Stridulation Frequency Dependence on Music Genre in *Acheta domesticus (Linnaeus)*(Orthoptera: Gryllidae)

Michael Boachie-Mensah

Edited by J. Michelle Shannon

Abstract: Crickets are mainly nocturnal species known for the loud, persistent, chirping sounds many of their species make. Cricket chirping, or stridulation, is produced when the insect rubs together stridulatory organs located on the forewings. Stridulation is a form of intraspecific acoustic communication used by males to entice females. However, predators and parasitic insects may exploit their singing, using it to find their cricket prey. Consequently, crickets cease chirping when they sense sound frequency vibrations nearby, indicating that a predator is nearby. In this experiment, the cricket species *Acheta domesticus* (Linnaeus)(Orthoptera:Gryllidae) was used to test stridulation frequency differences based on exposure to different music genres. Crickets were exposed to either silence (control), hip hop, jazz, country, or classical music. During this music exposure period, the number of chirps was counted for one minute. Stridulation frequency was 83.3 chirps per minute for the control setting, 65 chirps per minute for classical music, 61.3 chirps per minute for country music, 54 chirps per minute for jazz music, and 41 chirps per minute for hip hop music. Causative factors for this trend may be due to neurological characteristics of the cricket. A major auditory sensory neuron, Ascending Neuron 1 (AN1), is excited by both high-frequency sounds and self-generated chirps. We conclude that music genres dominated by high-frequency sounds, such as hip hop and jazz, stimulate AN1, causing increased auditory information to be sent to the brain, leading to decreased stridulation as crickets interpret this information as the presence of a possible threat.

Keywords: *Acheta domesticus,* stridulation, music genre, vibration frequency

Crickets are nocturnal insects of the order Orthoptera and the family Gryllidae. They are one of the most common stridulatory species. Stridulation refers to the phenomenon of sound production by the rubbing together of body parts. Other larger animals, such as fish, snakes, and spiders also stridulate. At any given time during the night, crickets can be heard outside making loud chirping noises. In crickets, the stridulatory organs are found on the tegmena, which are the forewings. There are two specialized body parts on the tegmena: a scraper (plectrum) on one tegmen and a file on the other (Fig.1). Both the scraper and the file have sclerotized ridges that are chisel-like and resemble teeth). Sound is produced when the forewings move back and forth and the teeth of both the scraper and the file rub against each other (Fig.2). This causes the forewings to vibrate as fast as the teeth, producing pulses with a whistle-like tone (Stephen and Hartley 1995).

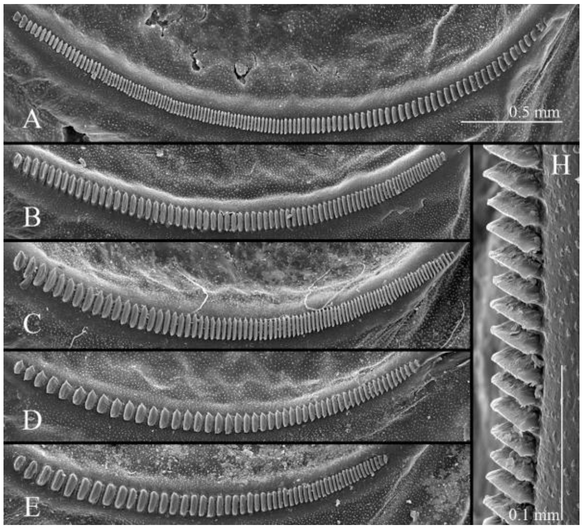

Figure 1. The stridulatory files of the cricket species (A) Isophya nagyi, (B) Isophya camptoxypha, (C) Isophya ciucasi, (D) Isophya posthumoidalis, and (E) Isophya sicula. (H) Close detail of the stridulatory file of Isophya nagyi (Szövényi et al. 2012).

Generally, only male crickets stridulate since most female crickets do not have the necessary adaptations to stridulate (Chapman 2013). The purpose of such behavior is to attract females and repel other males. Once successful mating has occurred, a triumphal song is produced that serves to encourage the female cricket to lay eggs instead of searching for a new mate (Chapman 2013).

