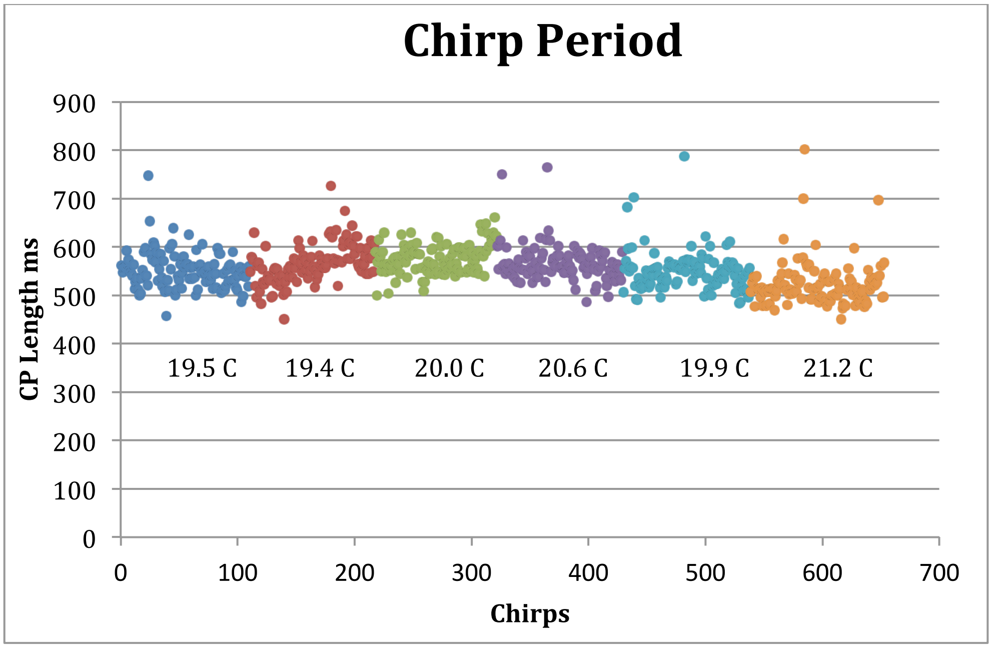

Fig. 3: Cricket 1. This graph shows the chirp period lengths over an hour. Each color represents a separate minute; each point is the length of a chirp period. There is some change over the hour but otherwise the chirp period length stays fairly constant with no temperature change.

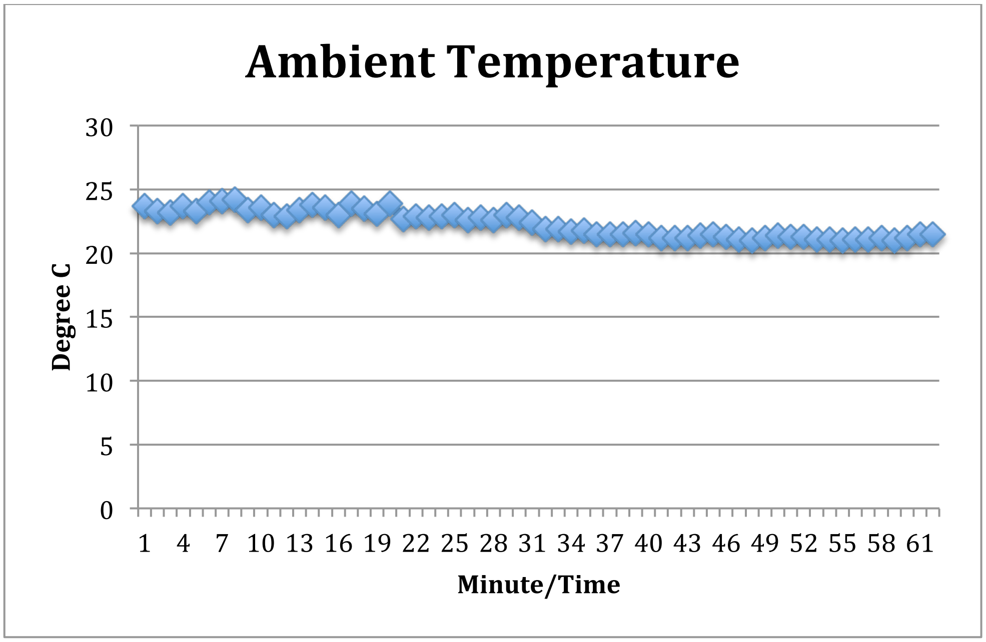

Fig. 4a

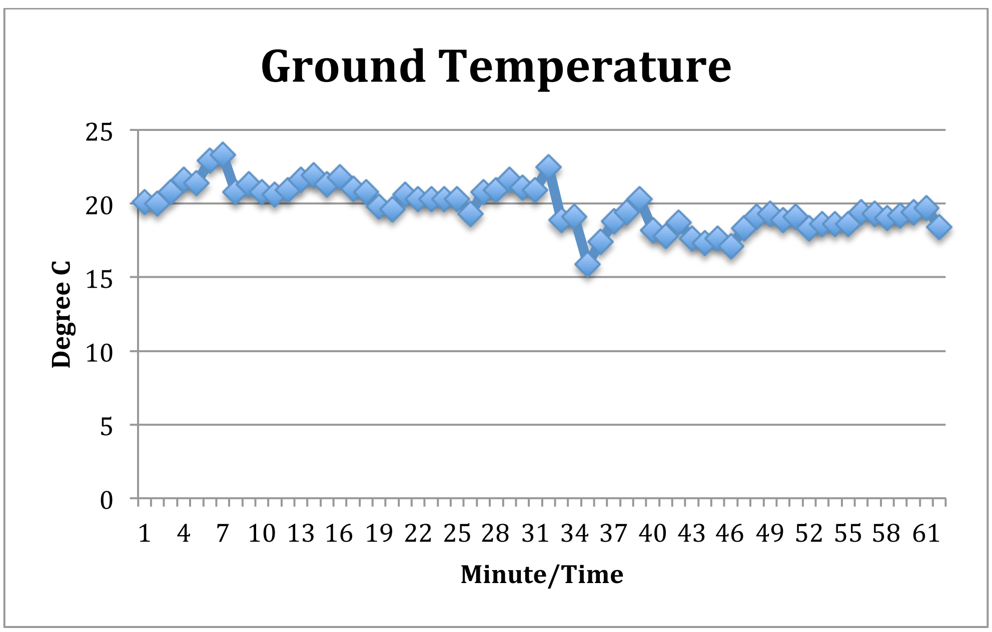

Fig. 4b

Fig. 4a: Cricket 2. This graph shows constant ambient temperature over an hour-long recording. Each point is a minute in the hour as corresponding to temperature. Minutes 4, 14, 24, 34, 44, and 54 were analyzed. **Fig. 4b:** This graph shows fairly constant ground temperature over an hour-long recording. Each point represents a minute in the hour-long recording.

