The Preference of Common Ant Species to Natural and Artificial Sugars Found in Beverages

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Abstract: The species selected to be surveyed are the common pest ants of non-forested areas in Texas: *Solenopsis invicta*, *Camponotus sp.*, *Atta texanus*, *Tapinoma sessile*, *Tapinoma melanocephalum, Solenopsis molesta, Dorymyrmex sp., Monomorium pharaonis, Prenolepis imparis, Paratrechina longicornis, Labidus coecus, Crematogaster sp., Pogonomyrmex barbatus, Tetramorium bicarinatum, Pheidole dentata,* due to these species being common pests to non forest aeas in Texas. Sweet tasting products, such as milk, has been observed attracting ants. Ant affinity for five different liquids containing different sugars was tested: water, sugar water (sucrose), Stevia (aspartame), apple juice (fructose), and Coca-Cola (high fructose corn syrup, glucose, manufactured fructose). Traps were set in five different, non-forest locations in Bryan/College Station, Texas to determine to which types of sugars the ants most gravitated. Based on previous experiments and conclusions, it was hypothesized that ants had adapted to equally favor all varieties of sugar found in conventional beverages. The variety of ants that were trapped in experimentation were: red imported fire ants (*Solenopsis invicta)*, carpenter ants (*Camponotus vicinus),* thief ants (*Solenopsis molesta),* pharaoh ants (*Monomorium pharaonis),* acrobat ants (*Crematogaster sp.),* and ghost ants (*Tapinoma melanocephalum).* Not all ant species that were planned to be surveyed were collected. From the ants obtained, it was determined which liquid tested for was most frequented, and by which types of ants. Cola soda was observed to have the most individual ant visits, with having 20 b the third week. A conclusion was made that ants do have a preference in sugar type, which contradicted the original hypothesis of the researchers. This can be inteplented in to telling what food ants are drawn to baised on the diffrent sugars present.

Keywords: ant, sugar, Bryan/College Station, red imported fire ant (*Solenopsis invicta*)

A diverse number of ants, belonging to Family Formicidae (Hymenoptera), have become common household pests. This is in part due to the wide variety of food sources that can be obtained in the home, that are absent in nature. Ants invade kitchens, eat away at food and drinks, and some species, such as *Solenopsis invictica* (red imported fire ants), can cause physical harm. Ants are especially well-suited for home invasions because they are social creatures and cohabitate in colonies. Within any given ant colony, there is a hierarchical system in place that consists of specific roles. First, there are drones, which are male ants whose sole purpose is to mate with the queen. Next, there are worker ants, which are female ants responsible for building, maintaining, and protecting the nest as well as for providing for the colony. These are the only ants to leave the nest, which they do in search of food. Then, there is the queen. While there are numerous drones and countless worker ants in a colony, there is only one queen, or a few queens depending on the species. The queen's job is to lay eggs to create the colony. A colony of ants is often referred to as a superorganism, which is a term used to describe a group of organisms whose collective abilities far outperform the abilities of a single organism. Ants live together in large numbers, and can grow quickly in size with the number of eggs a queen can lay ("Terminix 2017").

Ants are a major nuisance and concern for many homeowners because ants are attracted to household sugar varieties that mimic the honeydew they eat on from aphids. Ants have been shown to change their preference for honeydew when given sugar alternatives, so this is where their attraction stems from (Del Claro et al. 1993). They are able to detect chemical signatures from these sugary substances which is known as chemosense. In order to locate the source, ants rely on their sense of smell once again, which is considerably strong due to the additional odor receptors they have in their antennas ("Terminix 2017"). As ants leave the nest in search of food, they release pheromones that serve as chemical markers to lead them back to the nest when it's time. More markers can be left to reinforce a trail and indicate a successful path to food, which other ants can use if they come across it.

Past studies have shown that ants will commonly feed on sugars found in sweet-tasting products and milk (Drees and Summerlin 1998). Milk was predicted to have a potential advantage in attracting ants as a previous study found that the larvae had higher preferences for amino acids than sugar (Tschinkel et al. 1998). However, due to spoilage concerns milk was left for future experiments. All ant species used for this experiment have previously demonstrated some affinity for household sugars. The result for specific preferences were mixed between studies; some ants preferred artificial sugars, while others did not display a notable difference (Boaretto et al. 2003, Cammaerts et al 2016, Guerrant et al. 1981). Knowing which types of household sugars most appeal to different ant species could help homeowners manage and prevent future ant infestations. The focus of this experiment was to analyze if common Texas ants exhibit a preference for sugars that are found in common household beverages.