Morphological aspects of the tegmena, as well as environmental factors, direct both the length and frequency of cricket chirping (Huber 1962). For example, the number of teeth that are rubbed against each other during each strike determines the length of the chirp.

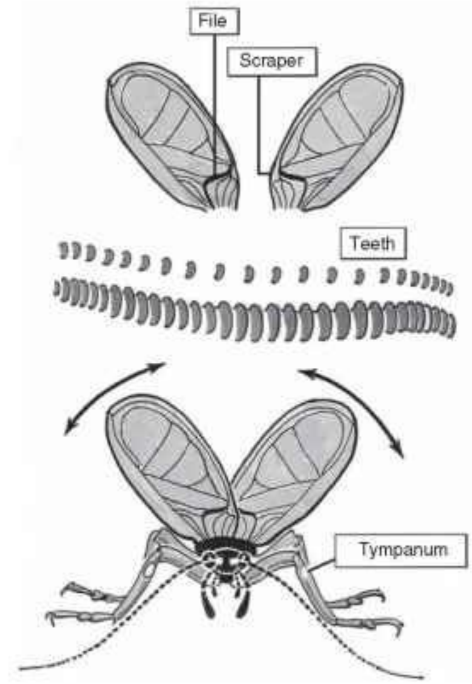

Figure 2. The scraper is on the right wing and the file on the left wing. The bottom figure shows the wings moving back and forth, causing the file to strike the scraper. This generates the chirp we hear from crickets ("Crickets (Insects)" 2017).

Environmental temperature also plays a significant role in the frequency of chirping due to the cold-blooded nature of crickets (Dolbear 1897). For example, as temperature rises, chirping occurs more rapidly. The present research was conducted to determine the effect, if any, that different music genres have on cricket stridulation.

Although crickets do not have ears, they can indeed hear. Hearing is achieved when a pair of tympanal organs located on their legs vibrates in response to vibrating air particles, or sound (Schmidt et al. 2011). Once these tympanal organs vibrate, a receptor known as the chordotonal organ translates the vibration into a nerve impulse that is sent to the brain for processing (Christensen 2005).

Each music genre has a distinct sound, enabling genre categorization to be possible. We thus hypothesized that due to the varying vibration patterns of different musical genres, crickets would alter their stridulation frequency. More specifically, we hypothesized that the more discordant vibrations of music genres like jazz and hip hop would decrease stridulation frequency.

Materials and Methods

We used adult *Acheta domesticus* crickets (house cricket) purchased from Petco Animal Supplies, Inc. (San Diego, CA). About 100 crickets were used in the experiment. Different genres of music were played in the vicinity of the crickets, loud enough for them to hear it. Four different musical genres were tested: hip hop, jazz, country, and classical music. For the hip hop music trial, we played songs by Future. For the jazz music trial, popular John Coltrane songs were played. For the country music trial, we played songs by country music artist Dierks Bentley. Lastly, we played compositions by Beethoven for the classical music trial. During each trial, while the music was playing, we counted the number of chirps the crickets made during a one-minute time period. Successive trials were conducted and chirp averages for each genre of music were calculated.

Results

Between the four musical genres tested, the crickets had the highest frequency of chirping when classical music was played. They chirped at a rate of 65 chirps per minute when classical music was played. Country music produced the second-highest number of chirps, with crickets chirping an average of 61.3 chirps per minute. Jazz and hip hop music produced the lowest number of chirps per minute: 54 and 41 chirps per minute, respectively. All of these values were significantly lower than the stridulation frequency during silence, which was recorded to be 83.3 chirps per minute (Fig. 3).