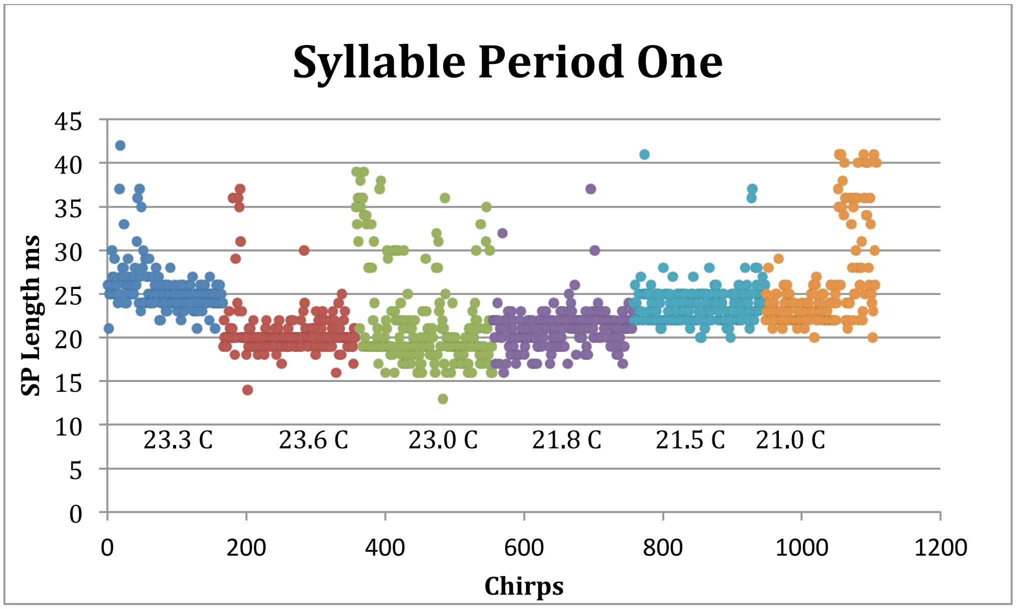
Syllable Period One
SP Length ms
Chirps
23.3 C
23.6 C
23.0 C
21.8 C
21.5 C
21.0 C
0
5
10
15
20
25
30
35
40
45
0
200
400
600
800
1000
1200

Fig. 5a

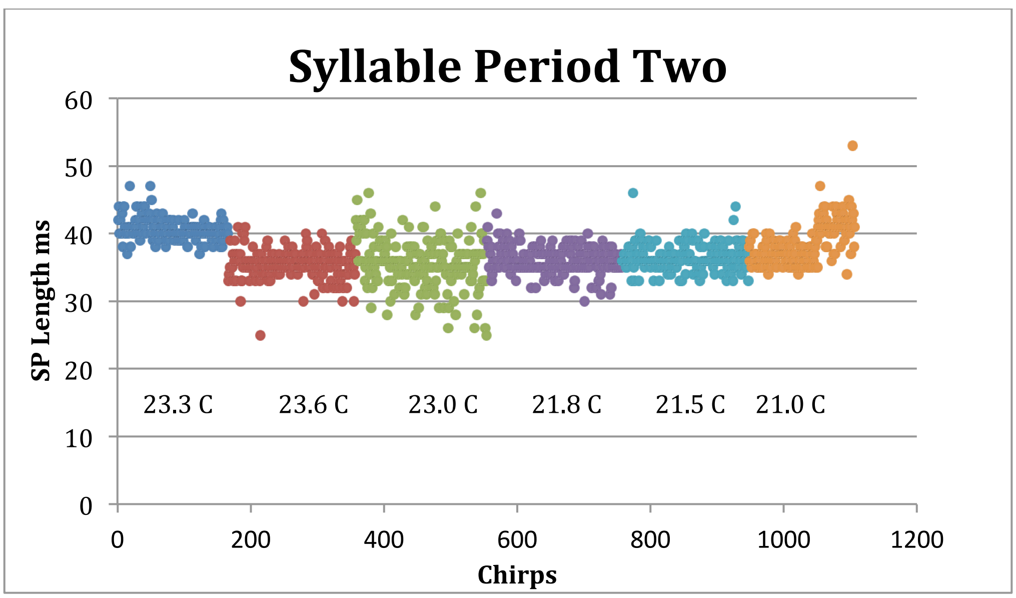
Syllable Period Two
SP Length ms
Chirps
23.3 C
23.6 C
23.0 C
21.8 C
21.5 C
21.0 C
0
10
20
30
40
50
60
0
200
400
600
800
1000
1200

Fig. 5b

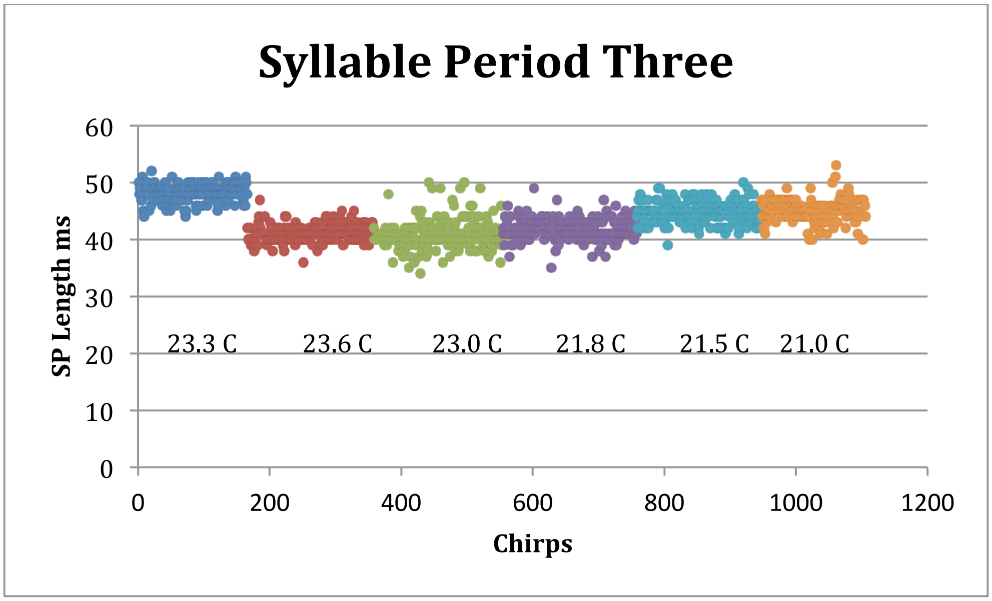

Fig. 5c

Fig. 5: Cricket 2. These graphs show syllable period lengths over an hour-long recording. Each color represents a separate minute in the hour; each point is a syllable period length. Although the temperature did not change much, there is a large decrease in syllable period length seen in these graphs. This suggests that there is intraindividual variability outside of temperature change.