The species of ants that are common in Texas include: *Solenopsis invicta* (red imported fire ants), *Camponotus sp.* (carpenter ants), *Atta texanus* (leafcutter ants), *Tapinoma sessile* (odorous house ants), *Tapinoma melanocephalum* (ghost ants), *Solenopsis molesta* (thief ants), *Dorymyrmex sp.* (pyramid ants), *Monomorium pharaonis* (pharaoh ants), *Prenolepis imparis* (winter ants), *Paratrechina longicornis* (black crazy ants), *Labidus coecus* (army ants), *Crematogaster sp.* (acrobat ants), *Pogonomyrmex barbatus* (red harvester ants), *Tetramorium bicarinatum* (pavement ants), and *Pheidole dentata* (big-headed ants). These ants can be common pests in non-forest areas in Texas, and can be identified using a Texas Pest Identification Key (Cook et al. 2014).

Materials and Methods

Survey Dates and Localities

The collection of specimen was performed in the Bryan/College Station area between the dates of 10-VI-19 to 11-I-19 (Table 1 and Fig. 1). Five arbitrary localities were surveyed for common presence of Texas pest ants located in non-forested areas: *S. invicta*, *Camponotus sp.*, *A. texanus*, *T. sessile*, *T. melanocephalum, S. molesta, Dorymyrmex sp., M. pharaonis, P. imparis, P. longicornis, L. coecus, Crematogaster sp., P. barbatus, T. bicarinatum,* and *P. dentata* (Table 1 and Fig. 1). These localities shared the commonality of non-forest urban/suburban environments in which the aforementioned ant species are found as household pests (Cook et al. 2014).

Table 1. Locality data, elevation, and dates surveyed for the common pest ants in Texas: *S. invicta*, *Camponotus sp.*, *A. texanus*, *T. sessile*, *T. melanocephalum, S. molesta, Dorymyrmex sp., M. pharaonis, P. imparis, P. longicornis, L. coecus, Crematogaster sp., P. barbatus, T. bicarinatum,* and *P. dentata.* These species were surveyed in different non-forest Bryan/College Station areas (Cook et al. 2014).

Locality	**GPS Coordinates**	**Elevation (m)**	**Forest Type**	**Date Surveyed**
College Station, Texas (**A**)	30°37’19.312”N, 96°18’38.327”W	90	Non-Forest	10-VI-19 to 10-XII-19 10-XVII-19 to 10-XXIII-19 10-XXVI-19 to 11-I-19
Bryan, Texas (**B**)	30°37’50.687”N, 96°21’16.674”W	102	Non-Forest	10-VI-19 to 10-XII-19 10-XVII-19 to 10-XXIII-19 10-XXVI-19 to 11-I-19
Bryan, Texas (**C**)	30°37’29.419”N,	102	Non-Forest	10-VI-19 to 10-XII-19

	96°21’9.469”W			10-XVII-19 to 10-XXIII-19 10-XXVI-19 to 11-I-19
College Station, Texas (**D**)	30°34'24"N 96°19'54.000"W	97	Non-Forest	10-VI-19 to 10-XII-19 10-XVII-19 to 10-XXIII-19 10-XXVI-19 to 11-I-19
College Station, Texas (**E**)	30°36'40.984"N 96°20'49.716"W	102	Non-Forest	10-VI-19 to 10-XII-19 10-XVII-19 to 10-XXIII-19 10-XXVI-19 to 11-I-19

