

AVERAGE RUNNING SPEEDS OF *ACHETA DOMESTICUS* AT DIFFERENT BODY TEMPERATURES

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ABSTRACT

The effects of different temperatures on *Acheta domesticus* speeds, based on metabolic changes, were determined to discover the biological implications on their survival during natural temperature fluctuations. As a result, the effects of both short term and long term climate change on the physical performance of house crickets can be assessed. Two separate treatment trials were conducted with hot and cold baths to attain three arenas of 20°C, 30°C and room temperature (22°C and 24°C). 10 replicates were placed into each arena and the average speeds of the crickets (cm/s) were found through tracing and timing. The crickets from Trial 1 had a larger mean speed difference and decreasing speeds with increasing temperatures, whereas the Trial 2 crickets had increasing speeds with increasing temperatures and a smaller difference in means. In both trials, the treatments resulted in sufficiently different speeds; however, the results were not statistically significant which indicates the null hypothesis, that states there is no difference between cricket speeds due to varying temperatures, cannot be rejected. Younger crickets in Trial 1 were more affected by temperature fluctuations and had speeds negatively correlated with temperature, whereas the older crickets in Trial 2 were less affected by temperature fluctuations but had speeds positively correlated with temperature. This suggests that younger crickets are less likely to survive in their natural habitats when temperatures slightly increase, while older crickets are more likely to survive when temperatures change; however, no definite conclusions can be made due to the experiment's statistical insignificance.

INTRODUCTION

Acheta domesticus, also commonly known as the

house cricket, is native to arid areas of Northern Africa and southwestern Asia (Ghoury 1961). Due to the species' sentimental values and commercial purposes, the house crickets are intentionally distributed to other parts of Asia and Africa, as well as Europe and North America as pets and dietary supplements (Ghoury 1961; Walker 1999; Weissman et al. 2012). In North America, the crickets are commonly found in the eastern districts of the Great Plains, a grassland biome (Millburn n.d.). In their natural habitats, house crickets are located in slightly wet areas with tall weeds, such as logs, caves, and burrows, and generally emerge during the night, as they are nocturnal (Millburn n.d.). When exposed to cold weather, house crickets can also be found in buildings and homes due to their preference for the warm and humid environments provided by humans (Millburn n.d.).

House crickets' locomotion is primarily composed of crawling and jumping, both of which utilize knee extensions in their elongated hind legs (Hustert & Baldus 2010). In a study by Lailvaux, Hall & Brooks (2010), it was found that with greater locomotive abilities, which include jumping distance and power, the average lifespans of *A. domesticus* significantly increased; likewise, as jumping distances and power decreased, the average lifespans decreased as well. These results correspond to the results from a study by Hustert & Baldus (2010), who found that this ability to jump over large distances allowed *A. domesticus* to evade predators and defend themselves, helping maintain high survival. The crickets must also move quickly in order to catch their prey, suggesting that increased speeds again improve their fitness (Hustert & Baldus 2010). Additionally, the crickets' locomotion is also used to reproduce and avoid unfavorable environments with extreme temperatures (Lailvaux, Hall & Brooks 2010). As a result, there is a large positive

correlation between locomotive performance and lifespan, suggesting changes in the amount and rate of house crickets' movements directly influence their survival.



