

The Effect of Temperature on *Solenopsis invicta* (Hymenoptera: Formicidae) and their Foraging Habits in Central Texas

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Abstract

The Imported Red Fire Ant *Solenopsis invicta* is not only a painful nuisance to your Sunday picnic but also of great importance to medical professionals and those with allergies associated with its painful bite. This study is aimed at providing information about *S. invicta* and their foraging habits in different temperatures in order to better control them in the College Station area. In order to collect data, six traps were placed next to ant piles throughout a grassy field indigenous to *S. invicta* over a period of about three weeks. These traps were baited with hot dog meat and set for a period of approximately 2 hours at the hottest time of day (2 P.M. - 4 P.M.) then collected and the ants were counted. This was done twice per week over the three week period. The resulting data showed that there was some correlation between temperature and amount of ants foraging, higher temperature related to higher amount of ants accounted for. Discrepancies in this trend were addressed by assessing additional climatic variables which may have caused interference, and a relationship was established between ant foraging behavior and mean wind speed. The size of the ant hills provided another clue into the number of ants found in each trap. The larger the ant bed the trap was placed to, the larger amount of ants were found foraging for food.

Keywords: ant, *Solenopsis invicta*, temperature

Despite their small size, ants are capable of causing serious destruction to plants, animals, and infrastructure, resulting in economic and property loss. One of the most harmful ants is an invasive species named *Solenopsis invicta*, more commonly known as the Imported Red Fire Ant. *Solenopsis invicta* are native to the Mato Grosso region of Brazil and were shipped to America through the port of Mobile in 1939 (Stafford 1996). The Imported Red Fire Ant is of particular relevance to human health, as a bite

from this insect has the potential to induce problems ranging from anaphylaxis to death (Prahlow 1998). *S. invicta* ants pose a health risk all over the US due to the allergic reactions they can cause, but are a significant public health issue in the South (Stafford 1996). Although there have been many control efforts implemented to subdue this species, they have not only failed at preventing its spread to different parts of the world including Taiwan and Australia, but

have also contributed to the loss of native ant species (Williams 2004).

In Texas, the climate and natural resources provide an ideal environment for many different ant species to thrive. Native species include the *Dorymyrmex* spp. (Pyramid ant), *Pheidole* spp. (Bigheaded ant), *Monomorium pharaonic* (Pharaoh ant), *Camponotus* sp. (Carpenter ants), *Paratrechina longicornis* (Crazy ant), *Crematogaster* sp. (Acrobat ant), and *Monomorium minimum* (little black ant). These species are currently in competition for resources with the Imported Red Fire Ant (Lennon).

The purpose of this study is to gain a better understanding about the foraging habits of the ant species invasive to the College Station area in relation to temperature and seasonal changes; this will provide a basis for learning how to control them.

Materials and Methods

Studied Species

The species of interest in this study, *Solenopsis invicta*, is commonly known as the Imported Red Fire Ant. It is widely divergent in appearance from other species in the area of College Station, and this quality, along with its medical relevance, makes it a fitting subject for field experimentation. Identification markers of *Solenopsis invicta* include the absence of the propodeal spines and the antennal scrobe, its ten segmented antennae and two segmented antennal clubs, the presence of a middle tooth between the two lateral teeth of the anterior clypeal

margin, and its polymorphic worker caste (Trager 1991).

Description of Experimental Habitat

Experimentation was centered on large, open, grassy fields free from areas of excessive shade which could affect the constancy of temperature. Additionally, this habitat type was chosen because it models the environments in which humans are normally medically affected by fire ants—namely parks, lawns, and sports fields. The open field, at the intersection of George Bush and Holleman Dr., was chosen as the testing site because the field contained many fire ant piles. The experimentation was carried out in the fall, from October to December, following the natural progressive cooling of the season. Six anthills of uniform size (approximately 30 cm in diameter) that were set apart from other anthills by at least 10 meters were selected for testing and assigned a letter (A, B, C, D, E, and F).