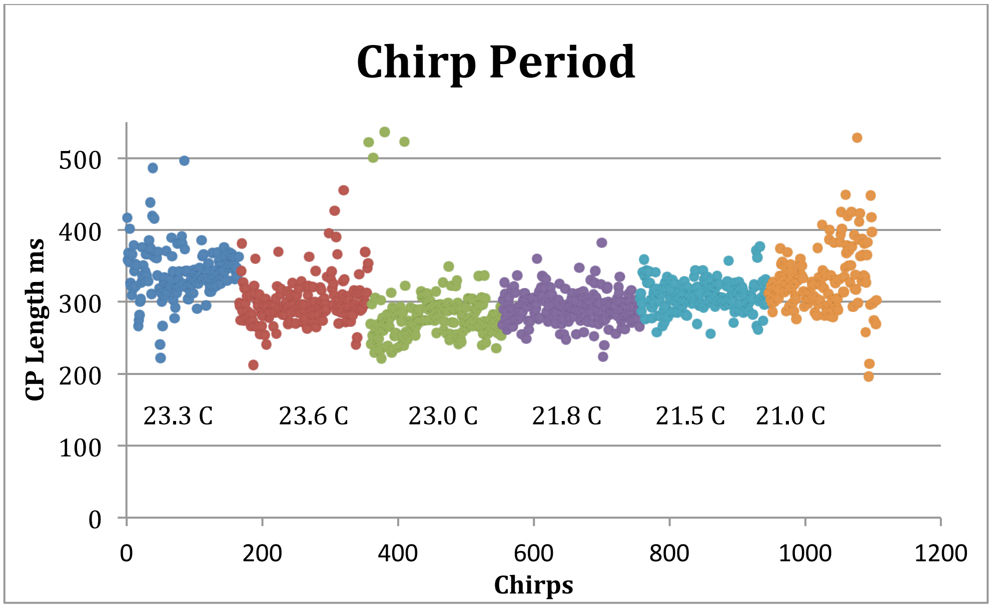

Fig. 6: Cricket 2. This graph shows the chirp period lengths over an hour. Each color represents a different minute; each point is a chirp period length. There is variability in chirp period lengths even though there is not much of a temperature change.

Standard Deviation

	Syllable Period 1	Syllable Period 2	Syllable Period 3	Chirp Period
Burden (2009)	6.33	5.84	5.71	270.18
My Research	3.68	2.82	2.59	189.84

Fig. 7: This table shows the standard deviation from Burdens research done in 2009 and also from the present study. Standard deviation for Burden's work is higher due to calculations from a population of crickets rather than an individual.

Changing Temperature

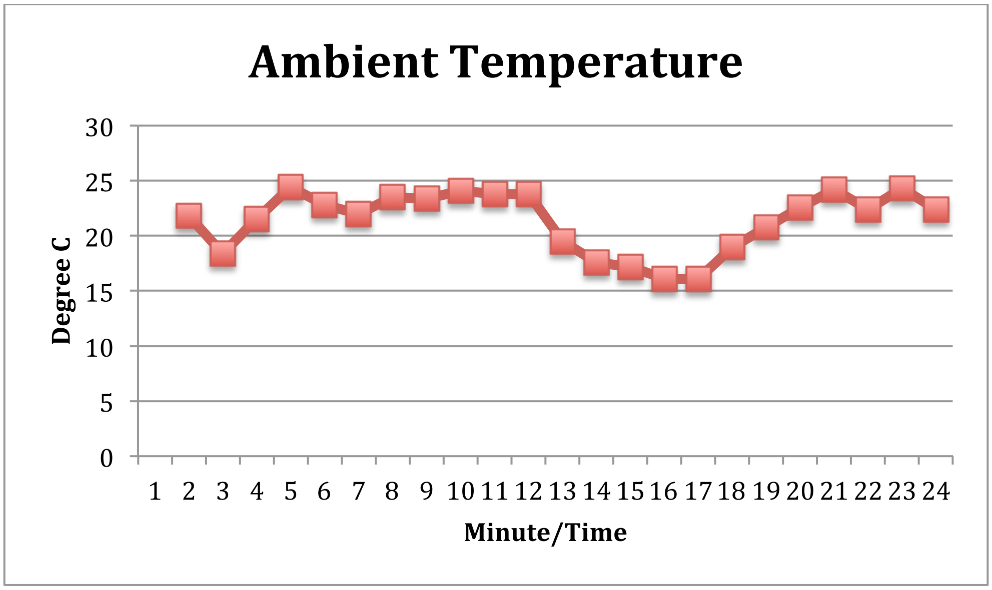

Fig. 8a

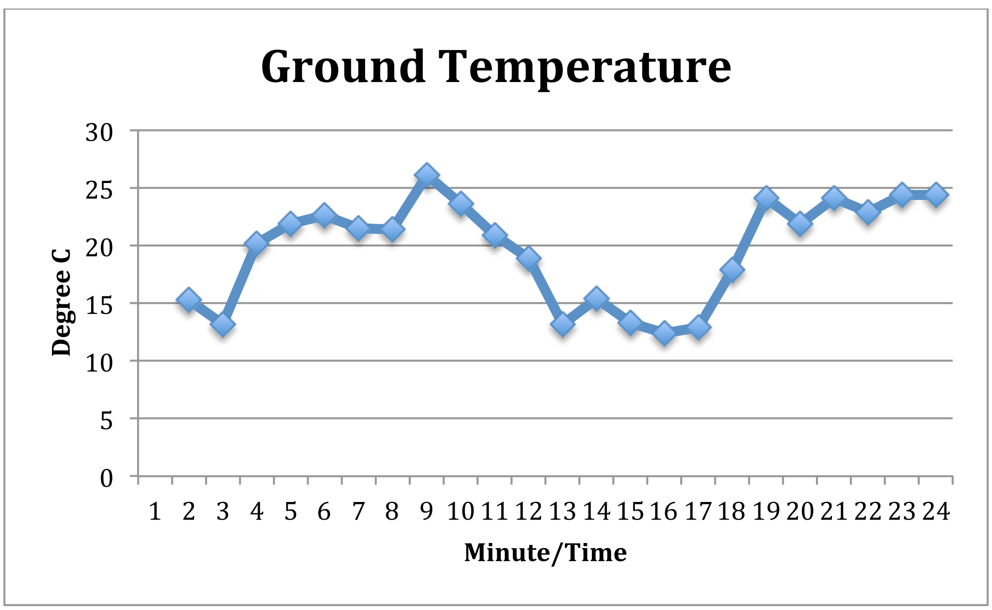

Fig. 8b

Fig. 8a: Cricket 3. This graph shows ambient temperature over a half-hour recording. Each point represents a minute in the half-hour as it corresponds to temperature. There is a large drop in temperature of about 10 °C. Minutes 9, 10, 12, 14, 16, 18, and 20 were analyzed. **Fig. 8b:** This graph shows ground temperature over a half-hour recording. Each point represents a minute in the half-hour as it corresponds to temperature. There is a large drop in temperature of about 10 °C.