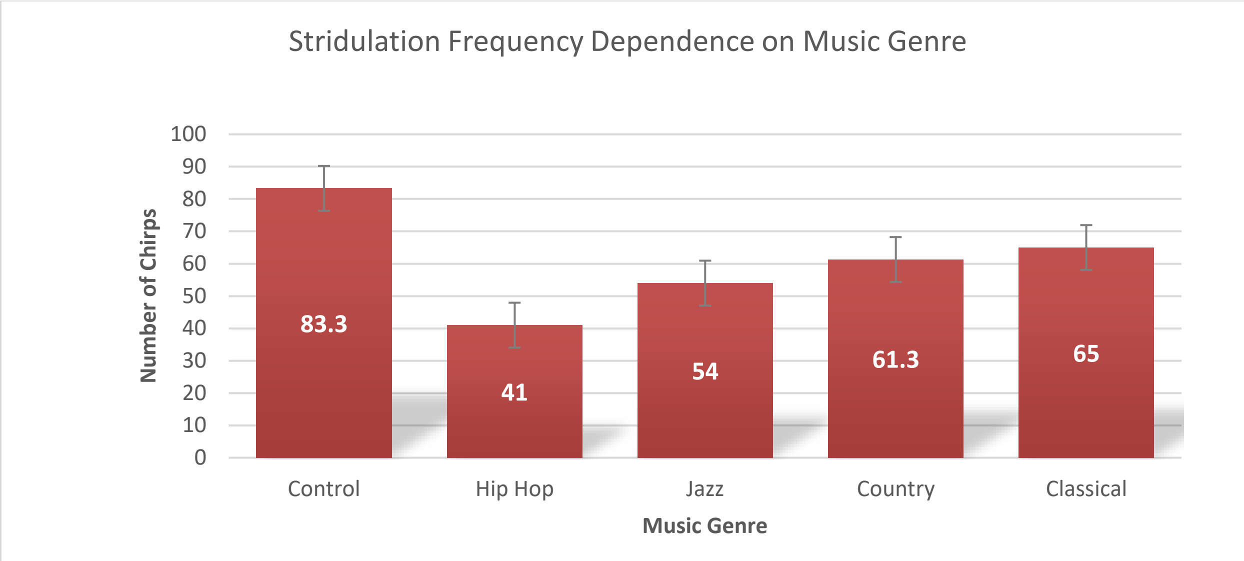

Figure 3. Bar graph comparing the number of chirps per minute between crickets during silence and crickets exposed to hip hop, jazz, country, or classical music.

Discussion and Conclusion

The objective of the present study was to compare the stridulation frequency of crickets while different genres of music are played. Crickets are always on the alert for predators so they are very sensitive to changes in vibration. Even subtle changes in movement, such as a human sneaking up on a cricket, can cause it to go silent. Such sensitivity to vibrations inevitably means that crickets respond to subtle changes in vibration between genres of music. In fact, Dr. Natasa Stritih, a researcher at the National Institute of Biology, made the following statement about vibrational sensitivity in the cricket; "With respect to sensitivity of the vibratory neurons in the cave cricket, their acceleration response thresholds reached down to 0.0005 to 0.01 m/s^2, making them among the most sensitive vibrational responses ever detected in animals" (Stritih 2010). This sensitivity to vibrational changes is implied when examining the cricket's response to changes in musical genre.

Viewing music through a spectrum analyzer produces astonishing results. Spectrum analyzers measure acoustic pressure waves, allowing the observation of changes in frequency. Amazingly, analyzing a lot of music that belongs to the same genre of music leads to the detection of patterns with respect to energy distribution over the frequency spectrum (Anderton 2015). Although generalization across the different types of music in a genre is faulty, it is useful to examine recurring similarities. For example, the spectral response curve for classical music (Fig. 4) depicts a rapid roll-off in the treble range (high frequency, 2 kHz – 16 kHz). This roll-off may be due to the absence of thrashing cymbals or synths with lots of harmonics. In contrast, the spectral response curve for the hip hop music genre show's significantly more midrange and bass emphasis (Fig. 5). The low-frequency increase is characteristic of the increased bass guitar/synth bass found in hip hop music. Also characteristic of hip hop is high-hat and percussion parts, leading to the increase in high-frequency vibrations.