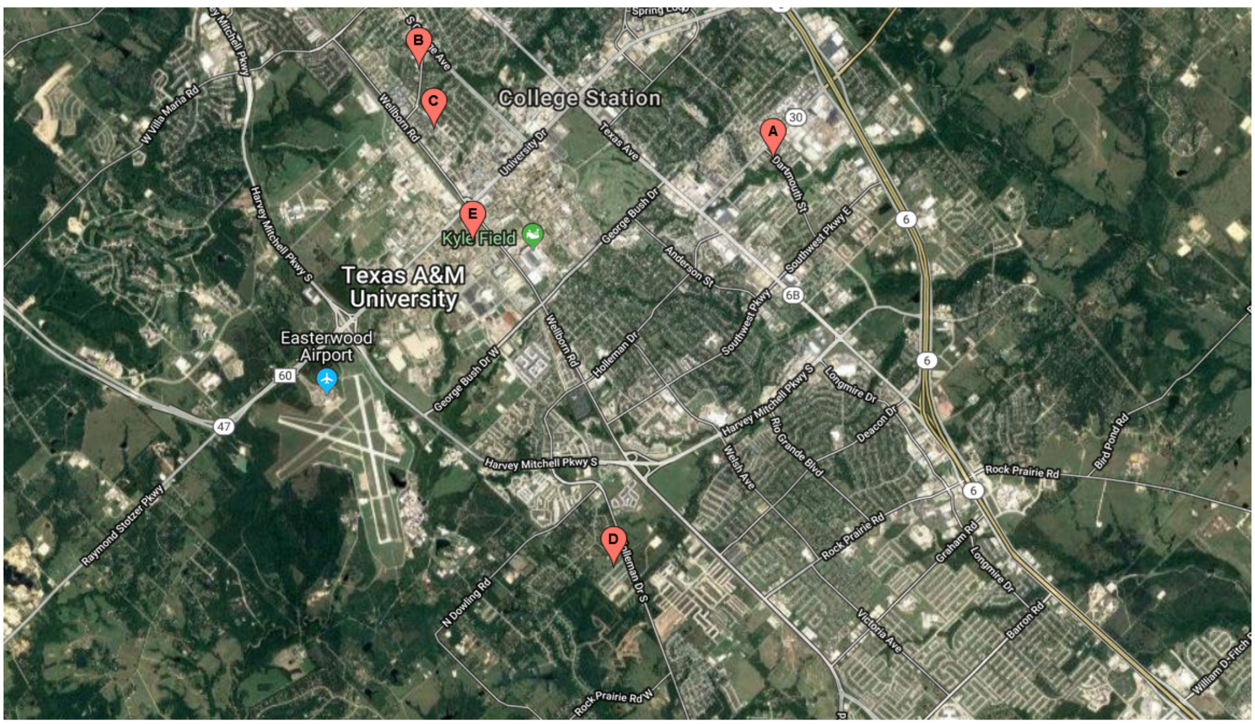

Fig. 1. A satellite image map of the Bryan/College Station area displaying where all the ant traps were located. All red markers A, B, C, D, and E are where the traps were placed and they are numbered with the table giving more information about them. The map is oriented North to South while being read from top to bottom.

Collecting Procedures

The common Texas ant species planned to be collected were red imported fire ants (*S.*

invicta), carpenter ants (*Camponotus sp.*), leaf cutting ants (*A. texanus*), odorous house ants (*T. sessile*), ghost ants (*T. melanocephalum*), thief ants (*S. molesta),* pyramid ants (*Dorymyrmex sp.),* pharaoh ants (*M. pharaonis*)*,* winter ants (*P. imparis),* black crazy ants (*P. longicornis*), army ants (*L. coecus*), acrobat ants (*Crematogaster sp.*), red harvester ants (*P. barbatus*)*,* pavement ants (*T. bicarinatum*)*,* or big-headed ants (*P. dentata*). These specimens were collected using traps placed in five locations in the Bryan/College Station area (Table 1 and Fig. 1) (Cook et al. 2014). Traps were designed using plastic water bottles with a total volume of ~237 mL of water. Each water bottle was filled with one of the following test liquids: only water (control 1), sugar water (control 2, sucrose), artificially-sweetened water Stevia (aspartame), milk (lactose)*, Coca-Cola (high fructose corn syrup, glucose, manufactured fructose), and apple juice (natural fructose).
Excluded due to spoilage concerns.