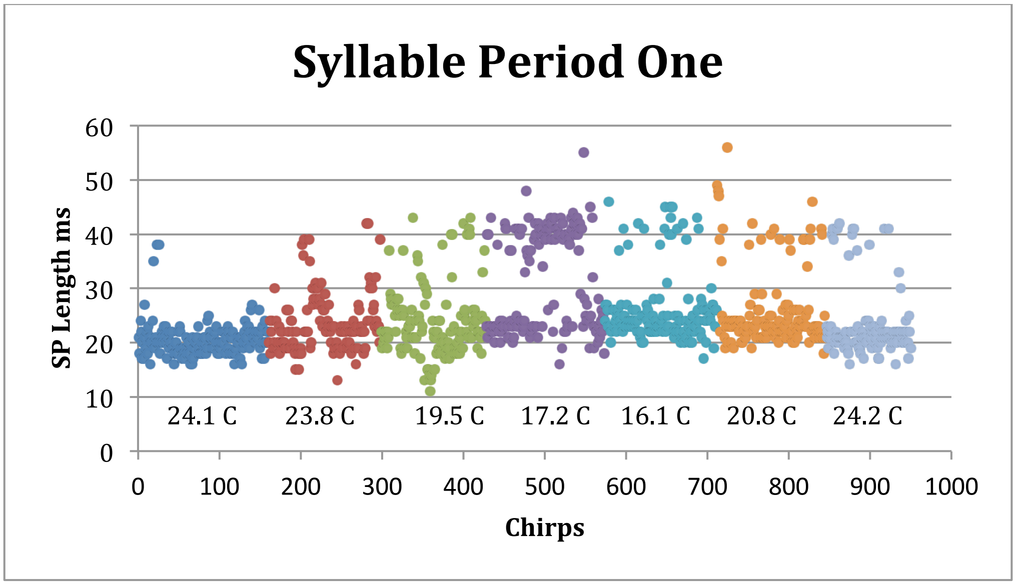
Syllable Period One
SP Length ms
60
50
40
30
20
10
0
24.1 C
23.8 C
19.5 C
17.2 C
16.1 C
20.8 C
24.2 C
0
100
200
300
400
500
600
700
800
900
1000
Chirps

Fig. 9a

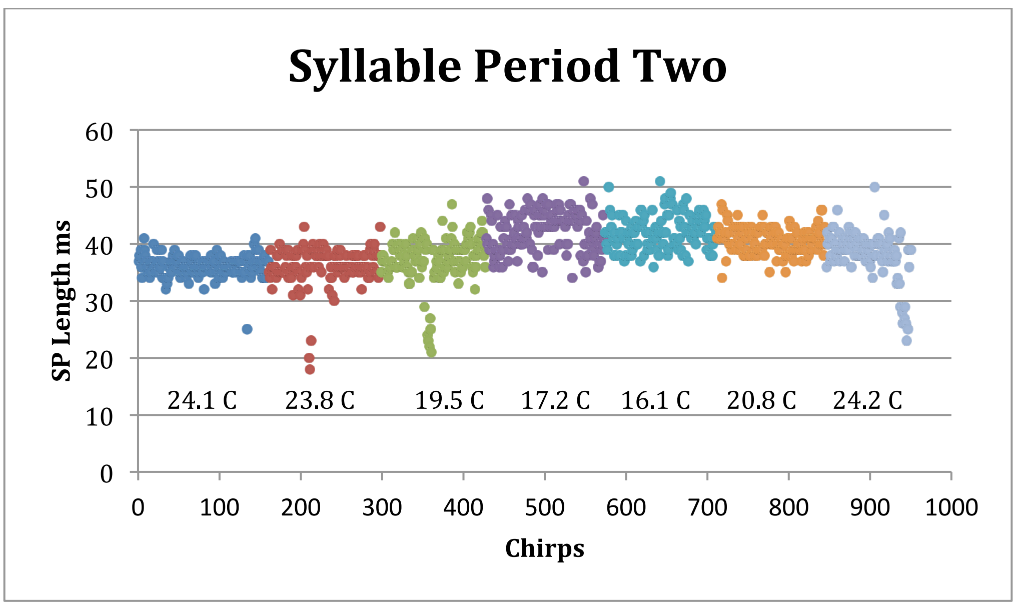
Syllable Period Two
SP Length ms
60
50
40
30
20
10
0
24.1 C
23.8 C
19.5 C
17.2 C
16.1 C
20.8 C
24.2 C
0
100
200
300
400
500
600
700
800
900
1000
Chirps

Fig. 9b

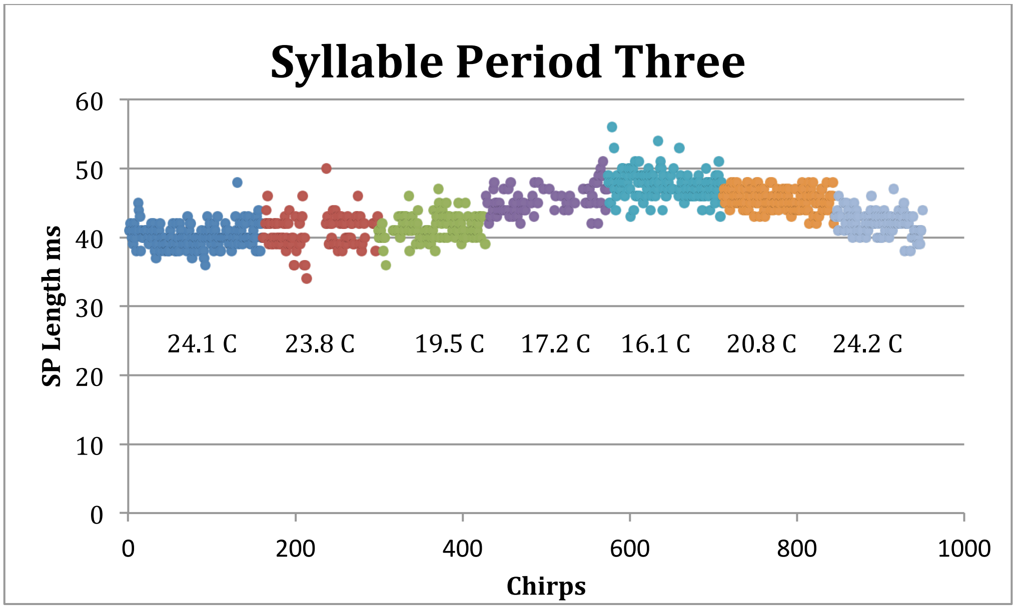

Fig. 9c

Fig. 9: Cricket 3. These graphs show the lengths of syllable period over the temperature change. Each color represents a separate minute in the recording, the first being the minute before the temperature change, the second being the minute after the temperature change, and then every change of color after that represents every other minute. Each point is a length measurement of syllable period. There is no instant change in syllable period length right after the temperature change, but there is an increase in syllable period length a few minutes after the temperature change.