Trap Design

The trap was constructed from a 6 oz. plastic cup (90 mm diameter x 75 mm height) that was lined interiorly with Vaseline (Unilever, London, UK) intended to capture the ants upon entrance. A pit was dug into the ground 3 m from the studied ant colony, and the trap was inserted flush with the soil. Soil was brushed up to the rim of the trap to cause it to blend naturally into the surrounding environment, and the bottom of the trap was baited with approximately 0.8 oz. of hot dog cut into 0.2 oz. pieces. A square tile was propped up on four stilts over the opening of the trap one inch above ground level to

prevent animal interference, while still allowing access to the trap from all sides.

Data Collection

For one week prior to setting the traps, the trap sites were baited with cotton balls soaked in a 25% sugar solution and placed on an index card. The cotton balls were replaced once during the week to insure an ample supply was available to the ants (Nyamukondiwa 2014). At the close of the week, the baits were removed. Twenty four hours later, the first trial was initiated. At 1:00 pm, the traps were placed and the temperature of the site was recorded. Three hours later, at 4:00 pm, the temperature was again taken and the trap was removed. The captured ants were killed and preserved using a 70% ethyl alcohol solution (Nyamukondiwa 2014), and two researchers independently identified and counted the ants. The same process was repeated in the middle of the week. Testing occurred over the course of eight weeks, allowing for a total of sixteen trials.

Graphical Analysis

For each trial day, the two temperatures collected were averaged. A scatter plot was generated for each trap site (A-F) plotting the number of ants collected versus average trial day temperature for the course of the whole experiment. Additionally, a scatter plot that plotted the number of ants collected versus the average temperature that trial day was created, and each of the six trap sites was represented by their own data point. Data from all sixteen trials was included.

To account for various other climatic effects on ant foraging behavior, the number of ants collected from each site was also plotted against daily values of maximum sustained wind speed, mean wind speed, maximum gust speed, and mean dew point temperature obtained from the National Climatic Data Center. Precipitation was discarded as a variable as the amount of rain received in the area during the extent of the experiment was considered negligible. The NCDC records for daily minimum temperature, mean temperature, and maximum temperature for College Station, TX was also analyzed with the experimental data.

Statistical Analysis

After graphing a scatter plot of the number of ants collected based on temperature, it is necessary to determine whether there was a clear positive or negative regression. The means and standard deviations were calculated for temperature and number of ants collected per site. The purpose of calculating standard deviation is to see whether there are any outliers within each data group. It is important to note outliers, because they may skew the data. These calculations were then used to calculate the correlation coefficient (R-value) for each site to analyze the strength of correlation between temperature and activity.

Data and Results

All of the data collected from the experiment has been grouped by site and consolidated into charts showing the temperature and amount of ants that were collected (Figure 1). Data was collected on seven separate

occasions between the dates of October 26th to November 19th. Site A and Site C regularly had the highest turnout in regards to number of ants collected, while the other 4 sites did not consistently show high numbers of collected ants. Sites A and C were in close proximity to the largest ant hills that were under direct sunlight throughout the course of the study. This suggests that the size and location of the ant hill plays a role in the activity of fire ants. The hottest day reported was November 5th, and on this day, the total number of ants collected was the highest for Site B (n=115) and Site C (n=653). The temperature increased an average of 3.4°C from November 2nd to November 5th; this shift in temperature was associated with an increase in ants collected for Sites A, B, C, and E along with a decrease in ants collected for Site F while Site D remained unchanged. The lowest temperature was recorded on November 9th. That day, Site C had the lowest amount of ant activity while Sites B and F did not have any ants collected at all (n=0). Interestingly, Site D had the largest number of ants collected (n=137) on the day with the lowest temperature reported (14 °C on November 9th). During the month of October, the highest number of ants collected were at Site A (n=894) and Site E (n=741). Data is not available on November 12th for Site A, B, E.

In addition to the average temperature of the trapping period, ant foraging behavior was analyzed in regards to the minimum, mean, and maximum daily temperature values for the area as recorded by the National Climatic Data Center. Because of the insufficient amount of ants that visited Sites B, D, and F, these sites were excluded in this part of the analysis. It was found that no strong relationship existed between foraging behavior and the minimum, mean, and maximum daily temperatures at Sites A, C, and E. However, an increasing trend was visible in the plot of maximum daily temperature (Figure 2). The R^2 values of the maximum temperature plots were 0.3152, 0.7898, and 0.0961 for an exponential fit, considerably higher than those of the minimum and mean temperature plots but still far too weak and variable to consider the possibility of a relationship. It is possible, however, that a higher sampling of data would drown out various climatic effects and other non-related variables to support a relationship between daily maximum temperature and ant foraging activity; however, the data collected in this experiment is insufficient to make this kind of conclusion.