Due to the house crickets' ubiquitous distribution, the daily and seasonal temperature based on their natural location differs from place to place. However, field habitat temperatures fluctuate between 12.9°C to 20.3°C with a range from 10°C to 24°C daily; home habitat temperatures fluctuate between 20.9°C to 23.3°C with a range from 20.6°C to 24°C daily (Ciceran, Murray & Rowell 1993). Additionally, in the grassland biome of North America, winter temperatures can decrease to -17.8°C, while summer temperatures can reach 32.2°C (Bailey 2015). House crickets undergo metabolic changes during exposure to these temperature fluctuations; consequently, these shifts significantly affect *A. domesticus*' locomotive behavior, according to a study by Lachenicht et al. (2010). Lachenicht et al. (2010) also found that average running distances of *A. domesticus* rose with small to moderate rises in temperature, and that the average height of jumping also increased. However, as temperatures increased or decreased in large increments, both running speeds and jumping distances of the crickets decreased (Lachenicht et al. 2010). These results can be explained through the changes in the crickets' temperature-dependent metabolisms; both the *A. domesticus*' respiratory metabolisms, as well as standard metabolic rates, directly affect both the amount and speed of movements, according to Lachenicht et al. (2010). As the metabolic rates rise with small increases in temperature, the crickets are able to crawl more quickly and to jump larger distances (Lachenicht et al. 2010). The metabolic rates decrease, however, with large fluctuations in temperature, suggesting that maximal locomotion only occurs within a moderate, optimum temperature range (Lachenicht et al. 2010). If these temperature fluctuations influence the house crickets' ability to move efficiently, it would then also affect their survival; temperatures outside the optimum range would decrease the crickets' rate of movement, leaving them more susceptible to predators and less capable of capturing prey (Dangles et al. 2007).

In this experiment, we will measure the effects temperature fluctuation, within a relevant range, have on magnitude and speed of movement in the house cricket, *A. domesticus*. Generally, slight rises in temperature increase the standard metabolic rates of *A. domesticus* compared to decreases in temperature, allowing *A. domesticus* to travel greater distances at a faster speed, according to the results obtained from a study by Lachenicht et al. (2010). Therefore, we predict *A. domesticus* will crawl more, and more quickly, at slightly higher temperatures compared to lower temperatures due to these surges in metabolisms. The purpose of this study was to examine how slight-to-moderate temperature fluctuations, similar to those in global climate change and local home conditions, could affect the physical behavior of house crickets.

METHODS

In this experiment, we measured the locomotive responses of *Acheta domesticus* to variations in temperature through the relative speeds (cm/s) of the crickets. Arenas with three temperatures were manipulated through two trials of separate treatments: the first consisted of two treatments of 30°C and a room temperature (control) of 24°C. The second trial consisted of three treatments: 20°C, 30°C, and 22°C (control).

Arena Set-up

Each treatment consisted of a sample size of 10 ($n=10$). The crickets were of small, medium, and large sizes, and were kept in constant extraneous conditions prior to and during experimentation: 316 lux light intensity (trial 1), 406 lux light intensity (trial 2), 200 mL of soil, 20s acclimation in the petri-dish, and 5s of acclimation in the arena before we began distance measurements. Some crickets moved a minimal amount due to not having limbs, indicating they were unhealthy. The unhealthy crickets were not used in the experiment to maintain consistency with trial results. We were unable to determine the crickets' sexes and we therefore chose randomly in order to minimize discrepancies in locomotive performance. Likewise, we were unable to determine the ages of the crickets, and thus chose randomly as well. We maintained the same numbers of different sizes in each treatment, to minimize response variations due to size.

Each cricket was only tested once.

Trials

In the first trial, we measured the speed responses with two treatments: room temperature (24°C) and 30°C. In the first treatment of 24°C, we did not manipulate the temperature, but just monitored it so that the temperature was maintained. The third treatment (30°C) consisted of a hot bath in which we heated water through a kettle and added it around the arena. It was covered by a plexi-glass cover to prevent floatation. The second trial included three treatments. The first treatment (20°C) consisted of an ice bath in which we placed ice in a bucket that surrounded the arena. The height of the bucket was again maintained through the experiment by using a plexi-glass cover to prevent the container from floating. The second room temperature (22°C) and third treatment (30°C) consisted of the same experimental set ups from trial 1. We maintained the temperatures by monitoring arena temperature with a thermometer between each replicate testing, and removing or adding ice or water.