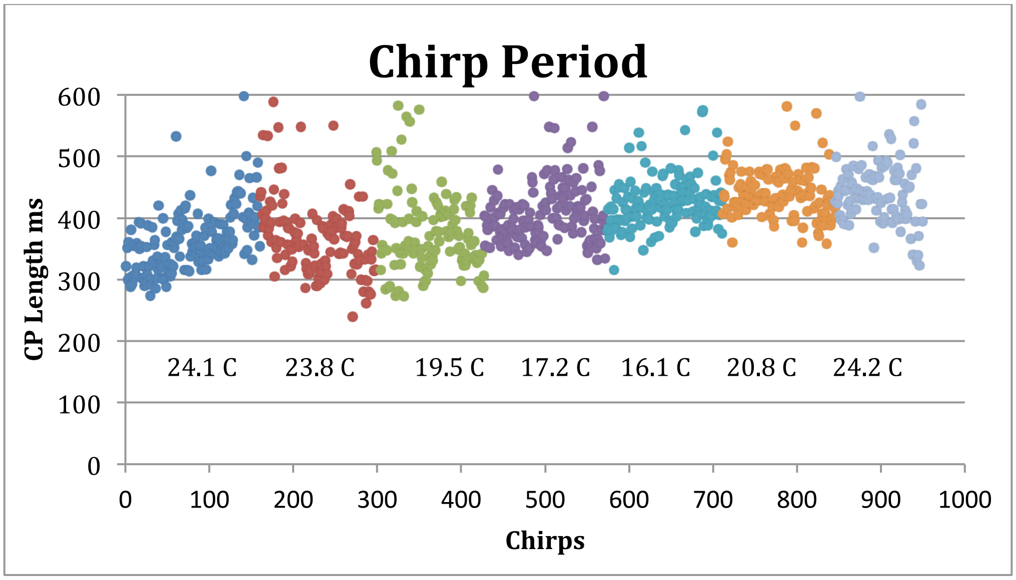

Fig. 10: Cricket 3. This graph shows the lengths of the chirp period during a temperature change. Each color represents a separate minute in the recording; each point is the length of a chirp period. Initially it seems as if the cricket is responding right away to the temperature change because we can see the chirp period lengths getting longer, but they abruptly go back to how they were and then gradually increase in length.

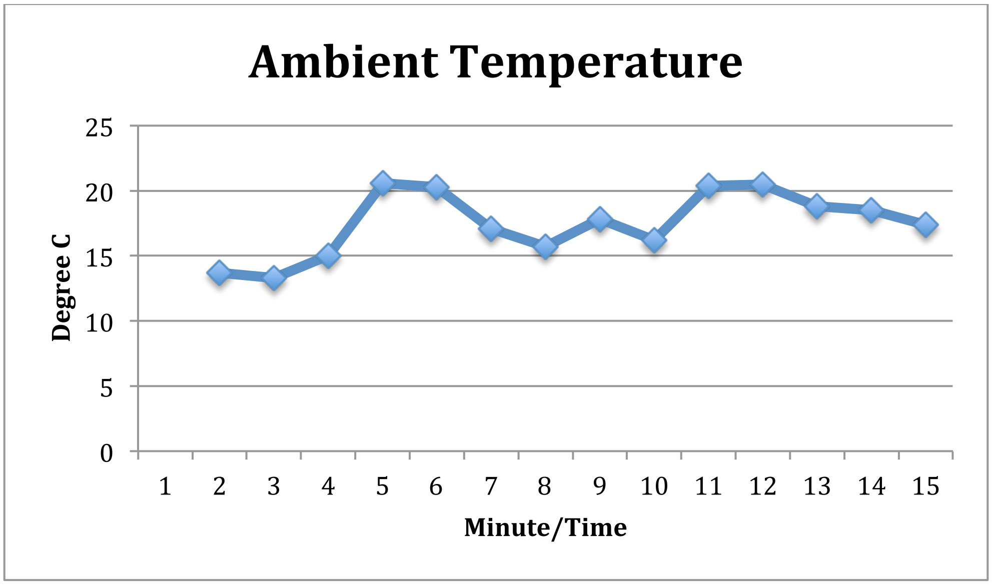

Fig. 11a

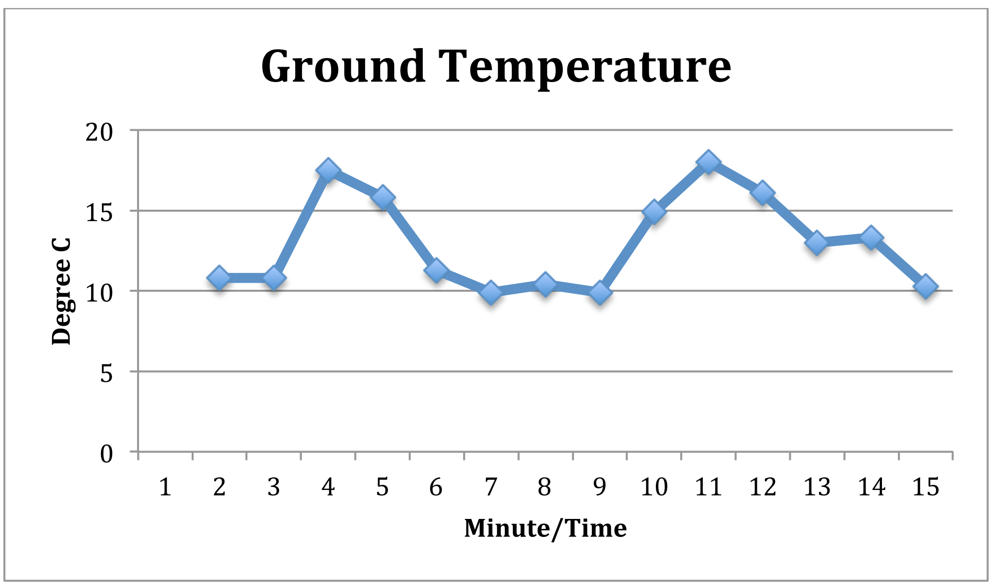

Fig. 11b

Fig. 11a: Cricket 4. This graph shows ambient temperature over a fifteen-minute recording. Each point represents minute in the recording as it corresponds to temperature. Minutes 1, 3, 5, 7, 9, and 11 were analyzed. **Fig. 11b:** This graph shows ground temperature over a fifteen-minute recording. Each point represents minute in the recording as it corresponds to temperature.