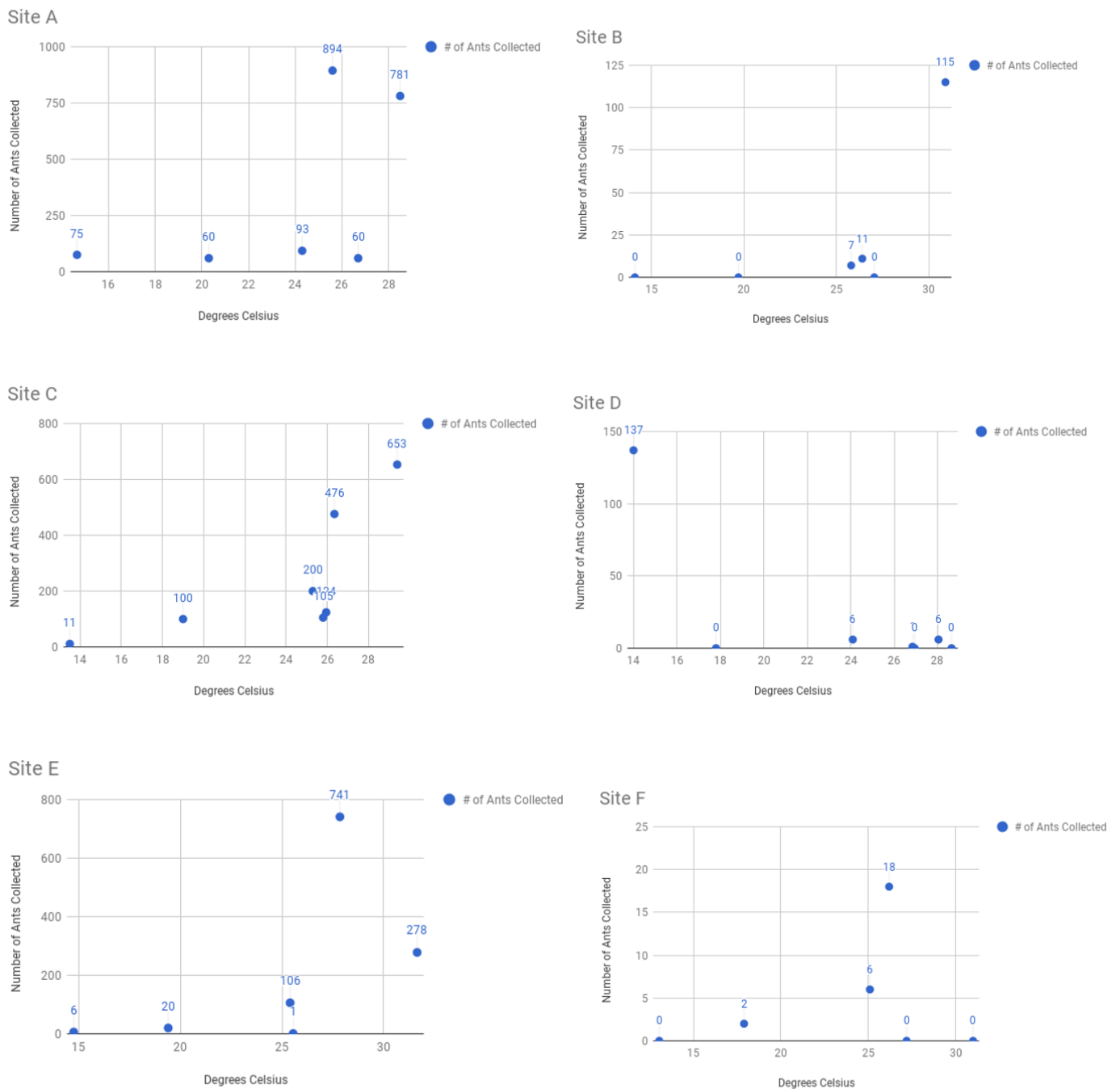


Figure 1. The number of ants counted for each site is plotted against the average temperature. While the results appear non-linear, there is a general positive trend evident at all sites, with the exception of site D. This suggests that there is a positive correlation between increasing temperatures and fire ant foraging activity, but more data is needed to conduct a more robust statistical analysis.