All liquids, except for water, were diluted to 0.05 g sugar/mL water. Water was added to 122.5 g sucrose until the volume reached 2450 mL, water was added to 122.5 g aspartame until the volume reached 2450 mL, 2402 mL milk (Borden, Conroe, TX) was added to 48 mL water, 1114 mL Coca-Cola (Coca-Cola, Atlanta, GA) was added to 1337 mL water, and 1114 mL apple juice (Minute Maid, Sugarland, TX) was added to 1337 mL water. After dilutions were made, 70 mL of each liquid was transferred into seven separate bottles for each location for each day of the week tested. Dilutions were prepared the week before the particular beverages were tested to prevent spoilage.

The bottles were closed, and holes were pierced in the cap to allow entry for the ants. The traps were laid sideways on the ground near a grassy area. The bottles were weighed down by rocks or sticks to prevent any easy movement from wind, animals, or external interference. With the exclusion of milk, seven traps for each location were made for each liquid, adding to a total of 35 bottles for each location. Three weeks of testing were performed; two test liquids were used per week at each location. Traps were checked daily; and at the end of each day, the bottles were collected. The liquids were replaced everyday during their respective week. Ants were separated from the liquid in each bottle via filtration using a coffee filter, and emptied in corresponding labeled plastic bags to keep track of each liquid tested and the date that it was collected. To finish killing any ants not drowned, the bags were placed in a freezer overnight. The next day, the ants were let to dry at room temperature. This process was repeated for each tested liquid over the three weeks of collection for each of the five locations. After the three weeks of collection, ants were brought in to be identified to the species or genus level and a survey of each species along with the quantity of specimens caught in the bottle corresponding with beverage type and date caught was made. A statistical report and analysis was determined to draw conclusions.

Specimen Preservation, Identification, and Imaging

After the third week of collection, each of the 35 plastic bags representing the 35 bottles tested for each of the locations (seven of each test liquid at each of the five different locations), the specimens were brought into the laboratory for identification. A small vial was filled halfway with ethanol for every bottle on the specified day where a collection was made. All the specimens for a single beverage type and date were placed into the vial of ethanol using forceps. Vials were categorized by bottle and location, not by specimen taxonomy. For example, a vial may contain two different species because they were collected from the same location on the same day. Next, the specimens were identified according to "Texas pest ant identification: An illustrated key to common pest ants and fire ant species" (Cook et al. 2014) under a stereo microscope (Model SZ2-ILST, Olympus Corporation, Tokyo, JP). For each beverage type, date, and location, ant 19) (Fig. 8), and then one additional *S. molesta* (11-I-19) were found, all from the bottles with soda.

Results

No ants were collected at either locations A or C over the course of this experiment. Reasons as to why are discussed below. A summary of all the species collected, which includes *S. invicta* (red imported fire ants), *Camponotus vicinus* (carpenter ants), *S. molesta* (thief ants), *M. pharaonis* (pharaoh ants), *Crematogaster sp.* (acrobat ants), and *T. melanocephalum* (ghost ants), can also be found below (Table 2).

First Week of Collection

At location B, one *S. invicta* was collected from the bottle containing water on the third day of collection (10-VIII-19). On this same day, five *S. invicta* and one *M. pharaonis* were collected from the bottle containing sugar water. In subsequent days, three *S. invicta* (Fig. 3) and one *M. pharaonis* (10-IX-19), one *S. invicta* and one *M. pharaonis* ant (10-X-19), and then one *S. invicta* (10-XI-19) were found, all from bottles with sugar water. No ants were collected from location D corresponding with the sugar water and the water control. At location E, one *S. molesta* was collected from the bottle containing water on the fourth day of collection (10-IX-19). One *S. molesta* was also collected later in the week (10-XI-19), but from a bottle containing sugar water. An additional four *S. molesta* were collected from the bottle with sugar water the following day (10-XII-19).

Second Week of Collection

At location B, one *S. invicta* was collected from the bottle containing Stevia on the first day of collection (10-XXVII-19) and another one *S. invicta* on the third day (10-XIX-19). Two ants were collected from the bottle with apple juice on the second day of collection (10-XVIII-19): one *S. invicta* and one *S. molesta* (Fig. 7). Two *S. molesta* were collected the next day (10-XIX-19) from the bottle containing apple juice. And one *M. pharaonis* was collected last day of

bottle with Stevia which was on the fourth day of collection (10-XX-19). Fourteen *S. invicta* in total were collected from the bottle with apple juice: eight on the second day of collection (10-XVIII-19), five on the third day (10-XIX-19), and then one on the collection (10-XXIII-19). At location D, only one *S. molesta* (Fig. 5) was collected from the

fourth day (10-XX-19). At location E, only one *S. invicta* was collected from the bottle with Stevia which was on the first day of collection (10-XVII-19). No ants were collected from the bottle containing apple juice at this locality.