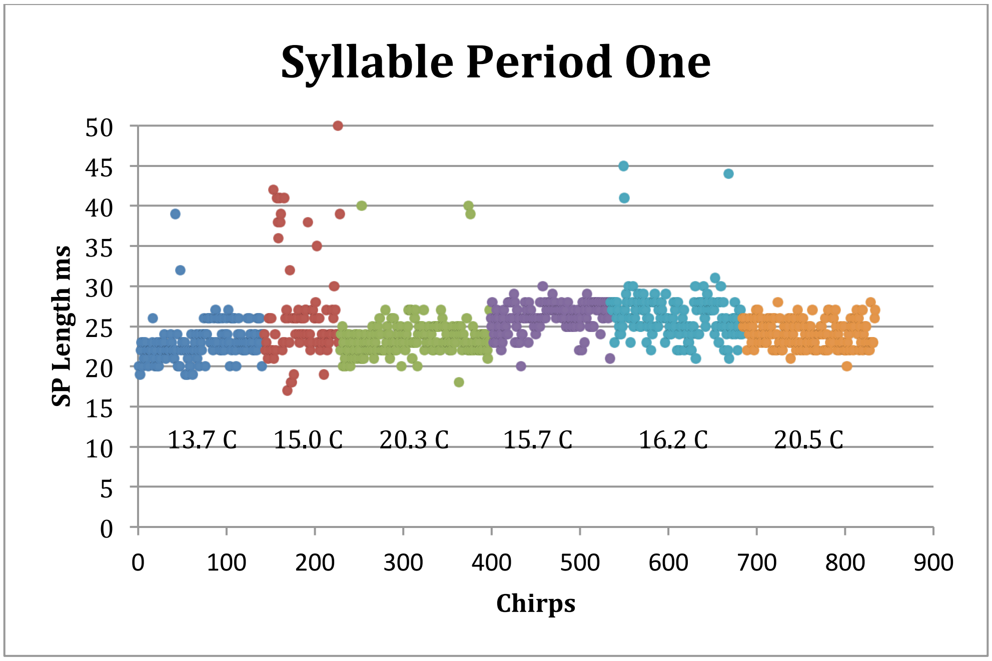

Fig. 12a

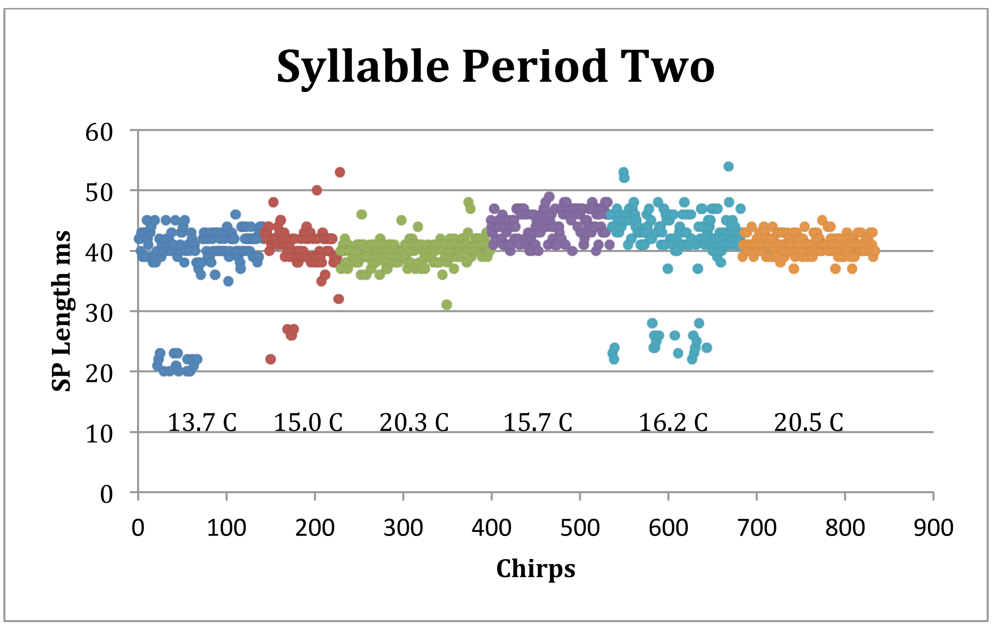

Fig. 12b

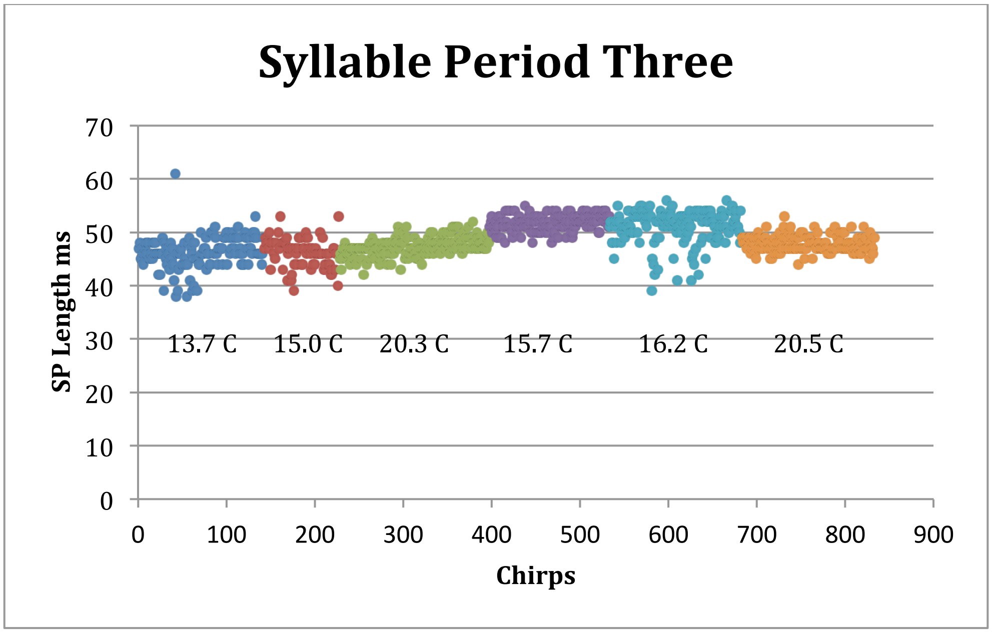

Fig. 12c

Fig. 12: Cricket 4. These graphs show the lengths of syllable period during a temperature change. Each color represents a different minute in the recording; each point is the length of syllable period within different chirps. The lengths of the syllables are longer as the temperature drops.

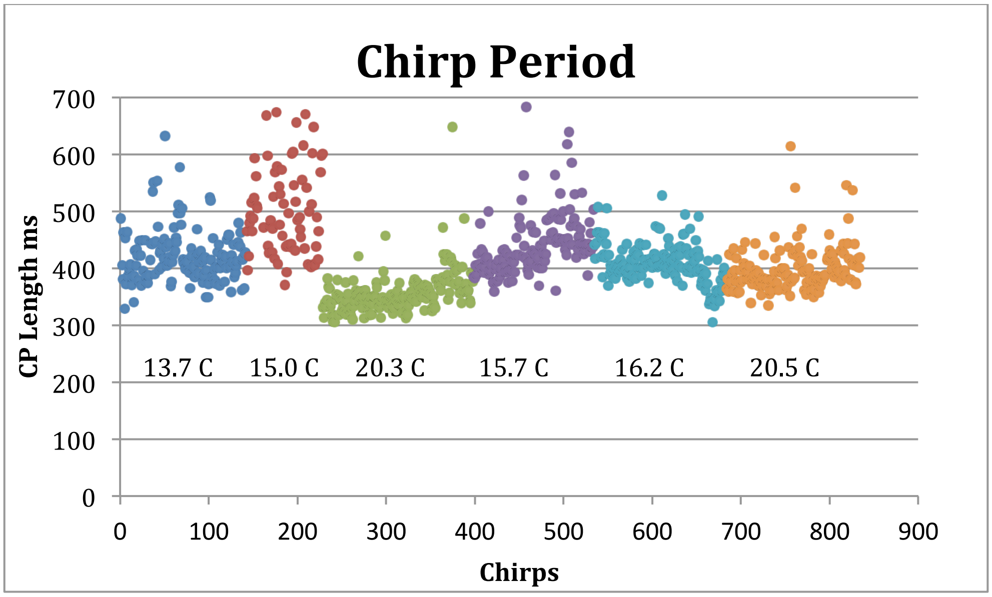

Fig. 13: Cricket 4. This graph shows the lengths of the chirp periods during the temperature change. Each color represents a different minute in the recording; each point is a chirp period length.