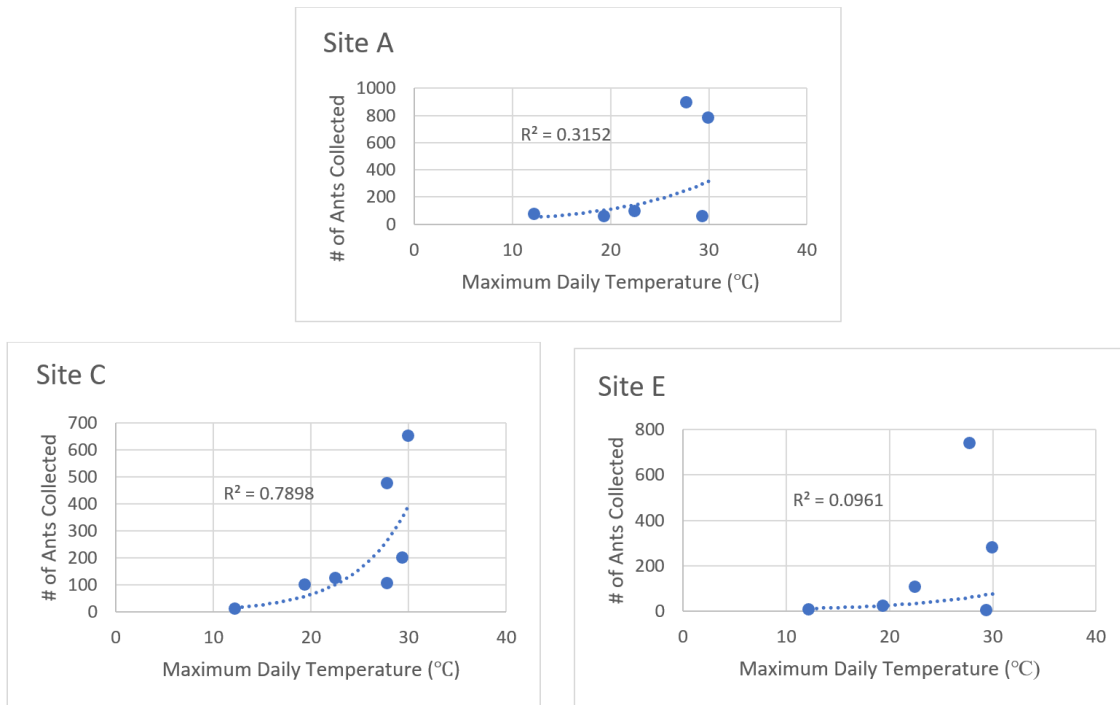


Figure 2. No strong relationship was able to be determined between maximum daily temperature and an increase in ant foraging activity, although a general positive trend can be seen for each plot. While the exponential trend line shows a moderate fit for Site C ($R^2 = 0.7898$), Site A and Site E show little to no correlation. More data is needed to evaluate this visual trend as the small amount of data produced by this experiment is insufficient to determine the existence of a relationship.

Because the trends between ant foraging behaviors were observable but weak, analysis of wind speeds as additional, off-setting climatic variables was conducted. Once again, because of the abundance of ant activity that was recorded at these sites, only Sites A, C, and E were considered. The data was related to maximum sustained wind speed (MSWS), which is defined as the highest average wind which lasts for a one minute interval at a height of 10 meters with unobstructed exposure. A logarithmic fit was applied to describe the relationship (Figure 3), which was negative and assumed to bottom out when reaching a certain lower threshold at which point MSWS would have minimal effect. Calculated R^2 values (0.8012, 0.3176, and

0.6996) once again showed varying fitness, so more data is needed to validate a conclusion that MSWS affects ant foraging behavior. On the other hand, analyzing the data in light of daily mean wind speeds (defined as the average wind speed over an hour-long interval at a height of 10 meters of unobstructed exposure) suggested a positive relationship with ant foraging activity. Because it was assumed that at a certain upper threshold of mean wind speed the positive trend would level out and eventually reverse itself as ants took shelter from high-speed wind, a second order polynomial fit was applied to the data. The R^2 values produced from the plots (0.9976, 0.825, and 0.8637) supported this fit (Figure 4).