Third Week of Collection

As with A and C, no ants were collected from location B. At location D, four Crematogaster spp. (Fig. 6) were collected from the bottle containing soda on the first day of collection (10-XXVI-19). One S. invicta was collected the following day (10-XXVII-19). At location E, three S. invicta, two M. pharaonis, and one S. molesta were collected from the bottle containing soda on the first day of collection (10-XXVI-19). In subsequent days, five S. invicta (10-XXVII-19), one T. melanocephalum (Fig. 4) (10-XXVIII-19), one S. molesta, one queen Camponotus vicinus (Fig. 8) (10-XXXI-ae spp. and *A. vulgare.* No data was collected for milk due spoilage concerns.

<u>Water</u>					
	Locality: **A**	**B**	**C**	**D**	**E**
Survey Date: **10-VI-19**	None	None	None	None	None
	Locality: **A**	**B**	**C**	**D**	**E**
10-VII-19	None	None	None	None	None
10-VIII-19	None	1 (*S. invicta)*	None	None	None
10-IX-19	None	None	None	None	1 (*S. molesta)*
10-X-19	None	None	None	None	None
10-XI-19	None	None	None	None	None
10-XII-19	None	None	None	None	None
<u>Sugar Water</u>					

	Locality: **A**	**B**	**C**	**D**	**E**
Survey Date: **10-VI-19**	None	None	None	None	None
10-VII-19	None	None	None	None	None
10-VIII-19	None	6 (5 *S. invicta,* *1 M. pharaonis)*	None	None	None
10-IX-19	None	4 (3 *S. invicta*, 1 *M. pharaonis*)	None	None	None
10-X-19	None	2 (1 *S. invicta,* *1 M. pharaonis*)	None	None	None
10-XI-19	None	1 (*S. invicta*)	None	None	1(*S. molesta*)
10-XII-19	None	None	None	None	4 (*S. molesta)*
<u>Stevia</u>					
	Locality: **A**	**B**	**C**	**D**	**E**
Survey Date: **10-XVII-19**	None	1 (*S. invicta*)	None	None	1 (*S. invicta*)
10-XVIII-19	None	None	None	None	None
10-XIX-19	None	1 (*S. invicta*)	None	None	None
10-XX-19	None	None	None	1 (*S. molesta*)	None
10-XXI-19	None	None	None	None	None
	Locality: **A**	**B**	**C**	**D**	**E**
10-XXII-19	None	None	None	None	None
10-XXIII-19	None	None	None	None	None
<u>Apple Juice</u>					
	Locality: **A**	**B**	**C**	**D**	**E**
Survey Date: **10-XVII-19**	None	None	None	None	None
10-XVIII-19	None	2 (1 *S. invicta,* *1 S. molesta*)	None	8 (*S. invicta*)	None
10-XIX-19	None	2 (*S. molesta*)	None	5 (*S. invicta*)	None

10-XX-19	None	None	None	1 (*S. invicta*)	None
10-XXI-19	None	None	None	None	None
10-XXII-19	None	None	None	None	None
10-XXIII-19	None	1 (*M. pharaonis*)	None	None	None
Coca-Cola					
	***Locality:* A**	**B**	**C**	**D**	**E**
Survey Date: **10-XXVI-19**	None	None	None	4 (*Crematogaster sp.*)	6 (3 *S. invicta*, 2 *M. Pharaonis, 1 S. molesta*)
10-XXVII-19	None	None	None	1 (*S. invicta*)	5 (*S. invicta*)
10-XXVIII-19	None	None	None	None	1 (*T. melanocephalum*)
10-XXIX-19	None	None	None	None	None
10-XXX-19	None	None	None	None	None
10-XXXI-19	None	None	None	None	2 *(1 C. vicinus, 1 S. molesta*)
11-I-19	None	None	None	None	1 (*S. molesta*)