We calculated the locomotive responses of the crickets by tracing over the plexi-glass, and measuring the distance the crickets moved, to determine the speed; in trial one, the distance was measured with a string and ruler, which would have resulted in a source of error due to the technical limits of human tracing. Our tracings were modified in trial two by using the image analysis software, JImage, in order to minimize time spent measuring and attain more accuracy. However, the source of error still remains, since the tracker relied on human tracing. We monitored the light intensity using a light intensity meter to reduce variation. In both trials, the same member traced crickets path to minimize the human uncertainty in measurements.

Statistical Analysis

We then inputted the data into Excel and online t-test calculators to determine the standard deviations, t-values, degrees of freedom, 95% confidence intervals, and p-values.

RESULTS

In our first trial, the arena temperatures were 24°C and 30°C. The average speed for the 24°C treatment was 1.732cm/s (Fig. 1).

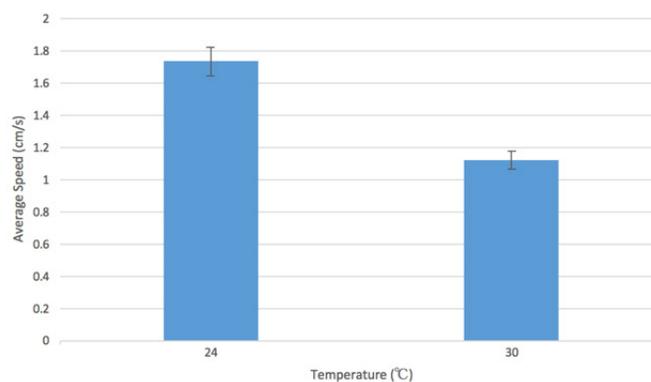


Figure 1. Trial 1 speed (cm/s) of house crickets, *Acheta domesticus*, when exposed to temperatures of 24°C (control) or 30°C. Bars represent the mean (\pm 95% confidence intervals) running speed in cm/s observed at 24°C (n=10) and 30°C (n=10).

The average speed for the 30°C treatment was 1.118cm/s. The 24°C treatment had a larger extreme value from the mean (3.50cm/s) while the 30°C treatment had a smaller extreme value (0.267cm/s). Based on Figure 1, there was a negative correlation between temperature and speed of movement. An increase in temperature was accompanied by a decrease in the speed of movement (y-axis). The p value is 0.113, which is larger than the alpha of 0.05; therefore, the difference between the means was not statistically significant and the null hypothesis could not be rejected. The t-value is 1.67; therefore, the two treatments resulted in sufficiently different speeds, but no concrete conclusions can be drawn. In both of our treatments, we observed that the crickets consistently ran in circular motions around the arena with some path retracing. In the 30°C treatment, more crickets tended to climb up walls.

In our second trials, the arena temperatures were 20°C, 22°C, and 30°C. The average speed for 20°C was 1.121cm/s (Fig. 2). The average speed for 22°C was 1.732 cm and the 30°C treatment had an average speed of 1.863cm/s. The standard deviation is 1.054. Based on Figure 2, there was a positive correlation between temperature and speed of movement. With an increase in temperature, we found there was an increase in the speed of movement. The p-value is 0.089, which is larger than the alpha of 0.05;

therefore, the difference between the means was not statistically significant and the null hypothesis could not be rejected. The t-value is 1.80; therefore, the two treatments resulted in sufficiently different speeds, but no concrete conclusions can be drawn. We observed that the crickets consistently ran around the arena in the same circular pattern with about half of them doubling back, retracing their path. The path retracing occurred more frequently in the control group (22°C) and occurred the least in the 30°C treatment, in which they moved forward the most.