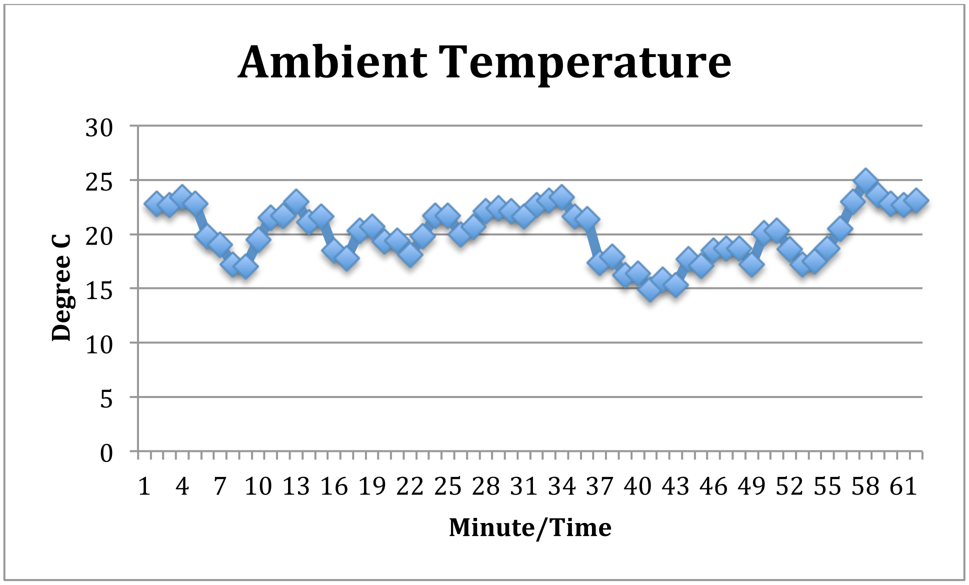

Fig. 14a

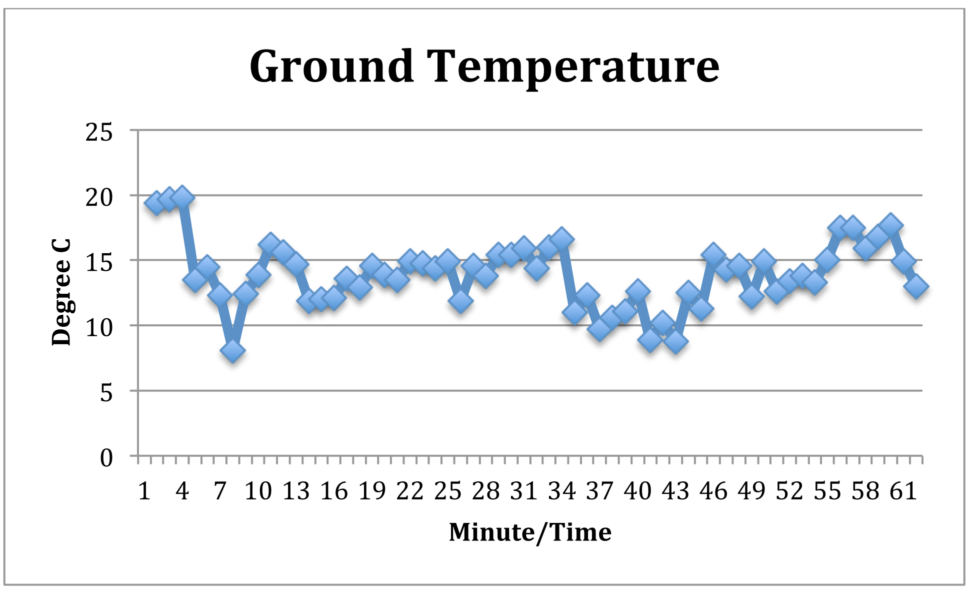

Fig. 14b

Fig. 14a: Cricket 5. This graph shows ambient temperature over an hour-long recording. Each point represents a minute as it corresponds to temperature. There is much variability in temperature in this recording. Minutes 8, 9, 11, 13, 33, 34, 36, and 38 were analyzed. There is a jump from minute 13 to 33 because the next temperature change of interest started at minute 33. **Fig. 14b:** This graph shows ground temperature over an hour-long recording. Each point represents a minute as it corresponds to temperature. There is much variability in temperature in this recording.

