The Effects of Blood Glucose Levels on the Attraction of Forensically Important Flies

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Editor: Marielle McInnis

Abstract: Necrophagous flies are flies that feed on decaying flesh. The two main families of flies that feed on decaying remains are Calliphoridae and Sarcophagidae, and these particular families can aid in forensic investigation due to their attraction to decaying matter such as human remains. This experiment focused on the attraction of forensically important flies to different blood glucose levels and attempts to answer the question of whether someone with elevated blood glucose levels at the time of death would attract more flies than someone with normal blood glucose levels at death. This information could be especially applicable to remains with open wounds or crime scenes in which lots of blood is present. To investigate this, fly traps containing bovine blood of different glucose levels were set outside for six days at a time. At the end of each six-day period, the flies from each trap were collected, counted, frozen, and analyzed to determine each specimen's family. It was determined that elevated blood glucose levels do attract more flies, particularly Calliphoridae, than normal blood glucose levels, as the most flies were found in one of the increased glucose level traps for all three trials.

Keywords*: Calliphoridae, Sarcophagidae, blood, glucose, forensic*

The field of forensic entomology is vast and incredibly important to criminal investigations due to the fact that insect evidence and time of colonization estimations can help investigators determine the information that is vital to an investigation. Various factors, both internal and external, can impact the colonization of remains by Diptera after death. Some external factors can include the location of the body, the ambient temperature, and whether or not the body was buried (Campobasso et al 2001). One of the most notable conditions of the human body affecting Dipteran colonization and larval development is antemortem or perimortem intoxication. Certain drugs present in a human body after death can impact the development of larvae, which is an important consideration for time of colonization calculations (Boulkenafet et al. 2020). This is known as entomotoxicology, which is a

relatively new but useful subfield of forensic entomology (Introna et al. 2001). As of now, more research has been done to broaden the subfield of entomotoxicology and studies have been done to demonstrate the effects of different drugs on the development of larvae (Liu et al. 2015). An example of this is a study on the effects of cocaine on the development of *Chrysomya albiceps* Wiedemann and *Chrysomya putoria* Wiedemann (Diptera: Calliphoridae). It was found that larvae that fed on rabbits injected with cocaine grew faster than those that fed on the control rabbits (de Carvalho et al. 2012). This demonstrates the idea that conditions of the human body can affect insect activity on remains. Regarding the attraction of adult flies to decaying remains, we do know that female flies are attracted to decaying flesh based on its smell (Holland 2013). Additionally, blowflies are attracted to blood (Brundage 2020), so a particularly bloody crime scene could lead to greater numbers of flies. Relating to nutrition, blowflies require both sugar and protein to develop (Brust et al. 1955), so the presence of sugar in a food source is essential. The impact of the bodily conditions of the decaying remains, the required nutrition for proper development of blowfly larvae, and the conditions that attract blowflies all beg the question: could an increase in blood glucose levels lead to an increase in the attraction of adult forensically important flies? The answer to this question could have potential forensic application, as someone with elevated glucose levels at the time of death and/or open wounds could lead to colonization of a body at a greater magnitude.

Materials and Methods

To begin, all materials were gathered, including a gallon jug of bovine blood from the Rosenthal Meat Center at Texas A&M University in College Station, TX. Before obtaining the blood, a 3.5% solution made from sodium citrate (Judee's Gluten Free ©, Plain City, OH) and water was added the gallon jug to serve as an anticoagulant. Soon after the blood was obtained, three homemade fly traps were assembled using three 2 liter plastic bottles. The necks of the bottles were cut off and the caps were removed. Next, 250mL of blood was measured out using a graduated cylinder and added to the first 2 liter bottle. Using a glucometer (CVS Health Advanced Glucose Meter, CVS Health ©, Woonsocket, RI) and test strips (CVS Health Advanced Glucose Meter Test Strips, CVS Health ©, Woonsocket, RI), the glucose level of the unaltered blood was tested and measured at 116mg/dL. The neck of the bottle was flipped upside down and placed in the bottom of the bottle to form a funnel and taped in place. This trap was labeled as the control. This process was repeated again, but this time, Sunny Side Up Bakery glucose syrup (Hobby Lobby Stores, Inc., Oklahoma City, OK) was added in small quantities to the blood until the glucose level was read at about 180mg/dL. The trap was labeled accordingly. Finally, this process was repeated once more, and glucose was added until the glucose level was read at about 200mg/dL. Then, the trap was labeled accordingly. Once the three traps were complete, they were set atop a shed and left outside in Bryan, TX for six consecutive

days and checked daily. These traps are depicted in Figure 1.

Fig. 1. The funnel fly traps baited with bovine blood of varying glucose levels used for this experiment.