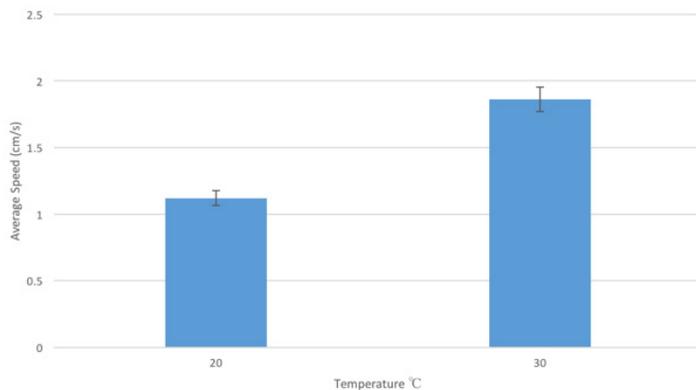


Figure 2. Speed (cm/s) of house crickets, *Acheta domesticus*, when exposed to temperatures of 20°C or 30°C. Bars represent the mean (\pm 95% confidence intervals) running speed in cm/s observed at 20°C (n=10) and 30°

DISCUSSION

In this experiment, we found the effects on mean speeds of *Acheta domesticus* acclimated to three different body temperatures, in order to explore how temperature variations in natural habitats affect the crickets' survival rates. Although both of our trials were statistically insignificant, the overall trends in Trial 1 revealed younger crickets were more affected by variations in temperature and thus had a large difference in mean speeds, while the older crickets in Trials 2 were less affected by the same temperature changes, leading to a smaller difference in mean speeds. Both trials resulted in sufficiently different speeds; the Trial 1 crickets had speeds that decreased as temperatures were raised, while Trial 2 crickets had speeds that increased as temperatures increased.

In a study by Lachenicht et al. (2010), small increases in body temperature were shown to cause both standard metabolic and respiratory rates of house crickets to increase, allowing them to crawl and move faster relative to speeds at lower temperatures. We therefore predicted that the crickets would crawl/run more quickly at slightly higher temperatures than at lower temperatures due to these physiological effects. The results from Trial 1 were not consistent with our prediction; however,

Trial 2 results were. In both cases, the results were not statistically significant.

The first study by Woodring, Roe, and Clifford (1977) examined the effects of age on metabolism in house crickets by measuring water and food consumption of 4800 female crickets at 30°C. They found that nymphs consumed high intakes of food in the beginning of each instar but decreased their intake during the latter portion of the instars. The nymphs continued this cycle until their final moult (8th instar), after which they became adults, and food and water intake began to level off; the results suggest that although younger crickets have higher metabolic rates compared to adults, their rates are also less stable and therefore more susceptible to abiotic factors (Woodring, Roe & Clifford 1977). The study by Woodring, Roe, and Clifford (1977) explains why smaller temperature fluctuations would have a larger impact on speeds of younger crickets by introducing metabolism based on age, which was not originally considered in our experiment. As a result, the discrepancy between the large difference in the younger crickets' mean speeds in Trial 1 compared to the older crickets' small difference in means in Trial 2, in our experiment, can be explained through the differing metabolisms between nymph and mature crickets.



Similarly to our experiment, the study by Lachenicht et al. (2010) also investigated the effects of body temperature variations on house crickets by testing the speeds of 400 randomly chosen adult crickets placed in arenas with temperatures ranging from 25 to 33°C (using water baths). Their study specifically examined the relationship between metabolism and temperature, which allowed them to determine that, although acclimation temperatures did not have an effect on speeds, average running speeds were generally higher with higher temperatures (Lachenicht et al. 2010). These results support our findings from Trial 2, where we found mean cricket speeds increased with temperature. However, the study's results contradict our findings from Trial 1, where mean speeds decreased with temperature elevations. This discrepancy may be due to the fact that adult crickets with stable metabolisms were used

both in the study by Lachenicht et al. (2010) and our Trial 2 treatments, but younger nymphs were used in our Trial 1 treatment; this age difference would affect the crickets' respective metabolic rates and consequently affect the mean speeds recorded in both trials.