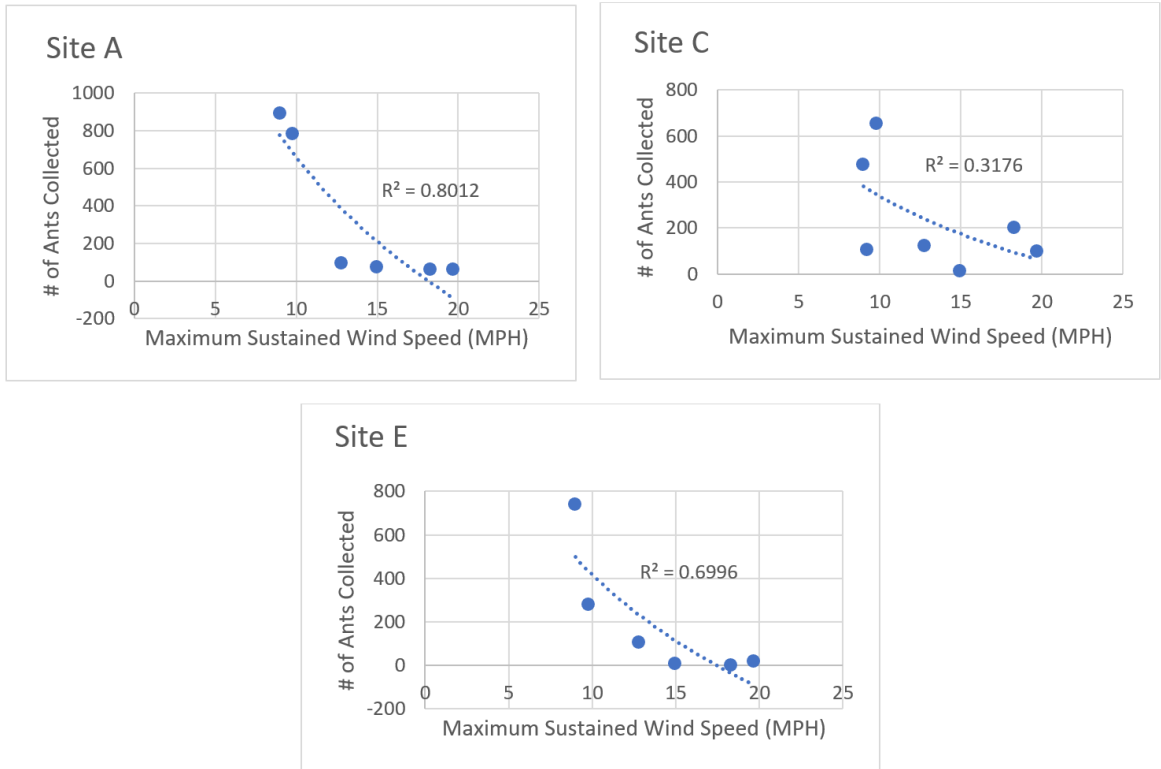


Figure 3. An attempt was made to describe an exponential trend between ant foraging activity and maximum sustained wind speed; however, the R^2 value for Site C disfavored the conclusion that the two variables were related. Further data collection would be necessary to confirm or deny the existence of a relationship.