At the end of the first trial, the flies from each trap were retrieved using forceps and placed in separate containers with a label corresponding to the label on the trap. The flies were frozen to preserve them and analyzed under a dissection microscope to determine what family they were a member of. The number of flies found in each trap, along with the number of flies from each identified family found in each trap, were recorded. This experiment was repeated a total of three separate times over the span of about a month.

Results

Ultimately, the greatest number of flies were always found in one of the increased blood glucose level traps. For the first trial, the greatest number of flies by far was found in the 180mg/dL trap. For the second trial, the greatest number of flies were found in the 200mg/dL trap. Finally, for trial three, the most flies were found in the 182mg/dL trap, but the 201mg/dL trap had only slightly fewer flies in it. This can be seen in Figure 2. Additionally, the collected flies were identified down to family. The majority of

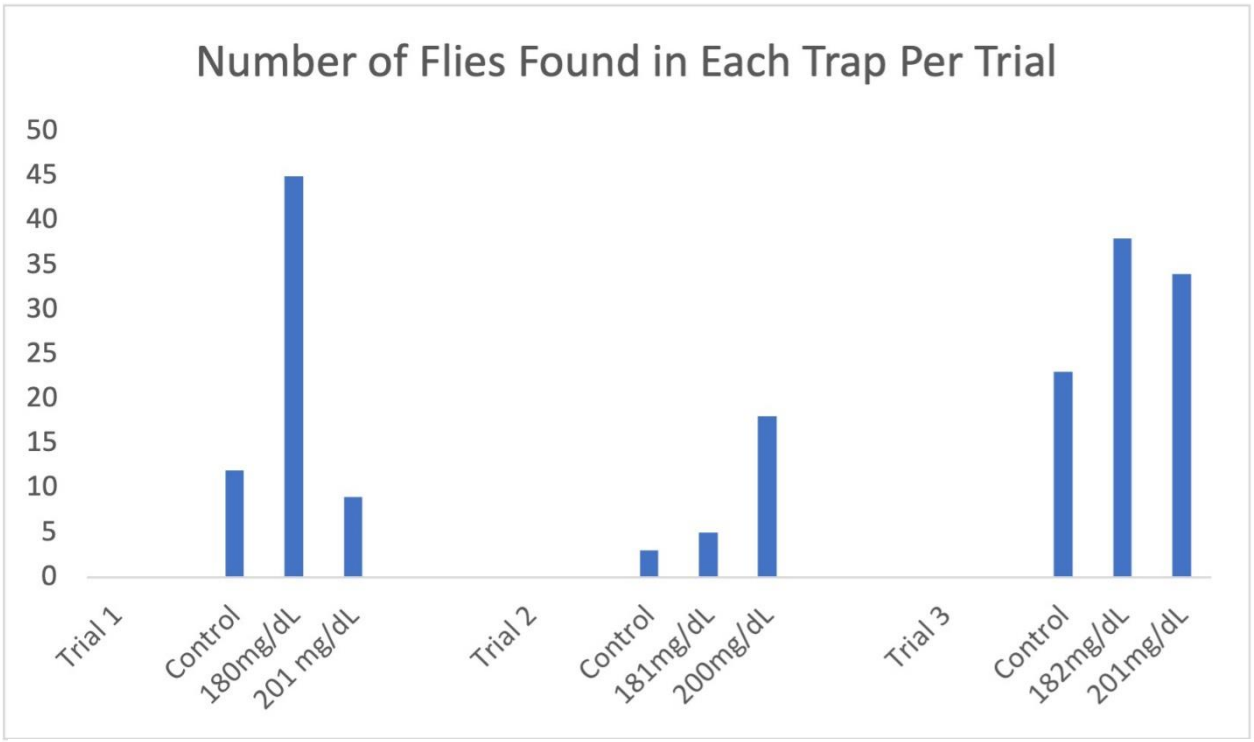

Fig. 2. Graph depicting the number of flies found in each trap for each trial.

the flies were identified as Calliphoridae. The total spread of families found for all three trials is shown in Figure 3. It was about 90% Calliphoridae, 3% Sarcophagidae, 6% Muscidae, and 1% unidentified.