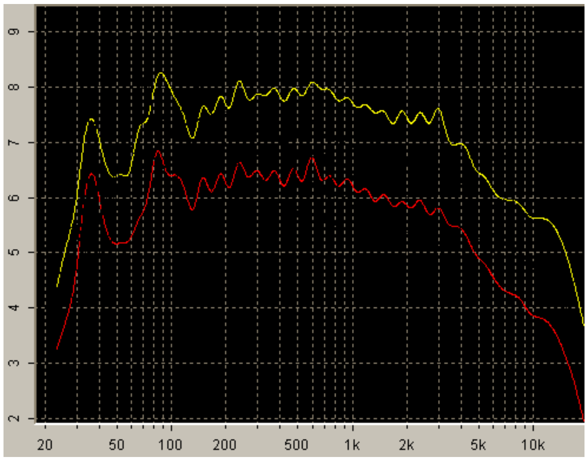

Figure 4. The spectral response curve for a typical song from the classical music genre. The rapid roll-off in the treble range is expected due to a lack of thrashing cymbals, synths, or boosted treble. Minimal processing also contributes to low high-end energy.

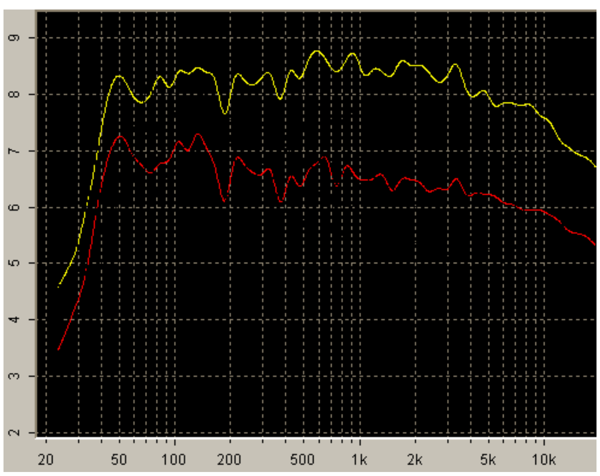

Figure 5. The spectral response curve for the hip hop music genre. There is significant midrange emphasis (vocals and instruments like guitar and piano), more bass, and a bit more high-frequency action. (Anderton 2015).

This somewhat extensive music review was provided to better understand our results. Sound is defined as the propagation of mechanical vibration waves of pressure and displacement. The higher frequency the sound, the more vibrations. As the higher frequency sound characteristic of hip hop and jazz reached the tympanal organs on the cricket, they reacted by increasing their frequency of stridulation. More vibrations in their surroundings could indicate the presence of a predator, so less chirping is ideal to not draw too much attention. In contrast, the low-frequency sounds in classical music produced less of an effect on stridulation frequency. Fewer vibrations in the environment meant the cricket was relatively safe and could continue chirping.

Another plausible explanation for the changes in stridulation frequency is seen in the neurobiology of the cricket. A pair of ascending neurons known as Ascending Neuron 1 (AN1) receives excitatory input from receptor neurons in each tympanal organ and sends the input to the brain (Pollack 2014). AN1 is sharply tuned to sounds with a frequency pf 4.5 kHz, characteristic of the male calling song (Poulet and Hedwig 2002).

Such high-frequency sounds are commonly found in the hip hop music genre (Anderton 2015). Researchers at the University of Cambridge showed that AN1 is rhythmically excited during sonorous chirps, or two-winged stridulation (Poulet 2005). As the tegmina opened at the beginning of a chirp, a depolarizing potential occurred in AN1. This excitation of AN1 in caused neuronal spikes, indicative of brain activity. We propose that a sort of feedback loop causes the results we witnessed in the experiment. Cricket chirping and high-frequency music in the environment simultaneously excite AN1, causing an increase in auditory information being sent to the brain. Crickets then respond to increased auditory input by decreasing the number of chirps, an instinctual response to sound vibrations. This phenomenon does not occur with the lower frequency music because the threshold for responding to high frequencies in the cricket brain is much lower than the threshold for low frequencies (Brodfuehrer and Hoy 1990).

In conclusion, crickets exhibit stridulation frequency differences when exposed to different genres of music. This is due more to general differences in the balance between frequency components characteristic of the genres of hip hop, jazz, country, and classical music. Classical music had the smallest effect on stridulation frequency, while hip hop music decreased stridulation frequency significantly. In the future, we will examine the effect that specific frequencies have on stridulation. A broader range of music genres will also be evaluated on stridulation frequency effect.

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