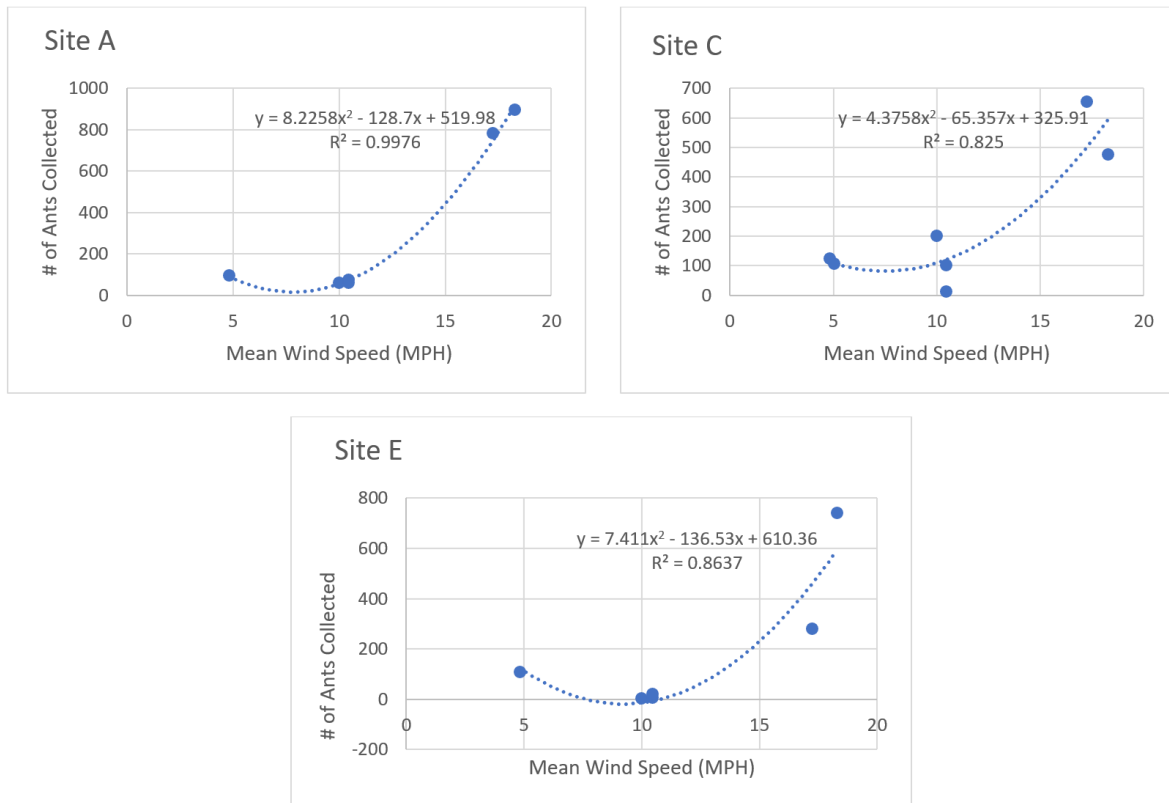


Figure 4. Because it was assumed that ant foraging activity would level off and drop at a high enough wind speed, a polynomial trend line was applied to the data in place of an exponential one. All three plots exhibited a moderate to strong fitness with the trend line, supporting the existence of this kind of relationship. It should be noted that Site A and E plots have highly similar trend line equations, which is additional evidence for the presence of a relationship between these two variables. The equation of the Site C plot does not agree as well with the other two, but this is to be expected as it showed similar divergence from the other plots when describing the relationship of the site data with maximum standard wind speed. Therefore, it is possible that some outside factor affected ant foraging activity at Site C. Nonetheless, more data is needed to confirm and quantify this relationship.

Statistical Analysis

Regression

As indicated above in the figures, graphs A, B, C, E, and F show a positive slope. Therefore, there is indication of a positive correlation between temperature and fire ant activity. However, this does not test for the

strength of the correlation. In order to do so, you have to calculate the correlation coefficient also known as R-Value. Site D showed a strong negative slope; however, it was due to outliers since no ants were collected for both times. Potentially, human activity disrupted the ant pile at site D.

Average Temperature During Ant Collection

Table 1: Mean and Standard Deviation of Temperature During Ant Collection		
Site	Mean (Average temperature in celsius)	Standard Deviation
A	24.3	5.5
B	24.8	6.3
C	24.1	6.1
D	24.9	6.1
E	25.0	6.2
F	26.6	8.1

Table 1. The average temperature for all sites were similar ranging from 24-27 degrees celsius. The standard deviations were relatively low and consistent; therefore, values of the temperature do not vary too far from the average temperature.