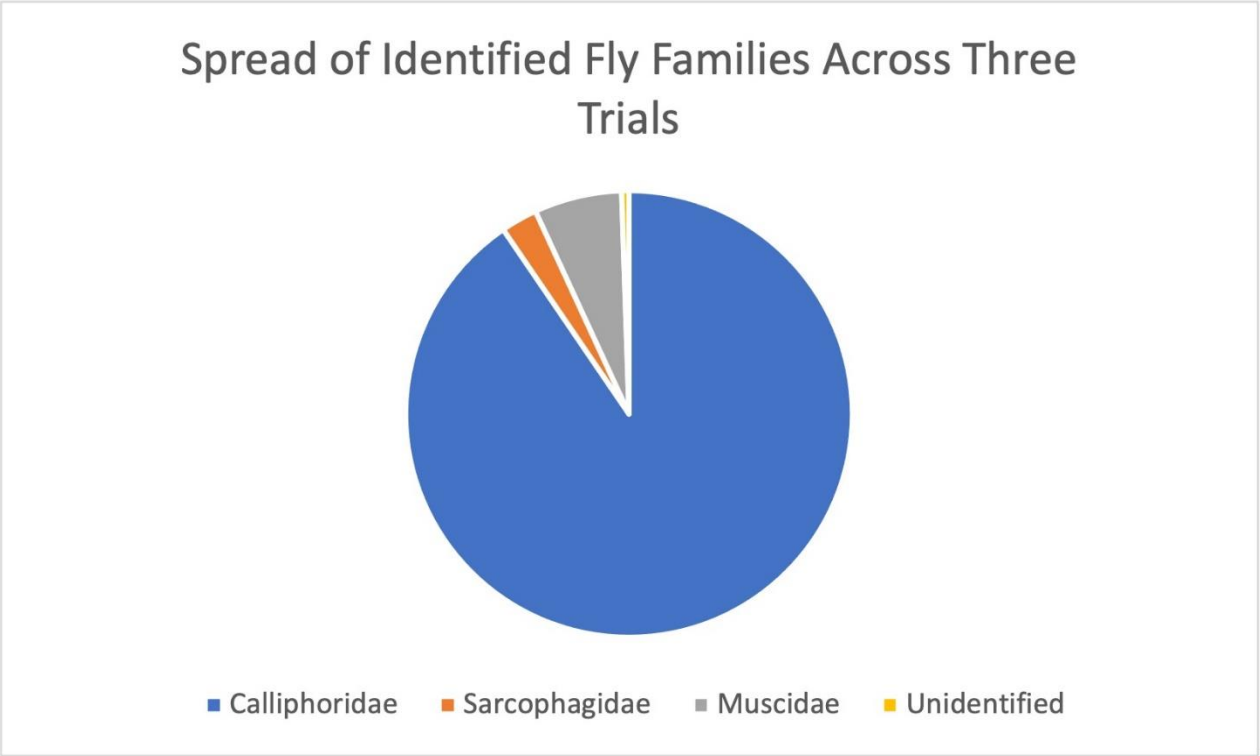

Fig. 3. Pie chart depicting the total percentages of families identified for the duration of the experiment.

Discussion

The data shows a correlation between an increase in blood glucose levels and an increase in flies attracted. This experiment was meant to mimic certain conditions in the body. The 116mg/dL (acting as the control) is the closest to normal blood glucose levels in the body, as this reading is only slightly higher than a normal reading (Katiyar 2003). The mid-level increase (ranging from 180mg/dL to 182mg/dL over three trials) simulates the threshold for prediabetes (Mouri et al. 2021). Finally, the highest increase in glucose (ranging from 200mg/dL to 201mg/dL over three trials) is said to be indicative of a diabetic condition. (Mathew et al. 2021). The results of the experiment show that an increase in blood glucose levels leads to an increase in adult necrophagous flies attracted. This means if the victim had open wounds and died with abnormally high glucose levels, they would attract more flies after death than someone with normal blood sugar levels at the time of death. Whether or not this conclusion stands when the victim has no open wounds is undetermined and would require further research. Nonetheless, investigators should keep in mind that increased blood glucose can lead to increased fly activity at a crime scene. If a particular victim regularly has high blood sugar, such as someone with a diabetic condition, this information could be useful. There were, however, some limitations to this experiment. For example, this experiment took place in

late October and November in Bryan, Tx. Because of the time of year in which this experiment was conducted, the ambient temperatures were overall cooler. Since flies are less active during the colder months, this resulted in some smaller sample sizes (such as in trial two). The most flies were collected in trial three when the weather was warmest, resulting in a better sample size, while the least flies were collected in trial two when the weather was coolest, resulting in a smaller sample size. Another limitation of this experiment was the fact that the collected bovine blood that was used in the experiment naturally had a glucose level that was slightly above the normal range for humans. This means that the experiment doesn't quite simulate the normal blood glucose levels for humans. Overall, the study of forensically important flies and their attraction and development patterns is incredibly valuable information. New data on the attraction or repulsion of flies to different substances and conditions of the human body, as well as data on how fly larvae develop in these certain conditions, could help us to have more accurate time of colonization calculations in the future and better the field of forensic entomology as a whole.

Acknowledgments

I would like to thank Rachel McNeal for taking time out of her busy schedule to let me use lab space and helping me learn how to identify different fly families for the purpose of this project. It was much appreciated! Also, I would like to thank Dr. Adrienne Brundage for allowing me to use her space and allowing me to use some of her equipment.

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