The major source of variation in our experiment stems from the differing ages of the crickets used in Trial 1 and Trial 2. Trial 2 took place two weeks after Trial 1, therefore the crickets used in Trial 2 were older and more mature than the Trial 1 crickets. According to the study by Woodring, Roe, and Clifford (1977), the difference in the mean speeds of the crickets in Trial 1 and 2 was influenced by this age difference, as younger crickets have metabolic rates more vulnerable to abiotic changes; consequently, the adult crickets used in Trial 2 were less likely to be affected by abiotic temperature changes. Our data shows large temperature changes, and higher temperatures, cause mature crickets to have a smaller mean speed difference between the temperature treatments. Likewise, smaller temperature changes result in younger crickets having a large mean speed difference, which is supported by the age dependent metabolism results from the study by Woodring, Roe, and Clifford (1977). However, both trials resulted in no statistical significance.

Based on our results, older house crickets would be less affected by temperature changes but have increased speeds with elevated temperatures, while younger nymphs are more affected by temperature fluctuations and have decreased speeds with temperature increases in their natural habitats. These results can be explained through the differing metabolic rates between adults and nymphs, which suggest that survival rates and age are positively correlated (Roe, Clifford & Woodring 1980). In mature crickets, as temperatures rise and thus stable respiratory and standard metabolisms, they move more quickly, consequently enabling their ability to find food, such as sponges, and evade natural predators, such as centipedes (Hoeffler, Durso & McIntyre 2012). Because of these temperature and age-dependent physiological changes, older crickets have improved chances of growing and reproducing with elevated temperatures, according to the results obtained from a study by Hustert and Baldus (2010). On the other hand, as temperatures increase by any amount, the speeds of younger crickets are negatively impacted due to their vulnerable metabolic rates; they would therefore be less likely to catch prey and additionally have an increased risk of predation, ultimately decreasing their fitness (Lailvaux, Hall & Brooks

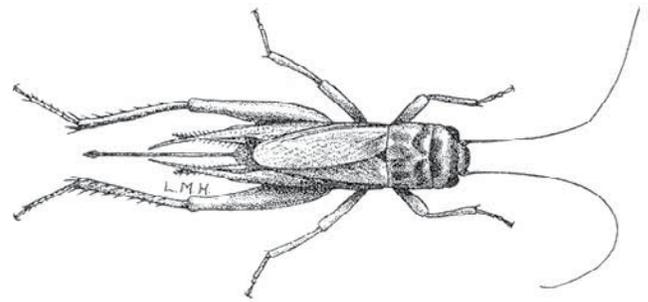
2010).

The primary constraints in our experiment were the age differences between crickets used in Trial 1 and 2, as well as the gender ambiguity of the crickets chosen. The results were based on the effects of temperature on crickets; however, the crickets used in Trial 1 were much younger than those used in Trial 2, which affects our ability to generalize the results towards a population comprised of differently aged crickets. Since the genders and sex ratio of the crickets were unable to be specified, crickets were picked randomly; therefore our results cannot be applicable towards populations of drastically different sex ratios. In order to overcome these constraints, experimentation with large populations comprised of different age groups (more similar to those found in nature) would be necessary to observe the overall trends temperature have on cricket populations. In order to apply the results towards natural populations, the specific gender ratios of crickets in their natural habitat would also have to be established for future experiments, instead of focusing on segregated ages and random genders. The data can also be explained by the different temperature intervals for both trials. The room temperatures during each trial varied by 2°C, perhaps affecting the motion of the crickets. However, both resulted in similar average speeds, thus we would also need to consider the temperatures the crickets are acclimated to already, then test temperature changes relative to those.

In Trial 1, the general trend revealed that younger crickets had decreases in mean speeds when temperatures increased, refuting our hypothesis that higher temperatures will increase speeds due to the accompanying surges in metabolic rates. The Trial 1 crickets also had a larger difference in mean speeds compared to those in Trial 2, which may be due to their susceptible and unstable metabolisms. The trends in Trial 2 supported our hypothesis as the older crickets had speeds that increased when temperatures increased, and additionally had a smaller difference in mean speeds for each treatment; however, no definite conclusions can be gleaned from our experiment due to the statistical insignificance of both trials. A larger sample size would provide greater statistical robustness to this experiment.

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