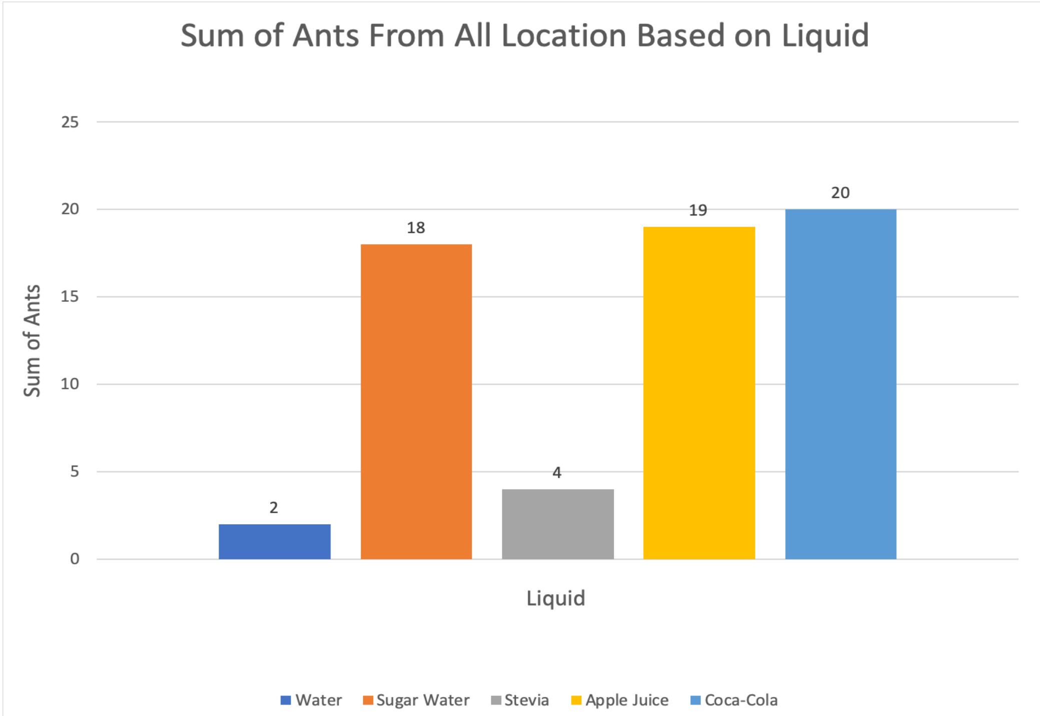

Fig. 2. Total counts of ants from different liquids were gathered from all locations.

Discussion

In this experiment, ants were collected using water bottles of various liquids, that served as substitutes for different sugars. These liquids were intended to attract and capture the ants so it could be determined the sugar that was most enticing to each species of ants. In these water bottles were water, sugar water, stevia water, apple juice and coca cola. It was planned to test milk as well, but due to spoilage concerns milk was excluded. After preserving and counting how many ants appeared in each liquid, the ants were then identified. The summary of all the species collected include *Solenopsis invicta* (red imported fire ants), *Camponotus vicinus* (carpenter ants), *Solenopsis molesta* (thief ants), *Monomorium pharaonis* (pharaoh ants), *Crematogaster sp.* (acrobat ants), and *Tapinoma melanocephalum* (ghost ants).

A greater diversity of ant species where found at the traps than was expected. It was initially hypothesized that a majority of the collected specimen would be *S. invicta*. While they were the most frequent ones trapped in the experiment, they were not the only visitors. Of the ants collected, *S. invicta* was the most abundant (35 specimens), followed by *S. molesta* (13 specimens), *M. pharaonis* (five specimens), *C. sp.* (four specimens), *T. melanocephalum* (one specimen), and *C. vicinus* (one queen ant) (Table 2). Not all ants that were prepared to be analyzed in the original survey were captured.

These results show that *S. invicta* was abundant in all the location tested, and could be the most abundant species in the non-forested areas of Bryan/College Station, Texas attracted to common sugary products found in households. Ants from the genus *Solenopsis* are the most common genus to appear in this experiment in all of the locations that were able to collect ants, composing 48 out of the 59 ants collected.