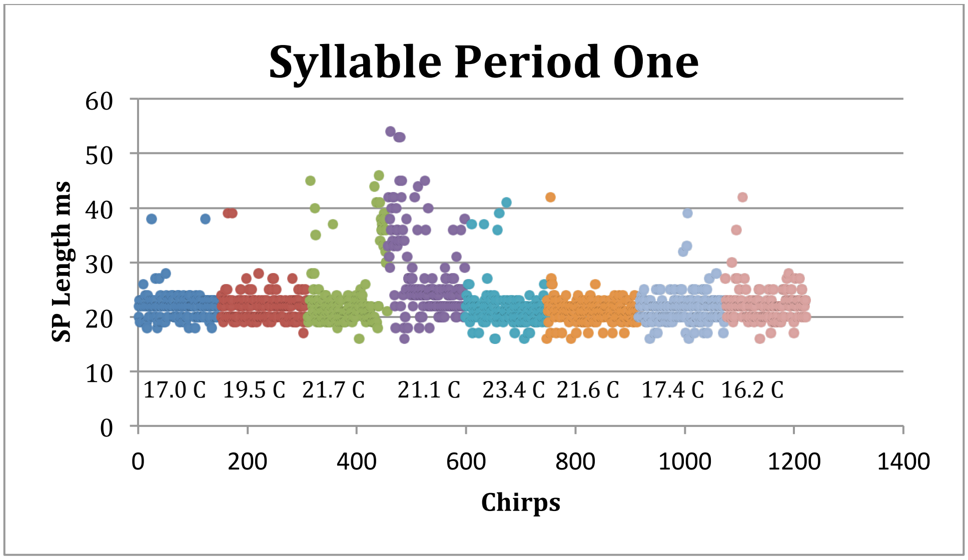

Fig. 15a

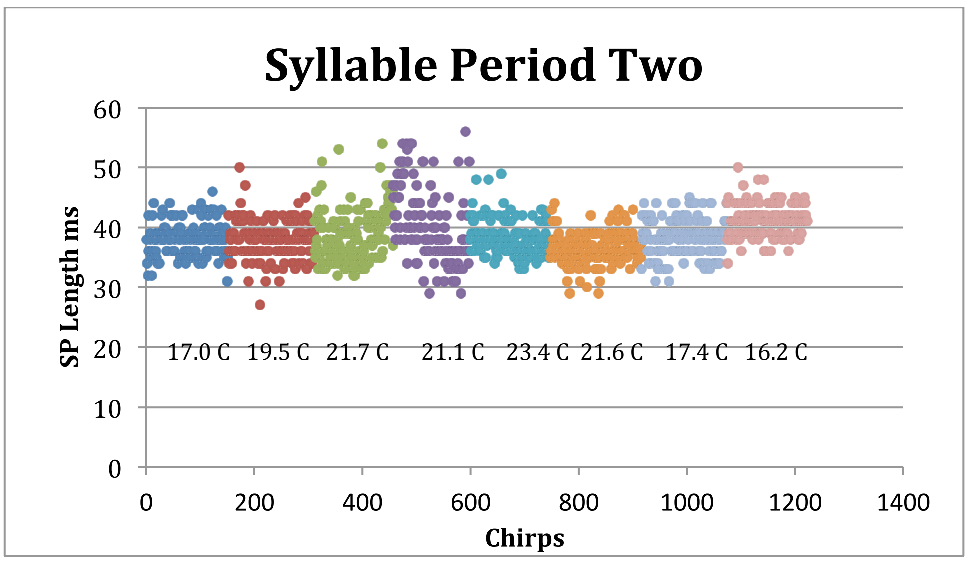

Fig. 15b

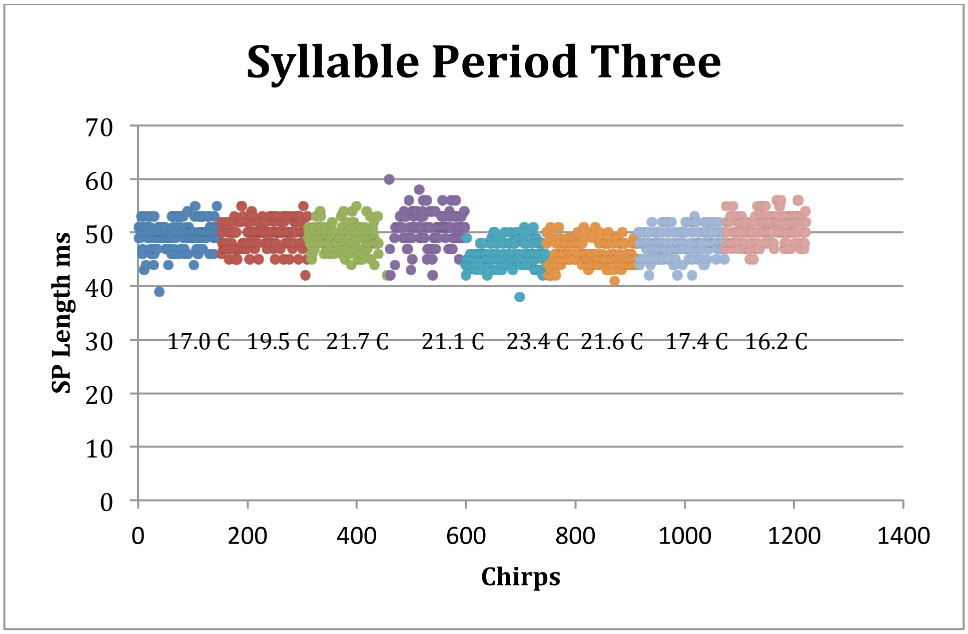

Fig. 15c

Fig. 15: Cricket 5. These graphs show the lengths of syllable period during two temperature changes. Each color represents a different minute in the recording; each point is the length of syllable period within different chirps. The first four colors belong to the first temperature change; the second four colors belong to the second temperature change. With the second temperature change, syllable period length is longer as temperature decreases.

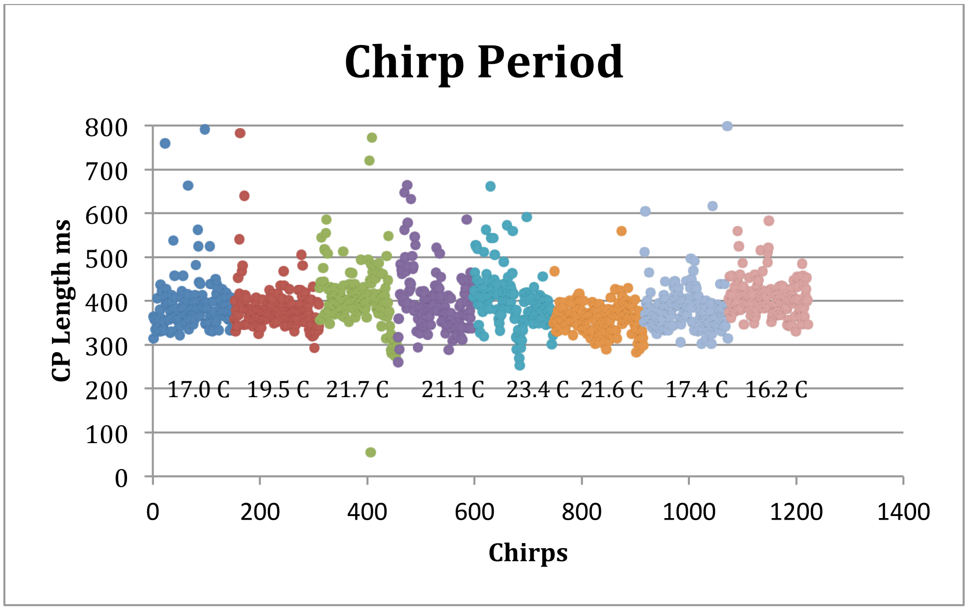

Fig. 16: Cricket 5. This graph shows the lengths of the chirp periods during two temperature changes. Each color represents a different minute in the recording; each point is the length of a chirp period. The lengths of the chirp are longer as the temperature drops.

Literature Cited

Atkins G, Kilmer J, Scalfani M, Navia B, Stout J. 2008. Modulation of syllable period – selective phonotaxis by prothoracic neurons in crickets (*Acheta domesticus*): juvenile hormone, picrotoxin and photoinactivation of the ON1 neurones. Physiol Entomol. 33: 322-333.

Burden, Christina Marie. (n.d.). "Variability in the Calling Song of Two Field Cricket Species (*Gryllus veletis and G. pennsylvanicus)".* A thesis presented in partial fulfillment of the requirements for the degree Master of Science.

Stout JF, Atkins GJ, Bronsert M, Hao J, Walikonis R. 2002. Influence of juvenile hormone III on the development and plasticity of the responsiveness of female crickets to calling males through control of the response properties of identified auditory neurons. In: Pfaff D, Arnold A, Etgen A, Fahrbach S, Rubin R, editors. Hormones, brains, and behavior. Vol. 3. New York: Academic Press. p. 167-193.

Stout JF, Navia B, Jeffery J, Samuel LR, Hartwig L, Butlin A, Chung M, Wilson J, Dashner E, Atkins GJ. 2010. Plasticity of the phonotactic selectiveness of four species of chirping crickets (Gryllidae): implications for call recognition. Physiological Entymology.

Stout JF, Samuel LR, Navia B, Atkins GJ. 2006. Plasticity of the phonotactic selectiveness of four species of chirping crickets (Gryllidae): implications for call recognition. Proc Invert Sound Vibration Meetings; 2006 Aug 08-11; Toronto: University of Toronto.

Thorson J, Weber T, Huber F. 1982. Auditory behavior of the cricket. J Comp Physiol. 146: 361-378.

Walker TJ. 1957. Specificity in the response of female tree crickets (Orthoptera Gryllidae, Oecanthinae) to calling songs of the males. Annals Entomol Soc Am. 50: 626-636.