Average Number of Ants Collected Per Site

Table 2: Mean and Standard Deviation for Ants Collected		
Site	Mean (Average number of ants collected)	Standard Deviation
A	367.5	413.1
B	28	48.7
C	277.6	273.1
D	30.2	59.7
E	247.4	292.7
F	9.6	13.8

Table 2. The range for average ants collected were variable to a high degree. Also the standard deviations calculated indicate high variation in the number of ants collected. Very often were there outliers that skewed the data. To level out the outliers, there needs to be more collections of ants taken over a period of time.

Correlation Between Temperature and Number of Ants Collected

Table 3: Correlation Coefficient	
Site	R-Value
A	0.191
B	0.354
C	0.510
D	0.987
E	0.288
F	0.305

Table 3. R-Value was calculated to determine the strength of correlation between temperature and number of ants collected. The closer the R-value is to one, the stronger the correlation. Our results show a weak correlation between temperature and number of ants collected. Note that although D shows the highest correlation coefficient, it is not a legitimate indicator because there was a malfunction of the ant pile, which led to outliers.

Discussion

The results of this study indicate that the temperature associated with the optimal fire ant activity in the course of the experiment was between 28.5°C and 31.65°C, suggesting that fire ants are more active during periods of warmer weather as opposed to times when the temperature is cooler. Overall, Sites A, C, and E showed a possible correlation between temperature and foraging while the other 3 sites showed little to no change. These results suggest that the foraging habits of fire ants are more closely correlated with the size and location of the ant hill rather than the temperature of the ambient environment.

The study was almost certainly affected by other climatic variables outside of the average temperature during the span of the trapping period. The lack of correlation between minimum and mean daily temperatures and the observed ant foraging activity indicates that the behavior is much

more complicated than what was originally believed; a strong relationship could not even be drawn with maximum daily temperature. More studies that employ a greater number of sites over a greater span of the year are necessary to gain a fuller understanding of the effect that temperature has on ant foraging. It is possible that during the late summer and early fall seasons, ambient temperature is not the most important factor in deciding ant foraging levels. This was supported by the relationship that was drawn between foraging and daily mean wind speed. The analysis of the plots seems to evince that the ants disfavor high maximum sustained wind speed will favoring high mean wind speed. This appears to be counter-intuitive as it seems that a high maximum sustained wind speed would be the only direct cause of elevated mean wind speed. However, this neglects to take into account wind gusts, which are brief yet powerful and can also be

responsible for raising mean wind speed. Based on the results of the analysis, it would seem that the ants favored gusty wind over long, sustained winds for foraging behavior. More research is needed to focus on this question and determine the effect that wind may have on ant activity.

While the majority of the results followed some sort of a pattern, the gathered data may have been slightly impacted by mildly inconsistent drop-off and pick-up times for the traps during the course of the study. Because researchers took turns in the drop-off and collection of the traps, the methodologies used to make the collections may have differed somewhat between the team members. Additionally, because counting errors may have occurred when processing the data and some sites drew very few ants throughout the course of the study, the data may not reflect ant foraging activity over the study period to the most accurate extent. Sites B, D, and F were even excluded from parts of the analysis because of the limited amount of ants that were attracted. It is possible that the traps were inappropriately placed so that the ants could not find them, or the size or robustness of those ant colonies may have limited the distance that the worker ants were willing to go to forage. With the possible sources of error in mind, the conclusions made from the observed trends would have been more reliable if there was a higher number of useable sites during the study, as the data would have been more consistent and substantive.

Conclusion

While temperature may affect the foraging habits of fire ants, the data collected in this study is not sufficient to show a concrete correlation. Many factors aside from temperature may impact fire ant foraging activity including wind speed, amount of sunlight, season, size of ant hill, and disruption of environment due to human activity. The lowest temperature was not always linked to the smallest number of ants collected, and the highest temperature was not always linked to the largest number of ants collected. This suggests that there is some other predominant factor, perhaps wind speed that controls ant foraging behavior during this span of time between late summer and early fall. Future studies will need to be conducted over a longer time span and with a greater number of sites in order to determine what these factors may be and to show a stronger correlation between temperature and fire ant activity.

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