The test demonstrated that the substances from least attractive to most attractive were: water with only two, stevia water with four, sugar water with 18, apple juice with 19 and Coca-Cola with 20. This suggests that ants have the greatest preference for the ingredients in Coca-Cola (high fructose corn syrup, glucose, manufactured fructose). It also discerned that ants are more attracted to real sugars (sucrose, glucose, and fructose) that occur in the sugar water, apple juice and Coca-Cola, versus artificial sugars or just plain water. These findings go against our hypothesis of the ants being attracted to all kinds of sugars (including artificial), but it does support what most house owners see when they spill something with high concentrations of sugar versus other liquids. However, this analysis can be countered from some observations that occurred in some of the bottles. Apple juice bottles over the courses of the week often became mold- some were moldy before used to attract specimens for that particular day - and this could have been a factor against why some locations did not receive any ants, as it is not that the ants were not gravitated toward the sugar in apple juice, but the mold in the apple juice was unattractive and too spoiled. To try to fix this problem, new bottles were bought instead of being washed and reused, as once the mold contaminated the water bottle, it was difficult to remove completely. To draw further conclusions about the attractiveness of apple juice by species, a repetition using only new bottles of this experiment will have to be repeated.

It was determined that elevation was not a relevant factor of the results because locations A and C (elevations 90 m and 102 m respectively), both did not collect any ants. These locations were the experiments highest and lowest elevations, and neither elevation collected ants in any of the sugars tested. Weather is also a crucial variable to consider, but since all the locations were in the same city, and thus experienced the same weather, this could not be used as a reason as to why some locations caught more specimens than the others. There were some unexpected occurrences that affected the experiment overall. The liquids in the bottles, and the filter paper used to drain out the ants, became moldy over time. The bottles were switched out every day during the week, but even that amount time caused mold, especially in the apple juice. This mold could have deterred ants from the traps, and also made separation of the ants later more difficult. There may have been some error on the amount of ants captured as a result.

Another surprising occurrence was the appearance of a fly and a pillbug in one of the liquids (apple juice). Researchers were not anticipating any other insects to be attracted to the traps, or able to enter. The fly was identified to the genus level, and determined to be a blow fly (*C. spp.*) due to its bronze metallic body and red eyes. This made its appearance more understandable, because blow flies are attracted to garbage and other filth including molding apple juice. The pillbug was *A. vulgare,* since it is the only one that really appears in southern texas and likes to make its home in well kept lawns around apartments and homes.

The most confusing event was that neither locations A or C were able to attract ants. This limited researchers in the number of ants that were examined, since there were only three functioning locations. One reason why locations A and C were unsuccessful could be because the locations were apartment complexes that were regularly sprayed with pesticides. The pesticides could have deterred ants from the area, or killed off any existing colonies. Another reason may be because there are children in the area who may play in the grass and accidentally break down ant piles in the process, causing the ants to relocate. These forthcomings could not be changed for the benefit of the experiment, and may be why there was a lack in ant activity.

Though this experiment had a few unanticipated hindrances, a collection was made that was analyzed to reach a final conclusion. The most favored liquid by ants was Coca-Cola, which contains the most amount of sugar, with high fructose corn syrup, glucose and fructose being mixed in. The red imported fire ant (*S. invicta*) was the most common ant to be attracted these sugars within Bryan/College Station, Texas. There is still more research that could be done on this topic. Researchers had originally wanted to include milk to incorporate the sugar lactose, but determined it could be difficult to prevent it from spoiling. In the future, more types of sugars, such as lactose, could be tested. This experiment was also limited to a single region, and results could prove different if it was extended to different climates and ecosystems. The question about ants and their relationship with sugars could also be implemented onto sugars found in food, and tested with those products. Only one type of trap was used for this experiment, using a variety of trap methods could ensure that ants are not being deterred simply by the means of capture. The findings of this experiment are important because as food and beverage products become more modified, the insect community has adapted with it. Many types of insects now regularly invade homes in the search for easy food sources. It is important for homeowners, and entomologists, to understand what will impact an ant infestation, so that they can be regulated and reduced. This experiment contributes which liquid (Coca-Cola) and sugars (glucose and fructose), will most likely draw ants into a home.

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